Southwestern U.S. Ground Motion Characterization
Project Plan

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List of Acronyms

APS	Arizona Public Services
CBR	Center, Body, and Range
CEUS	Central and Eastern United States
CFR	Code of Federal Regulations
DCPP	Diablo Canyon Power Plant
EE	Evaluator Expert
EPRI	Electric Power Research Institute
GMC	Ground Motion Characterization
GMPE	Ground Motion Prediction Equation
HID	Hazard Input Document
ITC	Informed Technical Community
NGA	Next Generation Attenuation
NGA-west2	Project name for the update of the 2008 NGA models
NRC	Nuclear Regulatory Commission
PE	Proponent Expert
PEER	Pacific Earthquake Engineering Research Center
PG&E	Pacific Gas & Electric
PM	Project Manager
PPRP	Participatory Peer Review Panel
PSHA	Probabilistic Seismic Hazard Analysis
PTI	Project Technical Integrator
PVNGS	Palo Verde Nuclear Generating Station
QA	Quality Assurance
RE	Resource Expert
RG	Regulatory Guide
SCE	Southern California Edison
SCEC	Southern California Earthquake Center
SONGS	San Onofre Nuclear Generation Station
SSC	Seismic Source Characterization
SSHAC	Senior Seismic Hazard Analysis Committee
SWUS	Southwestern United States
TDI	Technically Defensible Interpretation
TI	Technical Integrator
WUS	Western United States

USGS	United States Geological Survey
V_{S30}	Shear Wave Velocity in the upper 30m

INTRODUCTION AND CONTEXT OF THE STUDY

In response to the March 2012 50.54(f) letter, an updated probabilistic seismic hazard analysis (PSHA) based on a Senior Seismic Hazard Analysis Committee (SSHAC) Level 3 process (Budnitz et al., 1997; NRC 2012, NUREG 2117) is required to be conducted for all operating nuclear power plants. A seismic hazard analysis requires a Seismic Source Characterization (SSC) and a Ground Motion Characterization (GMC).

Previous SSHAC level 3 studies for source characterization and ground motion characterization are available for the central and eastern United States (CEUS) (EPRI, 2004; CEUS, 2012), but SSHAC level 3 studies are not available for the western United States (WUS). The four WUS plant sites (DCPP, SONGS, PVNGS, and Columbia) have different seismic source issues that require separate SSC studies, but they have similar ground motion issues. The three plants in the southwestern US, DCPP, SONGS, and PVNGS, have joined together to sponsor a single GMC project for the southwestern United States (SWUS).

This Project Plan outlines the approach for conducting the SWUS GMC for application to the DCPP, SONGS, and PVNGS sites. As shown on the Project Organization Chart (Figure 1), the three utilities (PG&E, SCE, and APS) are the Project Sponsors and the project will be coordinated under the direction of a Project Manager, Dr. Carola Di Alessandro. The Project Schedule is shown on Figure 2, together with the schedule of the three SSC studies for the individual nuclear power plants. The project organization and schedule are described below.

A SSHAC Level 3 process is a formal, structured process for developing the SSC and GMC for use in PSHA. The SSHAC process provides guidelines for how the GMC study should be conducted, including: (a) identification of significant issues and data; (b) identification and solicitation of expert opinions and alternative models; (c) evaluation of the available data, expert opinions and alternative models; (d) integration of the information into GMC models that incorporate the range of technically defensible interpretations; (e) documentation of the model development; and (f) participatory peer review of the technical results and process. As described within the SSHAC guidelines (Budnitz et al, 1997; Hanks et al., 2009; Coppersmith et al., 2010; NRC, 2012), the goal of following a SSHAC process is to provide reasonable regulatory assurance that the center, body and range (CBR) of the technically defensible interpretations (TDI) in the GMC models have been adequately captured. The purpose of this Project Plan is to describe the SSHAC methodology, in general, and how the SSHAC Level 3 process will be applied to develop the GMC models for the SWUS region.

DESCRIPTION OF SSHAC METHODOLOGY

In 1997, the Senior Seismic Hazard Analysis Committee published NUREG/CR-6372 (Budnitz et al., 1997) that detailed a methodology for capturing the epistemic uncertainty in input parameters for PSHAs. Factors motivating the development of this methodology were the observations that: (1) different PSHA studies (e.g., EPRI, 1988; Bernreuter et al., 1989) developed significantly different estimates of the mean seismic hazard for nuclear facilities; and (2) the primary reason for the difference in hazard estimates was that the SSCs and GMCs did not characterize the epistemic uncertainty within those characterizations in a consistent way. Recognizing the importance of characterizing epistemic uncertainty, the SSHAC spent approximately four years developing a methodology for characterizing epistemic uncertainties in SSC and GMC studies. Since publication of the original SSHAC methodology, there have been additional publications that have elaborated on the guidance and how it should be applied (e.g., Hanks et al., 2009; Coppersmith et al., 2010). These guidelines were finalized in NUREG 2117 (NRC, 2012). The following summary of the SSHAC methodology and the plan for the SWUS GMC study are consistent with these publications.

The stated goal of the SSHAC guidelines is to provide a methodology for developing SSC and GMC that "…represent the center, the body, and the range of technical interpretations that the larger informed technical community would have if they were to conduct the study" (Budnitz et al., 1997, p. 21). The terminology "center, body, and range" refers to the complete characterization of uncertainty. For simplicity, consider the single parameter of the maximum earthquake magnitude for a fault. In this case, "center" can be thought of as the average (i.e., median) maximum magnitude, "range" can be thought of as the extreme upper and lower estimates of the maximum magnitude limits, and "body" can be thought of as the shape of the distribution of potential maximum magnitudes within that range (e.g., symmetric or skewed distributions).

The use of the terminology "informed technical community" (ITC) also has an explicit meaning within the SSHAC guidance. This terminology is meant to communicate the hypothetical idea that if technical experts within the appropriate fields (e.g., GMC, SSC) (1) had detailed knowledge of the same data as those who developed the SSC and GMC, and (2) went through the same interactive process as the developers of the SSC and GMC, this ITC would develop characterizations that fit within the center, body, and range of those developed for the project. More recently, the NRC (2012, NUREG 2117) suggests replacing the term ITC with "technically defensible interpretations (TDI)" of the available data, models and methods to more clearly reflect the intent of the SSHAC process. They continue to emphasize that the careful evaluation of the larger technical community's viewpoints remains a vital part of the SSHAC process. By following the structured methodology of the SSHAC process, the intent is to provide reasonable regulatory assurance that the goal of representing the center, body, and range of the characterizations has been met, and thus provides the basis for developing seismic

hazard estimates that are reproducible, defensible, transparent, and stable (i.e., if someone else were to conduct a similar study they would not get significantly different results). For the remainder of this Project Plan, the term "technically defensible interpretations" (TDI) will be used rather than the earlier term "informed technical community" (ITC).

PROJECT ORGANIZATION

The project organization is shown on Figure 1. As described by Budnitz et al. (1997) and Hanks et al. (2009), specific roles and responsibilities of individuals within a SSHAC process must be clearly defined because the guided interaction between the different roles allows for the center, body, and range of the SSC and GMC to be robustly characterized.

Members of the project team (TI Team and PPRP) were selected to provide a broad spectrum of (1) past experience on GMC models, (2) knowledge of data, methods and technical approaches relevant to ground motion in the WUS, and (3) prior SSHAC Level 3 experience. In addition, there was a goal to involve younger scientists on the TI team to help build up the number of people with experience with the SSHAC process for future projects. The basis for the selection of the PPRP and TI team members is given in Appendix A. The Project Plan provides for bringing all members of the project team to a common level of understanding of the technical data as well as explicit training in the SSHAC process. Specific roles of the SSHAC Project Team are described below.

Project Sponsor –The Project Sponsors provide financial support and "own" the results of the study in the sense of property ownership.

Project Manager (PM) – The PM is responsible for the scope, schedule, and budget and coordinates the execution of the project. In addition, the PM interacts with the Project Sponsors to keep them informed on the progress.

Project Technical Integrator (PTI) – The PTI is a technical expert with knowledge of the SSHAC process, both GMC and SSC studies, and the site-specific application for site response effects. The PTI is responsible for ensuring coordination and compatibility between the joint SWUS GMC study and the SSC studies being conducted separately by the three utilities. Each utility will assign a PTI who will be responsible for the coordination of the SWUS GMC, and plant-specific SSC, and site-specific site response.

Technical Integrator Team (TI Team) – The TI Team is a team of Evaluator Experts with PSHA experience that are responsible for conducting the evaluation and

integration process. The TI Team also will have a staff of Evaluator Experts that are not officially part of the TI Team but assist the team during the data evaluation part of the project. The TI Team will perform the integration and model-building part of the study and ultimately will "own" the results of the study with respect to intellectual responsibility for the results. As such, the TI Team is responsible for ensuring: (1) that the various data, models, and methods proposed by the larger technical community and relevant to the hazard analysis are considered in the evaluation; and (2) that the final GMC models represent the center, body and range of the TDI. Dr. Norman Abrahamson will be the TI Team Lead. Members of the TI Team are shown on Figure 1. The basis for the selection of the TI team members is given in Appendix A.

Evaluator Expert (EE) – An EE is an expert with PSHA experience capable of evaluating the relative credibility of multiple alternative hypotheses to explain observations. All members of the TI Team will be EEs. EEs use their professional judgment to objectively quantify epistemic uncertainty based on evaluations of the data, knowledge, and alternative models presented by the Resource and Proponent Experts. In addition, a support staff will assist the TI Team in their evaluation by conducting analyses of certain datasets and proponent models as directed by the TI team. Only the members of the TI Team will have intellectual ownership of the final logic tree and weights.

Resource Expert (RE) – A RE is an expert with a specialized knowledge of a particular data set, interpretation, or hypothesis who can present this information without a proponent bias. REs generally are invited to one or more Workshops and/or may be contacted outside of the Workshop environment by the TI Team to present and discuss their specialized knowledge regarding the strengths and weaknesses of alternative models and data sets. The REs will be identified as needed during the project. The REs provide their specialized knowledge to assist the TI team in the evaluation but they do not take ownership or endorse the final GMC models. For example, scientists from the U.S. Geological Survey may act as Resource Experts during the Workshops, but their participation does not imply that they support the GMC model developed by the TI team.

Proponent Expert (PE) – In contrast to the unbiased RE, a PE is an expert who advocates a particular hypothesis or technical position. The PE's opinion may range from mainstream to extreme (outlier) views. PEs generally are invited to one or more Workshops and/or may be contacted outside of the Workshop environment by the TI

Team to present and discuss their position. PEs will be identified as needed during the project, but are expected to mainly include model developers from PEER and SCEC.

Hazard Analyst – The Hazard Analyst is a PSHA expert responsible for performing the PSHA calculations. Hazard Analysts are incorporated into all phases of the study (e.g., evaluation, integration) because they can provide: (a) valuable insight into how to represent uncertainty within different parameters; and (b) sensitivity feedback with respect to what parameters have the most impact to the hazard calculations. Each utility will provide its own Hazard Analyst who is knowledgeable with the site-specific SSC so that the hazard feedback addresses the key issues at all three sites. The basis for the selection of the Hazard Analysts is given in Appendix A.

Participatory Peer Review Panel (PPRP) – The PPRP is a panel of experts with SSHAC methodology and/or PSHA experience that provide participatory peer review of the SSHAC methodology implementation process and technical judgments of the TI Team. The PPRP assures that the range of TDI is captured and documented through proper implementation of the SSHAC process. PPRP members should be highly regarded and recognized as experts in their respective technical fields. The members of the PPRP serve as individuals and not as an affiliate of any organization. Each member of the PPRP in the employ of any organization must ensure that it is understood that, as Panel members, they are not representing the position of their respective organizations, but rather, they are serving as recognized experts in their respective fields.

Members of the PPRP will attend all of the formal Workshops and are encouraged to participate in field reviews and selected working meetings of the TI Team. Opportunities to participate in working meetings will be identified by the PPRP and coordinated with the Project Manager.

The members of the PPRP are shown on Figure 1 and will consist of Dr. Steve Day (Chair), Dr. Ken Campbell, Dr. Brian Chiou, and Dr. Tom Rockwell. The composition of the PPRP includes individuals with prior SSHAC Level 3 experience (Campbell, and Chiou), as well as captures the breadth of technical requirements for the project including both empirical GMPEs and numerical simulations of ground motion. The basis for the selection of the PPRP members is given in Appendix A.

Outside Observers – Outside observers are not explicitly defined within the SSHAC guidance (Budnitz et al., 1997), but are discussed in the implementation guidelines (NRC, 2012; NUREG 2117). Observers may include sponsors, regulators, and other invited individuals that would benefit from observing the Workshops. Outside observers do not participate in any aspect of the SSHAC process (e.g., evaluation, integration, peer review, documentation), but they may be invited to observe some Workshops depending on the specific needs of the Project Sponsors. Time for observer comments will be accommodated at the end of each day of each Workshop.

SWUS GMC WORK PLAN AND KEY STUDY TASKS

For the SWUS Project, the SSHAC Level 3 study will involve four components: (1) evaluation, (2) integration, (3) participatory peer review, and (4) documentation. Evaluation refers to the process of compiling and evaluating relevant data, alternative models/concepts, and alternative interpretations of the TDI. Integration refers to the assessment process where the various datasets, models, and interpretations are combined into a representation of the CBR of the TDI for the SSC and GMC. Participatory peer review refers to review of the evaluation and integration process by a peer review panel capable of providing feedback, during the project, on technical aspects of the project and whether the SSHAC Level 3 process was followed appropriately. By receiving feedback from the peer review panel during the project, the TI team can make necessary corrections before the project is complete. Documentation refers to the final reports produced by the project that document the technical results, the technical basis for the evaluation and assignment of weights on the logic tree, and how the SSHAC Level 3 process was implemented. The SSHAC Level 3 methodology formalizes the process of interaction between the technical community, the TI Teams, and the PPRP through a series of Workshops.

The process of evaluation, integration, peer review, and documentation will occur in a series of Workshops, Working Meetings, and internal work. These process components are described below.

Evaluation: The consideration of the complete set of data, models and methods proposed by the larger technical community that are relevant to the ground motion model's hazard at any of the three sites.

The process of evaluation includes, but is not limited to, the: (a) identification of hazard-significant issues; (b) compilation of relevant data and models; (c) evaluation of the data and models with respect to their impact on the GMC. The primary focus of the GMC evaluation process will be on (1) the applicability of the NGA-West2 empirical GMPE models and other candidate empirical GMPEs to the three SWUS

sites of interest, because each might require its own adjustment to the ground motion model(s), and (2) the applicability of the ground motions based on numerical simulations to the fault/site-specific geometries at each site. Through sensitivity analyses, those parts of the GMC Logic Tree that are most significant to hazard will be the focus for the discussions at the Workshops. Those parts of the GMC Logic Tree model that are not significant to hazard will be reviewed and updated to reflect the current state of scientific knowledge, as appropriate, but will not be the focus of detailed evaluation and further refinement.

The PPRP is involved in the evaluation process through attending Workshops, reviewing interim project documentation, and participating in Working Meetings of the TI Teams, as needed.

Integration: Representing the center, body and range of technically defensible interpretations in light of the evaluation process (i.e., informed by the assessment of existing data, models and methods).

Following the evaluation process, the TI Team will integrate the relevant data, models, and interpretations to develop a general GMC logic tree for the SWUS that captures the center, body, and range of the TDI. There will also be site-specific modifications of the GMC logic trees to address site-specific issues such as the reference V_S for the ground motion model. The process of integration commonly includes: (a) development of a version of the GMC Logic Tree; (b) hazard sensitivity analyses to document the impact of model parameters on the seismic hazard; (c) feedback from the Resource Experts, Proponent Experts, and PPRP members on the logic tree models, and hazard sensitivity; and (d) the development of the next versions of the GMC logic tree. This process is iterated until final site-specific GMC logic trees are developed for each site.

The GMC TI Team will lead the integration process; the Hazard Analysts will conduct the iterative hazard sensitivity analyses. The REs and PEs will be less active in this process, but they can be called upon by the TI Teams as needed to provide clarification, resolve new issues, and provide feedback on the preliminary model. The majority of the integration process will occur through informal Working Meetings and internal work. The Workshops are designed to present the models and sensitivity results, and to collect feedback. The PPRP will be involved in the integration process

through attending Workshops, reviewing interim project documentation, and attending selected Working Meetings, as needed.

Peer Review – Participatory peer review is an integral component of a SSHAC Level 3 study. The overall goals of this review will be to ensure that the SSHAC process is adequately followed and that the technical results adequately characterize the CBR of the TDI. The review is participatory in that it will be a continuous process throughout the study, and not a singular review that occurs at the end of the study. As such, the PPRP will be kept abreast of project developments through a combination of attending Workshops, reviewing interim project documents, and attending selected field reviews and/or Working Meetings, as needed. The TI team will have the opportunity to address PPRP comments and make modifications during the project.

Documentation – Documentation also is an integral component of a SSHAC Level 3 study in that it provides a record of the final technical results, how they were reached, and how the SSHAC Level 3 process was implemented. In addition, the documentation provides the basis for review by any pertinent regulatory officials, if needed. Documentation for the study will include the Workshop summaries and presentations, PPRP letter reports and TI Team responses, GMC data tables showing how the different data sets and models were used, GMC logic trees, and the final report including the PPRP review of the final report.

The four process components of the SSHAC Level 3 study (evaluation, integration, peer review, and documentation) will be conducted using a series of formal Workshops, Working Meetings, and internal work. The following work plan summarizes the individual tasks that will be conducted for the SWUS GMC study. The major milestones of the work plan are shown on Figure 2.

Databases

The GMC database will be the PEER NGA-west2 database with the addition of results from suites of numerical simulations computed using the SCEC broadband platform. The PEER NGA-west2 data will be stored at PEER which provides for public access to the data. If additional observed ground motion data are added to the PEER-NGA-west2 data set as part of the SWUS project, then these additional data will be provided to PEER for incorporation in the next version of the PEER ground motion database. It is expected that under the project a ground motion database for Arizona will be developed: it will include small magnitude recordings in the surrounding region of PVNGS and moderate to large magnitude recordings from California recorded in Arizona. The simulated ground motions developed specifically for the SWUS GMC will be archived at the Southern California

Earthquake Center (SCEC) and will be made available to the public after QA is completed. A project-specific website is being developed to maintain the project documents. The page is managed by SCE and has the format of a collaborative platform (cFolder). Full access will be warranted to Project Sponsor and participants, including PPRP members. We plan to provide specific limited access to REs and PEs. The platform will also include literature and other general information relevant to the three nuclear power plants. At the end of the project, final report, PPRP final letters, presentations from public Workshops, Workshop summaries minutes, Working Meetings material and reference documents will be made publicly available. The reference documents will include PEER reports describing the empirical ground motion studies and SCEC reports describing the simulation methods and the validation study. Project participants will have access to such repository throughout the project; critical reference material will be available prior to each Workshop to allow adequate time for PPRP review. If documentation for a specific model is not provided in a timely manner, the model might be downweighted in the subsequent evaluation process.

General Tasks

Task 1: Preparation of Project Plan and Kickoff Meeting

The Project Sponsors will prepare a letter that outlines sponsor expectations, required deliverables and schedule. The initial task for the SWUS GMC study will be to prepare the Project Plan and hold a Workshop 0 (the Kick-off Meeting). The kick-off meeting will involve the Project Sponsors, PPRP, TI team, Hazard Analyst from each utility, PTI from each utility, Project Manager, Project Contracting, and the representatives of the Project Sponsors. The purpose of the kick-off meeting is to review the project plan, discuss the roles of the project participants, and identify key interface issues (SSC, GMC, and site response) for the three sites. The PPRP will provide a letter documenting their review of the Project Plan after the Kick-off Meeting.

Task 2: University Research to Develop Proponent Models

Two major ground motion projects are currently being conducted that are relevant to the hazard evaluation for the SWUS: PEER NGA-west2 and SCEC broadband platform validation. The PEER and SCEC studies are not part of the formal SSHAC process for the SWUS GMC study, but brief descriptions of these two studies are given below as they will be key inputs for the SWUS GMC study.

PEER is developing an updated ground motion database including key data from shallow crustal earthquakes in active regions around the world. This data set will increase the number of recordings above magnitude 5 by about a factor of 3 as compared to the original NGA data set (Chiou et al, 2008). PEER is using this expanded data set to develop new ground motion

prediction equations (GMPEs) that will be finalized in January 2013. It is expected that those models will include the traditional ergodic sigma (where the total variability is treated as a random variable that can be decomposed into between-events variability and within-event variability). Other studies are being conducted at PEER in coordination with the NGA-west 2 program that are focusing on other aspects relevant to the ground motion characterization such as single-station sigma (where there is an effort to remove the epistemic uncertainty from the total variability by recognizing systematic site effects not captured in the GMPEs – AlAtik et al., 2010), Kappa scaling, near fault fling effects; preliminary results from these additional studies should be available by March 2013 and their completion is expected by summer 2013. The PEER studies will result in a set of proponent models that will then be evaluated for their applicability to the three sites as part of the SWUS GMC study under the SSHAC process. The TI team evaluation will not be restricted to the NGA-west2 models. Other available GMPEs that may be applicable to the SWUS, such as GMPEs from Japan, Taiwan, Italy, Turkey, New Zealand, will also be considered.

SCEC is conducting a major systematic evaluation of the methods for numerical simulation of ground motion for engineering applications. They are developing a series of validation exercises that will be used to test the numerical simulation methods. These include two parts. The first part is a comparison of simulated motions with observations from past earthquakes using the optimized source parameters for each earthquake. This provides an evaluation of how well the simulation method works if the source is known. The second part is a comparison of the median simulation for future earthquakes (average of many realizations of the source) in the magnitude and distance range that are well constrained by the empirical data. This provides an evaluation of how well the method for generating source parameters for future earthquakes is working. To capture the CBR of the available simulation methods, SCEC will incorporate a range of different models with different approaches into the broadband platform for the validation. SCEC will provide a report describing the evaluation and recommending a set of simulations methods that pass the validation tests and represent proponent models for simulations. This set of proponent models will then be evaluated as part of the SWUS GMC study under the SSHAC process. The schedule of SCEC activities is set up so to expedite the validation and evaluation process. SCEC will hold several workshops that evaluate preliminary results to allow for early correction, reducing the risk of not meeting the SWUS schedule. In the event that SCEC cannot produce simulation methods that pass validation test in due time, the TI Team will consider the range of results from previous simulations along with the validation results and will likely need to increase the uncertainty of the GM appropriately.

Task 3: Workshop 1 (Significant Issues, Available Data and Data Needs)

The TI team and staff will develop the agenda for Workshop 1 (WS1), and identify the appropriate REs for WS1. The agenda and list of REs will be provided to the PPRP for their review. The PPRP may identify additional REs for consideration and/or significant issues or topics to be covered at the Workshop.

Workshop 1 will last for three days and be attended by the PTI, the TI team and staff, the PPRP, the Hazard Analysts, Resource Experts (REs), the Project Manager and support staff. The goals of WS1 are to (1) provide SSHAC training to the project participants, (2) discuss issues significant to hazard, and (3) identify available data to address the significant issues. REs will be asked to discuss specific data sets and to assist in identifying available data to address significant issues. Prior to the Workshop, letters will be sent to selected REs identifying directed topics and issues that they should be prepared to address at the meeting. The letters will help focus the Workshop discussion on key issues related to a particular data set, including quality of data, expected use of data, uncertainty or limitations in the data or interpretations, etc. The REs will be asked to present data and/or to participate in interactive discussion sessions with the TI staff and other related REs. This will inform the TI staff of the available data, and evaluations and interpretations of the data.

Key outcomes of Workshop 1 will include the definition of the scope of the numerical simulations to be conducted including the selection of the simulation methods to be implemented, and identification of the key ground motion data that can be used to check and/or constrain the GMPEs for application to the SWUS.

The PPRP will attend Workshop 1 mainly as observers, but in some cases, PPRP members may serve as a Resource Expert during the Workshop to take advantage of their specific technical knowledge on a topic. The PPRP may also ask clarification questions during the Workshop. The PPRP will provide verbal comments to the Project Manager and the TI team at the end of each day and at the conclusion of the Workshop. Following the three-day Workshop, a PPRP deliberation will take place to review the Workshop proceedings. PPRP will have the flexibility to complete its post-Workshop deliberations by teleconference and/or email. During this deliberation process, the PPRP will prepare verbal comments and feedback to the PTI and TI Teams. A written version of the PPRP comments will be provided at a later date so that they can be carefully edited and a consensus built and confirmed among the PPRP members. The PTI and TI Team Leads will provide written responses to the PPRP comments. Following the Workshop and PPRP deliberation, the proceedings of the Workshop will be documented in a brief Workshop summary for distribution to the Project

Sponsors and members of the PPRP, and the PPRP will submit a letter to the TI Team Leads documenting their observations of the Workshop. The Workshop summary and PPRP letter will become part of the final documentation of the SWUS GMC study.

Topics to be addressed at Workshop 1 will include the following:

- SSHAC training for project participants
- Summarize project overview and objectives
- Review SSHAC procedures and Workshop ground rules
- Identification of data needs or gaps
- Present sensitivity analysis to ground motion models for the three sites (GMC model V0)
- Review new data and GMPEs from PEER
- Review other GMPEs developed for extensional regimes
- Review simulation validation from SCEC
- Review available models for near fault effects including directivity, fling, hanging wall effects, splay faults for M6-M7.5 earthquakes at distances of 0 to 15 km (for DCPP and SONGS)
- Review available models for moderate (**M** 5.5—6.5) earthquakes at distances of 30-100 km from a site, for a variety of rupture mechanisms, including normal faulting (for PVNGS)
- Evaluate applicability of close scaling models and distant attenuation in Arizona for PVNGS
- Review base rock characteristics (e.g. V_{S30}) of available ground motion models, and select a representative reference V_{S30} that is applicable to all three sites. Should a common V_{S30} not be applicable for all sites and difficulties are found in this regard, then site-specific reference V_{S30} can be selected.
- Interactive discussion with Resource Experts (selected presentations)
- Identify scenarios to be implemented in the numerical simulations

Task 4: Workshop 2 (proponent models)

Prior to Workshop 2, the TI Teams will identify all relevant proponent models for ground motions in the SWUS, develop version 1 of the GMC logic tree, and prepare the agenda for Workshop 2. A hazard sensitivity analysis will be conducted using the alternative proponent models to help focus the discussion of the proponent models on those features that are most important to the hazard at the three sites. The sensitivity analysis will be performed by the Hazard Analysts using version V1 of the GMC logic tree and the SSC models that are available at the time.

Prior to Workshop 2, REs and PEs will be identified and their names provided to the PPRP for their review. The PPRP may identify additional PEs and/or REs for consideration. The PEs and/or REs will be contacted prior to the Workshop and provided with a specific request for discussion topics.

Workshop 2 will last for three days and be attended by the PTI, the TI team and staff, the PPRP, the Project Manager, the Hazard Analyst, Resource Experts and Proponent Experts. The primary goal of WS2 will be to interactively use the PEs to evaluate the strengths and weakness of the candidate GMPEs and the data available for testing the models. The PEs may identify other alternative models or technical issues that are not currently captured in the V1 logic trees and that are needed to capture the CBR of the GMPEs. These alternative models or technical issues will be identified during the Workshop for evaluation by the TI Team and will be added to the GMC logic tree as appropriate.

The information gained from these interactions will form the basis for defining the CBR of the TDI and will then be used to develop the revised GMC model. The PPRP members will attend Workshop 2 as observers, but again, may also serve as Resource Experts when needed. The PPRP members will not serve as Proponent Experts for models. The PPRP will provide verbal comments at the end of each day and at the conclusion of the Workshop. Following the three-day Workshop, a PPRP deliberation will take place to review the Workshop proceedings. PPRP will have the flexibility to complete its post-Workshop deliberations by teleconference and/or email. During this deliberation process, the PPRP will prepare verbal comments and feedback to the PTI and TI Teams. A written version of the PPRP comments may be provided at a later date so that they can be carefully edited and a consensus built and confirmed among the PPRP members. The PTI and TI Team Leads will provide written responses to the PPRP comments. Following the Workshop and PPRP deliberation, the proceedings of the Workshop will be documented in a brief Workshop summary for distribution to the Project Sponsors and members of the PPRP, and the PPRP will submit a letter to the TI Team Leads documenting their observations of the Workshop. The Workshop summary and PPRP letter will become part of the final documentation of the SWUS GMC study.

<u>The topics to be addressed at Workshop 2 will include the following:</u>

- Review SSHAC procedures and Workshop ground rules
- Present hazard sensitivity analysis on the GMC V1 logic trees using available SSC models

- Present the proponent models and discuss their strengths and weaknesses through interactive discussion with Proponent Experts and Resource Experts
- Evaluate the proponent models with comparisons to data, as appropriate
- Identify model gaps, i.e. cases that don't appear to be covered by current models, and how to cover those gaps

Task 5: Workshop 3 (TI Evaluation)

Following Workshop 2, the TI Team will evaluate the proponent models and integrate the information into version V2 of the GMC logic tree based on the feedback from Workshop 2. Modeling gaps identified at Workshop 2 will be filled with modifications to existing models or development of new models. The Hazard Analysts will implement the new GMC model in the hazard code and conduct a hazard sensitivity analysis for each site to identify the key contributors to the uncertainty. The latest version of the SSC model will be implemented in the hazard sensitivity analysis. The latter will also be used to focus the discussion by the REs, PEs, and PPRP on the technical issues and parameters that have the greatest effect on the hazard at the three sites.

Workshop 3 will last for two days and be attended by the PTI, the TI teams and staff, the PPRP, the Project Manager, the Hazard Analysts, and selected REs and PEs that are identified by the TI Team, as needed. In contrast to Workshops 1 and 2, the PPRP will be active participants in Workshop 3 to fully query the model parameters, level of documentation, uncertainty, and rationale in developing the model. The focus of the PPRP review should be on the adequacy of the technical basis for the GMC model and not on the specific value of a particular weight on the logic tree. The primary focus of the Workshop 3 process will be for the TI Team to integrate information into models that represent the CBR of TDI.

The proceedings of Workshop 3 will be documented in a brief Workshop summary report for distribution to the Project Sponsors and members of the PPRP, and the PPRP will submit a letter to the TI Team Leads documenting their observations of the Workshop. The Workshop summary and PPRP letter will become part of the final documentation of the SWUS GMC study.

Task 6: Incorporation of PPRP Comments in GMC (V3) Models

Following Workshop 3, comments from the PPRP will be resolved and incorporated into the final GMC logic trees (V3), as needed.

Task 7: Documentation

The TI Team will develop the final documentation of the SWUS GMC study. An initial draft report will be prepared and submitted to the PPRP for review. It is expected that the main PPRP comments will have been addressed based on the PPRP comments in Workshop 3. The reporting will include complete documentation of the development of the GMC models and all of the parameters included within the models.

Upon completion of the PPRP review of the draft report, the TI Team will respond to PPRP comments and prepare a Final Report. The PPRP will review the response to comments and the Final Report, and provide a letter to the Project Sponsors and TI Team Leads documenting their evaluation of the SSHAC Level 3 process. This letter will be included in an appendix of the Final Report.

PROJECT SCHEDULE

The schedule for completing the SWUS GMC Study is presented on Figure 2. The project will commence with Workshop 0 (Kickoff Meeting) in August 2012, and will be completed in mid 2014, a 2-year duration. Workshops are anticipated to be held at 6-month intervals every October and March during the study. As described above, the goal of following the SSHAC Level 3 methodology is to have reasonable assurance that epistemic uncertainties in the GMC logic trees have been adequately captured for use in a PSHA for DCPP, SONGS, and PVNGS.

VALIDATION, VERIFICATION AND PEER REVIEW

Validation, verification and peer review provides the necessary quality assurance for development of the GMC models and is inherent in the SSHAC process itself and the participatory peer review. The participatory peer review is comparable to and, in many areas, much more thorough and comprehensive than the standard Independent Technical Review (ITR) of the QA procedures given in 10CFR50 Appendix B. Thus, following the guidelines in NUREG 2117, the SSHAC process will not be required to follow a formal 10CFR50 Appendix B QA procedure.

NOTE: The hazard calculations for the development of the GMRS are not part of this SWUS GMC project and are the responsibility of the Project Sponsors. QA of hazard codes is outside the scope of the project, however the translation of GMC models into PSHA inputs will be documented in Hazard Input Documents (HIDs) and the HIDs will be part of the QA documentation.

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Figure 1: Southwestern U.S. Ground Motion Characterization Project Organization

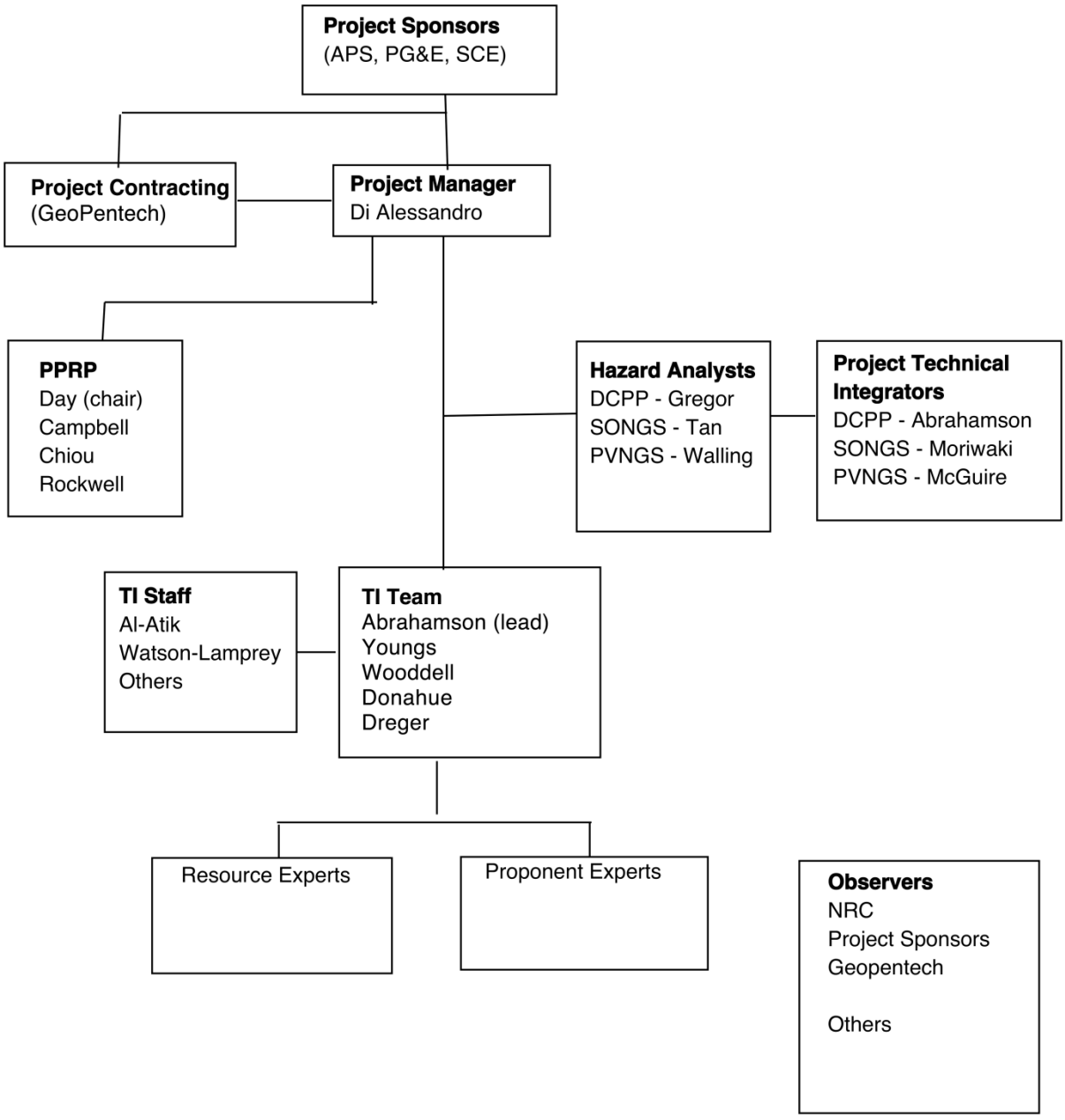
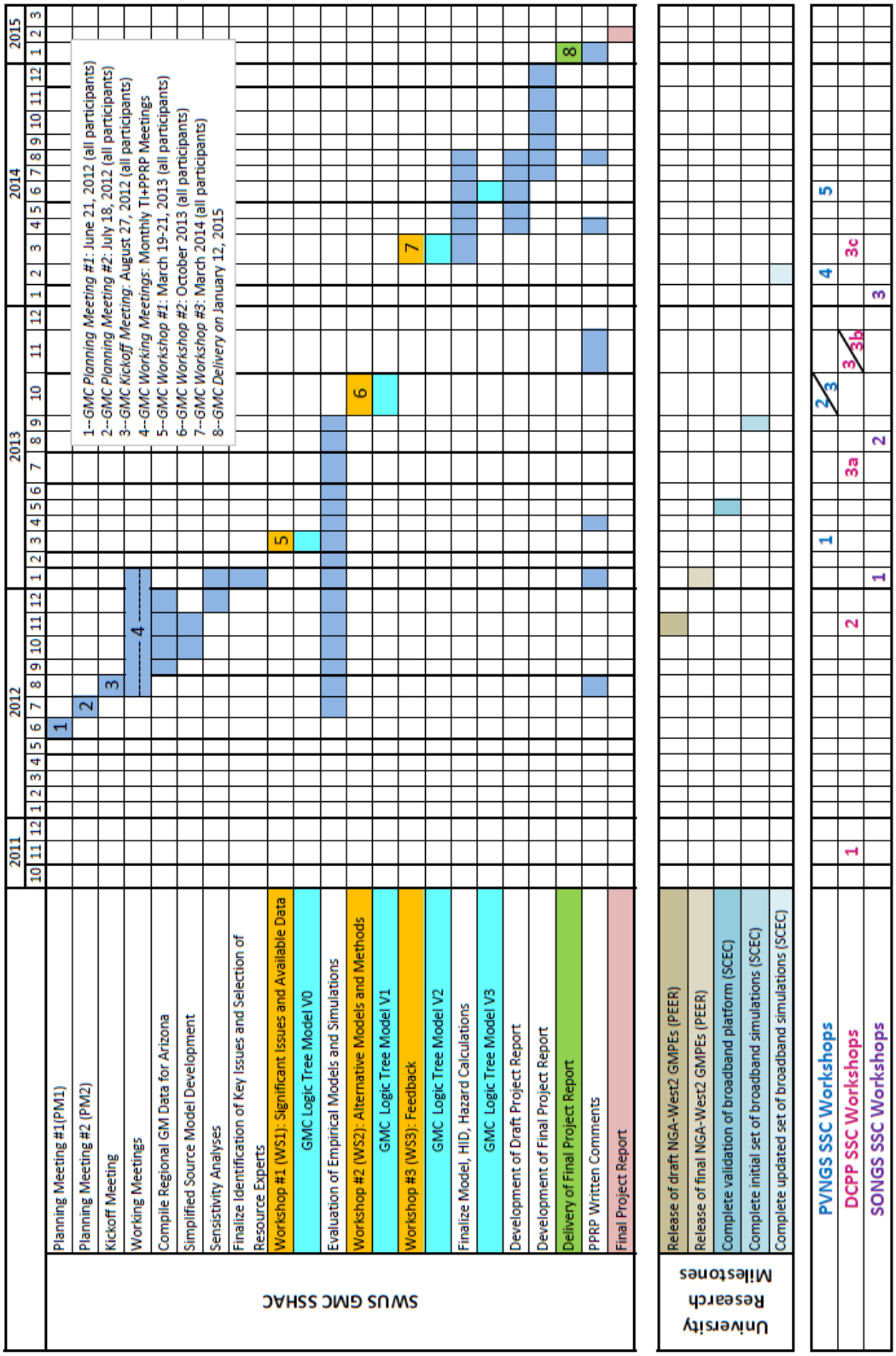


Figure 2: SWUS GMC Schedule and Major Milestones



APPENDIX A – SELECTION CRITERIA FOR PROJECT PARTICIPANTS

This appendix describes the selection criteria for the selection of the TI team lead, TI team members, PPRP members, and Project Manager.

1. Technical Integrator (TI) Lead

The TI Lead is selected by the Project Sponsors. The TI team is selected by the TI Lead. The roles and responsibilities of the TI lead are given in Table 1A and the selection criteria are given in Table 1B.

The Project Sponsors selected Dr. Norm Abrahamson as the TI lead for the SWUS GMC. Dr. Abrahamson is an internationally recognized expert in field of ground motion with experience developing empirical GMPEs and using numerical simulations to develop GMPEs. He has also past experience with the SSHAC studies having served as the Technical Facilitator/Integrator for the 1996-1998 Yucca Mountain and 2001-2004 Swiss SSHAC level 4 GMCs. He has also served as the TI lead for the 2008-2011 BCHydro SSHAC level 3 GMC, as the TI co-lead for the ongoing NGA-east SSHAC level 3 GMC, and as TI team member for the Blue Castle SSHAC level 3 GMC.

	Table 1A. Roles and Responsibilities of TI Team Lead
1	Preparation of Project Plan
2	Point of contact for all technical activities on the project
3	Selection of appropriate evaluator and integration experts for TI Team
4	Leading the evaluation and integration activities of the TI team, including the conduct of multiple working meetings
5	Finding and assuring participation of suitable Resource and Proponent Experts
6	Running Workshops and ensuring that the participants clearly understand the Workshop objectives, their individual roles, the required output from the Workshops, and the implication to hazard
7	Ensure that the project documentation is complete and comprehensive

	Table 1B. ATTRIBUTES / SELECTION CRITERIA for TI TEAM LEAD
1	A thorough understanding of the SSHAC goals and processes
2	Acknowledged technical expertise with particular emphasis in the GMC issues being addressed and in PSHA
3	Experience in conducting previous SSHAC Level 3 and 4 studies
4	Strong communication skills to work with the technical evaluators
5	Project management skills to ensure technical products are high-quality and delivered in a timely manner
6	Experience and familiarity with NRC regulations, quality assurance, and regulatory compliance

2. Technical Integrator (TI) Team

The TI team members were selected with the goal of having a balance between senior members with extensive experience in SSHAC studies and younger members that have limited or no SSHAC experience. The purpose of including younger members is to build up the pool of ground motion experts with SSHAC experience.

Past experience has shown that a TI team of 3 to 5 people works well for GMC projects. A five person TI team was selected for this project with three senior people and two younger people.

Dr. Robert Youngs was selected as the second senior person (in addition to Dr. Abrahamson). Dr. Youngs has extensive experience with SSHAC studies for both GMC and SSC: 1998 Yucca Mountain SSC (SSHAC level 4), 2004 Swiss SSC (SSHAC level 4), 2004 EPRI GMC (SSHAC level 3), 2011 BCHydro GMC and SSC (SSHAC level 3), ongoing NGA-East GMC (SSHAC level 3), and ongoing Hanford GMC (SSHAC level 3). He is also a recognized ground motion expert and is an active participant in the PEER NGA studies for WUS ground motion models.

Prof. Douglas Dreger has been selected as a third senior evaluator expert with experience with numerical simulations. Through his well established academic career, Prof. Dreger is

knowledgeable with respect to the techniques employed in numerical simulation studies, as well as knowledgeable in the appropriate selection of model parameters for those studies.

Ms. Katie Wooddell was selected as a younger person on the TI team. Ms. Wooddell is an active participant in the PEER NGA-west2 empirical ground motion studies. She has also experience over the last three years testing and using the SCEC broadband simulation platform. She is currently participating in the SCEC broadband validation project. Having experience in both empirical GMPEs and numerical simulations gives Ms. Wooddell a good background for the SWUS GMC. Ms. Wooddell has some recent experience in SSHAC studies: she was on the TI team for the GMC for the initial work on the 2011 DCPP SSHAC level 3 study. She is also the Hazard Analyst for the ongoing DCPP SSC SSHAC level 3 study.

Dr. Jennifer Donahue was selected as the second younger member of the TI team. Dr. Donahue is an active participant in the NGA-west2 ground motion project with a focus on evaluation of hanging wall effects using both empirical data and numerical simulations. As hanging wall effects are likely to be an important issue for DCPP and SONGS, Dr. Donahue is well qualified to evaluate the alternative hanging wall models that will be part of the proponent models. Dr. Donahue has also some recent experience in SSHAC studies: she was on the TI team for the GMC for the initial work on the 2011 DCPP SSHAC level 3 study and she is providing project management support for the ongoing DCPP SSC SSHAC level 3 study.

3. PPRP Members

The PPRP members are selected by the TI lead, PM, and the Project Sponsors. The roles and responsibilities of the PPRP are given in Table 2A and the selection criteria are given in Table 2B. The PPRP members are selected so that, collectively, their experience and specialized technical knowledge meets the requirements given in Table 2B with a focus on experience in the SWUS region. For this project, an additional goal for the PPRP is to have a mixture of experience with the SSHAC process by including some members with limited SSHAC experience to help build up the available pool of people with SSHAC experience for future projects. Based on the criteria in Table 2B, the TI lead and the Project Sponsors selected the following members for the PPRP: Prof. Steve Day (Chair), Dr. Ken Campbell,

Dr. Brain Chiou, and Prof. Tom Rockwell. A brief description of the qualifications of each PPRP member is given below.

Prof. Steve Day is a recognized expert in ground motions with over 30 years experience with methods for the numerical simulation of ground motion. He has experience with both kinematic and dynamic approaches for simulation of ground motions and has participated in the SCEC ground motion simulation studies. He also has experience in simplifying results of numerical simulations into useable engineering models as part of the 2008 NGA project. Prof. Day has served on the NRC peer review panel for the 1985-1991 DCPP Long Term Seismic Program and also as a member of the seismic technical advisory board for both DCPP and SONGS. Prof. Day's experience with the SSHAC process is as a member of the PPRP for the ongoing DCPP SSC SSHAC level 3 study. He was selected as the PPRP chair because of the breath of his knowledge on ground motion, his strong communication skills, and his availability to commit the required time to work with the PPRP members to achieve a consensus and complete reporting on schedule.

Dr. Ken Campbell is a recognized expert in ground motion and seismic hazard. He has over 30 years experience in developing empirically based GMPEs. He was one of the GMPE developers in the 2008 NGA project and is a developer of updated GMPEs in the ongoing NGA-west2 project. Dr. Campbell has also extensive experience with the SSHAC process. He participated as an Expert Evaluator in the 1998 Yucca Mountain SSHAC level 4 GMC and is currently an Expert Evaluator in the ongoing SSHAC level 4 GMC for the PEGASOS refinement project and Chair of the PPRP in the ongoing SSHAC level 3 GMC study for the Hanford PSHA. In addition, Dr. Campbell has served as a PPRP member for the 2011 BCHydro SSHAC level 3 SSC and GMC studies, was a Resource Expert in the 2004 EPRI CEUS SSHAC level 3 GMC study, and was a Proponent Expert for the hybrid empirical method of modifying GMPEs for regional factors in the Blue Castle and Thyspunt SSHAC level 3 GMC studies.

Dr. Brian Chiou is a recognized expert in ground motion and seismic hazard. He was one of the GMPE developers in the 2008 NGA project and is a developer of updated GMPEs in the ongoing NGA-west2 project. For this project, his key expertise is in empirical data sets, empirical GMPEs, treatment of variability, and directivity effects. Dr. Chiou has previous experience with the SSHAC process having been a Resource Expert in the recently

completed BCHydro SSHAC level 3 GMC study and the ongoing Blue Castle SSHAC level 3 GMC study. He is currently serving as a PPRP member for the ongoing Hanford SSHAC level 3 SSC and GMC studies.

Prof. Tom Rockwell is a recognized expert in earthquake geology and characterization of active faults with experience in the SWUS and around the world. He is involved in the SCEC program for source characterization in southern California. Prof. Rockwell is relatively new to the SSHAC process with experience as a member of the PPRP for the ongoing DCPP SSC SSHAC level 3 study. Prof. Rockwell was selected as a PPRP member to provide a link between the GMC and the source characterization issues for the SWUS.

	Table 2A. Roles and responsibilities of the PPRP
1	Provide a technical review of the TI team evaluation
2	Provide a process review of the SSHAC level 3 study
3	Attend all Workshops and selected working meetings
4	Review project plan
4	Review draft project report
5	Issue concurrence letter report (after review comments are adequately addressed)

	Table 2B. ATTRIBUTES / SELECTION CRITERIA of the PPRP
1	Technical expertise in empirical ground motion models for active crustal regions
2	Technical expertise in numerical simulations of ground motion models for active crustal regions
3	Technical expertise in source characterization in the SWUS (for interface issues between SSC and GMC models)
4	Working knowledge of PSHA
5	Past experience with SSHAC level 3 studies

4. Project Manager (PM)

The PM is selected by the Project Sponsors. The roles and responsibilities of the Project Manager are given in Table 3A and the selection criteria are given in Table 3B.

The Project Sponsors selected Carola Di Alessandro as the PM. Dr. Di Alessandro has experience in engineering seismology and has also good organizational skills. She recently served as the coordinator for the Global Earthquake Model (GEM) ground motion characterization project conducted by PEER, coordinating a large number of ground motion experts. In the GEM project, she organized technical meetings and the preparation of technical reports that involved over 20 ground motion experts around the world.

	Table 3A. Roles and responsibilities
1	With TI Lead, prepare Project Plan
2	Point of contact between Sponsors, TI Lead, PPRP, and QA
3	Responsible for development of and adherence to scope, schedule and budget
4	Responsible for establishing contracts and contractual compliance with all participants
5	Oversight of QA implementation Staff
6	Status reporting to Sponsors on schedule, scope, budget
7	Delivery of all technical products

	Table 3B. ATTRIBUTES / SELECTION CRITERIA
1	Familiarity with the SSHAC process, previous involvement in a SSHAC Level 3 or higher project
2	Proven ability to manage complex projects that involve multiple project roles, responsibilities, and participants
3	Technical background in seismic hazard
4	Experience and familiarity with NRC regulations, quality assurance, and regulatory compliance
5	Communication and management skills
6	Willingness to commit significant time to ensure timely delivery of all products

5. Hazard Analysts

The Hazard Analysts are selected by each utility based on the selection criteria given in Table 4A. The roles and responsibilities of the Hazard Analysts are given in Table 4B. Based on the criteria in Table 4B, the Project Sponsors selected the following Hazard Analysts: Dr.

Nick Gregor for DCPP, Dr. Phalkun Tan and Andrew Dinsick for SONGS, and Dr. Melanie Walling for PVNGS. A brief description of the qualifications of each Hazard Analyst is given below.

Dr. Nick Gregor has over 20 years of experience in seismic hazard assessment. He was part of the Technical Support Staff for the Yucca Mountain project, being involved in the application of site-specific amplification factors using the PSHA hazard results. Recently Dr. Gregor was a TI Team member for the BCHydro GMC Level 3 study, where he assisted in the development of a new subduction earthquake ground motion prediction equation (GMPE) model based on world-wide data. In addition, he was part of the Technical Support Staff for the DCPP Shoreline Fault hazard study and is a Proponent Expert in the Hanford SSHAC level 3 project. During the last 15 plus years, Dr. Gregor has assisted Dr. Abrahamson in the modification and upgrade of his PSHA program. As part of this support, he was involved in producing the necessary QA validation documents for the hazard program used in the 2010 Shoreline report for PG&E. It is expected that for this project, the PSHA will again undergo modifications and Dr. Gregor will be the lead member for these expected changes.

Dr. Phalkun Tan is an Associate Engineer with GeoPentech and is heavily involved in the firm's geotechnical earthquake engineering practice. Dr. Tan has 24 years of experience in geotechnical earthquake engineering and numerical analysis. He was involved as Hazard Analyst in the ground motion evaluations for several important structures, such as the Vincent-Thomas Bridge in Long Beach, California, the Coronado Bay Bridge in San Diego, the Foothill Transportation Corridor alignment in Orange County, California, high rise commercial buildings in downtown Los Angeles and San Diego, earth dams and earth structures. He was also appointed the role of Hazard Analyst for the 2001 and 2010 SONGS PSHA studies. Additionally, he developed Woodward-Clyde and GeoPentech's computer program for probabilistic seismic hazard analysis. The GeoPentech computer code was one of the computer programs used in the PEER Verification of Probabilistic Seismic Hazard Analysis Computer Programs in 2009.

Dr. Melanie Walling has three years experience in seismic hazard and ground motion studies. She was one of the main people responsible for the QA of the LCI seismic hazard code. She is also part of the LCI team to compute the seismic hazard for many of the

Central and Eastern plants as part of their response to the NRC letter on Fukushima. She is working under the direction of Robin McGuire which will provide her additional support in seismic hazard as needed.

	Table 4A. Roles and responsibilities
1	Responsible for hazard calculations and sensitivity analyses
2	Provide feedback to the TI Team and answer questions on the distributions used for the PSHA computation , identifying key contributors to uncertainty

	Table 4B. ATTRIBUTES / SELECTION CRITERIA
1	Technical expertise with hazard computation and analysis
2	Working knowledge of PSHA programs
3	Ability to perform hazard analysis under QA

November 29, 2012

Carola Di Alessandro, Ph.D.
Project Manager for the SWUS GMC SSHAC
GeoPentech, Inc.
525 N. Cabrillo Park Drive, Suite 280
Santa Ana, CA 92701

Dear Dr. Di Alessandro:

The Participatory Peer Review Panel (PPRP) has reviewed the Project Plan (dated November 12, 2012) for the Southwestern U.S. Ground Motion Characterization (SWUS-GMC) SSHAC Level 3 study. The Project Plan document is well prepared, explains the SSHAC Level 3 guidelines well, and provides a framework for successful implementation of those guidelines. It is responsive to earlier PPRP's recommendations, as detailed in our memoranda dated September 17 and November 3, 2012, respectively. The Plan includes a Technical Integration (TI) team that brings the project an appropriate balance between experienced experts and more junior members, and includes high-level expertise in both empirical and simulation-based ground motion estimation.

The PPRP believes that the Project Plan has the elements required for meeting the SSHAC Level 3 objectives. We thank the project team for its efforts in developing the plan and look forward to its implementation.

Sincerely,

Steven M. Day
Chair, PPRP

Kenneth Campbell
Member, PPRP

Brian Chiou
Member, PPRP

Thomas Rockwell
Member, PPRP

Carola Di Alessandro

Digitally signed by Carola Di Alessandro
DN: cn=Carola Di Alessandro, o=GeoPentech, INC., ou=Project Manager for SWUS GMC SSHAC Level 3, email=carola_dialessandro@geopentech.com, c=US
Date: 2013.02.19 21:59:12 -08'00'