Case No: A.12-11-009
Exhibit No: A4NR-1
Witness: John Geesman

Application of Pacific Gas and Electric Company for Authority, Among Other Things, to Increase Rates and Charges for Electric and Gas Service Effective on January 1, 2014. (U 39 M)	)	Application 12-11-009 (Filed November 15, 2012)
And Related Matter.	)	Investigation 13-03-007

PREPARED REBUTTAL TESTIMONY OF

JOHN GEESMAN

ON BEHALF OF THE

ALLIANCE FOR NUCLEAR RESPONSIBILITY

BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF CALIFORNIA
JUNE 28, 2013

TABLE OF CONTENTS

REBUTTAL TESTIMONY OF

JOHN GEESMAN, ATTORNEY FOR

ALLIANCE FOR NUCLEAR RESPONSIBILITY ("A4NR")

Q: Please state your name and business address for the record.

A: My name is John Geesman, and my business address is: Dickson Geesman LLP, 1999 Harrison Street, Suite 2000, Oakland, CA 94612.

Q: Are your professional qualifications included in your testimony?

A: Yes, my professional qualifications are contained in Appendix A to my testimony.

Q: Was your testimony prepared by you or under your direction?

A: Yes, it was.

Q: Insofar as your testimony contains material that is factual in nature, do you believe it to be correct?

A: Yes, I do.

Q: Insofar as your testimony contains matters of opinion or judgment, does it represent your best judgment?

A: Yes, it does.

Q: Does this written submittal complete your prepared testimony and professional qualifications?

A: Yes, it does.

I. PURPOSE OF THIS TESTIMONY.

The purpose of this testimony is to document, using materials recently provided by PG&E after A4NR's successful Motion to Compel Discovery,[1] the inapplicability of the "safety first" culture claims of PG&E witnesses Anthony F. Earley, Jr.[2] and Christopher P. Johns[3] to PG&E's seismic assessments at Diablo Canyon. The testimony details PG&E's response, shortly after the San Bruno explosion, to the challenge of subjecting new information about the Shoreline Fault to the demanding analytic requirements of the Diablo Canyon operating licenses. It identifies a sustained effort by PG&E to evade the most onerous of these requirements, the conservative assumptions about damping and soil-structure interaction associated with the Double Design Earthquake, culminating with an effort by PG&E shortly after the Fukushima catastrophe to simply amend the bothersome tests out of its Diablo Canyon licenses.

While A4NR considers PG&E's conduct in this matter to be profound misfeasance, the point of this testimony is not to lure the California Public Utilities Commission ("Commission" or "CPUC") into a subject more properly regulated by the federal government under the Atomic Energy Act.[4] Instead, A4NR asks the Commission to consider this example in evaluating the

[1] A.12-11-009, Ruling of ALJ Thomas R. Pulsifer, May 1, 2013.
[2] PG&E-1, pp. 1-1 to 1-5. Mr. Earley is Chairman of the Board, Chief Executive Officer and President of PG&E Corporation.
[3] PG&E-1, pp. 2-1 to 2-7. Mr. Johns is President of Pacific Gas and Electric Company.
[4] 42 U.S.C. § 2011 et seq.

prudence of PG&E's conduct of the seismic evaluations for which it seeks ratepayer funding in this proceeding. The Commission should quickly recognize the high stakes which California has in assuring the integrity of PG&E's review of seismic issues at Diablo Canyon. Based on additional materials recently provided by PG&E in response to A4NR's successful Motion to Compel Discovery, this testimony reveals the Diablo Canyon Senior Seismic Hazard Assessment Committee ("SSHAC") – especially its ground motion characterization activities – to be an insular, corner-cutting exercise in the self-justification of past work rather than an objective, robust, scientific inquiry.

Countering the overly simplistic recommendation of the Division of Ratepayer Advocates ("DRA") to cap ratepayer funding,[5] A4NR's testimony proposes a more comprehensive remedy: establish a two-way balancing account for Nuclear Regulatory Commission ("NRC") rulemaking expenses; provide for recovery of expenditures through PG&E's annual ERRA filing; engage the Commission's existing Independent Peer Review Panel in the SSHAC process; and require PG&E to record 50% of its forecast SSHAC costs below-the-line, consistent with D.11-05-018's treatment of "advocacy" expenditures for Nuclear Energy Institute membership.

Rather than rely solely on A4NR's characterization of PG&E's conduct, this testimony attaches each of the pertinent documents as an appendix and invites the Commission to judge for itself whether PG&E's request constitutes a reasonable proposed expenditure of ratepayer funds.

[5] DRA-11, pp. 71 – 74.

II. PG&E's REFUSAL TO APPLY LICENSE-REQUIRED TESTS TO NEW SEISMIC INFORMATION.

PG&E's initial 2008 assessment that the discovery of the Shoreline Fault would have no impact on Diablo Canyon operability was based on the ground motion response spectra developed between 1984 and 1991 for its Long-Term Seismic Program ("LTSP"). This operability determination was endorsed by the NRC's preliminary evaluation of the Shoreline Fault in April of 2009. However, the day after completion of a two-day, seismic information public workshop in San Luis Obispo on September 8 and 9, 2010, the NRC's Senior Resident Inspector, Dr. Michael Peck, posed the question to PG&E of whether the probabilistic approach of the LTSP should be the sole method of evaluating operability or whether the Shoreline Fault information should also be compared to Diablo Canyon's design basis as well.

Significantly, two of the elements of the plant's licensed design basis, the Design Earthquake ("DE") and the Double Design Earthquake ("DDE"), include materially more conservative assumptions about damping and soil-structure interaction than the third element, the Hosgri Evaluation ("HE"), which was the basis for the LTSP ground motion response spectra. The magnitude of these differences is identified in the table included in Section 3.7.1.3 of Diablo Canyon's Final Safety Analysis Report Update ("FSARU"):

Type of Structure	% of Critical Damping		
	DE	DDE	HE
Containment structures and all internal concrete structures	2.0	5.0	7.0
Other conventionally reinforced concrete structures above ground, such as shear walls or rigid frames	5.0	5.0	7.0
Welded structural steel assemblies	1.0	1.0	4.0
Bolted or riveted steel assemblies	2.0	2.0	7.0

Mechanical components (PG&E purchased)	2.0	2.0	4.0
Vital piping systems (except reactor coolant loop)	0.5	0.5	3.0
Reactor coolant loop	1.0	1.0	4.0
Replacement Steam Generators	2.0	4.0	4.0
Integrated Head Assembly	4.0	6.85	6.85
CRDMs (Unit 2)	3.0	4.0	4.0
Foundation rocking (containment structure only)	5.0	5.0	NA

Dr. Peck's inquiry set off a troubling chain of events which, over the next two years would include:

- PG&E's unseemly efforts to avoid performing such analyses;
- the NRC staff's determination that PG&E had violated its license by failing to perform the required analyses;
- PG&E's attempt to amend the requirements out of its license rather than comply;
- PG&E's acknowledgment in a Form 10-Q filing that failure of its license amendment strategy could result in the shutdown of Diablo Canyon;
- peculiar advice to PG&E from Dr. Peck's new supervisor, Neil O'Keefe, that the utility should eliminate the DDE from the licensing basis or appear to be "covering something up";
- Dr. Peck's submission of a rare "Non-Concurrence" when NRC management allowed PG&E to avoid performing the analyses;
- Mr. O'Keefe's response to the Non-Concurrence that no facts were in dispute and, despite overtones of safety, the actual questions were "procedural";

- PG&E's withdrawal of its proposed license amendment after the NRC staff allowed it to delay the DDE test until completion of its post-Fukushima seismic evaluation (i.e., the current SSHAC process) in 2015;
- the NRC's acknowledgment that the 2015 analyses would "most likely" show satisfying the DDE tests still to be a problem.

III. PG&E's INTERNAL EMAILS.

According to Dr. Peck's Non-Concurrence,[6] the NRC concluded in September, 2010 that "an earthquake on the Shoreline Fault could produce about 70 percent greater peak ground motion [than] assumed in the DDE/safe shutdown earthquake design basis."[7] PG&E's January, 2011 Shoreline Fault Zone report to the NRC reached the same conclusion for not only the Shoreline Fault, but also the San Luis Bay Fault and Los Osos Fault. The following excerpts from PG&E's internal emails (with emphases added by A4NR), obtained recently as a result of A4NR's successful Motion to Compel Discovery, provide insight into PG&E's reaction to Dr. Peck's September 10, 2010 question (coincidentally, the San Bruno explosion occurred on September 9, 2010):[8]

- **Sept. 14, 2010:** "*This issue was raised again by Peck at 605 mtg. He is continuing to make the case that Shoreline fault should have been compared to original design not*

[6] Attached as Appendix B to this testimony, it is also accessible on the NRC's website (http://www.nrc.gov/reading-rm/adams.html) as ADAMS Accession No. ML120450843.
[7] *Id.,* p. 3.
[8] The emails, in their entirety, are attached to this testimony in chronological order as Appendix C. Consistent with what it considers Commission policy most recently affirmed by an ALJ ruling in I.11-02-016 in 2011, PG&E informed A4NR that it has redacted the names of all of its employees below the director level.

hosgrai [sic] *in his opinion of our licensing basis* ***and that our operability position taken a year ago was to the wrong licensing basis."***

- **Sept. 20, 2010:** *"If the DE is now estimated to have a higher chance of occurring, then the plant just has* ***a greater chance of having to shut-down. This is an economic issue, not a safety issue."***

- **Sept. 29, 2010:** ***"could SF challenge the DE, DDE ground motions*** *if it was evaluated based on the methodology that DCPP[9] was licensed to (i.e., DE based on earthquakes A, B, C, D)?"*

- **Sept. 30, 2010:** *"M. Peck told him Region IV* ***recommended a violation*** *(instead of an URI[10]) for a poor operability determination because our operability determination (OD) in 50086062* ***did not address DE and DDE."***

- **Oct. 1, 2010:** *"I agree that we should not have to revisit DE and DDE with each new study or informational finding. The only reason this was an issue this time was* ***because Hosgri probability is so small that it would mask in PRA[11] space*** *any probability of an issue occurring."*

- **Oct. 1, 2010:** *"It appears Shoreline is outside our SSE[12] and Hosgri ground motion acceleration spectra and therefore the CLB[13]* ***does not appear to fully bound Shoreline."***

- **Oct. 1, 2010:** *"If we have* ***misrepresented our design and licensing basis requirements*** *or have compared to non-D&LB[14] (like LTSP) then this introduces new station vulnerability to additional violations regarding the* ***completeness and accuracy of our communications."***

- **Oct. 11, 2010:** *"The team needs to ensure that the path we are pursuing is technically viable* ***as well as understand the legal risk and implications,*** *but must meet licensing rules and policies."*

- **Oct. 13, 2010:** *"Dr. Peck again stopped by my office … He reiterated that he feels* ***we are obligated to review the Shoreline earthquake (and any new geological feature) to the same standard … that we are licensed*** *and based on that analysis make a call on operability. He argues that using LTSP is not appropriate because it is not a part of our*

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[9] DCPP is an acronym for the Diablo Canyon Power Plant.
[10] URI is an acronym for Unresolved Incident.
[11] PRA is an acronym for Probabilistic Risk Assessment.
[12] SSE is an acronym for Safe Shutdown Earthquake.
[13] CLB is an acronym for Current Licensing Basis.
[14] D&LB is an acronym for Design and Licensing Basis.

licensing basis…With respect to the 4/9/09 letter from NRR,[15] *he would conclude that the NRC statement that the CLB is bounding was* ***based on the essentially misleading information provided by us that we were within the LTSP."***

- **Jan. 6, 2011:** *"It would behoove us to explain the conservatisms in the Shoreline report with Dr. Peck. Be aware he will start asking about how we know we can safely shut down with the new spectra (ie, do we meet DDE) …* ***I suggest we'll have to keep him focused on addressing safety and capability vs licensing compliance."***

IV. SIGNIFICANCE OF MORE CONSERVATIVE DAMPING ASSUMPTIONS.

Much of the NRC's eventual climb-down from requiring that new seismic information be tested against the criteria embedded in each of the license's three design basis earthquakes centers on the truism that the peak acceleration of 0.75g attributed to the HE by the license substantially exceeds the 0.4g attributed to the DDE and the 0.2g attributed to the DE. With no acknowledgment of the contentious (and expensive) redesign of Diablo Canyon forced by PG&E's belated recognition of the Hosgri Fault, or the battlefield origin of the HE's accompanying damping assumptions, the argument is made that the more stringent requirements of the DE and DDE can be ignored because they are associated with lesser earthquakes. Dr. Peck graphically dispelled this premise in the following illustrations from his Non-Concurrence:

> *The HE represented the largest ground motion of the three design basis events. However, SSC*[16] *seismic qualification was limited by each of the three design basis earthquakes. For example, the safety analysis predicted higher vibratory motion for DE and DDE at the steam generators, as shown in Figure 1.*[17]

[15] NRR is an acronym for the NRC's Office of Nuclear Reactor Regulation.
[16] SSC is an acronym for Structures, Systems, and Components.
[17] Appendix B, p. 2.

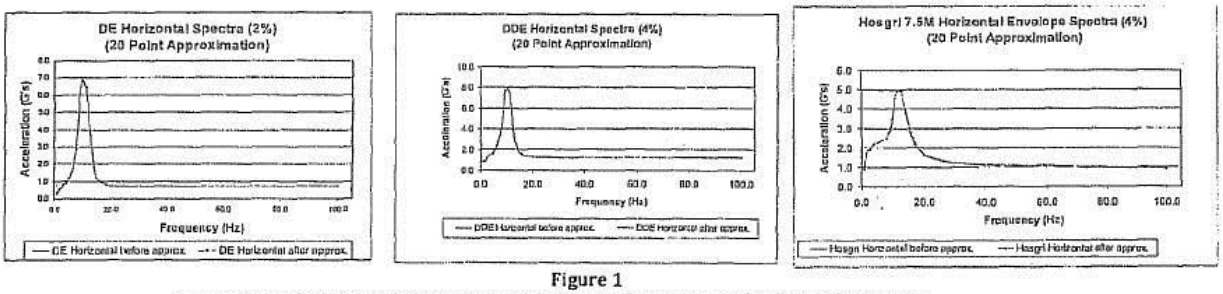

Figure 1
Comparison of DE, DDE, & HE Horizontal Response Spectrum at the Steam Generators

As shown in Figure 2, the DDE provided the limiting floor response spectrum for the 88 foot level of the containment building. The seismic qualification of plant structures was also limited by both the DDE and HE, dependant [sic] *on location. For example, the seismic qualification of the lower levels of the containment structure were limited by the HE design basis while the upper levels were dominated by the larger DDE spectrum. Portions of the reactor coolant pressure boundary were more limited by the DE and DDE than HE. These differences in qualification requirements resulted from different assumptions, methods, design basis values/inputs, and acceptance criteria approved for each seismic safety analysis.*[18]

***

For example, the FSARU[19] *credited the containment fan cooler to mitigate the design basis loss of coolant and steam line break accidents. The design basis required these coolers to be qualified to function following the vibratory motion (shaking) associated with the DDE. These coolers are located on the 88 foot level of the containment building. As shown in Figure 2, the DDE vibratory motion was greater than HE at this location. The POD*[20] *was inadequate because the licensee failed to demonstrate that the coolers would still function at the increased motion associated with the new seismic information for the DDE case.*[21]

[18] *Id.*
[19] FSARU is an acronym for Final Safety Analysis Report Update.
[20] POD is an acronym for Prompt Operability Determination.
[21] Appendix B, pp. 5 – 6.

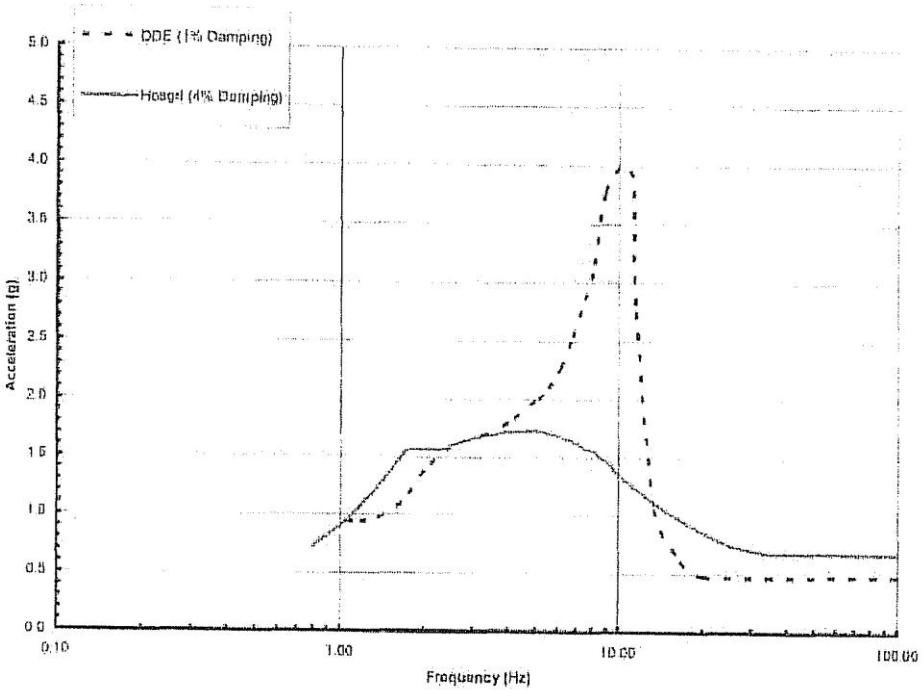

Figure 2
Comparison of DDE and HE Containments Floor Response at 88 Foot

V. NRC STAFF'S DETERMINATION OF LICENSE VIOLATION.

In response to Dr. Peck's September 10, 2010 questions, PG&E convened a meeting of its DCPP Seismic Strategy Team[22] the following month to discuss the issue and develop a plan for resolution. According to PG&E,

> *The team concluded that DCPP's licensing basis does not provide clear guidance on the 'connection between the on-going research activities in support of the Long Term Seismic Program and the DCPP licensing basis, as described in the FSAR.' The Team indicated that it was likely that a License Amendment Request (LAR) would be required to provide*

[22] According to p. 3 of an undated "Apparent Cause Evaluation" document, provided by P&E in response to A4NR's discovery request and identified as GRC2014-Ph-I_DR_A4NR_001-Q02Supp01Atch03, the DCPP Seismic Strategy Team was comprised of the Geosciences Department Director, Design Engineering Manager, Project Engineering Manager, Engineering Services Senior Director, Regulatory Services Manager, Law Department, Seismic Subject Matter Expert, and consultants.

clear guidance. This LAR would provide the final solution regarding the proper method to be used to assess the impact of new/updated seismic information on operability.[23]

What followed was an increasingly difficult series of pre-application meetings[24] between PG&E and the NRC staff to discuss the proposed LAR. PG&E's objectives transformed from "clarify long term seismic plan (sic) (LTSP) method use for the Shoreline Fault"[25] to replacing the DDE with the HE as Diablo Canyon's SSE. The transcript of the March 31, 2011 meeting – twenty days after commencement of the Fukushima catastrophe -- show Dr. Peck aggressively questioning PG&E over

- the impact on welds on the reactor head from an earthquake on the San Luis Bay Fault with "a 60 percent higher peak ground acceleration than what was used to demonstrate that this weld could hold together during an earthquake";
- the reduced number of seismic class one structures, systems and components "required to be qualified" under the HE when compared to the DDE; and
- exemption from the HE test of the accident loading of a loss-of-coolant accident in contrast to the DE and DDE tests, which incorporate accident loads as well as earthquake loads.[26]

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[23] *Id.*
[24] The NRC staff's written summaries of the December 9, 2010, January 26, 2011, March 31, 2011, June 20, 2011 meetings are accessible on the NRC's website (http://www.nrc.gov/reading-rm/adams.html) as ADAMS Accession Nos. ML103610074, ML110420183, ML111320637, and ML111920567, respectively.
[25] *Id.*
[26] Transcript of March 31, 2011 pre-licensing meeting at pp. 75 – 77, which is accessible on the NRC's website (http://www.nrc.gov/reading-rm/adams.html) as ADAMS Accession No. ML111020379.

The NRC project manager for DCPP within the NRC's Division of Operating Reactor Licensing complained to PG&E during a May 27, 2011 teleconference that the NRC staff had not understood during the earlier meetings that one of the purposes of PG&E's proposed LAR was to replace the DDE with the HE as the Diablo Canyon SSE. He suggested an additional pre-licensing meeting, which was held on June 20, 2011. The magnitude of what PG&E was proposing is clear from the NRC staff's July 29, 2011 written summary of the meeting:

> *The NRC staff asked, given the information that PG&E states is available regarding the seismic deign of the DCPP, why PG&E requested NRC approval rather than make this change under 10 CFR 50.59.* ***PG&E stated that some of the methods used for seismic reviews could not be reconciled under 10 CFR 50.59.*** *The NRC asked if there were any studies performed to support this proposed change to make the HE the SSE. PG&E stated no.* ***Mr. Kamal Manoly of the NRC staff noted that he believes this is a first of a kind request as he is not aware of any other instance where a licensee has requested to change its SSE.*** *As such, Mr. Manoly stated that the amendment needed to describe where the methodologies and acceptance limits used in the evaluation of structures and components for the HE are deviating from the applicable provisions in the Standard Review Plan (SRP). Mr. Manoly stated that a table providing the deviations from the SRP for the HE should be provided with this LAR. Mr. Michael Markley of the NRC staff stated that* ***because of the uniqueness of this review, he would propose that the LAR be presented to the Advisory Committee on Reactor Safeguards.***[27] (emphases added by A4NR)

Three days later, on August 1, 2011, the NRC staff issued Task Interface Agreement 2011-010 and minced no words in determining that PG&E had failed to comply with its license:

- *Although the LTSP margin analysis demonstrated that the new Shoreline Fault Zone information was bounded by the Hosgri Event,* ***the licensee didn't evaluate the new seismic information against the other two design basis earthquakes****, the Design Earthquake and the Double Design Earthquake.* (emphasis added by A4NR)

- *… the plant safety analyses concluded that seismic qualification for certain structures, systems and components* ***was more limiting for the Design***

[27] ML111920567, pp. 1 - 2.

Earthquake and Double Design Earthquakes than for the Hosgri Event. (emphasis added by A4NR)

- *New seismic information developed by the licensee is required to be evaluated against all three of the seismic design basis earthquakes and the assumptions used in the supporting safety analysis … **Comparison to the LTSP by itself is not sufficient to meet requirement**.*[28] (emphasis added by A4NR)

In October, 2013, some six weeks after the arrival of new CEO Anthony Earley, PG&E, filed its License Amendment Request.[29] The company's November 3, 2011 Form 10-Q was candid in its description of the stakes:

> *. . . in early August 2011, the NRC found that a report submitted by the Utility to the NRC on January 7, 2011, to provide updated seismological information **did not conform to the requirement of the current Diablo Canyon operating license**. On October 21, 2011, the Utility filed a request that the NRC amend the operating license to address this issue. If the NRC does not approve the request the Utility could be required to perform additional analyses of Diablo Canyon's seismic design which could indicate that modifications to Diablo Canyon would be required to address seismic design issues. **The NRC could order the Utility to cease operations until the modifications were made or the Utility could voluntarily cease operations if it determined that the modifications were not economical or feasible**.*[30] (emphases added by A4NR)

VI. PECULIAR COMMENTS FROM NEW NRC BRANCH CHIEF.

In mid-December, 2011, some two months after PG&E had submitted its LAR, a conference call was convened with the new NRC Branch Chief for DCPP, Neil O'Keefe. Based on

[28] Kriss M. Kennedy, NRC Director /RA/, Division of Reactor Projects, Region IV, "Task Interface Agreement (TIA) – Concurrence on Diablo Canyon Seismic Qualification Current Licensing and Design Basis (TIA 2011-010)," August 1, 2011, which is accessible on the NRC's website (http://www.nrc.gov/reading-rm/adams.html) as ADAMS Accession No. ML112130655.

[29] PG&E, License Amendment Request 11-05, "Evaluation Process for New Seismic Information and Clarifying the Diablo Canyon Power Plant Safe Shutdown Earthquake," October 20, 2011, which is accessible on the NRC's website (http://www.nrc.gov/reading-rm/adams.html) as ADAMS Accession No. ML11312A166.

[30] PG&E Corporation, Form 10-Q filing, November 3, 2011, p. 63.

the PG&E call report,[31] Dr. Peck appears to have also participated. According to the call report,

> *Following introductions, Steve started the meeting by explaining the reason for the call. Steve had called Neil on 12/07/11 to introduce himself and welcome Neil to his new role as the Branch Chief for DCPP. During the call, Neil commented that he had just concluded a three-hour meeting with Dr. Peck to get an update on the DCPP seismic status and a history of the issue. Based on some of Neil's comments, Steve had proposed that a phone call to allow PG&E to provide our perspective might be beneficial. Neil agreed, and PG&E scheduled the conference call.*
>
> ***
>
> *…Neil then asked us if there is any technical reason for leaving the DDE in the design basis. He stated that we had done a good job with the LAR of cleaning up the loose ends, but his advice is that we eliminate the DDE as our safe shutdown earthquake for our licensing basis.* ***His opinion is that by leaving it in, it appears as if we are covering something up. We need to be able to tell a simple story for people to be able to understand, and the simple story won't stand on its own if we leave the DDE in.*** *We should be using the DE to show that we can continue to operate and the Hosgri using the latest technology for safe shutdown.*
>
> ***Neil's greatest concern, and criticism of the POA, is that we cannot provide a good argument for why the analysis using the DDE can't be done.*** *We don't make the argument for why it should be removed completely, but that's what we need to do, in Neil's opinion.* ***He made the comment that it is better to be legally clean than legally correct but confusing*** *(and added that both have to be technically correct)…*
>
> *Neil talked about enforcement actions. He wants to close this issue out in the fourth quarter report and stated that he will be on site for the exit meeting on 01/04/12…*
>
> *Following the call, Jeff … and Steve had some additional discussion with Dr. Peck. Michael continues to stress his view that PG&E cannot use the alternate analysis method that we used in the updated POA.* ***If he is correct, and we can't use that approach, we have to apply Shoreline using the DDE approach. That would almost certainly result in exceeding code allowable limits that would require us to get NRC approval to continue to operate both units.***
>
> *He also made a comment, which is the first time we had heard this, that he has looked at the 100 year curves and he thinks he sees some that would exceed OBE,[32] implying that they must be worse than the DE earthquake.* (emphases added by A4NR)

[31] PG&E's call report is attached to this testimony as Appendix D.
[32] OBE is an acronym for Operating Basis Earthquake.

Closing out the inspection report in January, 2012 would prove to be the trigger for Dr. Peck's Non-Concurrence. In the section of the Non-Concurrence provided for comments from Peck's supervisor, Mr. O'Keefe wrote, "Dr. Peck has thoroughly researched these issues. The actual facts are not in dispute … While this concern has overtones of safety, the actual questions are procedural …"[33] In June, 2012, Dr. Peck transferred to the NRC's instructional facility in Chattanooga, Tennessee, two years before his deployment at Diablo Canyon was scheduled to come up for rotation.

VII. WITHDRAWAL OF PG&E's LAR; DDE ANALYSES DEFERRED TO 2015.

In October 2012, the NRC staff published Research Information Letter (RIL) 12-01, "Confirmatory Analysis of Seismic Hazard at the Diablo Canyon Power Plant from the Shoreline Fault Zone,"[34] reiterating the conclusion of its April 2009 "Preliminary Deterministic Analysis of the Seismic Hazard at Diablo Canyon Nuclear Power Plant from Newly Discovered 'Shoreline Fault,'"[35] that the deterministic seismic ground motions associated with the Shoreline Fault are below those for which the plant was previously reviewed, i.e., the HE and LTSP ground motion response spectra. Instrumental in arriving at this conclusion was the NRC staff's conclusion about the possibility of joint rupture of the Shoreline and Hosgri Faults:

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[33] Appendix B, Section B.

[34] This report is accessible on the NRC's website (http://www.nrc.gov/reading-rm/adams.html) as ADAMS Accession No. ML121230035.

[35] This report is accessible on the NRC's website (http://www.nrc.gov/reading-rm/adams.html) as ADAMS Accession No. ML090330523.

The NRC did not consider a scenario in which an earthquake on the Shoreline fault continues to rupture onto the Hosgri fault. Large earthquakes from simultaneous rupture on the two faults (i.e., those greater than M7) would produce large surface displacement, which are not evident in the geologic record. The NRC concludes that the lack of significant horizontal displacement across the Shoreline fault rules out the possibility of joint rupture.[36]

Premised on the assumption that indications on the surface of the sea floor are determinative of what occurs at seismogenic depth, the NRC staff's controversial refusal to even consider a joint-rupture scenario[37] has precipitated an intensifying conflict with the geologist at the United States Geological Survey ("USGS") widely credited with having discovered the Shoreline Fault, Dr. Jeanne Hardebeck.[38] This professional rift between the staffs of the NRC and the USGS bears some similarity to the bitter dispute between the scientists of the two agencies which haunted the original Diablo Canyon licensing process.

Simultaneously with publication of RIL 12-01, the NRC staff issued an October 12, 2012 letter to PG&E[39] signed by Joseph M. Sebrosky, Senior Project Manager for Plant Licensing Branch IV, Division of Operating Reactor Licensing, Office of Nuclear Reactor Regulation, which defers the DDE analyses until PG&E's response to the post-Fukushima review initiated by the NRC pursuant to 10 CFR 50.54(f) on March 12, 2012. The Sebrosky letter is more than a little coy with respect to the DDE:

- *Consistent with the DDP Final Safety Analysis Report Update, Revision 20, the DDE is the equivalent of the SSE at DCPP.*

[36] ML121230035, p. 35.
[37] A4NR's earlier correspondence with NRC Chair Allison Macfarlane on RIL 12-01 is attached to this testimony as Appendix E.
[38] Dr. Hardebeck's most recent peer-reviewed paper on this subject is attached to this testimony as Appendix F.
[39] This letter is accessible on the NRC's website (http://www.nrc.gov/reading-rm/adams.html) as ADAMS Accession No. ML120730106.

- *the LTSP material does not alter the design basis for DCPP.*

- *The first phase* [of the 10 CFR 50.54(f) response] *is to perform a reevaluation of the seismic hazards at the DCPP site using updated seismic information and present-day regulatory guidance and methodologies and then compare the results to the current seismic design basis.*

- *the NRC staff expects that the PG&E response … will compare the updated probabilistic ground motion … with the ground motion in the plant's current licensing basis that is stated as the equivalent of the SSE ground motion.*

- *the NRC staff expects PG&E to use the DDE for comparison with the reevaluated seismic hazard GMRS.*

- *The NRC recognizes that using the DDE as the basis of comparison will most likely result in the Shoreline fault and the Hosgri earthquake being reported as having greater ground motion than the SSE.*

- *The staff has concluded that it is appropriate to include these scenarios … and then follow the process set forth in the March 12, 2012 request for information, to determine whether any additional regulatory action is needed.*

- *Changes to the licensing basis may be appropriate to capture the information developed in response to the March 12, 2012, request for information.*[40]

On October 25, 2012, PG&E withdrew its License Amendment Request 11-05. Its heavily nuanced letter of withdrawal[41] may ultimately prove most notable for its simultaneous

[40] *Id.,* pp. 3 – 4. The Sebrosky letter goes on to significantly hedge the complacent findings of RIL 12-01, noting that *"PG&E plans to acquire new offshore and onshore two- and three-dimensional seismic reflection data to identify and characterize faults in the vicinity of DCPP. If during the collection of the data, new faults are discovered or information is uncovered that would suggest the Shoreline fault is more capable than currently believed, the staff expects that the licensee will provide the NRC with an interim evaluation that describes actions taken or planned to address the higher seismic hazard relative to the design basis, as appropriate, prior to completion of the evaluations requested in the NRC's March 12, 2012 request for information. The staff will use this information to independently assess whether the new fault or new information related to the Shoreline fault challenges or changes the staff's current position that the motions associated with the Shoreline fault are at or below those levels of the HE and LTSP ground motions."*

[41] This letter is accessible on the NRC's website (http://www.nrc.gov/reading-rm/adams.html) as ADAMS Accession No. ML12300A105.

withdrawal of PG&E Letter DCL-11-124,[42] a staggering 331-page response to the request of the NRC staff during its final pre-LAR meeting with PG&E for "a table providing the deviations" of the HE analyses from the "applicable" SSE criteria in 10 CFR 100.[43] Even if formally "withdrawn," this litany of deficiencies – unsurprising given the advances in seismic engineering in the four decades since the Diablo Canyon operating license applications were filed – may prove a very high hurdle for PG&E in completing the NRC's post-Fukushima 10 CFR 50.54(f) seismic re-evaluation.[44]

Completing the evisceration of its August 2011 reproach to PG&E, on November 19, 2012, the NRC staff pointed to the Sebrosky letter and the March 12, 2012 request for information and determined that these two documents "essentially supersede the guidance found in TIA 2011-010." The November 19, 2012 retraction[45] concludes on the ambiguous note,

> *The NRC's letter dated October 12, 2012, and the request for information dated March 12, 2012, provide guidance for assessing new seismic information and*

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[42] This document is accessible on the NRC's website (http://www.nrc.gov/reading-rm/adams.html) as ADAMS Accession No. ML11342A238.

[43] As identified in the July 29, 2011 written summary of the meeting, *"Mr. Kamal Manoly of the NRC staff noted that he believes this is a first of a kind request as he is not aware of any other instance where a licensee has requested to change its SSE. As such, Mr. Manoly stated that the amendment needed to describe where the methodologies and acceptance limits used in the evaluation of structures and components for the HE are deviating from the applicable provisions in the Standard Review Plan (SRP). Mr. Manoly stated that a table providing the deviations from the SRP for the HE should be provided with this LAR."* ML111920567, p. 2.

[44] The March 12, 2012 letter from the NRC to its licensees launched the 10 CFR 50.54(f) review process with the observation, *"the state of knowledge of seismic hazard within the United States (U.S.) has evolved and the level of conservatism in the determination of the original seismic design bases should be re-examined."* A4NR doubts that this admonition was intended to signal that, from the perspective gained by the Fukushima experience, seismic design bases at existing U.S. plants are likely too conservative and should be loosened. This letter is accessible on the NRC's website (http://www.nrc.gov/reading-rm/adams.html) as ADAMS Accession No. ML12053A340.

[45] This letter is accessible on the NRC's website (http://www.nrc.gov/reading-rm/adams.html) as ADAMS Accession No. ML12297A199.

what PG&E is expected to do in the event that it becomes apparent that the new seismic information will lead to a GMRS that is higher than the DDE.

VIII. NRC ENFORCEMENT FORBEARANCE = *DE FACTO* LICENSE AMENDMENT?

Overriding the persistent conclusions of its Senior Resident Inspector, Dr. Michael Peck, the NRC staff elected to waive enforcement of the DDE criteria for operability determinations against the new seismic information associated with the Shoreline Fault, the San Luis Bay Fault, and the Los Osos Fault.[46] NRC staff appears to have justified this decision on the basis of RIL 12-01, but chose to reiterate in the Sebrosky letter that the DDE remains the SSE for Diablo Canyon and that the 10 CFR 50.54(f) seismic re-evaluation is required to use the DDE as the basis for comparison.[47] The Sebrosky letter then makes the stunning observation,

> *The NRC recognizes that using the DDE as the basis of comparison* ***will most likely result*** *in the Shoreline fault and the Hosgri earthquake being reported as having greater ground motion than the SSE.*[48] (emphasis added by A4NR)

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[46] Oddly, neither the San Luis Bay Fault nor the Los Osos Fault is mentioned in the Sebrosky letter, and the permission it grants to PG&E to update its FSAR to include the Shoreline earthquake scenario as a lesser included case under the HE does not extend to them. The October 22, 2012 internal PG&E email included in Appendix C (GRC2014-Ph-I_DR_A4NR-001_Q07Supp01Atch06) expresses concern about this omission. The November 19, 2012 NRC retraction of TIA 2011-010 is similarly silent on the San Luis Bay and Los Osos faults, despite the suggestion in the aforementioned PG&E email that it *"may be another way of closing the POA."*

[47] Retention of the DDE as the basis for comparison in the 10 CFR 50.54(f) analyses seemingly undermines the pillars of NRC management's prior rejection of Dr. Peck's Non-Concurrence some ten months earlier. As described in Section C of ML120450843: "*Region IV held a meeting on January 30, 2012, to address how the Part 9900 operability evaluation guidance applies to this situation with representatives from NRR and RES. This meeting resulted in full agreement on the following statements:*

- *The ground motion data and the calculation method, including damping values, are correlated parameters. They must be based on the same assumptions for the calculation to have validity.*
- *It is appropriate for the licensee to use the available new ground motion data in the Hosgri Earthquake analysis because the new ground motion data is consistent with that evaluation.*
- ***The NRC will not ask the licensee to use the new ground motion input data in the Design Earthquake or the Double Design Earthquake evaluations because the new ground motion data does not match the assumptions in those analyses. Attempting to do so would create a numerical result that is not technically justified."*** (emphasis added by A4NR)

[48] ML120730106, p. 4.

And the letter goes on to predict: "Changes to the licensing basis may be appropriate …"[49]

Under the circumstances, the NRC's refusal to enforce the DDE standards in assessing operability of Diablo Canyon would appear precisely the type of informal NRC staff authorization of a licensee to engage in activities beyond the ambit of its original license which the First Circuit U.S. Court of Appeal determined requires a formal license amendment process under the Atomic Energy Act:[50]

> *If section 189(a) is to serve its intended purpose, surely it contemplates that parties in interest be afforded a meaningful opportunity to request a hearing before the Commission retroactively reinvents the terms of an extant license by voiding its implicit limitations on the licensee's conduct.*[51]

As determined by the PG&E Seismic Strategy Team as early as October, 2010, the compliance dilemma which would result from applying the DDE criteria to the new seismic information compelled a license amendment.[52] Nor, as PG&E would explain in its fourth pre-licensing meeting with NRC staff, was the easier path offered by 10 CFR 50.59 available:

> *The NRC staff asked, given the information that PG&E states is available regarding the seismic deign of the DCPP, why PG&E requested NRC approval rather than make this change under 10 CFR 50.59. PG&E stated that some of the methods used for seismic reviews could not be reconciled under 10 CFR 50.59.*[53]

Even indulging the caricature of DDE conservatisms as old-fashioned and in need of modernization, the argument that existing deterministic seismic requirements should be

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[49] *Id.*
[50] *Citizens Awareness Network, Inc, v, NRC,* 59 F. 3d 284 (1st Cir. 1995).
[51] *Id.,* pp. 294 – 295.
[52] GRC2014-Ph-I_DR_A4NR_001-Q02Supp01Atch03, p. 3.
[53] ML111920567, pp. 1 - 2.

weakened by greater reliance on sophisticated, probabilistic modeling was always going to be a tough sell to make in public. In the wake of Fukushima, coming from the same utility which had earned nationwide notoriety for its this-pipe-does-not-require-inspection certainty prior to San Bruno, the argument was a non-starter. But Congress has commanded that NRC licensees may not, under penalty of law, deviate from the terms of their reactor operating licenses.[54] If a licensee is unable to operate a reactor in strict accordance with its license, it must seek authorization from the NRC for a license amendment,[55] which is a process that triggers a right to request an adjudicatory hearing by persons whose interests may be affected by the proceeding.[56] Notably, 10 CFR § 50.91 provides for consultation with the State in which the facility is located. Is it inconceivable that the State of California would have an interest?

Except as context for the ratepayer funding requested by PG&E in A.12-11-009, federal pre-emption doctrine may limit the CPUC's curiosity about many of the details of PG&E's to date successful evasion of the seismic assessment requirements of the Diablo Canyon licenses. PG&E has gained a multi-year stay of enforcement of the DDE provisions through its *de facto* license amendment. But it will have to produce analyses which the NRC staff **actually has predicted will show exceedances** -- from both the Shoreline and the Hosgri faults, with the San Luis Bay and Los Osos faults inexplicably unaccounted for -- before it wins permanent exemption through a bonafide license amendment. Any confidence PG&E has in the outcome of that process, especially with DCL 11-124's 331-page roadmap of deviations from the

[54] See 42 USC § 2131.
[55] 10 CFR §§ 50.59, 50.90 thru 50.92.
[56] See 42 USC § 2239(a)(1)(A) and 10 CFR § 2.105.

"applicable" standards of 10 CFR 100, may prove short-lived.

IX. SELECTING THE WRONG LEVEL SSHAC.

PG&E is midway through its conduct of a SSHAC Level 3 seismic review, initiated prior to the NRC's March 12, 2012 requirement that each of the four western U.S. nuclear plants perform at least a SSHAC Level 3 re-examination. A.12-11-009 seeks ratepayer funding to complete the current SSHAC process as well as provide continued funding for PG&E's ongoing LTSP.[57]

PG&E explained at its first SSHAC workshop, conducted in San Luis Obispo on November 29, 2011, that the four different levels of SSHAC study are distinguished by an increasing level of sophistication, resources, and participation by technical experts. In PG&E's words, Level 4 is intended for regions of "active, complex tectonic settings"; "potential for significant public impact/scrutiny"; and/or "significant Regulatory scrutiny."[58] While A4NR suspects that most of the PG&E customers paying for the SSHAC review could probably imagine no U.S. nuclear power plant site better fitting the Level 4 criteria, the utility apparently determined none of those conditions are present at Diablo Canyon. According to PG&E's workshop presentation, "A SSHAC Level 4 study is not being used because of (1) significantly increased schedule

[57] Despite generous ratepayer funding since 1984 and a continuous stream of boastful PG&E press announcements about the sophistication of its LTSP, the U.S. Government Accountability Office reported in 2012 that PG&E had not actually updated its probabilistic risk assessment of the seismic hazard at Diablo Canyon since 1988. GAO-12-465, "Natural Hazard Assessments Could Be More Risk Informed," April 26, 2012, p. 19.

[58] William Lettis, PowerPoint presentation, "Diablo Canyon SSHAC Level 3 Study," SSHAC Conference, November 29, 2011, San Luis Obispo, slide 35.

requirement, (2) Iterative process of Evaluation and Integration, and (3) relatively minor increase in regulatory assurance associated with a Level 4 study."[59]

However, NUREG-2117, the NRC's official guidance on the conduct of the SSHAC process, did find additional regulatory assurance from a Level 4 study, particularly because of its greater transparency to those "outside the project":

> *Additional assurance is that the range of technically defensible interpretations may be provided in a Level 4 assessment because evaluations by individual experts or teams of experts lead to a suite of separate models that in aggregate constitute the final integrated distribution.* ***In terms of how the process is perceived from outside the project, this may be helpful compared to a Level 3 study where the way individual expert assessments contribute to the final composite distribution may be less obvious.*** *The choice of a Level 4 study may lead to greater confidence that the CBR[60] of the TDI[61] has been captured because of the number of individual logic-trees – each of which attempts to capture the full range of uncertainty – combined in a composite logic-tree.* ***This contrasts with a Level 3 study where the individual contributions and models of the members of the TI[62] team are not discernible in the presentations at workshops and in the final report.***[63] (emphases added by A4NR)

X. PACKING THE SSHAC WITH PG&E INSIDERS.

PG&E has structured its SSHAC process as an update to its LTSP work, and staffed the upper echelons of the project with longtime LTSP veterans who are effectively being called upon to review the very work upon which their professional careers have been based. This

[59] *Id.*
[60] CBR is an acronym for center, body, and range.
[61] TDI is an acronym for technically defensible interpretations.
[62] TI is an acronym for technical integration.
[63] "Practical Implementation Guidelines for SSHAC Level 3 and 4 Hazard Studies (NUREG-2117, Revision 1)," April 2012, p. 41. This document is accessible on the NRC's website at http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr2117/. Although noting that ANSI/ANS-2.29-2008 should only be used as a guide rather than a prescription for selection of the appropriate SSHAC Level, NUREG-2117 observes that "the Standard" for a "facility at a high nominal hazard site (such as in the western United States) and high uncertainty/controversy would be required to conduct a Level 4 study." *Id.,* pp. 59 – 60.

reliance on LTSP insiders, drawn from both PG&E staff and consultants, is a significant variance from the discussion of project participant selection found in NUREG-2117. *"Because the technical work that is done by the TI Team in a Level 3 study and Evaluator Experts in a Level 4 study is paramount to the success of the study,"* NUREG-2117 cites the *"useful insights"* found in the earlier guidance on selection criteria in NUREG-1563:[64]

> *This guidance states 'the panel of experts selected for elicitation should comprise individuals who: (a) possess the necessary knowledge and expertise; (b) have demonstrated their ability to apply their knowledge and expertise;* ***(c) represent a broad diversity of independent opinion and approaches for addressing the topic(s) in question; are willing to be identified publicly with their judgments; and (e) are willing to identify, for the record, any potential conflicts of interest.'***[65] (emphasis added by A4NR)

Citing the example of the Yucca Mountain Probabilistic Volcanic Hazard Analysis Update ("PVHA-U"), NUREG-2117 specifies, *"It may be useful to require that TI Team members or evaluator experts to (sic) disclose any potential conflicts of interest to remove any doubt that they are acting as independent evaluators and not as representatives of their agencies or under the influence of any business relationships."* [66] Among the information each expert on the Yucca Mountain PVHA-U was asked to disclose: 1) organizational affiliations and relevant business relationships; 2) sources of research support; and 3) other circumstances that might be construed as creating a potential conflict of interest.

The NRC guidance is even more to the point for SSHAC Level 3:

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[64] This document is accessible at the NRC's website at http://www.nrc.gov/reading-rm/doc -collections/nuregs/staff/sr1563/.
[65] NUREG-2117, p. 65.
[66] I*d.,* p. 68.

In a Level 3 study … careful thought must be given to the composition of the TI teams for the SSC and GMC subprojects. If possible, the teams ***should not be dominated by personnel from a single institution or company*** *because there could be a perception that this will not provide sufficient diversity of viewpoints and approaches.*[67] (emphasis added by A4NR)

XI. OPENLY EMBRACING COGNITIVE BIAS.

The NRC's formal guidance on how to conduct SSHAC Level 3 and Level 4 reviews specifically cautions against *"several known problems that can plague expert assessments."* [68] With the exception of motivational biases, NUREG-2117 states, *"most are not deliberate or intentional, but they must be countered."*[69] NUREG-2117 characterizes these non-motivational, unintentional influences as *"cognitive bias"* and cites the following as examples *"that are of clear relevance to conducting seismic hazard analyses:"*

- *Overconfidence: overestimating what is known (i.e., underestimating uncertainty).*
- *Anchoring: focusing on a specific number or model and not adjusting it sufficiently in light of new information.*
- *Availability: focusing on a specific, dramatic, or recent event; being inclined toward models that one is more familiar with or that one feels an affinity for because of knowing personally or by reputation the authors of a given model (or indeed, by being an author).*
- *Coherence/vividness: over-estimating the likelihood of an event because there is a 'good story.'*

[67] *Id.,* p. 92.
[68] *Id.,* p. 108.
[69] *Id.*

• *Ignoring conditioning events: these are often unstated assumptions that influence the assessments that experts make.*[70]

In his May 10, 2011 email providing an initial budget for PG&E's SSHAC, Dr. William Lettis,[71] the lead for the Seismic Source Characterization ("SSC") portion of the SSHAC, identified three principal budget advantages to an open embrace of "Anchoring" and "Availability":

(1) We already have an existing model with significant existing effort, documentation and pedigree

(2) We are only performing an "update" of this existing model versus a complete new model

(3) PG&E, SCEC and PEER are performing many studies under separate budget that will help reduce uncertainty and feed directly into the SSHAC models[72]

Dr. Lettis' initial Project Plan for both the SSC and Ground Motion Characterization portions of the SSHAC, dated May 9, 2011,[73] acknowledged that the effort would differ from a traditional Level 3 study "in several important aspects":

- *First, all of the proposed workshops **<u>will be open to the public</u>** and will include a 'public comment' session at their conclusion. The attending public will be observers*

[70] *Id.*
[71] Dr. Lettis is a veteran of the original 1984 – 1991 LTSP work and a longtime consultant to PG&E.
[72] GRC2014-Ph-I_DR_A4NR_001-Q09Supp01Atch05, p. 1. Dr. Lettis' email is attached to this testimony as Appendix G.
[73] GRC2014-Ph-I_DR_A4NR_001-Q09Supp03Atch21. The May 9, 2011 Project Plan is attached to this testimony as Appendix H. A4NR believes the May 28, 2013 date appearing on the bottom of each page reflects the date the document was produced in response to A4NR's discovery request.

*and **will help to achieve transparency** in the technical proceedings of the SSHAC process.*[74] (emphasis added by A4NR)

- *Second, the DCCP SSHAC study will constitute **an 'update' of the existing Long Term Seismic Program (LTSP) SSC Logic Tree model and GMC model** through 'hazard-informed' sensitivity analyses. Although all aspects of the models will be considered, discussed, and updated based on current scientific understanding and concepts, the intent of the sensitivity analyses will be to inform the SSHAC participants of those issues of greatest significance to the hazard results and **to focus further evaluation and integration of data and information on characterizing the uncertainty in these model parameters.** An important aspect of the LTSP update, therefore, will be to **avoid being anchored to pre-existing characterizations** and to be open to new data, evaluations, and alternative interpretations.* (emphases added by A4NR)

- *Third, a number of significant studies will be performed during the course of the SSHAC study … Because of the **significant amount of new data** that will progressively become available, several of the traditional SSHAC Level 3 Workshops will be repeated in order to **fully evaluate and integrate the newly available data** and models into the SSC and GMC models.*[75] (emphasis added by A4NR)

The May, 9, 2011 Lettis Project Plan saw value from combining the SSC and GMC components of the SSHAC, under a common 8-person Participatory Peer Review Panel ("PPRP"):[76]

> *All SSC and GMC Workshops will be co-convened at the same time and location. Each meeting will have first a joint session followed by separate technical meetings for the SSC and GMC. This will allow the sensitivity analyses to be presented to both groups and allow integrated feedback.*[77]

The May 9, 2011 Lettis Project Plan envisioned a need ("*in order to fully evaluate and integrate the newly available data and models")* to split the customary SSHAC Workshop 1 on data needs

[74] The public's status as "observers" would subsequently be identified in NUREG-2117, Table 4-2, as features of SSHAC Level 3 and Level 4 processes.
[75] GRC2014-Ph-I_DR_A4NR_001-Q09Supp03Atch21, p. 2.
[76] The PPRP is an integral aspect of a SSHAC Level 3 or Level 4 study. The peer review is considered "participatory" in that it is a continuous process that occurs throughout the study, not a singular review that occurs at the end. The PPRP is kept abreast of project developments by attending workshops and reviewing interim project documents, and the project's technical integration team is given the opportunity to address PPRP comments and make modifications during the project.
[77] GRC2014-Ph-I_DR_A4NR_001-Q09Supp03Atch21, p. 9.

and alternative models into two separate sessions separated by six months.[78] Similarly, the traditional SSHAC Workshop 2, addressing preliminary model construction and hazard feedback would be broken into "a series of iterative workshops at six-month intervals".[79]

XII. SCALING BACK THE SSHAC.

The SSHAC process for which A.12-11-009 seeks funding is materially less transparent and less interactive than that envisioned in the May 9, 2011 Lettis Project Plan. The supremely important GMC component has been severed off,[80] and enshrouded in an opaque joint SSHAC with SONGS[81] and Palo Verde whose workshops are not public,[82] videotaped, or transcribed. As a consequence, the interactions between experts -- which constitute the heart of the SSHAC process and serve to illuminate the areas where expert judgments diverge -- have been lost to anyone not in the room, and even to those attendees with less than perfect recall. On the SSC

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[78] *Id.*, pp. 12 – 14.
[79] *Id.*, p. 14.
[80] PG&E reports in GRC2014-Ph-I_DR_A4NR_002-Q21 that this allowed a 33% budget reduction for the GMC effort.
[81] On June 19, 2013, Southern California Edison reported at a California Energy Commission workshop that its closure of SONGS means the 10 CFR 50.54(f) requirements no longer apply, and that Edison is doubtful that its seismic review will continue.
[82] A4NR was escorted from the premises before the March 19, 2013 GMC workshop was allowed to start, having mistakenly assumed the GMC workshop was public after it had been announced at PG&E's earlier SSC workshop. PG&E's Vice President, Regulatory Relations, Brian K. Cherry explained in an April 1, 2013 letter to CPUC President Michael Peevey that the GMC workshop was *"a collaborative meeting with other western utilities and scientific experts to discuss and evaluate what type of data is needed to determine ground motions in the Western United States. PG&E was just one participant in this particular workshop and we did not have the authority to unilaterally open the meeting to the public. Some of the other participants preferred to limit attendance to invited persons in order to protect proprietary data and promote technical dialogue. In order to take part in the workshop, PG&E honored the interests of these other participants."* A4NR noted the date of Mr. Cherry's letter and, rather than contest its strained assertions, has posted at http://www.youtube.com/watch?v=jzS3vMBvAsg&feature=youtu.be the videotaped reactions of the Diablo Canyon Independent Safety Committee – including Dr. Robert Budnitz, the Chairman of the original Senior Seismic Hazard Analysis Committee which authored NUREG-2117's 1997 predecessor -- to this abuse of SSHAC principles.

side, the envisioned conversion of the traditional SSHAC Workshop 1 into two sessions separated by six months, and SSHAC Workshop 2 into a series of iterative sessions every six months ("*in order to fully evaluate and integrate the newly available data and models"*[83]*)* has also fallen by the wayside.

Significantly, the GMC component appears to have greatly diminished its efforts at assembling new data that might prove useful in assessing Diablo Canyon's highly unusual site conditions in preference to the opaque modeling simulations which have featured so strongly in the LTSP. At the conclusion of the initial three-day SSC/GMC SSHAC workshop December 1, 2011, Dr. Norman Abrahamson,[84] the GMC lead and Principal Technical Integrator for PG&E's entire SSHAC, provided a summary of the extensive data needs identified during the workshop for the GMC work.[85] After merging the Diablo Canyon GMC work with the SONGS/Palo Verde SSHAC, only a small fraction of these data needs are being addressed. PG&E's rambling answer to A4NR Data Request #26 gives a flavor for why:

> *The SSHAC process is intended to capture the center, body, and range of the seismic hazard based on the data and models that are available at the time of the study. The limitations of the available data and models are captured as part of the uncertainty included in the model. In this way, the hazard study carried out using the SSHAC guidelines is a snapshot in time in regard to the state of knowledge of the seismic source characterization and ground motion characterization.*
>
> *Collection of additional data is not required for a SSHAC study, but often there are data gaps identified that lead to large uncertainties in the computed hazard. If these data gaps can be addressed within the schedule and budget of the SSHAC study, then the collection of additional data should be considered (see section 4.5.2 of NUREG 2117).* ***<u>For</u>***

[83] GRC2014-Ph-I_DR_A4NR_001-Q09Supp03Atch21, p. 2.
[84] Dr. Abrahamson is a veteran of the 1984 – 1991 LTSP work and a longtime employee of PG&E's Geosciences Department.
[8585] PG&E transcript of SSHAC workshop, November 29 – December 1, 2011, pp. 234 – 249, provided to A4NR pursuant to a data request in A.10-01-014. These pages of the transcript are attached to this testimony as Appendix I.

> ***the GMC, the primary collection of new ground motion data was done as part of the Pacific Earthquake Engineering Research Center update of the ground motion data base*** *(released May 2013). The development of new simulated ground motion data is being conducted through the Southern California Earthquake Center. These new data are being incorporated into the PG&E GMC study.*[86] (emphasis added by A4NR)

As Dr. Abrahamson had emphasized, however, at PG&E's initial SSHAC workshop devoted to identifying data needs, that reliance on the updated NGA-West 2 models would be less than sufficient for the Diablo Canyon work:

> *…we are working with the PEER*[87] *center. There's a large effort updating the NGA*[88] *ground-motion models, and new NGA West 2 ground-motion model will be done next year. It has a significantly expanded database,* ***but it still doesn't have everything that we need to be capturing, so we want to be bringing in extra data that will not go into that database for the development of the new NGA model****, but we can use that data to check those models to make sure that we are capturing a broad enough range and not just limited to what was in that set.*[89] (emphasis added by A4NR)

Dr. Abrahamson's summary of data needs emphasized the analytic challenges posed by Diablo Canyon's peculiar status as a hard-rock site which performs like a soft-rock site:

> *Part of the – one of the issues that we've got on our – back to our kappa value is that Diablo Canyon is showing up at – currently interpreted as a high velocity site, 1200 meters per second, yet high kappa.* ***Okay. Kappa, meaning it's still attenuating the high frequencies more like a soft-rock site. So it's, how can you have a high velocity and a high kappa?***[90] (emphasis added by A4NR)

The NRC staff's October 2012 Research Information Letter (RIL) 12-01, "Confirmatory Analysis of Seismic Hazard at the Diablo Canyon Power Plant from the Shoreline Fault Zone,"[91] reiterating the conclusion of its April 2009 "Preliminary Deterministic Analysis of the Seismic

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[86] GRC2014-Ph-I_DR_A4NR_002-Q26.
[87] PEER is an acronym for the Pacific Earthquake Engineering Research Center at UC Berkeley.
[88] NGA is an acronym for Next Generation Attenuation.
[89] Appendix I, p. 235.
[90] *Id.,* p. 238.
[91] This report is accessible on the NRC's website (http://www.nrc.gov/reading-rm/adams.html) as ADAMS Accession No. ML121230035.

Hazard at Diablo Canyon Nuclear Power Plant from Newly Discovered 'Shoreline Fault,'"[92]

bluntly acknowledges the seminal nature of this issue at Diablo Canyon:

- *The NRC's results from the parametric study described in RIL 09-001 indicated that the* ***site characteristics (V_{S30}) represented the single biggest source of uncertainty*** *in the results of the study.*[93] (emphasis added by A4NR)

- *The value of kappa influences the shape of the ground motion spectrum observed at a given site. High values of kappa result in enhanced attenuation of the high-frequency portion of the spectrum.*[94]

- *Kappa is a site-specific property that can be determined by either using seismograms recorded at the site of interest or from correlations with other site properties such as V_{S30}. Generally, the harder the rock (i.e., the higher the V_{S30}) the lower the* [Kappa] *value; however, this is not universally true.* ***Kappa values of <0.01 to 0.02 s have been observed or estimated for hard rock sites*** *(i.e., V_{S30}) values greater than 1,100 m/s). However, considerable scatter in these estimates has been documented* [citations omitted].[95] (emphasis added by A4NR)

- *GMPEs*[96] *are developed from statistical regression of a database of seismograms recorded on sites with different geologic properties. As such, the limitations of the regressions must be considered. Generally, the rock underlying the DCPP is harder than in a typical interplate region, and so it is harder than the rock under the majority of the seismic stations from which the earthquake recordings were collected for the NGA GMPE development project.* ***The average V_{S30} parameter for the database of earthquake recordings used in the NGA GMPE development project is less than 400 m/s.***[97] (emphasis added by A4NR)

- *Only a very small percentage of the recordings in that dataset are from sites with V_{S30} values or higher. Of the 3551 recordings in the NGA-West PEER data base* [website omitted] *at the time of the development of the GMPEs,* ***there are only 51 recordings with sites defined with V_{S30} >= 900 m/s. This is less than 1.4% of the data base.***[98] (emphasis added by A4NR)

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[92] This report is accessible on the NRC's website (http://www.nrc.gov/reading-rm/adams.html) as ADAMS Accession No. ML090330523.
[93] ML121230035, p. 54.
[94] *Id.,* p. 55.
[95] *Id.*
[96] GMPE is an acronym for ground motion prediction equation, also known as an attenuation relationship.
[97] ML121230035, pp. 55 – 56.
[98] I*d.,* p. 56.

- ***There are only 15 records with V_{S30} >= 1,200 m/s (less than one-half of one-percent). Of these, only 11 are actually measured values from close to 30 m in depth (the rest are 'inferred').***[99] (emphasis added by A4NR)

- *As noted …* ***the measured V_{S30} value for DCPP is approximately 1,200 m/s. Hence, applying a V_{S30} directly in the GMPEs increases uncertainty, as this value is outside the range well constrained by observational data.***[100] (emphasis added by A4NR)

- *For very hard rock sites, an alternative technique … is to estimate ground motions for a soft-rock site condition where the data constraints are more robust and then to adjust these ground motion values based on the relative amplification (or de-amplification) as estimated using site response analyses.*[101]

- *In the Shoreline Fault Report, PG&E estimated ground motions for a reference site condition of 760 m/s and then applied the shear-wave velocity correction factors from the Silva (2008) … The Silva (2008) study estimated an average* [kappa] *value of 0.04 s for generic California soft-rock sites contained in the NGA database. The analysis conducted by PG&E (2011) estimated a site-specific* [kappa] *value of 0.045 s using a single recording from the 2003 M3.9 earthquake that occurred approximately 4 km from DCPP in Deer Canyon.*[102]

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[99] *Id.* As Dr. Abrahamson observed a year earlier at PG&E's data needs SSHAC workshop, ***"… are there some key hard-rock sites that it really makes sense to go spend the money and drill and find out what's there, and that we should measure instead of infer****, and, again, this need for a comprehensive characterization project on hard-rock sites. And this fits really well with what's going on in the eastern U.S. work. There's a lot of – we're looking how many hard-rock sites have measured V_{S30} values. Really, the answer was very few, I think; although, most of – because we have few small number, most of those have been characterized, but a key issue is how many of the sites that have been characterized as soft rock using inferred methods really were a harder site, and are there some out there like that. So we need to start to – one way is to look at a – just, there's a pilot study. Pick a subset of those that* ***we've used inferred methods and see, if we do a detailed characterization, are, you know, ten percent of them wrong or is it 50 percent of them wrong****, and so forth."* Appendix I, p. 240 (emphasis added by A4NR).

[100] *Id.*

[101] *Id.*

[102] *Id.* At PG&E's initial SSHAC workshop, nearly a year prior to publication of ML121230035, Dr. Abrahamson had lamented the shortage of data on California small magnitude earthquakes at short distances from stations with at least five recordings and the resultant larger standard deviations. Regarding the Deer Canyon earthquake, he said, *"we haven't looked at the other recordings from around that earthquake, so that should be recorded by the regional network, and we can go and better understand the source properties of that to help us constrain how we are interpreting that earthquake in terms of its shaking as well because – and this is affecting for us two parts. It's one, it affects the GMPE part, the median ground motion because we're using that as part of our kappa estimation, so it's helping control the high frequencies.* ***And if we can get regional data, we can now have more than five stations recording that site, and it now can become one of the points that we use in our partially ergodic data set. We are now working with two recordings, and that will get us up to three which is a 50-percent increase, so that's progress."*** Appendix I, pp. 236 – 237 (emphasis added by A4NR).

While deferential to PG&E's ground motion modeling finesse, the NRC staff had three muted criticisms of PG&E's abridged approach to data:

- *Is the* [kappa] *value used by Silva (2008) appropriate for the DCPP site? Using the 1,200 m/s V_{S30} value for the DCPP site in the published kappa-shear wave velocity correlations suggests a* [kappa] *value of 0.01-0.03 s* [citation omitted]. *As noted above,* ***PG&E estimated a value of 0.045 s for kappa at the DCPP site based on a single recording of a relatively small earthquake.***[103] (emphasis added by A4NR)

- *… PG&E (by incorporating the Silva (2008) results) used an approach that utilized a generic velocity profile with randomization of the near-surface velocity structure applied to develop the amplification factors.* ***While this may be an acceptable approach for sites with little or no available data, NRC staff feels adequate data exists at DCPP to develop site-specific amplification factors.*** *Further, the base rock velocity condition used in the Silva (2008) study (V_S = 1,130 m/s) differed slightly from the 1,200 m/s documented … for the DCPP site.*[104] (emphasis added by A4NR)

- ***The single-station-sigma correction applied by PG&E was developed based on data from two earthquakes. Generally a larger number of earthquakes would be needed to develop confidence in the correction factor*** *… Nevertheless, the analysis performed by PG&E provides a strong proof-of-concept.*[105] (emphasis added by A4NR)

XIII. CPUC HAS TO START SOMEWHERE.

As Southern California Edison's recent San Onofre closure announcement has shown,

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[103] ML121230035, p. 58.
[104] *Id.*
[105] *Id.*, p. 59. As Dr. Abrahamson explained at the 2011 SSHAC workshop, *"So, to be able to get data, enough recordings at our sites, to be able to estimate an average site turn; that is, I can see how my site response is different than what the model was predicting and in a stable way, we need to get –* ***this is as I said here, we're after five or more recordings per earthquake.*** *To do that, you've got to go to small. Okay? We can't wait at a site and say I need five magnitude 7s. That's not going to happen for us. So we're now working under an assumption that our site, that the differences in the amplification we get from magnitude – small magnitudes, say magnitude 4s, is the same as what we would be getting from magnitude 7s, and this needs to be checked out and really worked through. As well, you know, if there's nonlinearity in the amplification, that would start to affect that value as well.* ***We're also looking, as I said, the quality of the data from small metadata, particularly the location could be leading to significant errors in the short distance part,*** *and we're seeing – there's an indication that, again, we see a very large standard deviation, increase in the standard deviation at say, magnitude 4 to 5 in the zero- to 15-kilometer range. Well,* ***that's where an error in location could really change the prediction by quite a bit****, and then, we may simply be mapping location errors into what we call aleatory variability, and that's not right. That's not where it should be."* Appendix I, p. 243 (emphasis added by A4NR).

the path from problem to abandonment can be short and abrupt for an aging nuclear power plant. PG&E's successful evasion of the Diablo Canyon design basis tests for the Shoreline Fault, the Los Osos Fault, and the San Luis Bay Fault simply defers an inevitable day of reckoning. Even the NRC's crude acquiescence in that evasion has not disarmed the demanding standards of the Double Design Earthquake test, merely delayed its application until 2015. The alarming fact that the NRC staff has actually predicted that Diablo Canyon will fail that test, combined with PG&E's 331-page list of deviations between its preferred Hosgri Evaluation and the seismic requirements imposed on new plants since 1997, means significant regulatory consequences loom on Diablo Canyon's near horizon. And that prospect is clear before even considering any post-Fukushima seismic criteria that may emerge.

As established by the facts recounted in this testimony and the documents attached as appendices, PG&E has misused ratepayer funds since the discovery of the Shoreline Fault to obfuscate the seismic threat to Diablo Canyon. In the immediate aftermath of Fukushima, rather than engage in an objective re-evaluation of the assumptions and approaches underlying its LTSP, PG&E instead embarked upon an insular SSHAC-lite exercise in celebrating past work. In the two years since initiating its SSHAC Level 3, PG&E has stripped the vital GMC component of its data-gathering function[106] and any semblance of public transparency. While the CPUC has previously shown its willingness to commit substantial amounts of ratepayer funds to better

[106] NUREG-2117, p. 42, could not be clearer on the significance of PG&E's misplaced GMC priorities: *"… multiple-expert assessment should **never** be used as a substitute for data collection. In other words, the experts in a PSHA should **never** be used to infer or guess values that could reasonably be measured within the time and budget resource constraints of a project. **To do so is a misuse of the SSHAC process**."* (emphasis added by A4NR)

understanding of the seismic setting at Diablo Canyon,[107] PG&E now seeks additional ratepayer funds for activities that have elevated crass advocacy far above objective scientific inquiry.

A4NR recommends that the Commission establish a two-way balancing account for Nuclear Regulatory Commission ("NRC") rulemaking expenses; provide for recovery of expenditures through PG&E's annual ERRA filing; engage the Commission's existing Independent Peer Review Panel in the SSHAC process while bolstering its GMC capabilities through the use of expert consultants; and require PG&E to record 50% of its forecast SSHAC costs below-the-line, consistent with D.11-05-018's treatment of "advocacy" expenditures for Nuclear Energy Institute membership.

A4NR is mindful of the Commission's desire to avoid interference with the exercise of the NRC's federal authority over the regulation of nuclear power plants,[108] and does not suggest that the Commission do so. It is important, however, for the Commission to recognize that NUREG-2117's emphasis that the "greater levels of regulatory assurance" associated with SSHAC Level 3 and Level 4 studies are meant to apply to other regulators as well as the NRC.[109] Given the Commission's role in determining whether the economic costs of future seismic retrofits to Diablo Canyon should be incurred by ratepayers; or its role with the California Independent System Operator and California Energy Commission in assuring the reliability of the state's electricity system; or the effective veto power which the federal Coastal Zone

[107] A4NR acknowledges that the $64.25 million AB 1632 studies approved in D. 12-09-008 are not at issue in this proceeding, and this testimony does not address them.
[108] As D.12-09-008 most recently stated in its Conclusion of Law No. 8, "The Commission by its orders in this proceeding does not intend to interfere with the NRC's requirements set forth in the NRC's March 12, 2012 50.54(f) letter."
[109] NUREG-2117, p. xvii.

Management Act of 1972[110] gives the California Coastal Commission over any future extension of the Diablo Canyon operating licenses, it should be self-evident that California state agencies have a compelling interest in the scientific robustness and technical integrity of the seismic activities for which PG&E is seeking ratepayer funding in A.12-11-009.

[110] 16 U.S.C. § 1451 et seq.

Appendix A

Professional Qualifications of John Geesman

QUALIFICATIONS OF JOHN GEESMAN

John Geesman is an attorney with the Oakland law firm, Dickson Geesman LLP.

He was a member of the California Energy Commission from 2002 to 2008, and its Executive Director from 1979 to 1983. Between his two tours at the Commission, Mr. Geesman spent 19 years as an investment banker focused on the US bond markets.

He has previously served as

- Co-Chair of the American Council on Renewable Energy,
- Chairman of the California Power Exchange,
- President of the Board of Directors of TURN,
- a Board Member of the California ISO,
- and Chairman of the California Managed Risk Medical Insurance Board.

He is a graduate of Yale College and the UC Berkeley School of Law.

Appendix B

Non-Concurrence of Dr. Michael Peck, NRC Senior Resident Inspector

Non-Concurrence Process Record for NCP-2012-001

The U.S. Nuclear Regulatory Commission (NRC) strives to establish and maintain an environment that encourages all employees to promptly raise concerns and differing views without fear of reprisal and to promote methods for raising concerns that will enhance a strong safety culture and support the agency's mission.

Individuals are expected to discuss their views and concerns with their immediate supervisors on a regular, ongoing basis. If informal discussions do not resolve concerns, individuals have various mechanisms for expressing and having their concerns and differing views heard and considered by management.

Management Directive MD 10.158, "NRC Non-Concurrence Process," describes the Non-Concurrence Process (NCP). http://pbadupws.nrc.gov/docs/ML0706/ML070660506.pdf

The NCP allows employees to document their differing views and concerns early in the decision-making process, have them responded to, and attach them to proposed documents moving through the management approval chain.

NRC Form 757, Non-Concurrence Process is used to document the process.

Section A of the form includes the personal opinions, views, and concerns of an NRC employee.

Section B of the form includes the personal opinions and views of the NRC employee's immediate supervisor.

Section C of the form includes the agency's evaluation of the concerns and the agency's final position and outcome.

NOTE: Content in Sections A and B reflects personal opinions and views and does not represent official factual representation of the issues, nor official rationale for the agency decision. Section C includes the agency's official position on the facts, issues, and rationale for the final decision.

The agency's official position (i.e., the document that was the subject of the non-concurrence) is included in ADAMS accession number ML120450843.

NRC FORM 757
NRC MD 10.158
(7-2011)

U.S. NUCLEAR REGULATORY COMMISSION

NON-CONCURRENCE PROCESS

NCP TRACKING NUMBER
NCP-2012-001

SECTION A - TO BE COMPLETED BY NON-CONCURRING INDIVIDUAL

TITLE OF SUBJECT DOCUMENT DIABLO CANYON POWER PLANT - INSPECTION REPORT 05000275/323-2011005	ADAMS ACCESSION NO. ML 120450843
DOCUMENT SIGNER Neil O'Keefe,	SIGNER PHONE NO. (817) 200-1141
TITLE Chief	ORGANIZATION Project Branch B, Region IV
NAME OF NON-CONCURRING INDIVIDUAL(S) Michael Peck	PHONE NO. (805) 595-2354
TITLE Senior Resident Inspector	ORGANIZATION Project Branch B, Region IV

✓ DOCUMENT AUTHOR ☐ DOCUMENT CONTRIBUTOR ☐ DOCUMENT REVIEWER ☐ ON CONCURRENCE

REASONS FOR NON-CONCURRENCE AND PROPOSED ALTERNATIVES

Issue: Pacific Gas and Electric (PG&E) completed a deterministic reevaluation of the local seismology.[1] This reevaluation concluded that three local faults could produce about 70% greater vibratory ground motion than described in the Final Safety Analysis Report Update (FSARU) for the double design/safe shutdown earthquake. The licensee completed a prompt operability determination (POD)[2] to assess the effect on the capability of plant structures, systems and components (SSCs) to perform the specified safety functions at the higher vibratory motions.

The inspection report documented the results of the NRC inspection of the seismic POD.[3] The report stated that the POD provided an initial basis for concluding a reasonable assurance that plant equipment would withstand the potential effect of the new vibratory ground motion. The inspector non-concurs with the report because the POD failed to meet ether the licensee's procedural requirements or the NRC standard for operability. As a result, the licensee failed to demonstrate a reasonable assurance that all Diablo Canyon SSCs were capable of performing the specified safety functions as described in the plant design bases.

The POD was inadequate because the licensee failed to demonstrate that the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code acceptance limits were met for reactor coolant pressure boundary components at the higher structural stress levels represented by the new seismic information. As defined in 10 CFR 50.55a, "Codes, and Standards," the Code acceptance limits established a minimum standard for operability.

The POD was also inadequate because the licensee failed to demonstrate that all seismically qualified plant SSCs would continue to function at the higher vibratory motion associated with new seismic information in accordance with the double design (safe shutdown) earthquake design basis.

Background - Current Seismic Design and Licensing Basis (CLB)

Seismic qualification for Diablo Canyon SSCs were developed from three design bases[4] events:

- Design Earthquake (DE): This safety analysis implemented the 10 CFR 100 requirements for the Operational Basis Earthquake. The DE (0.2 g)[5] represented the maximum vibratory ground motion that could reasonably be expected during the operating life of the plant. The DE ensured the seismic qualification for which those plant features necessary for continued operation remain functional without undue risk to the health and safety of the public.

- Double Design Earthquake (DDE): This safety analysis implemented the 10 CFR 100 requirements for the safe shutdown earthquake. The DDE (0.4 g) represented the maximum earthquake potential (producing the maximum vibratory ground motion) for all earthquake epicenters within 200 miles and faults within 75 miles of the plant. The DDE established the seismic qualification requirements for plant SSCs necessary to:

✓ CONTINUED IN SECTION D

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DATE Jan 26, 2012

SEE SECTION E FOR IMPLEMENTATION GUIDANCE

- Ensure the integrity of the reactor coolant pressure boundary,
- Prevent or mitigate design basis accidents, and
- Safely shutdown the plant.

- Hosgri Event (HE): This safety analysis implemented a PG&E commitment to the NRC to demonstrate that the plant could be safely shutdown following a postulated 7.5 M earthquake on the Hosgri Fault line (0.75 g).

The HE represented the largest ground motion of the three design basis events. However, SSC seismic qualification was limited by each of the three design basis earthquakes. For example, the safety analysis predicted higher vibratory motion for DE and DDE than the HE at the steam generators, as shown in Figure 1. The bounding vibratory motion (shaking), used to seismically qualify individual plant components, was a function of the component location. As shown in Figure 2, the DDE provided the limiting floor response spectrum for the 88 foot level of the containment building. The seismic qualification of plant structures was also limited by both the DDE and HE, dependant on location. For example, the seismic qualification of the lower levels of the containment structure were limited by the HE design basis while the upper levels were dominated by the larger DDE spectrum. Portions of the reactor coolant pressure boundary were more limited by the DE and DDE than HE. These differences in qualification requirements resulted from different assumptions, methods, design basis values/inputs, and acceptance criteria approved for each seismic safety analysis.

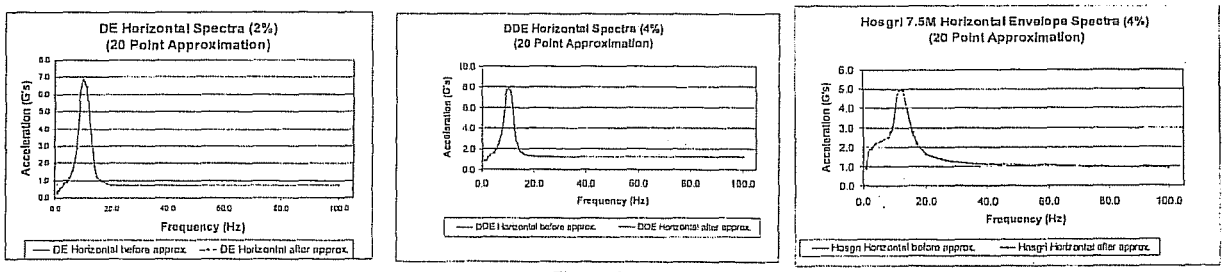

Figure 1
Comparison of DE, DDE, & HE Horizontal Response Spectrum at the Steam Generators

The Diablo Canyon Long Term Seismic Program (LTSP)

Several groups raised seismic safety concerns during the original Diablo Canyon licensing process. A major concern was related to the faulting style assumed in the HE safety analysis. To address these concerns, the NRC included Condition 2.C(7) with the original plant License. This license condition required PG&E to identify, examine, and evaluate all relevant geological and seismic data and information that became available since the 1979 Atomic Safety and Licensing Board hearing. From this information, the licensee was required to complete probabilistic and deterministic studies to assure the adequacy of seismic margins. This re-evaluation became known as the LTSP.

PG&E completed the LTSP and submitted the final report to the NRC in 1988.[6] The licensee concluded that the original seismic design basis (DE & DDE) plus the HE was adequate and no changes were necessary. In 1991 the NRC accepted the LTSP final report and closed the License Condition.[7] The NRC concluded that the LTSP did not alter the plant seismic qualification or design basis. In 1991, PG&E made three commitments associated with closure of the LTSP:

- Use the LTSP data to maintain seismic margins for future modifications of certain plant equipment,
- Maintain a strong geosciences and engineering staff, and
- Continue to operate a strong-motion accelerometer array and coastal seismic network.

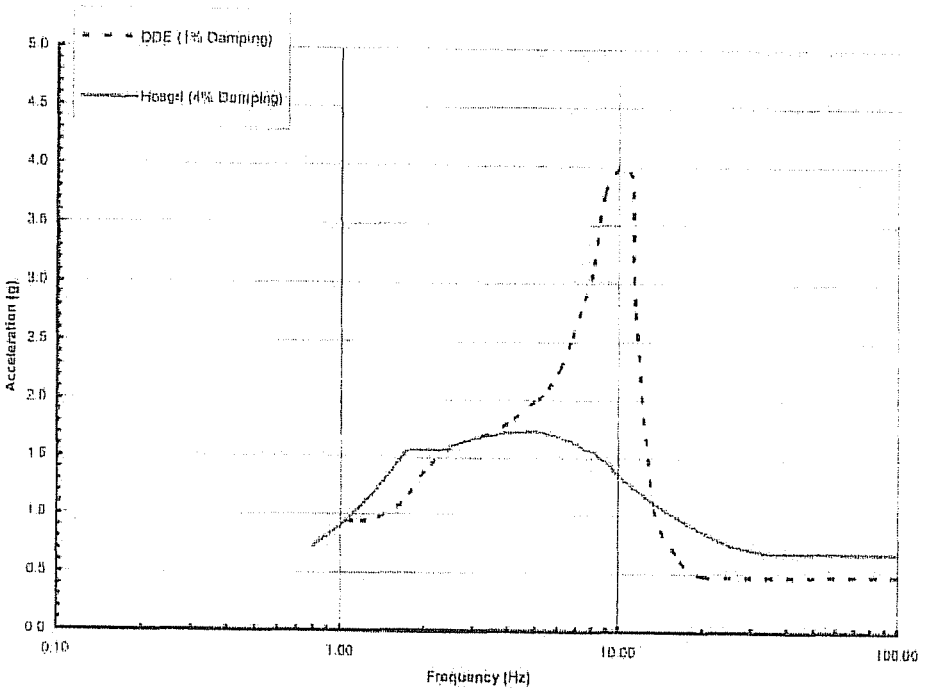

Figure 2
Comparison of DDE and HE Containments Floor Response at 88 Foot

Sequence of Events

- November 2008: The licensee notified the NRC of a new offshore seismic feature located about a mile from the plant. This offshore feature became known as the Shoreline fault. The licensee postulated that an earthquake on the Shoreline fault could produce between 0.69 to 0.74 g peak ground acceleration at the plant. The licensee concluded a POD was not required because the new ground motion was bound by the LTSP deterministic ground motion spectrum.

- September 2010: The NRC identified that an earthquake on the Shoreline Fault could produce about 70 percent greater peak ground motion assumed in the DDE/safe shutdown earthquake design basis.

- October 2010: The NRC requested that PG&E evaluate that capability (operability) of plant SSCs to perform the safety functions at the higher ground motions.

- December 2010: PG&E concluded that a POD was not required because of previous agreements reached with the NRC that new seismic information only needed to be evaluated by the LTSP.[8]

- January 2011: PG&E completed and submitted to the NRC a reevaluation of the local seismology. This report concluded that three local earthquake faults (Shoreline, San Luis Bay, and Los Oslo) could produce about 70% greater ground motion that the DDE.[9]

- March 2011: The NRC opened Diablo Canyon Unresolved Item: 05000275; 323/2011002-03, "Requirement to Perform an Operability Evaluation Following Receipt of New Seismic Information." This unresolved item was used to track NRC review of the licensee's conclusion that new seismic information did not have to be evaluated against the plant design basis.

- June 2011: PG&E concluded that the new seismic information was a nonconforming condition as defined by their corrective action program. The licensee completed a POD to assess the effect of the new information on the capability of plant equipment. The licensee concluded that all plant SSCs were operable because the new ground motions were enveloped by the HE ground motions. The licensee stated that NRC operability guidance allowed use of the HE safety analysis to demonstrate that the DDE design basis was met.[10]

- August 2011: The NRC concluded that new seismic information developed by the licensee was required to be evaluated against each of the three design basis earthquakes use to establish plant seismic qualification. Comparison only to the HE or LTSP (margin to Hosgri) was not sufficient to ensure all plant SSCs were capable of performing the specified safety functions.[11]

- October 2011: PG&E revised the POD to reformat the information. The licensee did not make any substantive changes supporting operability.[12]

- October 2011: PG&E requested the NRC approve the HE design basis as the safe shutdown earthquake for Diablo Canyon.[13]

- December 2011: PG&E supplemented the October 2011 request with a detailed list of deviations and exceptions between the HE design basis and NRC Standard Review Plan.[14]

Pacific Gas and Electric Seismic Prompt Operability Determination

PG&E concluded that all SSCs were operable because the new seismic deterministic ground motion spectrums were bound by HE design basis. The POD stated that HE safety analysis, including methods, design basis values/inputs, and acceptance criteria, was an acceptable alternative method for concluding that all plant SSC met the specified safety functions for the DDE.

NRC Operability Standard[15,16]

To be considered operable, plant SSCs must be capable of performing the specified safety functions specified by design and within the required range of design physical conditions, initiation times, and mission times. The specified function(s) are those safety functions described in the CLB for the facility and are based on safety analysis of specific design basis events.

Immediate operability determinations are made without delay, using the best available information. PODs are a follow-up to immediate determinations when additional information, such as supporting analysis, is needed to confirm the immediate determinations. In both cases, the available information should be sufficient to conclude that the SSC is operable. The scope of an operability determination must be sufficient to address the capability of SSCs to perform their specified safety function(s). The licensee should declare the SSC inoperable if at any time the available information is inadequate to support a reasonable assurance that degraded or nonconforming SSCs are capable of performing the specified safety function(s).

The failure to meet a General Design Criteria or a Regulation should be treated as a degraded or nonconforming condition and is an entry condition for an operability determination.

The operability determination should assess credible consequential failures previously considered in the design. For example, equipment described in the safety analysis needed to mitigate a loss of coolant accident must be capable of performing those functions after the shaking associated with the DDE.

Licensees may use alternative analytic methods (different methods than described in the CLB) when performing PODs. These alternative methods must be technically appropriate to the facility design and produce results consistent with the applicable acceptance criteria in the CLB. The alternative method should not over-predict SSC performance and licensees should perform benchmark comparisons with the CLB methods. Use of alternate methods does not include substitution of design basis, design basis functions or values/inputs. Use of alternative methods is not permitted in cases where a Regulation or license condition specifies the name of an analytic method for a particular application. In such cases, the application of the alternate analysis must be consistent with the licensing condition or Regulation. For example, ASME Boiler and Pressure Vessel Code methods and acceptance limits are specified by 10 CFR 50.55a. Licensees are not permitted use margins above the Code acceptance limits (or Code Cases) for demonstrating operability. These margins are reserved for the NRC.

A SSC is either operable or inoperable. The guidance does not provide for an indeterminate conclusion of operability.

Pacific Gas and Electric's Operability Standard[17]

The PG&E operability procedure closely paralleled the NRC Technical Guidance. The licensee's process allowed use of margin between the actual capability of degraded/nonconforming SSCs and the specified safety functions as defined in the design basis. The licensee's POD may credit conservatism within the design or margin gained by using compensatory actions.

The specified safety function(s) are those functions the SSCs were designed to accomplish as described in the UFSAR and other CLB documents. When SSC capability is degraded to point where it cannot perform the specified safety function, with a reasonable expectation of reliability, then the system should be judged inoperable. Alternate methods (engineering judgment) apply to calculational methods and should not be used to change design inputs.

Analysis of the Pacific Gas and Electric Seismic Prompt Operability Determination

The inspector concluded that the seismic POD did not meet either the NRC nor the licensee's standards:

- The POD failed to demonstrate that the integrity of the reactor coolant system pressure boundary would be maintained following a DDE

  The reactor coolant system specified safety functions included that pressure boundary integrity would be maintained following the combined structural loading resulting from the DDE (safe shutdown earthquake) and a loss of coolant accident. This safety function is met by demonstrating that the ASME Boiler and Pressure Vessel Code, Section III, acceptance limits would be met. The licensee was required to calculate the resultant component stresses use the Code methodology, as specified in the plant design, including the specified DDE design basis values and design information. The POD was inadequate because the licensee failed to provide a reasonable assurance that the Code acceptance limits would not be exceeded for the DDE design basis case given the 70% increase in seismic vibratory ground motion.

  The licensee's substitution of the HE design basis for demonstrating the DDE Code acceptance criteria were met was not an acceptance approach by either the licensee's operability procedure or the NRC operability guidance. This was a concern because in many cases, the reactor coolant pressure boundary stress was more limiting for the DDE than HE (see Figure 1).

- The POD failed to demonstrate that equipment necessary to prevent or mitigate an accident would remain functional following a safe shutdown earthquake

  In many cases the DDE safety analysis provided the bounding vibratory motion used to establish the seismic qualification for plant SSC. For example, the FSARU credited the containment fan coolers to mitigate the design basis loss of coolant and steam line break accidents. The design basis required these coolers to be qualified to function following the vibratory motion (shaking) associated with the DDE. These coolers are located on the 88 foot level of the containment building. As shown in Figure 2, the DDE vibratory motion was greater than HE at this location. The POD was inadequate because the licensee failed to

demonstrate that the coolers would still function at the increased motion associated with the new seismic information for the DDE case.

Safety Consequence

The seismic design bases and FSARU safety analyses provide reasonable assurance that nuclear safety is maintained following postulated earthquakes. PG&E developed new seismic information that concluded the bounding DDE safety analysis was no longer in conformance with NRC Regulations.[10] The licensee implemented corrective actions in the form of a license amendment request. This information is currently under NRC review. The operability process is used to determine if the licensee can continue to safely operate the plant pending completion of these corrective actions. The PG&E POD used to conclude that the operability threshold was met was inconsistent with the licensee's procedures and NRC Technical Guidance. As a result, the inspector was unable to conclude that key plant SSCs, including the reactor coolant pressure boundary, remain operable. An inoperable conclusion does not necessary equate to an unsafe condition. However, a declaration of inoperable SSC would require additional NRC engagement before the licensee would be permitted operate the plant beyond the Technical Specification out of service times.

Recommendation

The inspector recommends that the NRC issue a violation with this inspection report associated with the failure of PG&E to follow the station operability determination procedure.

Endnotes

[1] "Report on the Analysis of the Shoreline Fault Zone, Central Coast California to the NRC," January 7, 2011, ADAMS ML110140400
[2] PG&E Notification 50086062
[3] Diablo Canyon Integrated Inspection Report 05000275/2011005 and 05000323/2011005, Section 1R15
[4] FSARU Sections 2.5.2.9, "Maximum Earthquake," and 3.7.1.1, "Design Response Spectra,"
[5] Peak ground acceleration- gravity
[6] PG&E Long Term Seismic Program Final Report, DCL-88-192, July 1988
[7] SSER 34
[8] Notification 50086062, Task 30
[9] "Report on the Analysis of the Shoreline Fault Zone, Central Coast California to the NRC," January 7, 2011, ADAMS ML110140400
[10] Notification 50410266
[11] "Task Interface Agreement – Concurrence on Diablo Canyon Seismic Qualification Current Licensing and Design Basis," August 1, 2011, ADAMS ML112130665
[12] Notification 50410266
[13] Pacific Gas and Electric, License Amendment Request 11-05, "Evaluation of Process for New Seismic Information and Clarifying the Diablo Canyon Power Plant Safe Shutdown Earthquake," ADAMS ML113112A166
[14] Pacific Gas and Electric, "Standard Review Plan Comparison Tables for License Amendment Request 11-05," ADAMS ML11312A166
[15] NRC Inspection Procedure 71111.05, "Operability Determinations and Functionally Assessments"
[16] NRC Inspection Manual, Part 9900: Technical Guidance, "Operability Determinations & Functionality Assessments for Resolution of Degraded or Nonconforming Conditions Adverse to Quality or Safety," ADAMS ML073440103
[17] PG&E Procedure OM7.ID.12, Operability Determinations, Revision 22
[18] 10 CFR 100, Appendix A, "Seismic and Geologic Siting Criteria for Nuclear Power Plants."

NRC FORM 757
NRC MD 10.158
(7-2011)

U.S. NUCLEAR REGULATORY COMMISSION

NON-CONCURRENCE PROCESS

NCP TRACKING NUMBER
NCP-2012-001

TITLE OF SUBJECT DOCUMENT
DIABLO CANYON POWER PLANT - INSPECTION REPORT 05000275/323-2011005

ADAMS ACCESSION NO.
ML120450843

SECTION B - TO BE COMPLETED BY NON-CONCURRING INDIVIDUAL'S SUPERVISOR

NAME
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ORGANIZATION
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COMMENTS FOR THE NCP REVIEWER TO CONSIDER

See attached.

Additional information and explaination of the issues discussed in this non-concurrence can be found in ADAMS ML 12284A066

CONTINUED IN SECTION D

SIGNATURE
CFO'Keefe

DATE
2/8/12

SEE SECTION E FOR IMPLEMENTATION GUIDANCE

SECTION B

Comments:

Dr. Peck has thoroughly researched these issues. The actual facts are not in dispute. Some of the information he has presented involve some personal conclusions made as a result of connecting diverse documents and various sources of requirements and guidance. Dr. Peck has attempted to address concerns solely using the operability assessment process, but additional process(es) will be needed to be address the whole issue. This issue is an unusual case that required regional management discussions with NRR to determine the correct application of the Part 9900 guidance to inspectors. The first section of the Part 9900 specifically states that this is the way to deal with cases where the guidance may not be directly applicable. It is important to note that the Part 9900 document is guidance to the NRC staff, not a regulation.

While this concern has overtones of safety, the actual questions are procedural. In order to categorically show that there are no safety problems, a full and complete operability evaluation is ultimately needed. However, the generic process for performing an operability evaluation requires a clear current licensing basis that directly relates to the non-conforming condition that is being analyzed. The actual seismic current licensing basis did not provide a way to evaluate new information that becomes available. Therefore, the licensee has proposed a methodology to perform the full operability evaluation to the NRC as a license amendment request, and the staff is evaluating the best way to proceed.

NRC FORM 757
NRC MD 10.158
(7-2011)

U.S. NUCLEAR REGULATORY COMMISSION

NON-CONCURRENCE PROCESS

NCP TRACKING NUMBER: NCP-2012-001

TITLE OF SUBJECT DOCUMENT: DIABLO CANYON POWER PLANT - INSPECTION REPORT 05000275/323-2011005

ADAMS ACCESSION NO.: ML120450843

SECTION C - TO BE COMPLETED BY DOCUMENT SPONSOR

NAME: Neil O'Keefe

TITLE: Chief, Projects Branch B

PHONE NO.: (817)200-1141

ORGANIZATION: Region IV, Division of Reactor Projects

SUMMARY OF ISSUES

See attached.

ACTIONS TAKEN TO ADDRESS NON-CONCURRENCE

See attached

SIGNATURE--DOCUMENT SPONSOR: [signature] TITLE: Chief, Branch B

ORGANIZATION: Region IV, DRP DATE: 2/8/12

SIGNATURE--NCP REVIEWER: [signature] T. Pruett TITLE: Deputy Director DRP

ORGANIZATION: Region IV DATE: 2/13/2012

NCP OUTCOME

Non--Concurring Individual: CONCURS [ ] NON-CONCURS [X] WITHDRAWS NON-CONCURRENCE (i.e., discontinues process)

AVAILABILTY OF NCP FORM

Non--Concurring Individual: [✓] WANTS NCP FORM PUBLIC [ ] WANTS NCP FORM NON-PUBLIC

[ ] CONTINUED IN SECTION D

SEE SECTION E FOR IMPLEMENTATION GUIDANCE

Use ADAMS Template NRC-006

SECTION C

Summary of Issues:

Dr. Peck concluded that a Pacific Gas and Electric prompt operability determination, addressing new seismic information, failed to meet either the licensee's operability or the NRC inspection procedure requirements. As a result, the licensee has not provided an adequate basis to conclude that all seismically qualified structures, systems, and components, are capable of performing as described in the current licensing bases. Dr. Peck recommended that the NRC include a violation in Inspection report 05000275/2011005; 05000323/2011005 associated with the failure of the licensee to follow their operability determination procedure.

Dr. Peck believes that the Pacific Gas and Electric operability procedure and the NRC inspection guidance establish that licensees are expected to demonstrate that a reasonable assurance of equipment capability exist, at any point in time, to conclude that equipment is operable and that these evaluations are performed using the current licensing bases.

Actions Taken to Address Non-concurrence:

Regional management has reviewed and discussed these issues and the associated documents over a period of months. The Director and Deputy Director of DRP, as well as the new and previous branch chiefs for Diablo Canyon, have had numerous discussions with Dr. Peck on these specific concerns. The facts are well-understood. However, the regulatory path forward must be determined through discussions between regional management and NRR. Several discussions have already occurred. The complete operability evaluation that Dr. Peck wants cannot be made by the licensee without the NRC agreeing on the correct way to perform the evaluation, what calculation method and design values are appropriate for the new data, and what plant capability must be demonstrated by this evaluation.

Region IV held a meeting on January 30, 2012, to address how the Part 9900 operability evaluation guidance applies to this situation with representatives from NRR and RES. This meeting resulted in full agreement on the following statements:

- The ground motion data and the calculation method, including damping values, are correlated parameters. They must be based on the same assumptions for the calculation to have validity.

- It is appropriate for the licensee to use the available new ground motion data in the Hosgri Earthquake analysis because the new ground motion data is consistent with that evaluation.

- The NRC will not ask the licensee to use the new ground motion input data in the Design Earthquake or the Double Design Earthquake evaluations because the new ground

motion data does not match the assumptions in those analyses. Attempting to do so would create a numerical result that is not technically justified.

- The licensee's use of the Hosgri Earthquake as an immediate operability assessment method was consistent with the Part 9900 guidance for use of alternative evaluation methods. This immediate operability assessment was appropriate per the Part 9900 guidance, and is an adequate basis to conclude that there is reasonable assurance of operability. The NRC approved the Hosgri Earthquake analysis with the knowledge that the new (at the time) Hosgri seismic information was not able to be used in the Design and Double Design Earthquake analyses.

- It is also appropriate for the licensee to seek NRC approval of the method to perform the more detailed assessment of operability compared to the Design Earthquake and Double Design Earthquake consistent with the prompt operability assessment specified in the Part 9900 guidance.

- The plant continues to be operated safely, including consideration for the new seismic data.

The action proposed by Dr. Peck to take enforcement action at this time is not appropriate based on the discussion above. Procedure OM7 ID12, "Operability Determination," Revision 22 was reviewed in the places indicated by Dr. Peck as potentially involving a violation. No violation of the station procedure was noted during this review, since his conclusion that a violation existed was predicated on first agreeing with his conclusion that the licensee had not sufficiently demonstrated an initial basis for operability, which is contrary to the staff position.

The inspection report wording has been changed to modify the following sentence to which Dr. Peck objected:

> "The inspectors concluded that the revised operability determination provided an initial basis for concluding a reasonable assurance that plant equipment would withstand the potential effect of the new vibratory ground motion."
>
> will be revised to state:
>
> "The staff concluded that the revised operability determination provided an initial basis for concluding a reasonable assurance that plant equipment would withstand the potential effect of the new vibratory ground motion."

With this modification, the report will issue a violation for failure to perform an operability evaluation between June and October, 2011, and will state that the licensee has submitted a license amendment to address this issue.

Appendix C

PG&E Emails

Shoreline Fault Characterization Meeting
Dec 15, 2009

Attendees:

Michael Peck – NRC	Lloyd Cluff - PGE
Tony Brown – NRC	[redacted] - PGE
Alan Wang - NRC (Telephone)	Loren Sharp - PGE
Annie Kammerer - NRC (Telephone)	Bill Guldemond - PGE
Megan Williams - NRC (Telephone)	Rich Klimczak - PGE
Kamal Manoly - NRC (Telephone)	[redacted] – PGE
	[redacted] - PGE
	[redacted] - PGE
	[redacted] - PGE
	Emily Archer - PGE

Purpose:
Present results of Shoreline Fault Zone survey data collection and analysis and summarize significance to DCPP.

Presentation:
Lloyd and [redacted] presented the mapping data that had been gathered relevant to the Shoreline fault and they characterized their analysis of the new data. USGS interpretation of data is expected to be done by mid-year 2010. The North segment of the lineaments is inactive with no evidence of surface faulting. The central and southern segments are coincident with the microseismicity lineament. The shoreline fault is a vertical strike-slip fault about 10 km deep. Slip rate in the shoreline fault zone is estimated between 0.01 and 0.30 mm/yr. The fault is about 300 meters from the intake and 600 meters from the power block.

A probabilistic evaluation of ground motion to the 84th percentile determined that a magnitude 6.25 earthquake could be generated using the combined central and southern segments. The spectral accelerations that would be generated at a distance of 0.6 km remains bounded by the LTSP curve. At 0.3 km (intake structure) the accelerations could be a few percent higher. This would not be significant over the frequency range for fragility concerns (3-8.5 hz), but in the 11-30 hz range this could result in the Shoreline-generated acceleration exceeding the LTSP accelerations.

Secondary deformation at the ASW pipes could occur but is very unlikely. Annual probability of a 1.0 cm displacement at the ASW pipes has a maximum predicted occurrence of 2.4E-7, and 2.0 cm 6.9E-8. This is contrasted with the NRC's position on Yucca Mountain that allows exclusion of events with probability <1E-8. The impact on the DCPP seismic Core Damage Frequency of 3.7E-5 was determined to be negligible.

[redacted] stated that there was no evidence of cliff face slip secondary deformation, but noted that displacement of concern (1 cm) would not be detected. Lloyd said we would make a presentation on our findings to NRC/NRR on Jan 5, 2010.

Summary:
Shoreline is characterized as a new minor fault, the spectrum has been evaluated, and secondary deformation is improbable. The final report is forecast for completion mid-2010.

Action Items:
Civil engineering to update notification tracking Shoreline evaluation with the new information. Have shift manager review and render decision and document regarding continued operability.

Senior resident inspector said he'd be delaying issue closeout until 2Q10. Annie Kammerer stated the NRC would need to discuss the new information to discuss the information.

Set up 1/5/10 public meeting with NRR for Shoreline study presentation.

From: [redacted]
To: [redacted]
cc: Cluff, Lloyd;
Subject: FW: NRC Seismic Questions
Date: Monday, September 13, 2010 10:11:18 AM

[redacted],

f.y.i. - it appears that you are not on distribution for this message. [redacted] is taking the lead on developing responses, but your input will probably be required.

regards,

[redacted] P.E.
Senior Civil Engineer
Pacific Gas & Electric Company
Diablo Canyon Power Plant
[redacted]

From: Sharp, Loren
Sent: Friday, September 10, 2010 4:38 PM
To: [redacted]
Cc: [redacted]; Hinds, Jacqueline; [redacted]
Subject: RE: NRC Seismic Questions

Peck did indeed ask several questions of [redacted] at yesterday's meetings. I recollection was [redacted] told him we assess any new operability issues to all the applicable profiles. [redacted] is the one who should be assigned this action. Before you submit a notification please clarify with Peck that he agrees with the questions you have written.

Loren

From: [redacted]

Sent: Friday, September 10, 2010 4:30 PM
To: Sharp, Loren
Cc: [redacted]; Hinds, Jacqueline; [redacted]
Subject: NRC Seismic Questions

Loren,

This morning, Mr. Peck posed some questions regarding our presentations at the Seismic Workshop. I've tried to capture them below. Before I add them to a notification, I'd like to get comments from you regarding the content.

On 9/8/10 and 9/9/10, a NRC-sponsored public Seismic Workshop was conducted in San Luis Obispo. On 9/10/10, during discussions with the NRC, it was noted that there was confusion about our licensing bases for plant operability evaluations.

Background:

The plant is designed for a design bases earthquake (DBE) of which there are four (4) cases discussed in the FSAR (see 2.5.2.9 and 2.5.2.10). Section 3.7 of the FSAR describes the Design Earthquake (DE), Double Design Earthquake (DDE) and the Hosgri Earthquake (HE). The DE corresponds to the operating basis earthquake (OBE) as described in 10CFR100, Appendix A.

NRC Questions:

1. If the DE is considered the OBE, what is the basis for concluding the station is within design bases by comparing the "shoreline fault" earthquake to the HE rather than the DE or DDE? Should the "shoreline fault" earthquake be compared to the DE and not the Hosgri?
2. What is the station requirement to assess new events like the shoreline fault? What should we compare the new event to?
3. For operability evaluations, why is the station using the HE rather than the DE as the standard?

Loren - you were at the Seismic Workshop. Do these questions fall in line

with discussions there?

[redacted]
NRC Interface and Commitment Management
Regulatory Services - Diablo Canyon, Pacific Gas & Electric Co.
Phone [redacted]
Diablo Canyon Power Plant, 9 Miles NW of Avila, Mail Stop 104/5/18b
Avila Beach, CA 93424
E-mail: [redacted]

From: [redacted]
To: Sharp, Loren; Klimczak, Richard; [redacted];
cc: Westcott, Susan; Cluff, Lloyd; [redacted];
[redacted];
Subject: RE: NRC Seismic Questions
Date: Tuesday, September 14, 2010 3:54:19 PM

Loren;
We are scheduled to talk to SRI on Wednesday at 10:30. The point that we are going to make is that the shoreline fault discovery and evaluation is within the LTSP program and as such it needs to be evaluated in that space (i.e. PRA, margin assessment). The plant is designed to OBE (DE) and SSE (DDE) and evaluated to Hosgri. LTSP was a licensing condition to assess Margin. LTSP is a living program and all new findings (such as Shoreline fault) will be treated as such.

Thanks
[redacted]

Stay Tuned

From: Sharp, Loren
Sent: Tuesday, September 14, 2010 8:23 AM
To: [redacted] Klimczak, Richard; [redacted]
Cc: Westcott, Susan; Cluff, Lloyd; [redacted]
Subject: FW: NRC Seismic Questions

This issue was raised again by Peck at 605 mtg. He is continuing to make the case that Shoreline fault should have been compared to original seismic design not hosgrai in his opinion of our licensing basis and that our operability position taken a year ago was to the wrong licensing basis. Make sure we do a good research of our basis, what we did and whether we have an issue here before we go talk to Peck this week.

Loren

From: [redacted]
Sent: Monday, September 13, 2010 6:16 PM

To: [redacted] Sharp, Loren; [redacted]
Cc: Hinds, Jacqueline; [redacted]; Klimczak, Richard; Westcott, Susan
Subject: RE: NRC Seismic Questions

Mike;
I initiated SAPN 50341214 to document SRI request for additional information on this topic. I'd like to get a meeting with him to go over this. this week (I'd like to confirm [redacted]'s availability before setting up the meeting).

Thanks
[redacted]

From: [redacted]
Sent: Sunday, September 12, 2010 9:45 PM
To: Sharp, Loren; [redacted]
Cc: [redacted]; Hinds, Jacqueline; [redacted]
Klimczak, Richard; Westcott, Susan

Subject: RE: NRC Seismic Questions

[redacted]
First we need to talk to the inspector to clearly understand the question. The Shoreline fault is a continuation of LTSP program and needs to be dealt with in the Licensing space and we believe that is to be compared with the LTSP criteria not the Design Basis Cases of DE , DDE or Hosgri. I believe up until now, PG&E has shown that for credible scenarios for Shoreline fault, the motion is bounded by the LTSP.

As for definitions of OBE and SSE for DCPP, as Bill mentioned there is a licensing position 60. We need to re validate the paper before we can fully rely on it.

Let's get together (Civil, [redacted] and I) on Monday to go over this.
Thanks
[redacted]
<< File: lp-60.doc >>

From: Sharp, Loren
Sent: Friday, September 10, 2010 4:38 PM

To: [redacted]
Cc: [redacted]; Hinds, Jacqueline; [redacted]
Subject: RE: NRC Seismic Questions

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Loren - you were at the Seismic Workshop. Do these questions fall in line with discussions there?

[redacted]

NRC Interface and Commitment Management

Regulatory Services - Diablo Canyon, Pacific Gas & Electric Co.

Phone [redacted]

Diablo Canyon Power Plant, 9 Miles NW of Avila, Mail Stop 104/5/18b

Avila Beach, CA 93424

E-mail: [redacted]

From: Sharp, Loren
To: [redacted]; Cluff, Lloyd; Klimczak, Richard; [redacted]
cc: Westcott, Susan; [redacted]
Subject: RE: NRC Seismic Questions
Date: Wednesday, September 15, 2010 6:37:27 AM

[redacted] while I agree with the approach it is even more indicative of our need to clarify our licensing basis in the future so we are not having this discussion after LBVP is complete.

From: [redacted]
Sent: Wednesday, September 15, 2010 1:02 AM
To: Cluff, Lloyd; Sharp, Loren; Klimczak, Richard; [redacted]
Cc: Westcott, Susan; [redacted]
Subject: RE: NRC Seismic Questions

Loren, et al;
Attached is the talking point for discussions with SRI . There are two distinct points we'll try to make (Boxed red text).

Thanks
[redacted]

[redacted]
Please validate the statement in regards to the Shoreline fault being relatively long period and for OBE event, it is bounded by current DE

<< File: Shoreline fault Question.doc >>

From: Cluff, Lloyd
Sent: Tuesday, September 14, 2010 4:35 PM
To: [redacted]; Sharp, Loren; Klimczak, Richard; [redacted]
Cc: Westcott, Susan; [redacted]
Subject: RE: NRC Seismic Questions

I agree with [redacted]s assessment.

Lloyd

From: [redacted]
Sent: Tuesday, September 14, 2010 3:54 PM
To: Sharp, Loren; Klimczak, Richard; [redacted]
Cc: Westcott, Susan; Cluff, Lloyd; [redacted]
Subject: RE: NRC Seismic Questions

Loren;
We are scheduled to talk to SRI on Wednesday at 10:30. The point that we are going to make is that the shoreline fault discovery and evaluation is within the LTSP program and as such it needs to be evaluated in that space (i.e. PRA, margin assessment). The plant is designed to OBE (DE) and SSE (DDE) and evaluated to Hosgri. LTSP was a licensing condition to assess Margin. LTSP is a living program and all new findings (such as Shoreline fault) will be treated as such.

Thanks
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Stay Tuned

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To: [redacted]; Sharp, Loren; [redacted]
Cc: Hinds, Jacqueline; [redacted] Klimczak, Richard; Westcott, Susan
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NRC Interface and Commitment Management

Regulatory Services - Diablo Canyon, Pacific Gas & Electric Co.

Phone [redacted]

Diablo Canyon Power Plant, 9 Miles NW of Avila, Mail Stop 104/5/18b

Avila Beach, CA 93424

E-mail: [redacted]

From: Klimczak, Richard
To: [redacted] Sharp, Loren; [redacted]
Cluff, Lloyd;
cc: [redacted]
Subject: RE: shoreline
Date: Monday, September 20, 2010 11:51:55 AM

[redacted] and Loren,

Please include me in the discussion tomorrow. [redacted] is offsite tomorrow.

Rich Klimczak

From: [redacted]
Sent: Monday, September 20, 2010 11:02 AM
To: Sharp, Loren; [redacted]; Cluff, Lloyd
Cc: [redacted]; Klimczak, Richard
Subject: RE: shoreline

Loren:
I will be at DCPP tomorrow for a short meeting with the DCISC (11:00-12:00).

I should arrive at the plant at about 10am. Do you have 15 minutes available between 10:00 and 11:00 to discuss Peck's issues?

My thoughts on this topic are given below:

I think that Peck is not following NRC policy for addressing new hazard information. The recent GI-199 report addressing new seismic information says that 10 CFR 50.109 and NUREG/BR-0058 "provide a framework for changing regulatory positions in light of new information". Use of a PRA is encouraged. I think that Peck needs to hear this from someone from region IV.

The LTSP program is consistent with the framework. We use both margin and PRA methods to evaluate the impact of new seismic information.

It makes no sense to try to define a new DE (OBE) based on new information. IF the DE is now estimated to have a higher chance of occurring, then the plant just has a greater chance of having to shut-down. This is an ecomonic issue, not a safety issue.

[redacted]

From: Sharp, Loren
Sent: Saturday, September 18, 2010 2:55 PM
To: [redacted] Cluff, Lloyd
Cc: [redacted]; Klimczak, Richard
Subject: Fw: shoreline

[redacted] we need to take some action. Please assist site team to deal with regulatory history(from records) as soon as possible
Loren Sharp
Sr Director DCPP

From: [redacted]
To: Sharp, Loren
Cc: Cluff, Lloyd; [redacted] Klimczak, Richard; Bemis, Paul R
Sent: Sat Sep 18 14:05:53 2010
Subject: RE: shoreline

Loren;
Based on the last couple conversations; there are two things that we need to cover;
1- show clearly that our LTSP license commitment is to deal with all new discoveries in the Probabilist space; he said he has read SSER24 and does not get that impression; he has also researched GI-199. Need [redacted] and Lloyd to develop the case.

2- Do we have to address the Design basis events developed under 10CFR100 PartA . He believes that we are obligated to do that, regardless of LTSP.

We have set up a meeting on Wednesday morning to go over this issue; we have invited Paul Bemis and [redacted]

I believe that we need to get the LTSP strategy team members together ASAP (a workshop here on site) to address our actions leading to a response by the end of the year. What will be in the report, how will it be transmitted (LAR?) will it address item 2 above? Are there any actions for Engineering (.e.g. PRA?).

Thanks

[redacted]

From: Sharp, Loren
Sent: Friday, September 17, 2010 5:49 PM
To: [redacted]
Subject: shoreline

[redacted] do you have someone going after the records to research what was said in hearing for LTSP? If not who should be getting this started.

From: Sharp, Loren
Sent: Monday, September 20, 2010 8:27 PM
To: [redacted]
CC: [redacted]
Subject: RE: shoreline

Importance: High

[redacted] should be able to find some time to discuss issues with you. Note, His perspective is the new generic letter only applies to new plants. While I am sure we disagree we need the new info as well as the old information from our files on what we committed to do in court testimony or other records to resolve the issue to original seismic assessment.

Loren

From: [redacted]
Sent: Monday, September 20, 2010 11:02 AM
To: Sharp, Loren; [redacted] Cluff, Lloyd
Cc: [redacted] Klimczak, Richard
Subject: RE: shoreline

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2- Do we have to address the Design basis events developed under 10CFR100 PartA . He believes that we are obligated to do that, regardless of LTSP.

We have set up a meeting on Wednesday morning to go over this issue; we have invited Paul Bemis and [redacted] and [redacted]

I believe that we need to get the LTSP strategy team members together ASAP (a workshop here on site) to address our actions leading to a response by the end of the year. What will be in the report, how will it be transmitted (LAR?) will it address item 2 above? Are there any actions for Engineering (.e.g. PRA?).

Thanks
[redacted]

From: Sharp, Loren
Sent: Friday, September 17, 2010 5:49 PM
To: [redacted]
Subject: shoreline

[redacted] do you have someone going after the records to research what was said in hearing for LTSP? If not who should be getting this started.

From: Sharp, Loren
Sent: Thursday, September 23, 2010 2:53 PM
To: [redacted]
CC: [redacted] David, Steven
Subject: RE: shoreline

Yes, but also need a reg services person on the phone with you. What I really believe we need is either some formal correspondence from NRR to this effect or we may need to submit an LAR to ask for GL 199 application to DCPP.

Loren

From: [redacted]
Sent: Thursday, September 23, 2010 9:35 AM
To: Sharp, Loren
Subject: RE: shoreline

Loren:

I spoke to Annie Kammerer (NRC research) this morning.

1. She said that the process followed in GI 199 is applicable to all plants. It was use for CEUS plants, beacuse they ahd information that the estimate of the seismic hazard had increased at CEUS plants. A PRA is the appropriate method for evaluating new seismic information.

2. She agreed that the NRC does not require plants to revise the design basis ground motion based on new seismic information. Instead, the NRC checks that the plant has adequate safety.

3. She recommended that we talk to NRR (Mike Markley) about what Peck is requesting us to do.

Do you want me to follow up with NRR on this?

[redacted]

From: Klimczak, Richard
Sent: Thursday, September 30, 2010 10:35 AM
To: GrpCal DCPP RegSvcs; [redacted] Bemis, Paul R; Cluff, Lloyd; Grozan, Thomas C; [redacted] Nimick, Jan; [redacted]
CC: Sharp, Loren; Westcott, Susan
Subject: RE: Shoreline Fault Meeting

All,

Jim Welsch just contacted me and M. Peck told him Region IV recommended a violation (instead of an URI) for a poor operability determination because our operability determination (OD) in 50086062 did not address DE and DDE. Jan Nimick will need our help updating the OD today!

Rich

From: [redacted] **On Behalf Of** GrpCal DCPP RegSvcs
Sent: Thursday, September 30, 2010 7:26 AM
To: GrpCal DCPP RegSvcs; [redacted] Bemis, Paul R; Cluff, Lloyd; Grozan, Thomas C; [redacted] Klimczak, Richard; Nimick, Jan; [redacted]

Cc: Sharp, Loren; Westcott, Susan
Subject: Updated: Shoreline Fault Meeting
When: Tuesday, October 05, 2010 9:00 AM-10:00 AM (GMT-08:00) Pacific Time (US & Canada).
Where: CR DCPP 104-6-604 Boardroom

This is a followup meeting to our meeting on 9/22/10.

In our last meeting we had several actions:

1) Getting better clarification on the NRC's approach in dealing with new seismic information & how it was addressed in our LTSP commitment. ([redacted])

2) From a Design Basis approach, could SF challenge the DE, DDE ground motions if it was evaluated based on the methodology that DCPP was licensed to (i.e. DE based on earthquakes A, B, C, D) ? ([redacted])

3) Find the 1967 Benioff and Smith paper regarding Seismic activity at DCPP. See FSAR references. ([redacted]

Attendees may call in to a conference bridge line at X2004, if desired.

We are continuing our assessment of the following questions:

1) Is the LTSP part of the DCPP licensing and design bases? What is its role in evaluating the Shoreline Fault (SF)?

2) Should the SF be compared to the DE and the DDE in addition to Hosgri (HE)? If not, why not? Should new faults be compared only to the LTSP on a probabilistic bases rather than to the DE, DDE, and HE on a deterministic bases?

3) At the end of 2010, a report regarding LTSP is to be sent to the NRC. The NRC residents suggested that the report should address the SF and our analysis to DE, DDE, etc.. Is that what we

should be doing?

4) Is the SF considered an unanalyzed condition of the plant, requiring a POA or some type of operability evaluation?

[redacted]
NRC Interface
Regulatory Services - Diablo Canyon, Pacific Gas & Electric Co.
Phone [redacted]
Diablo Canyon Power Plant, 9 Miles NW of Avila, Mail Stop 104/5/18b
Avila Beach, CA 93424
E-mail: [redacted]

From: [redacted]
Sent: Thursday, September 30, 2010 2:07 PM
To: [redacted]
Subject: RE: Shoreline Fault NRC question

[redacted]

1. Last week, I talked to Annie Kammerer at NRC research about the NRC approach to new seismic information. She said that the approach used in GI 199 (based on risk) is NRC policy and applies to all plants, not just eastern plants. She said that the design earthquake is not changed. That is a part of the license.

2. If I follow the approach used by Benioff and Smith, then I would not increase the DE over the 0.2g currently used. Their approach was to look at the historical earthquakes as "likely" to occur in the life of the structure. The historical earthquakes in the region with M>5 have not changed much in the last 45 years.

I don't recommend doing this as it is not consistent the NRC policy for addressing new seismic information. If we submit this approach, it will appear silly at best.

[redacted]

From: [redacted]
Sent: Wednesday, September 29, 2010 10:15 AM
To: [redacted]
Cc: [redacted] Klimczak, Richard
Subject: Shoreline Fault NRC question

[redacted]
In our last meeting you had a couple actions to follow up on;
1) Getting better clarification on the NRC's approach in dealing with new seismic information & how it was addressed in our LTSP commitment

2) from the Design Basis approach; could SF challenge the DE, DDE ground motions if it was evaluated based on the methodology that DCPP was licensed to (i.e. DE based on earthquakes A, B, C, D) ?

Do you have any updates on these ?

[redacted] please schedule a meeting for next week (Tuesday?) to reassemble the team to address the SRI's question.

Thanks
[redacted]

From: [redacted]
Sent: Thursday, September 30, 2010 2:12 PM
To: Sharp, Loren
Subject: RE: Shoreline fault

Loren:

I am in my office all day and I am available for a phone call (415) [redacted]

If we ddo what Peck asks, I can show that using the approach from the orginal SAR, the DE of 0.2g is still applicable for the ground motion that is "likely" to occur during the life of the plant. This is not a good precent to set. The seismic design basis is not updated every time we have new seismic information.

Annie suggested that we talk to Mike Markly at NRR about this. She said that he ahs the final say about license issues.

[redacted]

From: Sharp, Loren
Sent: Wednesday, September 29, 2010 4:16 PM
To: [redacted] Klimczak, Richard; [redacted]
Cc: Westcott, Susan; [redacted]
Subject: Shoreline fault
Importance: High

[redacted] On the unresolved item, Peck had identified his opinion that the Shoreline fault issue should also have been assessed relative to original seismic design criteria.

You and I have had several discussions on that. As I recall you were talking a parallel look to see if original design basis also bounded shoreline fault while also talking on issue to ANNE. What date will you have that assessment complete?

Did Anne make any commitment on further forthcoming letters or positions out of NRR to either us or the industry?

Please give me a call relative to your insights when you are done to ensure we have timely communication. Thanks

Loren

From: [redacted]
Sent: Friday, October 01, 2010 3:05 PM
To: Bemis, Paul R; Klimczak, Richard; [redacted]
CC: Cluff, Lloyd; Grozan, Thomas C; [redacted] Nimick, Jan; Sharp, Loren; [redacted] Westcott, Susan; [redacted]; Fledderman, Jude
Subject: Seismic "Unanalyzed condition"

I discussed the concern further with Dr Peck today. He points out that our original and subsequent reporting has been that we meet our design and licensing basis. However it appears that we have been basing that on comparison to the LTSP spectra. Our FSAR states that LTSP is not the licensing and design basis. So what is our basis for stating that Shoreline is bounded by the existing design and licensing basis?

It appears Shoreline is outside of our SSE & Hosgri ground motion acceleration spectra, and therefore the CLB does not appear to fully bound Shoreline. Note that the information we have been using to date has been for an 84th percentile ground motion vs maximum (maximum, reduced by one standard deviation)- and may accordingly be non-conservative with respect to addressing 10CFR100 requirements.

III.(c) "The *Safe Shutdown Earthquake* is that earthquake which is based upon an evaluation of the maximum earthquake potential [that could *ever* occur at the plant site] considering the regional and local geology and seismology and specific characteristics of local subsurface material. It is that earthquake which produces the maximum vibratory ground motion for which certain structures, systems, and components are designed to remain functional. These structures, systems, and components are those necessary to assure

(1) The integrity of the reactor coolant pressure boundary,

(2) The capability to shut down the reactor and maintain it in a safe condition, or

(3) The capability to prevent or mitigate the consequences of accidents which could result in potential offsite exposures comparable to the guideline exposure of this part." (emphasis and [editorial comments] added)

Review of the analysis that supports the April 8, 2009 letter from NRR indicates that NRR used LSTP data in performing their analysis. Since LTSP is not the current licensing basis to address 10FR100 the question has been raised as to how our existing analysis (DE, DDE, HOSGRI) bounds Shoreline.

We should be able to address DE by documenting expected frequency of occurrence of exceedance for the 0.2 g DE from the Shoreline fault. Presumably this is exceedingly small and we can take the same approach we did with HOSGRI, which resulted in the following NRC statement:

The applicant has evaluated the exceedance probability of ground motion at the site. ...Drawing upon these studies, the applicant has stated that the design earthquake of 0.2g has, as a conservative estimate, a probability of 14.5 percent of being exceeded during the projected operating life of the plant of 40 years. This corresponds to an average return period of about 275 years.

[redacted]: What is our expected annual Shoreline exceedance frequency?

This still leaves us with reconciling the Shoreline to the DDE/HOSGRI in accordance with the methodology used for establishing the spectra the DDE/HOSGRI. The April 8, 2009 letter appears to be saying that they our basing their statement that we meet the design and licensing basis on our statements to that end. If we have misrepresented our design and licensing basis requirements or have compared to non-D&LB (like LTSP) then this introduces new station vulnerability to additional violations regarding the completeness and accuracy of our communications

[redacted]

Regulatory Services Manager
Diablo Canyon Power Plant

[redacted]

From: Bemis, Paul R

Sent: Friday, October 01, 2010 9:54 AM

To: Klimczak, Richard

Cc: [redacted] Cluff, Lloyd; Grozan, [redacted] Nimick, Jan; Sharp, Loren; [redacted] Westcott, Susan; [redacted]; Fledderman, Jude

Subject: RE: Benioff and Smith Paper (1967)

Rich,
I will look over the material. I agree that we should not have to revisit DE and DDE with each new study or informational finding. The only reason this was an issue this time was because Hosgri probability is so small that it would mask in PRA space any probability of an issue occurring. [redacted] wants to confirm that we meet our licensing basis which is not, to my knowledge, PRA rather it is deterministic. We should consider in the future if PGE/DCPP desires committing to the Guide 199, but this would require a LAR to change the licensing basis. If most plants use this now we should have no problem obtaining this change.

I do feel if this information bears up to critical review it should also convince NRC a violation on the operability previously performed is not an issue.

Paul

Paul Bemis
Office: 805-545-6495
Cell: 805-305-5013
pnb9@pge.com

From: Klimczak, Richard
Sent: Friday, October 01, 2010 7:06 AM
To: Bemis, Paul R
Cc: [redacted] Cluff, Lloyd; Grozan, Thomas C; [redacted] Nimick, Jan; Sharp, Loren; [redacted] Westcott, Susan; [redacted]
Subject: RE: Benioff and Smith Paper (1967)

Paul,

[redacted] has setup another meeting for Tuesday, 10/5 at 08:30 in Rm 604. [redacted] has responded to our request from our last meeting in the first attached email. We feel our documented operability determination (50086062) is per our licensing basis (i.e. evaulate new information, Shoreline Fault, per LTSP program). We feel our position is confirmed by the NRC's evaluation of our data in April 2009. The second file attached is our reasoning. [redacted] has talked with Alan Wang and NRR appears to agree with us. A meeting between NRR, Region IV, SRI and us is being setup to get all parties on the same page. We do not want to set a precedence that all new earthquake information has to be reviewed for potential changes to our design basis earthquakes, as this is not our licensed process.

<< Message: FW: Shoreline Fault NRC question >> << Message: Action: Enhanced Functionality Evaluation for Shoreline Fault >> << Message: FW: Shoreline fault >>

Rich

From: Bemis, Paul R

Sent: Thursday, September 30, 2010 4:06 AM

To: [redacted]

Cc: [redacted] Cluff, Lloyd; Grozan, Thomas C; [redacted] Klimczak, Richard; Nimick, Jan; Sharp, Loren; [redacted]; Westcott, Susan

Subject: RE: Benioff and Smith Paper (1967)

[redacted]

In our last meeting we discussed getting back together in a couple of weeks to discuss how the Shore Line Fault fit into Deterministic analysis, particularly for Double Design earthquake (SSE), and sic design earthquake (OBE). Have you set up this meeting yet? I realize we are going to be in outage, but I do feel we can at least have a conference call, this could end one of [redacted]s issues.

Thanks,
Paul

Paul Bemis
Office: 805.545.6495
Cell : 805.305.5013
Pager: X6495
PNB9@pge.com

From: [redacted]

Sent: Wednesday, September 29, 2010 4:12 PM

To: [redacted] Bemis, Paul R; Cluff, Lloyd; Grozan, Thomas C; [redacted] Klimczak, Richard; [redacted] Nimick, Jan; Sharp, Loren; [redacted]; Westcott, Susan

Subject: Benioff and Smith Paper (1967)

In our meeting on 9/22 regarding the Shoreline Fault, it was requested that the original 1967 paper from Benioff and Smith be found and reviewed. Attached is the 1967 paper:

<< File: Benioff and Smith 1967.pdf >>

[redacted]
NRC Interface and Commitment Management
Regulatory Services - Diablo Canyon, Pacific Gas & Electric Co.
Phone [redacted]

Diablo Canyon Power Plant, 9 Miles NW of Avila, Mail Stop 104/5/18b
Avila Beach, CA 93424
E-mail: [redacted]

From: Sharp, Loren
Sent: Sunday, October 03, 2010 9:06 PM
To: [redacted]
Subject: Fw: URI on Shoreline

I am trying to get a call or mtg set up next week.

[redacted] I need to talk with you on monday as we make the points of why we need NRR clarification
Loren Sharp
Sr Director DCPP

From: [redacted]
To: Nimick, Jan; Sharp, Loren
Sent: Sun Oct 03 17:08:38 2010
Subject: URI on Shoreline

I just got done reviewing the Unresolved Issue (URI) draft our senior resident inspector has prepared for their 3rd quarter report regarding our failure to perform an acceptable operability determination. It reads very well, and identifies SSERs and FSAR 3.7 that present HOSGRI, DE and DDE as DCPP seismic design and licensing basis, whereas Long Term Seismic is non-design basis, a commitment to be applied to future designs. Our current SAPN has OPS entry stating that we have no non-conforming condition. This is based on comparison of ground motion to the LTSP (whereas it should have been HOSGRI).

This is currently going to be characterized as a URI for significance determination, not for whether there was a problem.

[redacted]
Regulatory Services Manager
Diablo Canyon Power Plant

[redacted]

From: Sharp, Loren
Sent: Tuesday, October 05, 2010 6:10 PM
To: [redacted] Cluff, Lloyd; [redacted]
CC: Westcott, Susan; [redacted] Klimczak, Richard; [redacted] (DCPP); Becker, James; [redacted]
Subject: FW: LTSP Strategy Meeting

Importance: High

Lloyd [redacted], We need to have a LTSP strategy meeting before the end of the outage. The meeting needs to be at DCPP to ensure we are part of this dialog on how we submit this report at the end of the year. In addition a way to avoid the issues we are currently being challenged with on our licensing basis. Please start working to set this meeting up or contact [redacted] to help setting this meeting up within the current month. We have little time left in 2010 to craft a strategy on how report is submitted as well as what we expect NRR staff to complete for confirmation.

We need to have a meeting (ASAP) with the LTSP Strategy Team (here at DCPP) to discuss the following items:

Immediate Actions:

- Shoreline Fault Findings report to the NRC
  - What will be in it?
  - How will it be reported? LAR? Letter Report?
  - SF study Commitments going forward

Longer term; LTSP" Program Strategy

- Clarify our reporting commitments going forward. How? How often?
- Clarify relationship between LTSP and Part 100 assessment (i.e. Design Basis deterministic evaluations) in dealing with new information
- Based on our past 20+ years of learning; can we propose a new approach going forward? Provide clarity to program consistent with new NRC PRA approach.
  - Do we need to continue margin assessment and Hazard Analysis ? PRA as it was originally developed?
  - Can we propose GSI-199 Like approach in dealing with new earthquake data? What does that look like?
  - How Can we propose going to OBE/SSE (DE/ Hos) with LTSP check going forward?
- How does LTSP program line up with GSI-199 approach

This is an important piece of our LBVP that needs to be clarified ASAP thru upcoming correspondences (or Submittals) with the NRC.

Thanks

From: Sharp, Loren
Sent: Thursday, October 07, 2010 4:52 PM
To: Becker, James; [redacted] Westcott, Susan; Klimczak, Richard; [redacted] Conway, John; [redacted] Cluff, Lloyd
Subject: NRR mtg

Spent most of the hour with Mike Markley, Alan Wang, and Kamal Manoly. They recognize our commitment for LBVP is significant and also believe it will address many of issues that they have also been drawn into discussions with the resident inspectors or region.

Markley stated several times that NRR response could not have been more clear for shoreline fault. NRR stated that DCPP complies with our licensing basis.

I mentioned that one could argue precedence on how deterministic seismic information is handled as new geo-technical information comes to light. I did point out that current NRC guidance and documentation does not directly specify how deterministic seismic info is handled relative to LTSP either in their GI-199 or so far other licensing basis I am still researching. Kamal and Mike agreed that is a gap in their process. I shared my strategy of potentially submitting an LAR to clarify how new geo-technical information from shoreline, 3D or other insights would be updated via LTSP process with no impact to deterministic information. They agreed that sounded like a viable approach but also suggested a pre-licensing meeting at NRR to discuss it. I responded that I was bringing my LTSP expert panel back together to review this approach and a pre-licensing meeting after that was a good idea.

Markley has also recently sent some type of correspondence to the region stating they are limiting work on other DCPP issues unless a TIA request is submitted due to number of requests and impact on NRR staff workload.

Good meeting.
Markley stated he has recently requested RIC subject include some of the papers submitted at seismic workshop and whether someone on my staff could support. I agreed if his request is approved we would be happy to have someone present some of the recent seismic work.

Loren Sharp
Sr Director DCPP

From: [redacted]
Sent: Wednesday, October 13, 2010 12:03 PM
To: Cluff, Lloyd; Klimczak, Richard
Subject: FW: Shoreline and Unanalyzed and Operability

Lloyd;
please call Rich and I , we need to discuss this issue with you. I send an invite for 10:30 call.
[redacted]

From: Johnston, Kenneth (DCPP)
Sent: Wednesday, October 13, 2010 7:49 AM
To: [redacted] David, Steven; Welsch, James; Klimczak, Richard; Westcott, Susan; Sharp, Loren; Nimick, Jan; [redacted] Bemis, Paul R
Subject: RE: Shoreline and Unanalyzed and Operability

All -

Dr. Peck again stopped by my office this morning to continue the discussion we had on Sunday. He reiterated that he feels we are obligated to review the Shoreline earthquake (and any new geological feature) to the same standard (Part 100 App A) that we were licensed and based on that analysis make a call on operability. He argues that using LTSP criteria is not appropriate because it is not part of our licensing basis. He concedes that if using a App A filter we conclude it either would not have been included or would have been bounded, we can make a case for not "non-conforming" with respect to operability. However, he also stated his doubts that this would be the case.

With respect to the 4/9/09 letter from NRR, he would conclude that the NRC statement that the CLB is bounding was based on the essentially misleading information provided by us that the we were within the LTSP.

His characterization of the GI-199 issue and why CEUS plants are not on the hook for operability is that their fundamental geological information did not change, so their Part 100 App A analysis would not have changed. However, applying a RG 1.208 risk based analysis applied to new sites would require more robust seismic design.

He's still working on the NCV. As I understand, he is pushing for a revised operability evaluation to provide significance information in how the NCV is evaluated.

KJ

From: Sharp, Loren
Sent: Monday, October 11, 2010 10:34 AM
To: Cluff, Lloyd; [redacted] Post, Jennifer (Law); [redacted] Klimczak, Richard; [redacted] Grozan, Thomas C
Cc: Fledderman, Jude; Westcott, Susan; [redacted]
Subject: FW: Shoreline and Unanalyzed
Importance: High

As a site I need to push for a LAR in the near future to ensure it is submitted before end of 2010(deadline) prior to shoreline fault report. The team needs to ensure that the path we are pursuing is technically viable as well as understand the legal risk and implications, but must meet licensing rules and policies. I need a team meeting within the next week or so to ensure we are all moving toward timely research and a solution path. That meeting should also consider seismic expert panel involvement. I have a call in to Post and would like to set up a call in my office at 3pm today to discuss path forward

---

From: Johnston, Kenneth (DCPP)
To: [redacted]; David, Steven; Welsch, James; Klimczak, Richard; Westcott, Susan; Sharp, Loren; Nimick, Jan; [redacted]
Sent: Sun Oct 10 15:47:26 2010
Subject: Shoreline and Unanalyzed

All,

Had a long conversation with Dr. Peck today regarding Shoreline and "unanalyzed conditions." To make a long story short, I argued that the Shoreline was not in our current licensing basis (FSAR Chapter 2.5) and therefore we did not need to evaluate our SSCs against it for operability. Dr. Peck argued that the CLB includes GDC 2 and 10 CFR 100 App A (since that is the basis for the FSAR) and that information of a new fault which would have been considered had the review been done today represents our CLB. Since it is not, it is considered "unanalyzed" and requires an operability review.

What doesn't help is that the operability RIS does not have a definition of unanalyzed. CLB includes "…the set of NRC requirements applicable to a specific plant…" However, in addition to providing how seismic data is evaluated, 10 CFR 100 App. A provides how the information is collected. While I'd argue that once it's been collected, reviewed and the earthquakes established the CLB is set; Dr. Peck would argue that any new possible fault becomes something we have to evaluate SSCs to using 10 CFR 100 App A methodology. If it is outside the earthquakes previously evaluated, then it is "unanalyzed."

Seems to come down to what is CLB and what isn't. He was open to more expert opinion (such as Ramendick). He did note that as it stands today, he is proposing a minor violation on two examples of inadequate operability evaluation. I have initiated a notification on the definition of unanalyzed. 50349398

To refresh - the two examples of inadequate operability is 1) a conclusion on 1/15/09 that there was no nonconfoming condition because Shoreline was bounded by LTSP analysis and 2) on 2/26/10 we made a probablistic argument on the ground deformation occuring.

KJ

From: [redacted]
Sent: Friday, October 15, 2010 3:01 PM
To: Sharp, Loren
CC: Cluff, Lloyd
Subject: RE: Expert panel

Loren:

The recurrence interval for M>6 earthquakes on the shoreline fault is between 1000 and 3000 years, depending on how the assumed rupture.

The OBE and DE are for setting levels of shaking below which there is no need to shut-down the plant. This level is determined by the testing and qualification of the equipment. It does not change with new seismic information.

IN the meeting Tuesday, I will recommend that the shoreline fault should not be evaluated in terms of revising the OBE or DE. New seismic information should only be evaluated in terms of the impacts on safety. We have already shown that the impact on safety is small.

[redacted]

From: Sharp, Loren
Sent: Friday, October 15, 2010 11:15 AM
To: [redacted] Cluff, Lloyd
Subject: RE: Expert panel
Importance: High

I do need to talk to Lloyd, but you can help with one portion prior to next Tuesdays meeting. What is the return period for the Shoreline Fault? And second based on that answer can we defend that the frequency is beyond what would have to have been considered per 10CFR50 Appendix A for OBE or DE?

From: [redacted]
Sent: Friday, October 15, 2010 10:42 AM
To: Sharp, Loren
Subject: RE: Expert panel

Loren:

Is this something that I can help with or do you need to talk to Lloyd>

[redacted]

From: Sharp, Loren
Sent: Friday, October 15, 2010 10:19 AM
To: Cluff, Lloyd; [redacted]
Cc: Post, Jennifer (Law); [redacted]
Subject: Expert panel

Lloyd, I really need to talk to you today. Please call me or get on my schedule with [redacted]

From: Klimczak, Richard
Sent: Monday, October 18, 2010 2:13 PM
To: [redacted] Cluff, Lloyd
CC: [redacted] Sharp, Loren
Subject: FW: Expert panel
Attachments: 780411.DOC; Appendix A to Part 100.doc

[redacted] and Lloyd,

Loren forwarded the attached file from a 1978 letter from DCPP to the NRC. I see from the letter that our DE was based on earthquakes with a 275 year return period with an exceedance probablity for a forty year plant life of 14.5%. Does this mean the Shoreline, if known in 1978, would have been excluded for consideration as an earthquake for DE and DDE (2XDE) based on the stated criteria?

<<...>>
Also, since 10 CFR Part 100 Appendix A is being cited by M. Peck I am attaching a copy. This document should be used for our determination of secondary ground deformation as we currently have no licensing basis for this condition.

<<...>>
Rich

From: Sharp, Loren
Sent: Friday, October 15, 2010 12:03 PM
To: Klimczak, Richard
Subject: RE: Expert panel

From: [redacted]
Sent: Friday, October 15, 2010 12:01 PM
To: Sharp, Loren
Cc: Cluff, Lloyd
Subject: RE: Expert panel

Loren:

The recurrence interval for M>6 earthquakes on the shoreline fault is between 1000 and 3000 years, depending on how the assumed rupture.

The OBE and DE are for setting levels of shaking below which there is no need to shut-down the plant. This level is determined by the testing and qualification of the equipment. It does not change with new seismic information.

IN the meeting Tuesday, I will recommend that the shoreline fault should not be evaluated in terms of revising the OBE or DE. New seismic information should only be evaluated in terms of the impacts on safety. We have already shown that the impact on safety is small.

[redacted]

From: Sharp, Loren
Sent: Friday, October 15, 2010 11:15 AM
To: [redacted] Cluff, Lloyd
Subject: RE: Expert panel
Importance: High

I do need to talk to Lloyd, but you can help with one portion prior to next Tuesdays meeting. What is the return period for the Shoreline Fault? And second based on that answer can we defend that the frequency is beyond what would have to have been considered per 10CFR50 Appendix A for OBE or DE?

From: [redacted]
Sent: Friday, October 15, 2010 10:42 AM
To: Sharp, Loren
Subject: RE: Expert panel

Loren:

Is this something that I can help with or do you need to talk to Lloyd>

[redacted]

From: Sharp, Loren
Sent: Friday, October 15, 2010 10:19 AM
To: Cluff, Lloyd; [redacted]
Cc: Post, Jennifer (Law); [redacted]
Subject: Expert panel

Lloyd, I really need to talk to you today. Please call me or get on my schedule with [redacted]

From: Sharp, Loren
Sent: Thursday, November 11, 2010 1:19 PM
To: Cluff, Lloyd; [redacted]
CC: [redacted]
Subject: Geo-sciences process

Lloyd, I have been having a lot of discussions and dialog with internal and NRR on the LAR we are likely going to request for new geo-technical information and how we assess that info to ensure we continue to be bounded by our licensing basis(clarified LTSP hazard/risk review process). While I continue to believe we are going to get the LAR response we want you need to start looking at your processes.

This is a major change on how you do work. You can not update your hazard model or risk process without going thru the licensing basis review(50.59) before you make the change because LTSP would now be specifically in the DCPP licensing basis. Note based on how they word their LAR response back to us will determine what changes we can make to the process on our own versus which updates or process changes will require prior NRC review and approval before they are implemented. So to be clear when you get new information you may have to review it with the old process if a process change(hazard update) requires NRC review and approval.

I have asked [redacted] to continue to push the LAR preparation as fast as he can to ensure we can submit it prior to the shoreline fault report. If you want/need to have some particular feature included in the LAR to minimize impacts to your organization/process it needs to be considered now. I suggest you two talk to Rich as a minimum to make sure you are prepared for how this process will impact new 3D information currently being collected.

Loren

From: Sharp, Loren
Sent: Tuesday, November 16, 2010 6:45 PM
To: [redacted] Klimczak, Richard; Cluff, Lloyd
CC: [redacted]
Subject: RE: Shoreline trip Update

Importance: High

All, Here is my suggested responses please review from your perspectives.
[redacted], you need to specifically review my perspective on how a LTSP profile would be used as a hazard/risk screen to avoid impact to deterministic seismic design basis.
Loren

From: [redacted]
Sent: Tuesday, November 16, 2010 1:27 PM
To: [redacted] Sharp, Loren; Klimczak, Richard; Cluff, Lloyd
Subject: Shoreline trip Update

I just got a call from [redacted] There was a big meeting today in NRR for them to come to common understanding of DCPP licensing basis and identify what they should be looking for from us in our LAR.

He said they concluded they needed to have [redacted] in the meeting, but will be speaking on 12/8 elsewhere. He said they were firm on needing her so that will result in a date change for the meeting.

Feedback to us to help us prepare for the meeting:

Draw parallels between our proposal and existing reg guide precedent or other similar licensing precedent to allow NRC to stay as much as possible on familiar ground

Things they are looking to hear in our presentation:

- Scope and extent of LAR (include interaction with current design and licensing basis - just SSE or OBE apps too) LTSP would be used as a licensing basis screen to assess whether any new geo-technical information has an impact to DCPP licensing basis. If a hazard was identified that was above a portion of the LTSP profile then a risk assessment would be completed to determine if risk was acceptable. If risk was determined unacceptable then change in licensing basis, or NRC acceptance would be required. If risk was acceptable then LTSP screening process verifies that new geo-technical information is still bounded by existing licensing basis.
- Schedule for implementation Immediately since we are clarifying the process DCPP is currently using. (Caution do I need more specific procedures/processes to implement this approach formally).
- How we plan to communicate to stakeholders (intervenors, industry, regulator etc) Since this is a clarification I assume we would issue a press release stating that we are clarifying our current seismic licensing basis commitments into the FSAR.
- How we'll address future discoveries (prescriptive details, thresholds) Same as first bullet. May need to specify a CDF threshold here.
- Clarity regarding LTSP to be bounding of other earthquakes (DDE/HOSGRIs) - completely, merged, piece meal) LTSP is used as a screen to judge no impact to design basis for all deterministic seismic basis earthquakes.
- How do we evaluate or handle decrease in effectiveness / loss of margin (50.59, periodic reports, LA's...) This is a good question on who controls the margin. I would state that we control the margin to the LTSP hazard and risk process. NRC would control the margin between the LTSP and Hosgrai profile in an approach like this unless others have a better idea.
- How does LTSP manage safe shutdown exemptions from HOSGRI (it has a different safe shutdown) LTSP is still used as a bounding screen to judge no impact to deterministic seismic basis earthquakes.

[redacted]

From: Miklush, David B
Sent: Tuesday, November 23, 2010 3:56 PM
To: [redacted]
Cc: [redacted]; Sizemore, Brandy
Subject: Seismic qualification SSER 34 . LTSP

Terry, here's my discussion of seismic qualification and the impact of the LTSP program.

DCM T-10 discusses various methods to seismically qualify (design basis) equipment at DCPP. These are:

- **static analysis** for rigid equipment with first frequency above 20 Hz (DE,DDE) and 33 HZ (Hosgri). Only used for base mat located equipment or where there is a clear floor spectra available.

- **dynamic analysis** using a computer model and either spectral motion input or time history input (DE,DDE,Hosgri). All buildings, large components and piping systems analyzed this way .

> Note, PG&E time histories, when used, appear to have been developed from real earthquakes as compared to synthetic generation of time histories, which can be used but require extensive Monte-Carlo analysis (using current regulations).

- drop test (they dropped it on the floor and it didn't break) . Not widely used but it was on a few items.

- **shake test** , almost all electrical , instrumentation and some mechanical equipment that would fit on shake table was tested. Extensive rules on simultaneous input motions and number test repetitions.

- explosions under a raft with the DG on it (our DG's). This was something like a shake test.

The first two methods require the equipment to meet code allowables (ex ASME, AISC, and ACI) for various loading combinations. These analyses must be done with the parameters described in the FSAR (such as damping). Often the controlling earthquake is DE or DDE , the former because of tight margins in the code for normal loadings and the latter because of higher frequency accelerations and low damping allowed for the DDE compared to Hosgri.

SSER 34 observations:

1. Section 3.8.1.5 - The NRC accepted HCLPF methods for DCPP's assessment using the Fragility Analysis (PRA) of the plant; however,

2. Section 3.8.1.7 - To check the HCLPF results the NRC required specific deterministic analysis on the Containment, Aux Bldg, Turbine Bldg, FHB crane , CFCU and DG control panel. They did not require DCPP to re-shake equipment on a large scale. Deterministic analysis followed the Conservative Deterministic Failure Margin (CDFM) method developed by EPRI using the parameters of **Table 3.3 in SSER 34**. The parameters in Table 3.3 are much more liberal than the applicable codes or FSAR.

3. The lowest HCLPF values (ultimate siesmic margin) were for the DG control panel, turbine building, and 4KV bus relays. I mention these since this "lowest margins list" is a place for future evaluations. Unless a new "lowest margin" SSC reveals itself in a new HCLPF review , this would be the list of equipment to assess further

4. PG&E agreed to assess significant modifications in the future to the LTSP. Since future modifications usually entail a new seismic analysis , this LTSP evaluation can be done deterministically and in practice that's what DCPP Engineering has been doing (ex: sump strainers, SG's, Replacement Reactor Heads) . I have not seen us use the parameters in Table 3.3 for CDFM's for new mods.

5. Section 3.8.1.4 - as long as Hosgri responses were found to be greater than the LTSP responses , no additional evaluation would be required.

6. Section 3.8.1.1 horizontal and vertical LTSP exceedance from the Hosgri are acceptable based on HCLPF margins with some extra analytical work (the list of SSC's in section 3.8.1.7) to prove the argument.

7. No where did I see any reference to review of the DE or DDE earthquake in SSER 34.

8. Extensive deterministic re-analysis of all SSC's for LTSP at DCPP was not required.

Shoeline fault implications on seismc qualifications:

Based on the above, there does not seem to be a requirement to re-evaluate the design basis earthquakes , especially DE. Assuming the shoreline fault has changed the exisitng LTSP earthquake it looks we would need to :

- check for the impact on the overall plant Fragility Analysis based on the Shoeline fault exceedances to the LTSP spectra

- check the CDFM analysis on the above SSC's for Shoreline fault exceedances

- make sure we address the lowest margin HCLPF components and determine if there are any new ones to add to the list.

Dave M.

From: Sharp, Loren
Sent: Friday, January 07, 2011 1:05 AM
To: 'abrahamson@berkeley.edu'; Cluff, Lloyd
CC: [redacted]
Subject: Fw: NRC preps for 1/19 meeting

Fyi
Loren Sharp
Sr Director DCPP

From: [redacted]
Sent: Thursday, January 06, 2011 07:53 PM
To: Sharp, Loren
Cc: Peters, Kenneth
Subject: NRC preps for 1/19 meeting

Dr Peck has been tasked to prepare speaking points for Mr Vegel on why the NRC considers the plant to be safe with the Shoreline fault for the 1/19 meeting. It would behoove us to explain the conservatisms in the Shoreline report with Dr Peck. Be aware he will start asking about how we know we can safely shut down with the new spectra (ie, do we meet DDE)

HOSGRI is bounding, and we have qualified a safe shutdown strategy with HOSGRI active-qualified equipment. He will undoubtedly say that is our licensing basis. I suggest we'll have to keep him focused on addressing safety and capability vs licensing compliance.

[redacted]

[redacted]

From: Klimczak, Richard
Sent: Wednesday, January 12, 2011 2:36 PM
To: [redacted]
CC: Sharp, Loren; Westcott, Susan; [redacted]
Subject: FW: Shoreline mtg 1/19

Importance: High

[redacted]

During the 1/10/11 meeting that Loren and I had with [redacted] he shared some of the questions he was in the process of developing for the 1/19 public meeting. They were:

1) Did the rupture length assumed for the development of the Shoreline ground motion spectra include all three segments?

We stated it was all three segments.

2) What are the deltas, if any, between the methods used in the development of the seismic hazard curves for the report versus the RG 1.208 methods (used for GI-199)? If there are differences, what are the impacts?

We did not know the answer to this.

3) Did we evaluate the appropriateness of using Hosgri acceptance criteria (code allowables, damping) for Shoreline, Los Osos and San Luis Bay?

We stated that per our licensing basis we compare to LTSP and all are enveloped. Hosgri acceptance criteria does not come into play. He disagreed.

4) [redacted]'s opinion is that GI-199 addresses methodology changes that resulted in increases in seismic hazard curves and it does not address discovery of new geological information (new faults). Is this true?

We did not know the answer to this.

5) Are the Hosgri spectra shown in the FSAR Chapter 3 figures based on the 84% ground motion Hosgri spectra shown in Figure 6-15 and Figure 6-19 in the Shoreline report?

We did not provide an answer to this. But, I have looked at the FSAR Chapter 2 free field (ground) spectrum for Hosgri Blume (Fig 2.5-29) and Hosgri Newmark (Fig 2.5-30) and they appear to match the 1977 HE Design Spectrum shown in Figure 6-15 and Figure 6-19 in the final Shoreline Report. The FSAR Chapter 3 figures are building spectra. I believe the building spectra were developed from the Chapter 2 ground spectra. Therefore, our answer would be yes, the Hosgri ground spectra in the FSAR Chapter 3 our based on the Hosgri 84% ground motion spectra. He was thinking we designed for something other than 84% percentile ground motion spectra. Please verify.

Please review questions and provide responses to the open questions and comments on the responses I provided.

Thanks,
Rich

From: Sharp, Loren
Sent: Monday, January 10, 2011 2:28 PM
To: Klimczak, Richard
Subject: Shoreline mtg 1/19
Importance: High

Pls review

Jim, First [redacted] is working on the slides to have prepared for submittal to NRC by 1/13. I believe the format should be similar to how [redacted] presented the information in our Sept 9 mtg. Since most of the Sept 9 meeting was describing earthquakes, it was only [redacted]s that described results anticipated for Shoreline report.

Rich and I just finished talking with Peck at noon today. We described in general the most significant areas/insights that had impact on the Shoreline results:

New industry ground motion data on strike-slip faults(less motion) as well as on hanging wall faults(more motion)
Site specific ground motion response(from DCPP sensor responses during earthquakes San Simeon and Parkfield)
Hard rock insights(ISFSI results now also applied to DCPP)
New offshore geo-technical information collected near DCPP

Peck agreed with our statement that we continue to demonstrate that DCPP has seismic margin based on the latest information and resulting report.

I made the statement that message to the public needs to be no adverse safety impact to DCPP. Peck did not agree with my statement and implies he is coaching his leadership in Region IV to support him if he makes a similar comment in 1/16 meeting. I asked if Anne was coming Peck said to the 1/26 meeting but not the 1/16 meeting. I have asked Cluff to contact Anne and be sure she is aware of the meeting and find out if she is planning on attending. I really believe Anne needs to be at the meeting or on the phone if Peck continues to imply he will make statements relative to DCPP safety.

From: [redacted]

Sent: Friday, February 11, 2011 12:34 AM

To: [redacted] Klimczak, Richard <RLK1@PGE.COM>; [redacted] Sharp, Loren <LDSL@PGE.COM>

Cc: David, Steven <SAD1@PGE.COM>; Post, Jennifer (Law) <JLKM@PGE.COM>

Subject: 3rd LTSP Pre-licensing request

I got a call from Jim Polickoski a little bit ago. The staff is requesting a 3rd pre-licensing meeting. Again telecon style, although preferred with video conference.

The staff has some confusion and concern is around our position that we are not changing our licensing basis but that LTSP is bounding.

He communicated that we would get written concerns from him early next week but gave us a head up on their questions.

a) Describe the entry criteria for use of the LTSP
b) What side of the chart would be used for operability determinations
c) How do the results of the LTSP seismic evaluation relate to the associated performance criteria of the DE/DDE/HOSGRI earthquakes with respect to licensing basis
d) How do we intend to apply LTSP to degraded / nunconforming conditions
e) How would the LTSP be applied to modifications

Jim said that they are particularly unsure how LTSP related to DE and DDE since LTSP appear to be based on HOSGRI

Note that Dr Peck recently completed his paper which collected his position on the DCPP statements regarding the Shoreline fault and seismic design basis. This was sent to the region and presumably NRR this past week.

[redacted]

Regulatory Services Manager
Diablo Canyon Power Plant

[redacted]

From: [redacted]
Sent: Friday, February 25, 2011 10:54 AM
To: Sharp, Loren <LDSL@PGE.COM>; Klimczak, Richard <RLK1@PGE.COM>; [redacted] Post, Jennifer (Law) <JLKM@PGE.COM> [redacted]
Cc: [redacted]
Subject: FW: Questions for pre-licensing meeting #3 for DCPP proposed LTSP license amendment

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All,

Below are the NRC follow up questions on the LTSP LAR. They are requesting if a clarification phone call is needed and have a proposed meeting date of 3/24/2011. The NRC is requesting for feedback if clarification on the questions is needed and if the meeting date can be supported by Tuesday March 1, 2011.

[redacted]

Regulatory Services - DCPP
Office [redacted]
Cell - [redacted]

From: Polickoski, James [mailto:James.Polickoski@nrc.gov]
Sent: Friday, February 25, 2011 6:59 AM
To: [redacted]
Cc: [redacted] Markley, Michael; Manoly, Kamal; Kammerer, Annie; Smith, Maxwell; Farnholtz, Thomas; Peck, Michael; Denissen, Christie; Braisted, Jonathan; Deese, Rick; Wang, Alan; Miller, Geoffrey; Uselding, Lara; Vegel, Anton; Kennedy, Kriss; Lent, Susan; Burkhardt, Janet
Subject: Questions for pre-licensing meeting #3 for DCPP proposed LTSP license amendment

[redacted]

As discussed, the questions the NRC staff would like PG&E to discuss at the third pre-licensing meeting for the Diablo Canyon Power Plant (DCPP) proposed Long Term Seismic program (LTSP) license amendment are:

1. What are the entry conditions (criteria) for using the LTSP flowchart? For what will this flowchart be specifically used?

2. How will the LTSP analysis flowchart be utilized to qualify new plant equipment, perform plant modifications, perform condition evaluations, and/or evaluate non-conforming/degraded conditions with specific discussion on the LTSP analysis and licensing basis relationship to the existing design and licensing bases of the OBE, SSE, HE, GDC 2, and Part 100?

3. How do the results of an LTSP flowchart evaluation (either deterministic, probabilistic, or both) for LTSP evaluated ground motions specifically relate to the three licensed, associated, and existing seismic ground motion equipment performance criteria of the OBE, SSE, HE as well as GDC 2, and Part 100, and how will these LTSP analysis results be used together in conjunction with the OBE, SSE, HE, GDC 2, and Part 100 as

licensing basis for future licensing actions?

4. When performing future operability determinations, how will the LTSP analysis flowchart be utilized to include specific discussions on the employment of each side of the chart?

5. For the Shoreline Fault and for future unevaluated seismic ground motions, how are safety-related SSC code allowables being evaluated for exceedance for the OBE, SSE, and HE where the LTSP ground motion spectra is not immediately bounding and safety-related SSC's are relevant in the applicable parameter range where LTSP is not bounding?

Also, we have selected Thursday, March 24, 2010 from 1-4 pm EST (10-1 PST) as our primary time slot for the public meeting.

Please provide feedback if a call is needed to clarify these questions and whether your staff can accommodate the March 24 date in question by COB, Tuesday, March 1, 2011.

Thanks,
Jim

James T. Polickoski
Project Manager – Callaway, Diablo Canyon
US NRC/NRR/DORL/LPL4
james.polickoski@nrc.gov
301-415-5430

From: Klimczak, Richard </O=PG&E/OU=CORPORATE/CN=RECIPIENTS/CN=RLK1>
Sent: Tuesday, March 29, 2011 4:00 PM
To: [redacted] Sharp, Loren <LDSL@PGE.COM>; [redacted] Post, Jennifer (Law) <JLKM@PGE.COM>; [redacted]
Subject: RE: Attn: Second Update to LTSP Process Flowchart *** Updated Response ***

All,

We would not want to ever modify the 1977 HE but, we have to recognize that any justification of exceedance would be part of a LAR that the NRC would have to approve. Their approval of the justification to not revise the 1977 HE is not guaranteed. Also, depending on where the exceedance is, it could have a significant impact. We are not committing to revising the 1977 HE we are recognizing it may need to be updated.

Rich

From: [redacted]
Sent: Tuesday, March 29, 2011 1:29 PM
To: Sharp, Loren; [redacted] Klimczak, Richard; [redacted] Post, Jennifer (Law); [redacted]
Cc: [redacted]
Subject: RE: Attn: Second Update to LTSP Process Flowchart *** Updated Response ***

All,

In today's update to Flowchart B, I use the term "1977 Hosgri" to reference our design basis Hosgri ground motion and added Note (6) to indicate that this is as defined in UFSAR Section 2.5.

Note that I have discussed this with [redacted] and we have certain miss-givings regarding ever making changes to the 1977 Hosgri Spectrum - just as the DE and DDE spectra are considered to be untouchable, the 1977 Hosgri spectrum should also be untouchable. Any exceedances of this spectrum should be addressed through the LTSP seismic margins evaluation, as was previously done (circa 1988-1991) for the high frequency exceedance of the 1991 LTSP spectrum relative to the 1977 Hosgri spectrum.

regards,

[redacted]
Senior Civil Engineer
Pacific Gas & Electric Company
Diablo Canyon Power Plant
[redacted]

From: Sharp, Loren
Sent: Tuesday, March 29, 2011 1:02 PM
To: [redacted] Klimczak, Richard; [redacted] Post, Jennifer (Law); [redacted]

Subject: Re: Attn: Second Update to LTSP Process Flowchart

[redacted] raises a good comment similar to one we had with last nrc mtg. We clearly need to identify hosgri bounding profile versus latest hosgri curve from shoreline report. May need a date on hosgri like we are using on ltsp.
Loren Sharp
Sr Director DCPP

From: [redacted]
Sent: Tuesday, March 29, 2011 11:54 AM
To: [redacted] Klimczak, Richard; [redacted] Post, Jennifer (Law); [redacted]
Subject: RE: Attn: Second Update to LTSP Process Flowchart

I focused my comments on Flowchart B

- Once you answer the first block NO (Outside Licensing Basis GM), we are in operability land and final solution is LAR
  - Suggest removing the second decision block (Do changes to DGMRS……..) . Because once you said we are not bounded we have to go into assessment
  - Suggest Substituting the "Does 1991LTSP…" with "Submit LAR to Update…."

There are refernces to updating "Hosgri DGMRS" but no mention of other active faults. They need to be updated as well. We need to clarify that updated Hosgri DGMRS will not be used for Design going forward. What do we do with them?

Question will be asked. Have we applied this to Shoreline fault? What was our findings? Did we go to the right side (Chart B) and did we update anything?

[redacted]

From: [redacted]
Sent: Wednesday, March 23, 2011 4:41 PM
To: [redacted] Sharp, Loren; Klimczak, Richard; [redacted] Post, Jennifer (Law); [redacted]

Subject: Attn: Second Update to LTSP Process Flowchart

All,

I have updated the flowchart for the second time today, in order to capture comments from the meeting a 1:00 pm today.

Please review and be prepared to discuss and/or provide comments on Monday, March 28th.

Thank you,

[redacted]
Senior Civil Engineer
Pacific Gas & Electric Company
Diablo Canyon Power Plant
[redacted]

[redacted]

<< File: LTSP Parts A B C (03-23x-11).vsd >> << File: LTSP Parts A B C (03-23x-11).pdf >>

From: [redacted]
Sent: Friday, April 1, 2011 9:11 AM
To: Klimczak, Richard <RLK1@PGE.COM>
Subject: RE: NRC Meeting

Rich,

Thanks.
In reading this, my feedback is the sooner we submit the LAR the better.risk is minimized by minimizing the time of the URI.
Can the LAR go in any sooner? (I have no idea what is involved)

[redacted]

From: Klimczak, Richard
Sent: Friday, April 01, 2011 6:59 AM
To: [redacted]
Subject: FW: NRC Meeting
Sensitivity: Confidential

Glad to hear you are wrapping up in the OCC.

How it went is described below:

From: Klimczak, Richard
Sent: Thursday, March 31, 2011 8:48 PM
To: [redacted] Westcott, Susan
Cc: Sharp, Loren
Subject: NRC Meeting
Sensitivity: Confidential

[redacted] and Susan,

The meeting was good from the perspective of having open dialogue. Clearly, Jim Polickowski buys into [redacted]s position. We did get them to agree that the new fault does not change the DE, DDE design spectra. BUT, from an operability perspective, Jim P. and M. Peck, think that we need to address the impact of the Shoreline, Los Osos or San Luis Bay spectra for component qualification cases where the DE or DDE yield higher seismic stresses than the Hosgri. Our evaluation states since the Shoreline spectra is bounded by LTSP and HE, as required by the LTSP, there is no operability issue. I heard some of the NRC state that LTSP is not our licensing basis. We took exception to this but, we did not get consensus. So far, this issue is still an URI.

Loren's opinion is that we didn't win and didn't lose. We told them we would submit an LAR in June, they did not object. The June LAR will be reviewed by Anne, who is on our side.

The addition of [redacted] and Greg Hardy to the team was good.

I do not see [redacted] giving up. This was a tough, but necessary meeting.

Rich

From: [redacted]
Sent: Friday, April 1, 2011 9:46 AM
To: Klimczak, Richard <RLK1@PGE.COM>; Sharp, Loren <LDSL@PGE.COM>; [redacted]
Subject: Re: NRC Meeting

He did send me the SF based on DE for 110 year return. It fell under DE by a wide margin at the peak and lower margins at the right and left of the peak we need to run this for 275 year return.

[redacted]

From: Klimczak, Richard
Sent: Friday, April 01, 2011 06:53 AM
To: [redacted] Sharp, Loren
Subject: RE: NRC Meeting

[redacted]

[redacted] agreed to place the DDE ground motion spectra onto the deterministic spectrum slide from the Shoreline report. [redacted] told us he would do this at 5% damping like the rest of the spectra. He will provide it to us first. We need to strategize about this.

Rich

From: [redacted]
Sent: Thursday, March 31, 2011 8:52 PM
To: Klimczak, Richard; Westcott, Susan
Cc: Sharp, Loren
Subject: RE: NRC Meeting
Sensitivity: Confidential

Listened to it on the phone. Agree on Policoski assessment. I did not follow [redacted]'s response to Peck that he will show Shoreline Fault (Impact, assessment or contribution to De/DDE)

[redacted]

From: Klimczak, Richard
Sent: Thursday, March 31, 2011 5:48 PM
To: [redacted] Westcott, Susan
Cc: Sharp, Loren
Subject: NRC Meeting
Sensitivity: Confidential

[redacted] and Susan,

The meeting was good from the perspective of having open dialogue. Clearly, Jim Polickowski buys into [redacted]s position. We did get them to agree that the new fault does not change the DE, DDE design spectra. BUT, from an operability perspective, Jim P. and M. Peck, think that we need to address the impact of the Shoreline, Los Osos or San Luis Bay spectra for component qualification cases where the DE or DDE yield higher seismic stresses than the Hosgri. Our evaluation states since the Shoreline spectra is bounded by LTSP and HE, as required by the LTSP, there is no operability issue. I heard some of the NRC state that LTSP is not our licensing basis. We took exception to this but, we did

not get consensus. So far, this issue is still an URI.

Loren's opinion is that we didn't win and didn't lose. We told them we would submit an LAR in June, they did not object. The June LAR will be reviewed by Anne, who is on our side.

The addition of [redacted] and Greg Hardy to the team was good.

I do not see [redacted] giving up. This was a tough, but necessary meeting.

Rich

From: Klimczak, Richard </O=PG&E/OU=CORPORATE/CN=RECIPIENTS/CN=RLK1>
Sent: Tuesday, April 26, 2011 3:15 PM
To: Sharp, Loren <LDSL@PGE.COM>
Subject: RE: NRC Request - Return Rate for Shoreline, LO, SLB, and Hosgri in Shoreline Fault Report

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I would say No, but we need to check with [redacted] Bemis....

From: Sharp, Loren
Sent: Tuesday, April 26, 2011 12:52 PM
To: Klimczak, Richard
Subject: Re: NRC Request - Return Rate for Shoreline, LO, SLB, and Hosgri in Shoreline Fault Report

So??? Does that commit us to that return period.
Loren Sharp
Sr Director DCPP

From: Klimczak, Richard
Sent: Tuesday, April 26, 2011 12:14 PM
To: Sharp, Loren; [redacted]
Subject: RE: NRC Request - Return Rate for Shoreline, LO, SLB, and Hosgri in Shoreline Fault Report

I found the reference to the Hosgri return period in the Hosgri report, Section 1.0, "Summary":

Even if the Hosgri fault is postulated to be capable of a magnitude 7.5 event, the Company and its consultants believe that an effective peak ground acceleration Of 0.75g would have an average return period of 52,600 years.

Rich

From: Klimczak, Richard
Sent: Monday, April 25, 2011 7:24 AM
To: Sharp, Loren; [redacted]
Subject: RE: NRC Request - Return Rate for Shoreline, LO, SLB, and Hosgri in Shoreline Fault Report

[redacted]

I did a word search on "return period". I am not aware of a 55,000 year return period for Hosgri in our licensing basis. Where is it? I also agree that return period is not part of our licensing basis other than for the DE, where the NRC licensed a 275 year return period for DE. I attached all documents I found in my search,except for the letter where we discussed return period for DE.

Rich

From: Sharp, Loren
Sent: Friday, April 22, 2011 11:18 AM
To: Klimczak, Richard; [redacted]
Subject: Fw: NRC Request - Return Rate for Shoreline, LO, SLB, and Hosgri in Shoreline Fault Report

Fyi
Loren Sharp
Sr Director DCPP

From: [redacted]
Sent: Friday, April 22, 2011 11:07 AM
To: Sharp, Loren; [redacted]
Cc: [redacted]
Subject: RE: NRC Request - Return Rate for Shoreline, LO, SLB, and Hosgri in Shoreline Fault Report

Loren:

I am working with [redacted] to develop a response to the NRC request.

Short Answer: This is not an issue from a licensing basis because the ground motion percentile level for deterministic analyses for critical strucutres uses the 84th percentile. It is not adjuisted based on the rate of earthquakes on a fault. (This is not stated in Part 100 Appendix A, but the NRC does not use a ground motion level above the 84th percentile for deterministic evaluations).

If you are interested, here is the Long Answer:

The terminology used in the question is not standard, but [redacted] provided some additional background information from Peck. With this background information, I have rephased the question using standard seismic hazard terminology.

Rephrased Question:
If the recurrence interval for the design earthquake magnitude on the Hosgri fault is 55,000 years and the 84th percentile ground motion was accepted for the Hosgri, then wouldn't a higher a high percentile (less likely) ground motion level be needed for the other faults if they have shorter recurrence intervals (e.g. 5,000 years)?

The concept behind the question is valid, but this just points out a short-coming of deterministic approaches. The deterministic approach is a simplfied method that ignores the rates of earthquakes and uses either the 50th or the 84th percentile ground motion. For critical structures, we use the 84th percentile and not the 50th. We don't adjust the ground motion probability level based on the rate of earthquakes on the fault. So from a licensing perspective, this is not an issue.

If you want to account for the differences in the rate of earthquakes on different faults, you would use a probabilistic approach which does consider higher ground motion probability levels for faults with higher rates of earthquakes as part of the method. This makes more sense and is why we use probabilistic methods.

For the DCPP case, Peck has missused the recurrence values in developing his question. The Hosgri fault is more active than the other faults and the recurrence interval for large earthquakes on the Hosgri is smaller, not larger, than on the other nearby faults. This makes his question moot, even if adjusting the ground motion percentile for a deterministic approach was allowed.

The problem (confusion) comes about because the 55,000 year recurrence interval is not representative of the recurrence interval for large earthquakes on the Hosgri fault. I think that the 55,000 year value is for M7.5 earthquakes on the Hosgri fault (I need to double check this), but the recurrence interval of large magnitudes (e.g. M>6.5) on the Hosgi, which are most likely to cause strong shaking at DCPP, is much smaller.

[redacted]

From: Sharp, Loren
Sent: Thursday, April 21, 2011 10:10 AM
To: [redacted]
Subject: Fw: NRC Request - Return Rate for Shoreline, LO, SLB, and Hosgri in Shoreline Fault Report

[redacted] we apparently are being asked this issue from nrc review. What is your response from a licensing'design perspective
Loren Sharp
Sr Director DCPP

From: [redacted]
Sent: Thursday, April 21, 2011 09:47 AM
To: Klimczak, Richard; Sharp, Loren
Subject: FW: NRC Request - Return Rate for Shoreline, LO, SLB, and Hosgri in Shoreline Fault Report

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From: [redacted]
Sent: Thursday, April 21, 2011 9:42 AM
To: [redacted]
Cc: [redacted]
Subject: FW: NRC Request - Return Rate for Shoreline, LO, SLB, and Hosgri in Shoreline Fault Report

Can anyone answer the NRC's question?

From my quick attempt to answer, all I could find was that in discussions of the deterministic earthquake magnitudes, the Shoreline Fault Report (Section 6.7) and the supporting calculation (GEO.DCPP.10.03, Section 5.1) refers to the "90th fractile of the mean characteristic magnitude", but I don't know if this can be translated into a return period.

Regards,

[redacted]
Senior Civil Engineer
Pacific Gas & Electric Company
Diablo Canyon Power Plant
[redacted]

From: [redacted]
Sent: Thursday, April 21, 2011 9:19 AM
To: [redacted]
Subject: NRC Request

Received this morning:
Request #40:
Please provide the return rates (and references) for the Jan 7th deterministic evaluation of Shoreline, Los Osos, San Luis Bay and Hosgri Faults.

When can you respond?

[redacted]
NRC Interface
Regulatory Services - Diablo Canyon, Pacific Gas & Electric Co.
Phone [redacted]
Diablo Canyon Power Plant, 9 Miles NW of Avila, Mail Stop 104/5/18b
Avila Beach, CA 93424
E-mail: [redacted]

From: [redacted]
Sent: Monday, April 25, 2011 11:37 AM
To: [redacted]
Cc: [redacted] Klimczak, Richard <RLK1@PGE.COM>; [redacted] Sharp, Loren <LDSL@PGE.COM>; [redacted]
Subject: RE: NRC request - accel vs freq response for DDE
Attach: DDEHELTSPSL(F).pdf

[redacted]

The attached figure is a composite of Fig. ES-1 from the Shoreline Fault Report (Jan. 2011) and Fig. 1 from DCM C-30 (switched from Period to Frequency and doubled for the DDE).

Caution: this is my own creation, and has not been peer-checked.

[redacted]
Senior Civil Engineer
Pacific Gas & Electric Company
Diablo Canyon Power Plant
[redacted]

From: [redacted]
Sent: Monday, April 25, 2011 8:17 AM
To: Klimczak, Richard; [redacted]
Cc: [redacted]
Subject: NRC request - accel vs freq response for DDE

Seismic design and licensing experts
NRC SRI has requested a copy of the chart we have been showing LTSP, HOSGRI, Shoreline..... with DDE plotted as well.

Can you please provide a copy?
Thank you

[redacted]
Regulatory Services Manager
Diablo Canyon Power Plant

[redacted]

From: Sharp, Loren </O=PG&E/OU=CORPORATE/CN=RECIPIENTS/CN=LDSL>
Sent: Tuesday, April 26, 2011 2:52 PM
To: Klimczak, Richard <RLK1@PGE.COM>
Subject: Re: NRC Request - Return Rate for Shoreline, LO, SLB, and Hosgri in Shoreline Fault Report

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So??? Does that commit us to that return period.
Loren Sharp
Sr Director DCPP

From: Klimczak, Richard
Sent: Tuesday, April 26, 2011 12:14 PM
To: Sharp, Loren; [redacted]
Subject: RE: NRC Request - Return Rate for Shoreline, LO, SLB, and Hosgri in Shoreline Fault Report

I found the reference to the Hosgri return period in the Hosgri report, Section 1.0, "Summary":

Even if the Hosgri fault is postulated to be capable of a

magnitude 7.5 event, the Company and its consultants believe that an

effective peak ground acceleration Of 0.75g would have an average return

period of 52,600 years.

Rich

From: Klimczak, Richard
Sent: Monday, April 25, 2011 7:24 AM
To: Sharp, Loren; [redacted]
Subject: RE: NRC Request - Return Rate for Shoreline, LO, SLB, and Hosgri in Shoreline Fault Report

[redacted]

I did a word search on "return period". I am not aware of a 55,000 year return period for Hosgri in our licensing basis. Where is it? I also agree that return period is not part of our licensing basis other than for the DE, where the NRC licensed a 275 year return period for DE. I attached all documents I found in my search,except for the letter where we discussed return period for DE.

Rich

From: Sharp, Loren
Sent: Friday, April 22, 2011 11:18 AM
To: Klimczak, Richard; [redacted]
Subject: Fw: NRC Request - Return Rate for Shoreline, LO, SLB, and Hosgri in Shoreline Fault Report

Fyi
Loren Sharp
Sr Director DCPP

From: [redacted]
Sent: Friday, April 22, 2011 11:07 AM
To: Sharp, Loren; [redacted]
Cc: [redacted]
Subject: RE: NRC Request - Return Rate for Shoreline, LO, SLB, and Hosgri in Shoreline Fault Report

Loren:

I am working with [redacted] to develop a response to the NRC request.

Short Answer: This is not an issue from a licensing basis because the ground motion percentile level for deterministic analyses for critical strucutres uses the 84th percentile. It is not adjuisted based on the rate of earthquakes on a fault. (This is not stated in Part 100 Appendix A, but the NRC does not use a ground motion level above the 84th percentile for deterministic evaluations).

If you are interested, here is the Long Answer:

The terminology used in the question is not standard, but [redacted] provided some additional background information from Peck. With this background information, I have rephased the question using standard seismic hazard terminology.

Rephrased Question:
If the recurrence interval for the design earthquake magnitude on the Hosgri fault is 55,000 years and the 84th percentile ground motion was accepted for the Hosgri, then wouldn't a higher a high percentile (less likely) ground motion level be needed for the other faults if they have shorter recurrence intervals (e.g. 5,000 years)?

The concept behind the question is valid, but this just points out a short-coming of deterministic approaches. The deterministic approach is a simplfied method that ignores the rates of earthquakes and uses either the 50th or the 84th percentile ground motion. For critical structures, we use the 84th percentile and not the 50th. We don't adjust the ground motion probability level based on the rate of earthquakes on the fault. So from a licensing perspective, this is not an issue.

If you want to account for the differences in the rate of earthquakes on different faults, you would use a probabilistic approach which does consider higher ground motion probability levels for faults with higher rates of earthquakes as part of the method. This makes more sense and is why we use probabilistic methods.

For the DCPP case, Peck has missused the recurrence values in developing his question. The Hosgri fault is more active than the other faults and the recurrence interval for large earthquakes on the Hosgri is smaller, not larger, than on the other nearby faults. This makes his question moot, even if adjusting the ground motion percentile for a deterministic approach was allowed.

The problem (confusion) comes about because the 55,000 year recurrence interval is not representative of the recurrence interval for large earthquakes on the Hosgri fault. I think that the 55,000 year value is for M7.5 earthquakes on the Hosgri fault (I need to double check this), but the recurrence interval of large magnitudes (e.g. M>6.5) on the Hosgi, which are most likely to cause strong shaking at DCPP, is much smaller.

[redacted]

From: Sharp, Loren
Sent: Thursday, April 21, 2011 10:10 AM
To: [redacted]
Subject: Fw: NRC Request - Return Rate for Shoreline, LO, SLB, and Hosgri in Shoreline Fault Report

[redacted] we apparently are being asked this issue from nrc review. What is your response from a licensing'design

perspective
Loren Sharp
Sr Director DCPP

From: [redacted]
Sent: Thursday, April 21, 2011 09:47 AM
To: Klimczak, Richard; Sharp, Loren
Subject: FW: NRC Request - Return Rate for Shoreline, LO, SLB, and Hosgri in Shoreline Fault Report

---

From: [redacted]
Sent: Thursday, April 21, 2011 9:42 AM
To: [redacted]
Cc: [redacted]
Subject: FW: NRC Request - Return Rate for Shoreline, LO, SLB, and Hosgri in Shoreline Fault Report

Can anyone answer the NRC's question?

From my quick attempt to answer, all I could find was that in discussions of the deterministic earthquake magnitudes, the Shoreline Fault Report (Section 6.7) and the supporting calculation (GEO.DCPP.10.03, Section 5.1) refers to the "90th fractile of the mean characteristic magnitude", but I don't know if this can be translated into a return period.

Regards,

[redacted]
Senior Civil Engineer
Pacific Gas & Electric Company
Diablo Canyon Power Plant
[redacted]

From: [redacted]
Sent: Thursday, April 21, 2011 9:19 AM
To: [redacted]
Subject: NRC Request

Received this morning:
Request #40:
Please provide the return rates (and references) for the Jan 7th deterministic evaluation of Shoreline, Los Osos, San Luis Bay and Hosgri Faults.

When can you respond?

[redacted]
NRC Interface
Regulatory Services - Diablo Canyon, Pacific Gas & Electric Co.
Phone [redacted]
Diablo Canyon Power Plant, 9 Miles NW of Avila, Mail Stop 104/5/18b
Avila Beach, CA 93424
E-mail: [redacted]

From: Klimczak, Richard </O=PG&E/OU=CORPORATE/CN=RECIPIENTS/CN=RLK1>
Sent: Friday, April 29, 2011 9:17 AM
To: [redacted]
Cc: [redacted] Sharp, Loren <LDSL@PGE.COM>; [redacted] Post, Jennifer (Law) <JLKM@PGE.COM>
Subject: RE: Seismic fault frequency

[redacted]

My point is that the specification of a return period is not in our licensing basis, other than for DE. Appendix A, 10 CFR Part 100 has no return period requirement. If there is a licensing basis requirement for return period, it would be nice to know. Therefore, to characterize our faults via return period would just be additional information, but no relevance to our licensing basis (except for the DE).

Rich

-----Original Message-----
From: [redacted]
Sent: Thursday, April 28, 2011 11:25 AM
To: Klimczak, Richard
Cc: [redacted] Sharp, Loren; [redacted]
Subject: RE: Seismic fault frequency

They did not ask a question - just a data request.

Obviously a more frequent large ground motion events would be a new challenge for us. I expect they are looking to characterize the various faults as within life of plant, vs inactive fault (or somewhere in between). Christie is on her last week here and would appreciate the input

They are not interested in the DE return period - they are interested in the return period of the Shoreline, reforecast Los Osos, San Luis Bay, etc which were in the Shoreline final report as being on par with the reforecast HOSGRI

[redacted]
Regulatory Services Manager
Diablo Canyon Power Plant

[redacted]

-----Original Message-----
From: Klimczak, Richard
Sent: Thursday, April 28, 2011 7:29 AM
To: [redacted]
Cc: Sharp, Loren; [redacted]
Subject: RE: Seismic fault frequency

[redacted]

Is the request to see how the return period for the subject faults compare to the 275 years for DE? The DE return period is in a PG&E docketed letter to the NRC and in an SSER 7 response as 275 years. Is the question

whether we have to consider them as the OBE?

Rich

-----Original Message-----
From: Sharp, Loren
Sent: Thursday, April 28, 2011 7:19 AM
To: [redacted]
Cc: Klimczak, Richard; [redacted]
Subject: FW: Seismic fault frequency

[redacted] Please provide the requested response for the DCPP to review prior to providing to NRC.

Loren

-----Original Message-----
From: [redacted]
Sent: Wednesday, April 27, 2011 6:28 PM
To: Sharp, Loren
Subject: Seismic fault frequency

Loren
NRC has requested return period or annual probability of the major quakes provided in the shoreline final report. Can you please provide?
Once Per 275 yrs or less frequent is best Los Osos San Luis bay. Shoreline etc [redacted]

From: [redacted]
Sent: Friday, April 29, 2011 10:45 AM
To: Sharp, Loren <LDSL@PGE.COM>
Subject: Re: Seismic fault frequency

Loren, I'm sure [redacted] will explain this, in fact I believe he already rephrased the question asked by Peck, but "recurrence" is associated with a certain magnitude earthquake happening, and "return period" is associated with the ground motion (from a grond motion hazard curve, usually expressed as a probability of exceedance). In a (deterministic case) M7.5 EQ on the Hosgri, we look at the 84th percentile ground motions, per NRC regs. [redacted]

----- Original Message -----
From: Sharp, Loren
Sent: Friday, April 29, 2011 07:57 AM To: [redacted]
Cc: [redacted]
Subject: FW: Seismic fault frequency

fyi
-----Original Message-----
From: Klimczak, Richard
Sent: Friday, April 29, 2011 7:17 AM
To: [redacted]
Cc: [redacted] Post, Jennifer (Law)
Subject: RE: Seismic fault frequency

[redacted]

My point is that the specification of a return period is not in our licensing basis, other than for DE. Appendix A, 10 CFR Part 100 has no return period requirement. If there is a licensing basis requirement for return period, it would be nice to know. Therefore, to characterize our faults via return period would just be additional information, but no relevance to our licensing basis (except for the DE).

Rich

-----Original Message-----
From: [redacted]
Sent: Thursday, April 28, 2011 11:25 AM
To: Klimczak, Richard
Cc: [redacted] Sharp, Loren; [redacted]
Subject: RE: Seismic fault frequency

They did not ask a question - just a data request.

Obviously a more frequent large ground motion events would be a new challenge for us. I expect they are looking to characterize the various faults as within life of plant, vs inactive fault (or somewhere in between). Christie is on her last week here and would appreciate the input

They are not interested in the DE return period - they are interested in the return period of the Shoreline, reforecast Los Osos, San Luis Bay, etc which were in the Shoreline final report as being on par with the reforecast HOSGRI

[redacted]
Regulatory Services Manager
Diablo Canyon Power Plant

[redacted]

-----Original Message-----
From: Klimczak, Richard
Sent: Thursday, April 28, 2011 7:29 AM
To: [redacted]
Cc: Sharp, Loren; [redacted]
Subject: RE: Seismic fault frequency

[redacted]

Is the request to see how the return period for the subject faults compare to the 275 years for DE? The DE return period is in a PG&E docketed letter to the NRC and in an SSER 7 response as 275 years. Is the question whether we have to consider them as the OBE?

Rich

-----Original Message-----
From: Sharp, Loren
Sent: Thursday, April 28, 2011 7:19 AM
To: [redacted]
Cc: Klimczak, Richard; [redacted]
Subject: FW: Seismic fault frequency

[redacted] Please provide the requested response for the DCPP to review prior to providing to NRC.

Loren

-----Original Message-----
From: [redacted]
Sent: Wednesday, April 27, 2011 6:28 PM
To: Sharp, Loren
Subject: Seismic fault frequency

Loren
NRC has requested return period or annual probability of the major quakes provided in the shoreline final report. Can you please provide?
Once Per 275 yrs or less frequent is best Los Osos San Luis bay. Shoreline etc [redacted]

From: Klimczak, Richard </O=PG&E/OU=CORPORATE/CN=RECIPIENTS/CN=RLK1>
Sent: Monday, May 30, 2011 9:05 AM
To: [redacted]
Cc: Sharp, Loren; [redacted]
Subject: FW: SRI Comments on phone call

Norm,

We can now see how [redacted] intends to use the frequency of occurrence information. Is there a regulatory document that differentiates fault activity for determination of the SSE? I am not aware of one.

Rich

>_____
>From: [redacted]
>Sent: Sunday, May 29, 2011 3:05 PM
>To: Klimczak, Richard; Sharp, Loren
>Cc: [redacted]Peters, Kenneth
>Subject: SRI Comments on phone call
>Sensitivity: Confidential
>
>All
>Following is for consideration on LAR framing and determining need for public meeting.
>
>NRC SRI asked (today) where, if anywhere, PG&E has ever made a statement that the HE is our SSE. The SRI stated he had not found that in any of our submittals or our internal documentation. Our operability (50086062-30) references the NRC SER vs PG&E statement.
>
>NRC SRI also pointed out PG&E did not commit to change the design basis when we submitted additional analyses as documented in the HE report, App F. If we cannot find something where PG&E takes the position that HE=SSE we will continue to get challenged on our statement that no degraded/non-conforming condition exists - the SRI will keep opining that we needed to compare against our SSE and show that our SSE bounds.
>
>We can also expect that our LAR request to clarify HE=SSE may get some new challenge by NRR staff depending on return rate if the new events are more frequent than HE. However, based on what I have heard, our only vulnerability is really just with the structures. SRI implies that the more frequent Shoreline would not get the same accommodation as HE and staff would require separate analysis. Our previous discussions that conclude HE is a realistic analysis would allow NRR staff to conclude that the HE was not accommodations and that HE is therefore a realistic bounding analysis. I would also respond to SRI contention by pointing out our proposed method explicitly addresses the frequency of occurrence in determining an overall risk.
>
>SRI could be expected to advocate that higher damping was only appropriate for larger earthquakes and is therefore not applicable to smaller events (particularly the 7% damping allowed for structures). I would counter that RG 1.61 Rev 1 provides staff position that it IS appropriate to apply the 7% damping for the DDE. RG 1.61 provides separate guidance on OBE vs SSE. Since our DDE is greater than most plants SSE I would say it is incorrect to suggest that the higher damping values are inappropriate for DDE use.
>
>For our operability determination the position we took previously that LTSP is a licensing basis commitment that we appropriately applied to determine Shoreline was bounded remains our best defense (unless we can find where we requirement
>
>[redacted]
>
>_____
>From: Klimczak, Richard

>Sent: Friday, May 27, 2011 10:48 PM
>To: Sharp, Loren
>Cc: [redacted] Peters, Kenneth
>Subject: RE: Phone call with NRC
>Sensitivity: Confidential
>
>Loren,
>
>Per our conversation I understand that we need to consider submitting the LTSP LAR as is or split apart the LTSP LAR and make the HE/SSE a separate LAR.
>
>Points about why we constructed the LTSP LAR the way we did:
>* Uses existing LTSP process, with additions to address exceedances and how they are handled and the ability to use latest advancements for the development of GMRS, spectral shapes, fragilities and hazard curves.>
>* Supports why this process is technically justifiable. The 1991 LTSP GMRS is enveloped by the 1977 HE GMRS. The HE produces the largest vibratory ground motion that the plant is designed (definition of a SSE in part 100).
>* Since our FSAR states the DDE is the SSE we decided to change the FSAR to state the HE is the SSE in agreement with SSERs and ASLB and ACRS meeting minutes. As well as GDC 2, SG 1.29 and 10CFR100 Appendix A definitions.>
>* The LTSP process fits with GI-199 where the NRC requires new GMRS be compared to the SSE.
>* Clearly states that new seismic information does not require re-evaluation of the DE and DDE. Provides explanation that they are historical and SSCs qualified to them were done with conservative methodologies for that time period.
>* Clarifies the list of SSCs that impact SCDF
>* Removes the SSE designation from the DDE as it does not meet the definition of a SSE in the regulatory documents. Also, eliminates confusion if we have two SSEs.
>
>If we removed the HE is the SSE from our LTSP LAR there would leave the issue with the DDE is the SSE but, our largest vibratory ground motion is the HE:
>* Our process would be based on comparison to the LTSP which envelopes the DDE, the SSE
>* We would be in conflict with the GI-199 process that requires comparison to the SSE
>* It would call into question the logic for why our LTSP process does not require addressing impact on the DDE
>
>My recommendation is to submit the LTSP LAR as is. If it requires a public meeting, so be it. The meeting would be about the new element, the change to designating the HE as the SSE in our FSAR.
>
>I can also support splitting the HE is the SSE out, but we would need to submit the HE is the SSE LAR close behind the LTSP LAR. I believe the HE/SSE LAR would still require a public meeting.
>
>Rich
>_____
>From: [redacted]
>Sent: Friday, May 27, 2011 4:07 PM
>To: Klimczak, Richard
>Cc: Sharp, Loren
>Subject: RE: Phone call with NRC
>
>Rich,
>
>The NRC's confusion is coming from what they are hearing from [redacted] and CLB inconsistencies for the shutdown flowpath and LOCA load requirements. The discussions started to go into technical topics and [redacted] would rein those in stating that the technical discussion has to occur in a public meeting. But [redacted] did a good job of emphasizing the analyses and qualifications that were done for [redacted] before [redacted] would pull the conversation back to process. [redacted] from the NRC also talked a little while about how NEI is going through an initiative to lay out a standard expectation for pre-licensing meetings on complex submittals to help improve the NRC's understanding of what will be submitted and therefore cut down on the number of RAIs and improve review times. [redacted] re-iterated that they will receive anything that PG&E wishes to submit and they will follow their standard acceptance and review process.
>
>A couple of the technical topics that were discussed briefly were from [redacted] asked if HE were to become the SSE, which "earthquakes" would we design to. [redacted] asked if HE became the SSE would we have two SSEs and then went into the argument that HE can not be your only SSE because it is not always the

limiting one.
>
>[redacted] and maybe someone else from the NRC, stated that they are not necessarily opposed to what we are proposing, but that the "significant scope change" of defining HE as the SSE was a surprise. The NRC seemed to be in alignment with being ready to receive an LAR containing a request to define the LTSP evaluation method for new seismic information and clarification to ongoing commitments for LTSP.
>
>[redacted]
>
>Regulatory Services - DCPP
>Office - 805.545.6984
>Cell - 805.459.3701
>
>
>_____
>From: Sharp, Loren
>Sent: Friday, May 27, 2011 12:10 PM
>To: Klimczak, Richard
>Cc: [redacted]
>Subject: FW: Phone call with NRC
>Importance: High
>
>Rich, Phone call went pretty well in that I was able to reiterate several times that we do indeed have more than one analyzed, reviewed and accepted safe shutdown path and reiterated most of the points in our email at least at a bullet level to demonstrate we are not making a drastic change. Clearly they are struggling under the false impression provided by [redacted] They are willing to consider and process a LAR that we might submit but clearly they want us to have a public meeting so they understand what we are asking for and the issues associated with the HE to SSE change. I committed to Peters to have a discussion with you tonight. Ken is leaning toward removing> the HE is Sse portion from the LAR and submitting it in a separate LAR in parallel or after a public meeting on that subject. Real question is how does it affect your world if we implement separately. [redacted] is willing to consider either option of separating them or leaving them together but option he will likely pick is no public meeting to submit a LAR and then either submit another one later or not at all. Call me on my cell when you want to talk tonight.
>
>[redacted] If you can summarize any more detail of discussion for Rich that would be helpful.
>
>Loren
>
>_____
>From: [redacted]
>Sent: Friday, May 27, 2011 11:06 AM
>To: [redacted] R; Sharp, Loren
>Cc: [redacted]
>Subject: RE: Phone call with NRC
>
>
>[redacted] and Loren:
>
>I didn't say anthing during the call as they did not want to discuss the technical issues and details in a non-public meeting, but it sounds like the NRC is not sure what we mean by changing the SSE from the DDE to the 1977 Hosgri. Loren explained this several times, but this may be what would be useful to discuss in a public meeting.
>
>I think that part of the reason for the confusion is that we are saying that we will continue to require SSCs to meet the DDE with its old methods even though we are calling the 1977 Hosgri the new SSE. So it looks like we have two SSEs (as asked by Peck). If we are still checking against the DDE, then why are we making the change? As I understand it, we are saying the the 1977 Hosgri ground motion is our only SSE, but we will continue to check against the old DDE so that there is no reduction in the requirements from the original licensing basis. This is a source of conservatism due to the use of out-dated methods of structural analysis.
>
>I think that the main effect of the change will be in that we use the 1977 Hosgri ground motion to check against new earthquake information. This makes sense because it is our largest ground motion for which the plant has been qualified.
>
>I am continuing to think about how this fits with GI-199 as the NRC staff will have to reconcile any differences in the

approaches. I think the reason that there has not been an issue with operability of the eastern plants is that they have never tried to recompute the SSE based on the new earthquake information. The reason for this is that the methods used to develop the SSE ground motion for the eastern plants is so out of date that it makes no sense to try to apply it today (this is the same problem we have with the DDE). Instead, the NRC proposed to compare the SSE to what you would get if you designed a new plant today (e.g. using GMRS based on RG1.208). The staff prefers the probabilistic approach used in RG1.208 and is much more confortable with those values as compared to deterministic approaches.
>
>If the GMRS exceeds the SSE, they don't say that the SSE needs to be revised because the GMRS is for new plants. Instead, they go to PRA to check what are the main contributors to risk and what can be done to reduce those risks, considering the cost-benefit of any modifications.
>
>If we wanted to join the GI-199 method, we would compare our SSE (either the DDE or 1977 Hosgri) to a GMRS. Then, if there is an exceedance, we would follow the GI-199 method and use the PRA results to identify main contributors to risk and the the cost-benefoot of plant modifications to the reduce the this. There are two advantage to this method that I see. First, using a GMRS based on RG1.208, there is no single magnitude that is considered. It is a probabilistically based and focuses on the ground motion level. This gets us away for this issue about what earthquake magnitude DCPP is design for. Second, it does not create a new estimate of the SSE for DCPP because it only compares the current design ground motion to what the design ground motion would be for a new plant. The SSE stays unchanged.
>
[redacted]
>
>
>
>
>
>
>
>

From: Soenen, Philippe R </O=PG&E/OU=CORPORATE/CN=RECIPIENTS/CN=PNS3>
Sent: Friday, April 27, 2012 6:42 PM
To: Summy, Jeff <J51D@pge.com>; [redacted] Klimczak, Richard <RLK1@pge.com>; [redacted] Strickland, L Jearl <LJS2@pge.com>; Post, Jennifer (Law) <JLKm@pge.com>; [redacted]
Cc: [redacted]
Subject: Update on Seismic RIL

During a briefing on the Seismic LAR withdrawal letter with [redacted] and resident inspectors [redacted] and [redacted] the NRC identified that there may be additional delays in the issuance of the research information letter and cover letter (RIL). The NRC identified the potential for additional delay in issuance of the RIL when it was discussed that PG&E anticipated the issuance of the RIL to address continued operability of DCPP regarding the Shoreline Fault. The NRC discussed that the RIL had focused almost completely on the Shoreline Fault and originally did not address the additional fault spectra that were identified in the Final Shoreline Fault Report that exceed the double design earthquake but are bounded by the 1977 Hosgri Earthquake. The NRC is determining the path forward with the RIL and how to address the additional spectra in the Final Shoreline Fault Report.

The NRC is currently considering the following three options with the RIL:

1) Determine if the Final Shoreline Fault Report contains enough information on the additional faults so that research can continue its evaluation with the available information and issue the RIL after it makes a conclusion.
2) Request additional information from PG&E for the additional faults and then issue the RIL after it makes a conclusion.
3) Revise the current version of the RIL to provide a path to address the additional faults as part of 50.54(f).

No timeframes for NRC determinations or issuance dates were provided by the NRC.

[redacted]

[redacted]

From: Summy, Jeff </O=PG&E/OU=CORPORATE/CN=RECIPIENTS/CN=J51D>
Sent: Saturday, April 28, 2012 1:43 PM
To: [redacted] Klimczak, Richard <RLK1@pge.com>; [redacted] Strickland, L Jearl <LJS2@pge.com>; Post, Jennifer (Law) <JLKm@pge.com>; [redacted]
Cc: [redacted]
Subject: RE: Update on Seismic RIL

[redacted]
Thanks for the update. Doesn't the NRC have metrics for timeliness of dealing with LAR submittals? Are they concerned with that aspect since we do not intend to withdraw our LAR until we have the RIL.
Jeff S

From: [redacted]
Sent: Friday, April 27, 2012 4:42 PM
To: Summy, Jeff; [redacted] Klimczak, Richard; [redacted] Strickland, L Jearl; Post, Jennifer (Law); [redacted]
Cc: [redacted]
Subject: Update on Seismic RIL

During a briefing on the Seismic LAR withdrawal letter with [redacted] and resident inspectors [redacted] and [redacted] the NRC identified that there may be additional delays in the issuance of the research information letter and cover letter (RIL). The NRC identified the potential for additional delay in issuance of the RIL when it was discussed that PG&E anticipated the issuance of the RIL to address continued operability of DCPP regarding the Shoreline Fault. The NRC discussed that the RIL had focused almost completely on the Shoreline Fault and originally did not address the additional fault spectra that were identified in the Final Shoreline Fault Report that exceed the double design earthquake but are bounded by the 1977 Hosgri Earthquake. The NRC is determining the path forward with the RIL and how to address the additional spectra in the Final Shoreline Fault Report.

The NRC is currently considering the following three options with the RIL:

1) Determine if the Final Shoreline Fault Report contains enough information on the additional faults so that research can continue its evaluation with the available information and issue the RIL after it makes a conclusion.
2) Request additional information from PG&E for the additional faults and then issue the RIL after it makes a conclusion.
3) Revise the current version of the RIL to provide a path to address the additional faults as part of 50.54(f).

No timeframes for NRC determinations or issuance dates were provided by the NRC.

[redacted]

[redacted]

From: [redacted]
</O=PG&E/OU=CORPORATE/CN=RECIPIENTS/CN=TRB1>
Sent: Thursday, October 4, 2012 9:06 PM
To: [redacted]
Cc:
Subject: 50426106 to LBVP

Guys
I reassigned above SAPN from [redacted] to LBVP to correct the HE depiction in FSAR 3.7.6

Telecon with NRR today concluded they will send the Shoreline RIL and transmittal on 10/12/12, and it will conclude Shoreline is a subset (aspect?) of the Hosgri and enveloped by HE GMRS, and accordingly DCPP remains operable. It also tells us to update our FSAR with the information in accordance with 50.71(e). We expect that this will allow complete resolution of the Shoreline fault non-conforming condition

The transmittal maintains that our SSE remains the DDE

[redacted]

[redacted]

From: [redacted]
Sent: Wednesday, October 10, 2012 1:21 PM
To: Post, Jennifer (Law) <JLKm@pge.com>
Subject: RE: REVIEW REQUEST - NRC Shoreline Report

We have not seen a draft of the RIL. There was a phone call with the NRC last Thursday to discuss what the RIL and cover letter will contain. It will state that the shoreline is a more limiting condition than what has been previously analyzed. That the Fukushima 50.54(f) process address what to do with new seismic information. These will make it possible to withdraw the LAR citing the existence of the 50.54(f) process the LAR is no longer required and be able to update the FSAR to include the Shoreline Fault.

The NRC also discussed that the associated TIA is not consistent with the current requirements and that they are going through the process for revision/retracting the TIA.

[redacted]

From: Post, Jennifer (Law)
Sent: Wednesday, October 10, 2012 11:09 AM
To: [redacted]
Subject: Fwd: REVIEW REQUEST - NRC Shoreline Report

Please forward any info we have on th RIL.

Sent from my iPhone

Begin forwarded message:

> **From:** "Post, Jennifer (Law)" <JLKm@pge.com>
> **Date:** October 10, 2012 10:53:53 AM PDT
> **To:** [redacted]
> **Cc:** [redacted]
> **Subject: Fwd: REVIEW REQUEST - NRC Shoreline Report**
>
> We've seen the RIL? Please forward to me.
>
> Sent from my iPhone
>
> Begin forwarded message:
>
> > **From:** "[redacted]
> > **Date:** October 10, 2012 10:34:44 AM PDT
> > **To:** "Jones, Thomas G&PR" <TPJ2@pge.com>, [redacted]
> > "Post, Jennifer (Law)" <JLKm@pge.com>
> > **Cc:** [redacted]
> > **Subject: REVIEW REQUEST - NRC Shoreline Report**
> >
> > [redacted]/Jennifer –
> >
> > Please see the attached draft statement/tps/Faq on the NRC's report regarding the Shoreline fault due to come out on Friday.
> >
> > Appreciate any guidance/comments/feedback you have.
> >
> > [redacted]

From: [redacted]
</O=PG&E/OU=CORPORATE/CN=RECIPIENTS/CN=TRB1>
Sent: Wednesday, October 17, 2012 3:43 PM
To: Halpin, Ed <E1H8@pge.com>
Cc: Summy, Jeff <J51D@pge.com>; Klimczak, Richard <RLK1@pge.com>
Subject: FW: seismic nrc violation Non-Concurrence Package

Ed
Per your request, the following ties the violation, the nonconcurrence and the RIL. I would further reduce detail if you intend to use this as a public document.

[redacted]
Regulatory Services Manager
Diablo Canyon Power Plant

[redacted]

The DCPP seismic licensing basis is comprised of the Design Earthquake (DE), Double DE (DDE) and Hosgri Earthquake (HE). Each have specific analysis methodologies and acceptance criteria. An additional methodology, the Long Term Seismic Program (LTSP) was developed by PG&E to satisfy a license condition, was maintained as a license commitment, but was never made part of the plant seismic licensing basis.

PG&E initially compared the expected Shoreline ground motion to the LTSP spectra per our license commitment and concluded Shoreline was bounded by LTSP and did not represent a degraded/unanalyzed/nonconforming condition. After NRC prompting that the LTSP was not licensing basis, PG&E compared the Shoreline ground motion to the DE, DDE and HE ground motion and concluded that the new Shoreline was bounded by the 1977 HE. PG&E documented this in a prompt operability assessment (POA) and concluded it provided a reasonable expectation that plant equipment would remain operable following a Shoreline event.

Dr Peck objected to this conclusion. He opined that the Shoreline ground motion required evaluation using each of the DE, DDE and HE methodologies and acceptance criteria. He had high confidence that using the DDE methods would conclude that equipment would not meet acceptance criteria and be declared inoperable. The NRC disagreed with his opinion and issued PG&E a violation for not initially performing an operability assessment. This violation resulted in Dr Peck's nonconcurrence.

PG&E, seeing no clear standard for assessing new seismic information relative to the three specific analysis methodologies and acceptance criteria, concluded that resolution would require a license amendment to establish a process for reviewing and incorporating new seismic information into the licensing bases. A license amendment was submitted October 2011 to the NRC to establish this new process.

On October 12, 2012, the NRC published their assessment of the Shoreline fault (the RIL). NRR summarized the RIL in a letter that included the NRR conclusion that the Shoreline represented a lesser included case under the 1977 Hosgri evaluation that should be incorporated into the FSAR in accordance with 10 CFR 50.71(e).

The NRR statement that Shoreline is a lesser included case of the Hosgri evaluation effectively

directs PG&E to apply the Hosgri analysis methodologies and acceptance criteria to the Shoreline faults. This clarifies, at least for the Shoreline fault, which of our three seismic licensing bases are applicable to Shoreline.

From: Halpin, Ed
Sent: Monday, October 15, 2012 1:15 PM
To: Summy, Jeff; Klimczak, Richard; [redacted]
Subject: FW: seismic nrc violation Non-Concurrence Package

Is there a way to boil down the RIL and the non-concurrence report made by Dr. Peck as to clearly explain, succinctly and in an understandable manner, what transpired with the Shoreline fault and this violation?

Thanks

Ed

From: Conway, John
Sent: Monday, October 15, 2012 11:08 AM
To: Halpin, Ed
Cc: Manheim, William (Law); Post, Jennifer (Law); Summy, Jeff
Subject: FW: seismic nrc violation Non-Concurrence Package

Ed, this makes for some very interesting reading. I suggest you share it with the NSOC members if you have not already done so. It helps put the RIL in more clear context?

John T. Conway
Office: 415-973-3336
Cell: 805-801-5821

From: Klimczak, Richard
Sent: Monday, October 15, 2012 8:11 AM
To: Conway, John
Subject: FW: seismic nrc violation Non-Concurrence Package

John,

FYI. NRC Non-Concurrence Documents provided by Region IV Branch Chief, Neil O'Keefe to [redacted]

Rich

From: [redacted]
Sent: Friday, October 12, 2012 5:40 AM
To: Post, Jennifer (Law); [redacted] Summy, Jeff; [redacted] Klimczak, Richard; [redacted]
Strickland, L Jearl
Subject: Fwd: seismic nrc violation Non-Concurrence Package

FYI and Awareness the attachments are regarding a disagreement within the nrc on the disposition of a DCPP violation from 4Q11. The NRC has not provided these via their automatic Email distribution services but they are available on the NRC Adams website. Questions could come up from public or news organizations.

Sent from my iPhone

Begin forwarded message:

> **From:** "OKeefe, Neil" <Neil.OKeefe@nrc.gov>
> **Date:** October 12, 2012, 5:00:24 AM PDT

To: [redacted]
Cc: "Micewski, Laura" <Laura.Micewski@nrc.gov>
Subject: Non-Concurrence Package

[redacted]

The attached documents are now publicly accessible in ADAMS, so I am sending you copies for your awareness. Feel free to share them with anyone you think should see them.

One is the non-concurrence document and the associated answer, while the other is a copy with my annotations explaining or discussing details raised in the first document that might confuse the public without the added details.

Neil O'Keefe
Chief, Projects Branch B, RIV
(o) (817) 200-1141
(c) (817) 917-5646

From: Post, Jennifer (Law) </O=PG&E/OU=CORPORATE/CN=RECIPIENTS/CN=JLKM>
Sent: Monday, October 22, 2012 5:24 PM
To: [redacted]
Subject: Re: Draft Submittal "Withdrawal of License Amendment Request 11-05, "Evaluation Process for New Seismic Information and Clarifying the Diablo Canyon Power Plant Safe Shutdown Earthquake""

Thanks.

Sent from my iPhone

On Oct 22, 2012, at 3:22 PM, [redacted] wrote:

The discussion was more on the steps to follow after the withdrawal of the LAR than on the letter itself. We want to discuss with the NRC our desire to incorporate the Shoreline, Los Osos, and San Luis Bay Faults into the FSAR, but want to make sure that was the intent of the RIL and cover letter, versus just the Shoreline Fault. This will potentially impact our ability to close the POA if we can only incorporate the Shoreline Fault. We also want to discuss the proposed revision to the TIA, as that may be another way of closing the POA if we cannot incorporate the Los Osos and San Luis Bay faults in the FSAR.

[redacted]

From: Post, Jennifer (Law)
Sent: Monday, October 22, 2012 3:18 PM
To: [redacted]
Subject: Re: Draft Submittal "Withdrawal of License Amendment Request 11-05, "Evaluation Process for New Seismic Information and Clarifying the Diablo Canyon Power Plant Safe Shutdown Earthquake""

[redacted]. I don't have any additional comments but I did miss the call this morning. Anything I should know?

Sent from my iPhone

On Oct 22, 2012, at 11:55 AM, "Soenen, Philippe R" <PNS3@pge.com> wrote:

All,

This is a reminder that comments are due today from all primary reviews.

Thank you,
[redacted]

From [redacted]
Sent: Thursday, October 18, 2012 8:42 AM
To: Klimczak, Richard; Summy, Jeff; [redacted] Post, Jennifer (Law)
Cc: [redacted] Allen, Barry; Halpin, Ed; [redacted] Jones, Thomas G&PR; [redacted]

Subject: Draft Submittal "Withdrawal of License Amendment Request 11-05, "Evaluation Process for New Seismic Information and Clarifying the Diablo Canyon Power Plant Safe Shutdown Earthquake""
Importance: High

A draft submittal is attached for your review. The NRC's Research Information Letter 12-01 and the associated cover letter are also attached for your information.

Action Plan:

1. Primary Reviewers:

Lead Technical Reviewer – Rich Klimczak
Lead Technical Director – Jeff Summy
Lead Technical Director – Jearl Strickland
Independent Technical Reviewers – [redacted]
Licensing Management – [redacted]
Lead Licensing Engineer – [redacted]
Legal – Jennifer Post

Comments and concurrence are due by **Monday October 22, 2012**. Your response is required.

2. Secondary Reviewers (all individuals cc'd on this e-mail):

Review the draft for information only. Your response is not required, however, if you have comments, provide them to the Lead Licensing Engineer by the above due date.

3. The following individuals have reviewed this draft: [redacted] Rich Klimczak, [redacted]

4. The designated Company signatory is: Barry Allen

5. The required submittal due date is: October 26, 2012

Thank you,

[redacted]

Appendix D

PG&E Call Report

Date: 12/15/11	**Subject**: Shoreline Fault Zone (SFZ) discussion with Neil O'Keefe	
Time: 0600 – 0715	**Location**: Building 201 conference room	**Confidential**? **Yes** ☐ **No** ☑

Attendees: Neil O'Keefe and Rick Deese (phone); Dr. Michael Peck, Jeff Summy, [redacted] and Steve David

Notes:

Following introductions, Steve started the meeting by explaining the reason for the call. Steve had called Neil on 12/07/11 to introduce himself and welcome Neil to his new role as the Branch Chief for DCPP. During the call, Neil commented that he had just concluded a three-hour meeting with Dr. Peck to get an update on the DCPP seismic status and a history of the issue. Based on some of Neil's comments, Steve had proposed that a phone call to allow PG&E to provide our perspective might be beneficial. Neil agreed, and PG&E scheduled the conference call.

Jeff added his comments about what we hoped to accomplish with this call and thanked Neil for his willingness to hear our input. Jeff turned it over to [redacted] to provide the detailed commentary.

[redacted] took us through the high-level seismic history of the station. See the timeline that follows.

DCPP Seismic History (Summary)	
1960s	DCPP Seismic Design to "DE" for 0.2g (pga) and "DDE" for 0.4g (pga)
1968, 1970	Construction Permits U1 & U2
1971	Discussions of Hosgri come to light
1973	OL review began
Oct. 1974	SER issued. NRC found the Design acceptable (Except seismic qualification of electrical equipment)
Dec. 6, 1974	NRC requested seismic reevaluation (to normalized 0.5g) based on preliminary Hosgri fault's potential.
Dec. 27, 1974	PG&E responded to request for 0.5g reevaluation using a simplified approach. NRC found the simplified approach adequate for 0.g conditions (Subject to resolution of electrical equipment)
Jan 1975	USGS stated that 0.5g is would not be adequate for Hosgri fault
April 1976	NRC completed Independent review of Hosgri Fault. NRC consultant Dr. Newmark's review recommended GMRS with pga of 0.75g (associated with 7.5 Magnitude earthquake on Hosgri fault). NRC again asked PG&E to reevaluate based on new spectra,
Jan 1977	Amendment 50 to OL; Hosgri report (extensive 6 volume report on the reanalysis) was submitted. It was subsequently revised and expanded by Amendments 53, 54, 56,59,60,62,64,66,68,70,72,75,76,77,79,82 ad 83.
1978	SSER 7 and SSER 8 discuss Hosgri evaluation
78-84	ASLB and ASLAB Public hearings
1984, 1985	OL U1 and U-2 granted. U-1 was conditional to reassess Engineering and equipment response and to perform PRA and deterministic evaluations as required.
1985-1988	PG&E formed LTSP and responded to the NRC
1991	SSER 34 NRC accepted LTSP report and acknowledged PG&E commitment to continue to study earthquakes (regional) and further the science. PG&E maintains full time staff to study Geology and seismology of the DCPP region

Nov. 2008	In Cooperation with USGS, PG&E reported discovery of new potential seismic lineament; which was later labeled as "Shoreline Fault Zone.
Nov. 2008	The issue was entered in CAP, with IOD based on comparison to LTSP program and Hosgri GMRS.
2/2009	NRC Independent Study concurs that plant is safe to operate
Dec. 2010	CAP updated to document the Applicability of LTSP process for evaluation of new seismic information
Jan.2011	P&E issued Final Shoreline Fault Zone report.
6/2011	POA was initiated as a conservative measure on the advice of NSOC. POA addressed impact on CLB (DE, DDE, HE)
8/2011	NRC issued a TIA stating that use of LTSP process is not appropriate and impact on CLB (DE, DDE & HE) need to be addressed.
8/2011 - 10/2011	DCPP solicited Independent reviews of the POA from internal and external Subject Matter Experts: Ellis Merschoff Pete LeBlond Roger Walker Excel Corporation
10/21/2011	POA was updated based on comments by the reviewers. The comments did not change the conclusions and added greater detail for clarity.

At the conclusion of [redacted]s presentation, Neil thanked [redacted] for a good overview. He said that he learned a few new pieces of information from the presentation. Neil commented that the updated POA that he reviewed was a well-written POA, smooth and easy to follow. He said that it was good to break out the attachments and have them included separately. He generally agreed with the conclusions.

[redacted] described again that the POA was meant to provide a reasonable assurance of operability. When PG&E discovered the Hosgri fault, we did not go back and change or evaluate to the DE and DDE. For the Shoreline Fault Zone, we are following the same process that we used for the Hosgri evaluation. This use of alternate methodology is acceptable per inspection manual 9900 (Section C4) . It was pointed out that none of the elements that went into creating a "design spectra" for DDE was affected by discovery of SFZ. DDE was termed as a hypothetical design curve to gain margin during design. The methodology used for DE/DDE are entirely different (perhaps not peer reviewable) than new SFZ. The primary concern is the shaking at the site regardless of what earthquake it's associated with.

Dr. Peck provided a clarification on the DE, DDE, and the time histories associated with the four events that were used as the basis for DE. He said that the DDE was not a completely hypothetical earthquake.

Neil asked why PG&E doesn't want to plug the SFZ values into the DDE analysis. Now that we have answered the technical question (POA), we need to address the legal question (TIA). We need to provide a technical basis for why we can't apply the Shoreline fault the same way we did DDE. Neil then asked us if there is any technical reason for leaving the DDE in the design basis. He stated that we had done a good job with the LAR of cleaning up the loose ends, but his advice

is that we eliminate the DDE as our safe shutdown earthquake for our licensing basis. His opinion is that by leaving it in, it appears as if we are covering something up. We need to be able to tell a simple story for people to be able to understand, and the simple story won't stand on its own if we leave the DDE in. We should be using the DE to show that we can continue to operate and the Hosgri using the latest technology for safe shutdown.

Neil's greatest concern, and criticism of the POA, is that we cannot provide a good argument for why the analysis using the DDE can't be done. We don't make the argument for why it should be removed completely, but that's what we need to do, in Neil's opinion. He made the comment that it is better to be legally clean than legally correct but confusing (and added that both have to be technically correct). He strongly cautioned us that we had better be able to demonstrate (through reviewable evidence such as calculations) all safety related seismically qualified components are qualified for Hosgri.

Neil talked about enforcement actions. He wants to close this issue out in the fourth quarter report and stated that he will be on site for the exit meeting on 01/04/12. He said that he will arrive on site about 1530 on Tuesday and will be here all day Wednesday and Thursday. Neil's concern was not particularly with the POA; he is asking why the POA was not requested in January when we issued the SFZ report.

Following the call, Jeff, [redacted], and Steve had some additional discussion with Dr. Peck. Michael continues to stress his view that PG&E cannot use the alternate analysis method that we used in the updated POA. If he is correct, and we can't use that approach, we have to apply Shoreline using the DDE approach. That would almost certainly result in exceeding code allowable limits that would require us to get NRC approval to continue to operate both units.

He also made a comment, which is the first time we had heard this, that he has looked at the 100 year curves and he thinks he sees some that would exceed OBE, implying that they must be worse than DE earthquake.

Note: Neil O'Keefe's phone number is 817.860.8137. This may change after the move to the new NRC offices is complete, at which time Neil indicated he might end up with Geoff's old number, 817.860.8141.

Appendix E

A4NR Correspondence With NRC Chair

ALLIANCE FOR NUCLEAR RESPONSIBILITY

PO Box 1328
San Luis Obispo, CA 93406
(858) 337-2703
(805) 704-1810
www.a4nr.org

November 13, 2012

Dr. Allison Macfarlane, Chair
United States Nuclear Regulatory Commission
11555 Rockville Pike
Rockville, MD 20852

Re: Research Information Letter 12-01 -- Confirmatory Analysis of Seismic Hazard at the Diablo Canyon Power Plant from the Shoreline Fault Zone ("RIL 12-01")

Dear Dr. Macfarlane:

The Alliance for Nuclear Responsibility ("A4NR") wishes to alert you to three inexcusable deficiencies in the above-captioned report and to register our objection to the misleading press release ("ADDITIONAL NRC ANALYSIS CONFIRMS EARTHQUAKE SAFETY AT DIABLO CANYON NUCLEAR POWER PLANT" – No. 12-112, October 12, 2012) that accompanied it. That these efforts have allowed an ongoing violation of the Diablo Canyon license to remain uncorrected–-a violation first reported by NRC regional staff more than a year ago—is inexplicable.

Deficiency 1. It has now been more than 15 months since the NRC regional staff's extraordinary written rebuke to PG&E for its truncated evaluation of new seismic information concerning the 2008 discovery of the Shoreline Fault, located some 600 meters from the reactors at Diablo Canyon. The August 1, 2011 memorandum from Region IV minced no words:

- *Although the LTSP margin analysis demonstrated that the new Shoreline Fault Zone information was bounded by the Hosgri Event, the licensee didn't evaluate the new seismic information against the other two design basis earthquakes, the Design Earthquake and the Double Design Earthquake.*

- *... the plant safety analyses concluded that seismic qualification for certain structures, systems and components was more limiting for the Design Earthquake and Double Design earthquakes than for the Hosgri Event.*

- *New seismic information developed by the licensee is required to be evaluated against all three of the seismic design basis earthquakes and the assumptions used in the supporting safety analysis ... Comparison to the LTSP by itself is not sufficient to meet this requirement.*[1]

RIL 12-01 disingenuously attempts to focus attention on the larger vibratory ground motion assumed for the Hosgri design basis earthquake ("HE"), but ignores the significantly tougher damping assumptions required for the Design Earthquake ("DE") test and the Double Design Earthquake ("DDE") test. The magnitude of these differences is identified in the table included in Section 3.7.1.3 of Diablo Canyon's Final Safety Analysis Report Update:

Type of Structure	% of Critical Damping		
	DE	DDE	HE
Containment structures and all internal concrete structures	2.0	5.0	7.0
Other conventionally reinforced concrete structures above ground, such as shear walls or rigid frames	5.0	5.0	7.0
Welded structural steel assemblies	1.0	1.0	4.0
Bolted or riveted steel assemblies	2.0	2.0	7.0
Mechanical components (PG&E purchased)	2.0	2.0	4.0
Vital piping systems (except reactor coolant loop)	0.5	0.5	3.0
Reactor coolant loop	1.0	1.0	4.0
Replacement Steam Generators	2.0	4.0	4.0
Integrated Head Assembly	4.0	6.85	6.85
CRDMs (Unit 2)	3.0	4.0	4.0
Foundation rocking (containment structure only)	5.0	5.0	NA

Omission of any discussion in RIL 12-01 of the tri-partite test requirements of the Diablo Canyon license arouses considerable suspicion. In light of the earlier staff criticism of PG&E's Shoreline Fault Zone assessment, this editorial sleight-of-hand verges on regulatory misconduct. What cannot be concealed is that PG&E has yet to produce the analysis of the Shoreline Fault required by the Diablo Canyon license.

Deficiency 2. Apparently convinced that indications on the surface of the sea floor are determinative of what occurs at seismogenic depth, RIL 12-01 buries its most significant analytic shortcut on page 35:

> *The NRC did not consider a scenario in which an earthquake on the Shoreline fault continues to rupture onto the Hosgri fault. Large earthquakes from simultaneous rupture on the two faults (i.e., those greater than M7) would produce large surface displacement, which are not evident in the geologic record. The NRC concludes that the lack of significant horizontal displacement across the Shoreline fault rules out the possibility of joint rupture.*

[1] Kriss M. Kennedy, NRC Director /RA/, Division of Reactor Projects, Region IV, "Task Interface Agreement (TIA) – Concurrence on Diablo Canyon Seismic Qualification Current Licensing and Design Basis (TIA 2011-010), August 1, 2011, accessible at http://pbadupws.nrc.gov/docs/ML1121/ML112130655.pdf

Rather than patronize you, a professional geologist, with A4NR's lay opinions about the current significance multi-fault rupture plays in understanding large earthquakes, let me simply reference Slide 22 from the presentation made at PG&E's SSHAC workshop last week by Dr. Jeanne Hardebeck[2], widely credited with having discovered the Shoreline Fault and repeatedly cited in RIL 12-01:

"Doesn't seem prudent to rule out a Shoreline-Hosgri joint rupture; Mmax≈7.2."

Deficiency 3. RIL 12-01 goes to some length in describing how the NRC staff assembled five scenarios for its deterministic seismic hazard assessment. The three middle scenarios were characterized as "found within the PG&E logic tree." Another (Scenario 1) established a lower, "aseismic" bound with a magnitude of M5.9. A fifth (Scenario 5) extended the Shoreline Fault southeast along a magnetic lineament "hypothesized as … representing the maximum permissible length" and established an upper bound with a magnitude of M6.9. Declaring simply that Scenario 5 "is not supported as well as other scenarios by the data", RIL 12-01 abruptly dismisses Scenario 5 as "speculative" and opts instead for a "a more realistic, though still conservative" M6.7 derived from Scenarios 3 and 4. A4NR finds this discussion highly conclusory and considers it peculiar that a range of M values was not fully analyzed. Given the larger concerns identified in Deficiency 1 and Deficiency 2 above, the aroma of reverse engineering is impossible to dispel.

A4NR has other concerns with RIL 12-01, particularly the degree to which the ground motion analysis is largely untethered from site-related data, but we are more troubled by the implied purpose of the report itself. What started with detection by regional NRC staff of PG&E's significant failure to analyze new seismic information (i.e., discovery of the Shoreline Fault Zone) in the manner required by the Diablo Canyon license, somehow transformed into a corner-cutting, eyes-averting minimization of risk – coronated with a celebratory press release. What message must this send to enforcement staff?

This unseemly cheerleading is unworthy of a regulatory agency aspiring to the confidence of Californians who depend upon the NRC for objective, thorough analysis. You may not have been in your position long enough to bear any direct responsibility for this disgrace, but surely you have some duty to correct it.

Sincerely,
/s/

Rochelle Becker
Executive Director

cc: U.S. Senator Dianne Feinstein
U.S. Senator Barbara Boxer
Congresswoman Lois Capps
California Energy Commission Chair Robert B. Weisenmiller

[2] Dr. Hardebeck is a USGS geophysicist and the recipient of the Presidential Early Career Award for Scientists and Engineers (2009), the James B. Macelwane Medal of the American Geophysical Union (2007), and the Charles F. Richter Early Career Award of the Seismological Society of America (2006).

ALLIANCE FOR NUCLEAR RESPONSIBILITY

PO Box 1328
San Luis Obispo, CA 93406
(858) 337-2703
(805) 704-1810
www.a4nr.org

July 26, 2012

Dr. Allison Macfarlane, Chair
United States Nuclear Regulatory Commission
11555 Rockville Pike
Rockville, MD 20852

Dear Dr. Macfarlane:

I want to congratulate you on your recent appointment and compliment your insightful testimony this week before the House Subcommittee on Environment and the Economy. Your professional grounding in geology fills a longstanding void among NRC members that is particularly meaningful to the Alliance for Nuclear Responsibility (A4NR).

As you may be aware, our exclusive focus is the two seismic outliers among the NRC's licensed reactor sites, Diablo Canyon and San Onofre.

It has now been one year since the NRC staff's extraordinary written rebuke to PG&E for blatant deficiencies in its evaluation of new seismic information concerning the 2008 discovery of the Shoreline Fault, located some 600 meters from the reactors at Diablo Canyon. The August 1, 2011 memorandum from Region IV minced no words:

- *Although the LTSP margin analysis demonstrated that the new Shoreline Fault Zone information was bounded by the Hosgri Event, the licensee didn't evaluate the new seismic information against the other two design basis earthquakes, the Design Earthquake and the Double Design Earthquake.*

- *… the plant safety analyses concluded that seismic qualification for certain structures, systems and components was more limiting for the Design Earthquake and Double Design earthquakes than for the Hosgri Event.*

- *New seismic information developed by the licensee is required to be evaluated against all three of the seismic design basis earthquakes and the assumptions used in the supporting safety analysis … Comparison to the LTSP by itself is not sufficient to meet this requirement.*[1]

[1] Kriss M. Kennedy, NRC Director /RA/, Division of Reactor Projects, Region IV, "Task Interface Agreement (TIA) – Concurrence on Diablo Canyon Seismic Qualification Current Licensing and Design Basis (TIA 2011-010), August 1, 2011, accessible at http://pbadupws.nrc.gov/docs/ML1121/ML112130655.pdf

A4NR has been particularly distressed that, when confronted with this license infraction less than five months after Fukushima, PG&E's instinctive response was to ignore the NRC's requirement for evaluation against the two more demanding elements of Diablo Canyon's license. Instead, the utility chose to quietly submit a License Amendment Request[2] to simply eliminate these more stringent tests.

As required by federal securities law, PG&E acknowledged the seriousness of this standoff with the NRC staff in its November 3, 2011, 10-Q filing with the Securities and Exchange Commission:

> *…in early August 2011, the NRC found that a report submitted by the Utility to the NRC on January 7, 2011 to provide updated seismological information did not conform to the requirement of the current Diablo Canyon operating license. On October 21, 2011, the Utility filed a request that the NRC amend the operating license to address this issue. If the NRC does not approve the request the Utility could be required to perform additional analyses of Diablo Canyon's seismic design which could indicate that modifications to Diablo Canyon would be required to address seismic design issues. The NRC could order the Utility to cease operations until the modifications were made or the Utility could voluntarily cease operations if it determined that the modifications were not economical or feasible.*[3]

The fourth quarter 2011 NRC onsite inspections at Diablo Canyon identified the same evaluative deficiency, albeit in the type of backsliding language A4NR has come to associate with the NRC's look-the-other-way oversight of the plant:

> *The inspectors determined that the licensee's failure to promptly evaluate the new seismic information against the plant design and licensing bases was a performance deficiency. The finding was more than minor because the performance deficiency was associated with the Mitigating Systems Cornerstone initial design control attribute and affected the cornerstone objective to ensure the availability, reliability, and capability of systems that respond to initiating events to prevent undesirable consequences. The senior reactor analyst evaluated the significance of the finding using a Phase 3 analysis because the inspectors were unable to confirm that the operability of plant systems was not impacted. The senior reactor analyst concluded that the finding was of very low risk significance (Green) because no significant change in overall core damage frequency resulted from the new seismic hazards. This finding had a cross-cutting aspect in the area of human performance associated with the decision-making component because the licensee used non-conservative assumptions in deciding not to evaluate the new seismic information against the current plant design and licensing bases [H.1.(b)] (Section 1R15.2).*[4]

More recently, the NRC staff has suggested to A4NR that the seismic evaluation process initiated for all licensees pursuant to 10 CFR 50.54(f) on March 12, 2012 raises "a possibility that PG&E

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[2] PG&E, "License Amendment Request 11-05, 'Evaluation Process for New Seismic Information and Clarifying the Diablo Canyon Power Plant Safe Shutdown Earthquake,'"October 20, 2011, accessible at http://pbadupws.nrc.gov/docs/ML1131/ML11312A166.pdf

[3] PG&E Corporation, Form 10-Q filing, November 3, 2011, p. 63.

[4] Neil O'Keefe, NRC Branch Chief, Project Branch B, Division of Reactor Projects, February 14, 2012, p. 5, accessible at http://pbadupws.nrc.gov/docs/ML1204/ML120450843.pdf

may withdraw the amendment."[5] This would be consistent with what a PG&E official admitted April 18, 2012 under cross-examination in a California Public Utilities Commission proceeding: "I believe it has a potential to provide a different mechanism for being able to address the points raised under the license amendment request. It may provide a path to rescind the license amendment."[6] The same PG&E official testified that the 50.54(f) process would extend the evaluation of a new seismic hazard by six years, or to March 12, 2018.[7]

A4NR is hopeful that you will quickly rectify this unconscionable situation. We doubt that PG&E has failed to evaluate the Shoreline Fault information against the two more demanding elements of the plant's seismic design basis, but find it quite plausible that the company would refuse to submit this analysis to the NRC because of dissatisfaction with the assessment. We are unable to evaluate the seriousness of this omission, and so are you, until PG&E is required to adhere to the terms of its license.

We ask that the NRC do so immediately.

Sincerely,

/s/

Rochelle Becker
Executive Director

cc: U.S. Senator Dianne Feinstein
U.S. Senator Barbara Boxer
Congresswoman Lois Capps
California Energy Commission Chair Robert B. Weisenmiller

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[5] Joseph Sebrosky, NRC Project Manager (Diablo Canyon Power Plant), Division of Operating Reactor Licensing, email to Rochelle Becker, A4NR Executive Director, May 24, 2012.
[6] Jearl Strickland, PG&E Director of Nuclear Projects, CPUC Transcript in A.10-01-014, April 18, 2012, p. 52.
[7] *Ibid.*, p. 53.

Appendix F

Dr. Jeanne Hardebeck Paper

Bulletin of the Seismological Society of America, Vol. 103, No. 1, pp. 447–462, February 2013, doi: 10.1785/0120120175

Geometry and Earthquake Potential of the Shoreline Fault, Central California

by Jeanne L. Hardebeck

Abstract The Shoreline fault is a vertical strike-slip fault running along the coastline near San Luis Obispo, California. Much is unknown about the Shoreline fault, including its slip rate and the details of its geometry. Here, I study the geometry of the Shoreline fault at seismogenic depth, as well as the adjacent section of the offshore Hosgri fault, using seismicity relocations and earthquake focal mechanisms. The Optimal Anisotropic Dynamic Clustering (OADC) algorithm (Ouillon *et al.*, 2008) is used to objectively identify the simplest planar fault geometry that fits all of the earthquakes to within their location uncertainty. The OADC results show that the Shoreline fault is a single continuous structure that connects to the Hosgri fault. Discontinuities smaller than about 1 km may be undetected, but would be too small to be barriers to earthquake rupture. The Hosgri fault dips steeply to the east, while the Shoreline fault is essentially vertical, so the Hosgri fault dips towards and under the Shoreline fault as the two faults approach their intersection. The focal mechanisms generally agree with pure right-lateral strike-slip on the OADC planes, but suggest a non-planar Hosgri fault or another structure underlying the northern Shoreline fault. The Shoreline fault most likely transfers strike-slip motion between the Hosgri fault and other faults of the Pacific–North America plate boundary system to the east. A hypothetical earthquake rupturing the entire known length of the Shoreline fault would have a moment magnitude of 6.4–6.8. A hypothetical earthquake rupturing the Shoreline fault and the section of the Hosgri fault north of the Hosgri–Shoreline junction would have a moment magnitude of 7.2–7.5.

Introduction

The Shoreline fault was first recognized by Hardebeck (2010), based on seismicity relocations, as a ~25-km-long, vertical, right-lateral, strike-slip fault running along the coastline near San Luis Obispo, California (Fig. 1). The surface trace of the Shoreline fault was later partially imaged as several scarps in high-resolution bathymetry (Nishenko *et al.*, 2010; Pacific Gas and Electric Company [PG&E], 2011). This fault contributes to the seismic hazard of San Luis Obispo, as well as that of nearby coastal areas that are particularly prone to liquefaction (e.g., Holzer *et al.*, 2005; Lowman, 2009). Additionally, the Shoreline fault runs within 1 km of the Diablo Canyon nuclear power plant. This fault is clearly seismically active, as it has produced approximately 50 recorded $M \leq 3.5$ earthquakes since 1987 (Hardebeck, 2010). In order to include the Shoreline fault in probabilistic seismic hazard assessments (e.g., Working Group on California Earthquake Probabilities [WGCEP], 2008), an estimate of the maximum plausible (or characteristic) earthquake magnitude and an estimate of the fault slip rate are required. The slip rate of the Shoreline fault is currently unknown.

The maximum plausible (or characteristic) earthquake magnitude can be estimated from the largest plausible fault rupture. However, the geometry of the Shoreline fault, and its potential for interaction with other faults, are currently debated. There is no consensus as to whether the Shoreline fault is segmented at seismogenic depths. Hardebeck (2010) proposed an unsegmented fault based on the continuity of seismicity locations at depth. Nishenko *et al.* (2010) proposed three segments based on discontinuities of the surface trace and differences in surface expression. PG&E (2011) interpreted the surface segmentation as extending to seismogenic depths, where they identified small warps in the seismicity locations and differences in the maximum depth of earthquakes.

The southeastern extent of the Shoreline fault is currently unclear, as is the nature of its possible interaction with the San Luis Bay, Oceano, and/or Wilmar Avenue reverse faults (Fig. 1b). These reverse faults are thought to accommodate the uplift of the Irish Hills block near the city of San Luis Obispo (Lettis *et al.*, 1994). The Shoreline fault must

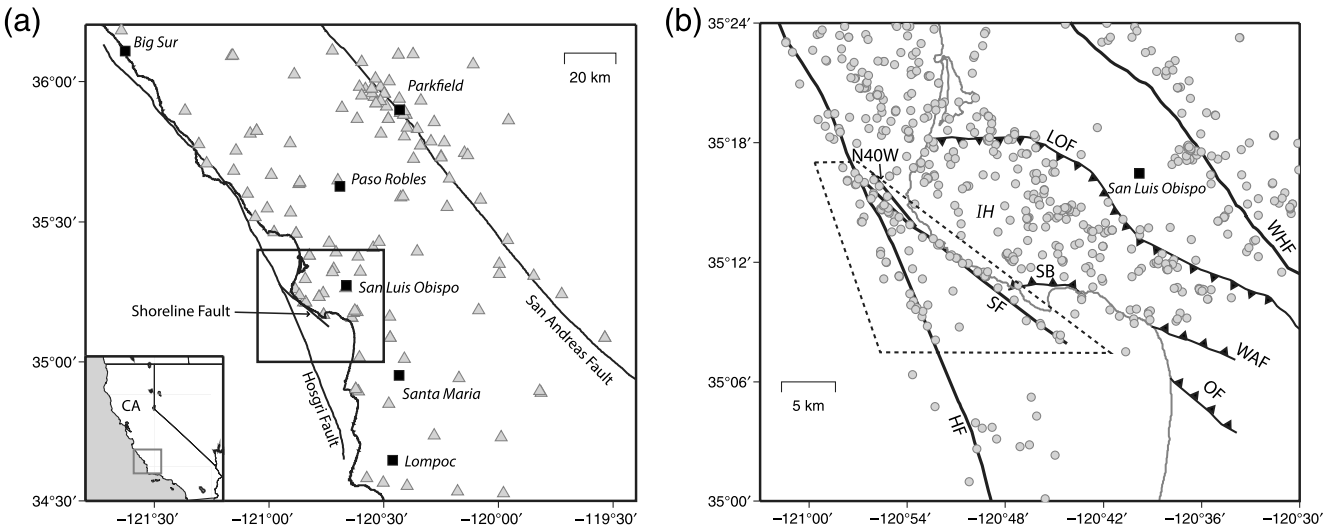

Figure 1 (a) A map of the central California coast, with the location in California (CA) shown in the inset map. Coastline and faults in black; cities, black squares; seismic stations used in this study, gray triangles; box, area in part (b). (b) A map of the earthquakes and faults of the Shoreline fault region. Earthquake locations from Hardebeck (2010), gray circles. Earthquakes within the dashed polygon are relocated in this study. HF: Hosgri fault; IH: Irish Hills; LOF: Los Osos fault; N40W: N40W fault; OF: Oceano fault; SF: Shoreline fault; SB: San Luis Bay fault; WAF: Wilmar Avenue fault; WHF: West Huasna fault. Hosgri and San Andreas faults modified from WGCEP (2008); Shoreline fault from Hardebeck (2010); other faults from (PG&E, 1988, 2011).

extend southeast of its intersection with the San Luis Bay fault, as the largest recorded Shoreline fault earthquake (an M 3.5 on 10 August 2000) occurred southeast of this intersection. A magnetic anomaly observed along the Shoreline fault extends at least another 5 km southeast of the southernmost seismicity (Sliter *et al.*, 2010). The southeastward projection of the Shoreline fault comes onshore near the reverse Oceano fault, which is not the simple continuation of the Shoreline fault due to the change in apparent faulting style.

Additionally, there is not consensus as to whether the northwestern end of the Shoreline fault connects to the Hosgri fault. The ~170-km-long Hosgri fault is the major fault in the region, with a right-lateral slip rate of 1–3 mm/yr (Hanson and Lettis, 1994; Hanson *et al.*, 2004). Hardebeck (2010) interpreted the Shoreline fault as connecting to the Hosgri fault based on the geometry of earthquakes at seismogenic depths, and Watt *et al.* (2011) reached a similar conclusion based on the seismicity and the projection of a magnetic anomaly gradient. Nishenko *et al.* (2010) noted that no northern Shoreline fault surface trace has been observed that would connect the Shoreline to the Hosgri fault, suggesting that there is no active northern Shoreline fault, and the two faults are not connected. Nishenko *et al.* (2010) suggested that the earthquakes that appear to be on the northern Shoreline fault may actually be on an eastward dipping Hosgri fault. Alternatively, these earthquakes may occur on a westward dipping N40W fault, a previously imaged surface feature hypothesized to be a possible northward continuation of the Shoreline fault (PG&E, 2011; Watt *et al.*, 2011).

These differences in the interpreted fault geometry have important implications for the earthquake potential of the Shoreline fault. If the fault is segmented at seismogenic depths, and the segment boundaries pose barriers to earthquake rupture, this would limit the size of the largest possible earthquake to be smaller than the full fault length of ≥25 km would suggest. For example, PG&E (2011) gives the highest weight in their logic tree to a segmented scenario with a maximum rupture length of 16 km. The potential connection with the Hosgri fault also suggests the possibility of an earthquake spanning both faults that would be larger than the Shoreline fault could generate on its own. Although high-frequency energy saturates for large earthquakes, a larger magnitude earthquake produces shaking and damage over a larger area.

I address these unresolved issues regarding the geometry of the Shoreline fault at seismogenic depths, and the Shoreline fault's potential for interaction with the Hosgri fault, using new seismicity relocations and new earthquake focal mechanisms. An objective method is used to determine whether the Shoreline fault seismicity, given the location uncertainty, warrants division into multiple segments or is consistent with a single fault plane. This objective method is used, along with earthquake focal mechanisms, to determine whether or not earthquakes occur on the northernmost Shoreline fault, and hence whether the Shoreline fault is connected to the Hosgri fault.

Methods

I relocate and reinterpret the recorded seismicity to study the geometry of the Shoreline fault and its possible intersection with the Hosgri fault. Earthquake locations can illuminate fault structures at seismogenic depth, but their interpretation is often subjective as fault planes are usually interpreted from the earthquake locations by eye. Alternatively, the Optimal

Anisotropic Dynamic Clustering (OADC) algorithm (Ouillon *et al.*, 2008) can be used to objectively identify the simplest fault geometry that fits all of the earthquake locations to within the location uncertainty. I use the OADC algorithm, along with first-motion focal mechanisms, to determine the fault geometry of the Shoreline fault and the nearby section of the Hosgri fault.

Earthquake Locations and Uncertainty

I relocate ~100 earthquakes occurring along the Shoreline fault and the adjacent section of the Hosgri fault (events inside the dashed polygon in Fig. 1b) between 1 January 1984 and 31 December 2010. Relocations are based on waveform cross-correlation differential times and catalog arrival time picks, using the double-difference programs hypoDD (Waldhauser and Ellsworth, 2000), and tomoDD (Zhang and Thurber, 2003). Cross-correlation was performed on waveforms from stations of the Central Coast Seismic Network (CCSN) and the California Integrated Seismic Network (CISN); catalog arrival times for both networks were obtained from the CISN. All waveforms were inspected by eye for quality, and relative arrival times with correlation coefficients of ≥ 0.8 are used in the relocations. Earthquakes are linked to neighboring events with at least 8 differential times at common stations, with a maximum linking distance of 8 km for catalog differential times and 3 km for cross-correlation differential times. I perform 8 iterations of hypoDD and tomoDD with the catalog picks weighted 10 times the cross-correlation times, to first fit the lower-precision catalog data. Then I perform 8 iterations with the cross-correlation differential times weighted 10 times the catalog times, to refine the relative locations of nearby earthquakes using the higher-precision cross-correlation times. The 3D seismic velocity model of Hardebeck (2010) is used for the tomoDD relocations, and a 1D average of this model is used for the hypoDD relocations. The hypoDD and tomoDD programs return formal errors, but these are likely to underestimate the true uncertainty because they assume that the seismic velocity structure is perfectly known, which is not a good assumption for the study area. Additionally, the formal errors are computed using the final travel-time residuals to approximate the arrival time errors, which may underestimate the uncertainty if the data are overfit.

The earthquake location uncertainty was estimated using synthetic earthquake catalogs instead. Because the "true" locations of synthetic events are known, it is possible to quantify how well the locations are recovered by the relocation procedure, given the distribution of recording stations and random data errors. The error distribution can then be found from multiple realizations of the synthetic data. The synthetic events are constructed to have the same source–receiver geometry as the real earthquakes. The "true" locations of the synthetic events are defined by projecting the catalog earthquake locations onto simplified planar Hosgri and Shoreline faults. Aligning the "true" locations along these planes has no effect on the uncertainty estimates; it merely aids in visualizing the results. Each synthetic event is "recorded" at the same stations as the corresponding real event, travel times are generated using a known "true" velocity model, and realistic travel-time errors are added. Each realization of the synthetic catalog is then relocated using tomoDD following the same procedures as for the real earthquakes, using a velocity model perturbed from the "true" model to reflect velocity model uncertainty. I relocate 300 realizations of the synthetic catalog, each with different random errors in the travel times and velocity model. Any shift in the catalog centroid is removed from the relocated synthetic catalogs, because the goal is to quantify the relative location uncertainty for studying fault geometry. The 95% confidence ellipsoid for each event is determined individually from the distribution of errors of the recovered locations for that event over the 300 realizations. The error is defined as the vector difference between the recovered location and the known "true" location of the synthetic event. The covariance matrix of the 300 errors in the north, east, and vertical directions is used to define the confidence ellipsoid for that event.

The travel-time errors used in the synthetic catalog realizations are based on estimates of the true error in the observed arrival times. The error in the catalog arrival times is estimated by comparing the cross-correlation relative arrival times and the catalog relative arrival times for the same pairs of events, and attributing the differences to errors in the catalog picks (Fig. 2). This assumes that the cross-correlation times are correct, which is a reasonable assumption because the errors in the cross-correlation times are small compared to the errors in the catalog picks. The catalog error is best modeled as an exponential distribution, with the mean equal to 0.3 times the network formal pick error. A consistency check between the cross-correlation relative arrival times, for all sets of three earthquakes linked by cross-correlation times with correlation coefficients of ≥ 0.8, shows that the errors are almost entirely below the sampling rate of 0.01 sec (Fig. 3). Given that the self-consistency check provides a lower bound on the cross-correlation error, and that errors on the order of the sampling rate are likely, an exponential distribution with a mean equal to the sampling rate is used. The velocity model error was estimated from the checkerboard tests of Hardebeck (2010). The percent error for each velocity grid node is chosen from a uniform distribution up to the percent difference between the true and recovered models in the checkerboard tests. Additionally, a systematic velocity model error of up to $\pm 5\%$ is added to the entire model.

OADC

The OADC algorithm (Ouillon *et al.*, 2008) can be used to objectively identify the simplest collection of planar faults that fits all earthquakes in a catalog to within the location uncertainty. Although more complex fault geometries could

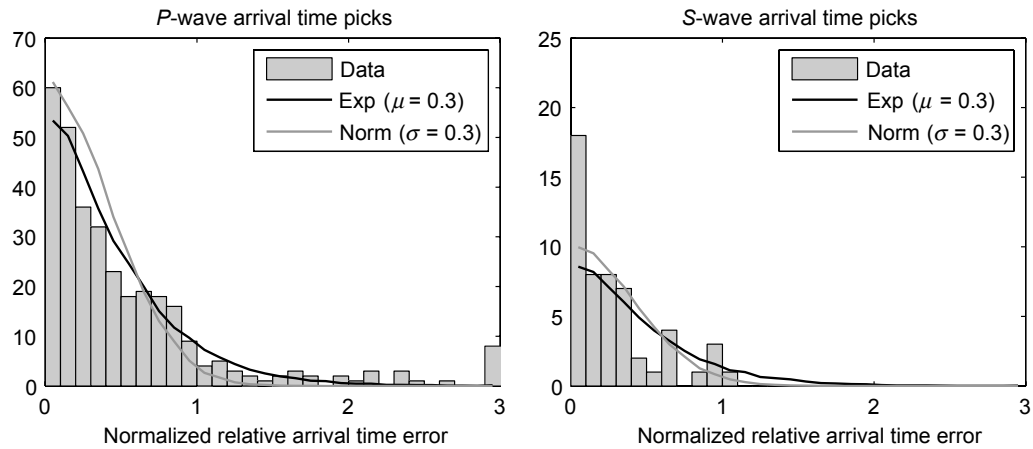

Figure 2. Histograms of the error in relative arrival times for pairs of earthquakes. The error is defined as $|xcor_{i,j} - (tt_i - tt_j)|$ where $xcor_{i,j}$ is the cross-correlation arrival time difference between events i and j, and tt_i and tt_j are the catalog arrival times for those two events, referenced to the same origin times. The assumption is that any error in $xcor_{i,j}$ is so small relative to the errors in tt_i and tt_j that it can be assumed that $xcor_{i,j}$ is correct and that $|xcor_{i,j} - (tt_i - tt_j)|$ reflects the error in $(tt_i - tt_j)$. Picks of different quality are combined in the histograms by normalizing the relative arrival time error by the network formal pick error (quality 0 formal error is 0.1 s; quality 1, 0.2 s; quality 2, 0.5 s; and quality 3, 1.0 s). Shown is the expected distribution of the error in $(tt_i - tt_j)$ if the errors in tt_i and tt_j are each chosen randomly from a normal or exponential distribution, with $\sigma = 0.3$ or $\mu = 0.3$, respectively. The exponential distribution better captures the long-tailed character of the distribution of error in the relative arrival times.

be found that fit the earthquake locations as well or perhaps better, the OADC algorithm follows Occam's razor in favoring the simplest consistent solution. More complex fault geometries, that fit the earthquakes more closely than the location uncertainty, would likely overfit the data, reflecting the random errors in the locations rather than true fault structures. The OADC algorithm partitions the catalog into a given number of sets, such that the distance from the events in each set to the plane representing the set is minimized. The algorithm iteratively updates the best-fitting plane for each set and the assignment of earthquakes to the sets until a stable configuration is reached. The initial planes are chosen randomly and different starting planes may result in different solutions. The number of sets is increased until all events fall on a plane to within the location uncertainty. The only parameter used by the OADC algorithm is the location uncertainty, which is considered tunable by Ouillon *et al.* (2008), but in this work is fixed to the uncertainty estimated from the synthetic catalogs. There are no other parameters that can be tuned.

I implement the OADC algorithm, as described in Ouillon *et al.* (2008), with the following modifications: (1) the algorithm stops when every event is fit to within its 95% confidence ellipsoid, rather than when all events are fit to within

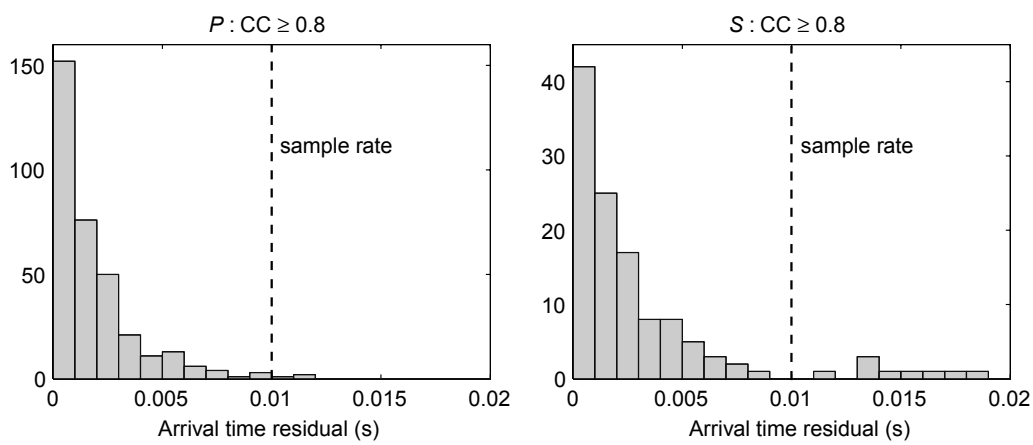

Figure 3. An internal consistency check of the cross-correlation relative arrival times. Histograms show residuals $|xcor_{i,j} + xcor_{j,k} - xcor_{i,k}|$, where $xcor_{i,j}$ is the cross-correlation arrival time difference between events i and j. All sets of three earthquakes linked by cross-correlation times with correlation coefficient of ≥ 0.8 are used. Almost all residuals are less than the sample rate of 0.01 s for both P waves and S waves, with only a few large outliers. The consistency deteriorates for correlation coefficients of < 0.8, indicating that 0.8 is an appropriate threshold for the cross-correlation times. This internal consistency check provides a lower bound on the cross-correlation relative arrival time error.

the average location uncertainty. The normal distance from the event to the plane is computed, and compared to the radius of the 95% confidence ellipsoid in the direction normal to the plane. Earthquakes are assigned to the plane that is closest relative to the radius of the ellipse in the normal direction to the plane. Planes with ≤3 events are counted in all processing steps, but are discarded in the final analysis. (2) The algorithm checks if planes are effectively co-planar, and combines any that are. This is to avoid the situation of divided planes, as illustrated in figure 4 of Ouillon *et al.* (2008). Co-planar planes are identified as those whose assigned events are all also consistent with the other plane. (3) The length and width of a plane are defined by the distances between the most distant events assigned to that plane. (4) Repeated runs are performed, with different random starting planes, in order to sample the full solution space. For each run, the initial plane is chosen randomly, and as the number of planes increases, each new plane is chosen randomly. The iterative procedure rapidly corrects these random planes. I consider all unique solutions with the smallest number of planes necessary to fit all of the earthquakes, and compile the statistics of the strike and dip of the planes to quantify the fault plane uncertainty. (5) The OADC algorithm has a tendency to produce spurious subhorizontal planes, as recognized by Ouillon *et al.* (2008), because earthquake locations have less variation in depth than horizontally. I recognize this drawback, but do not attempt to correct it.

Focal Mechanisms

First-motion focal mechanisms are poorly constrained because of the one-sided station coverage of the offshore Shoreline and Hosgri faults (e.g., Hardebeck, 2010). Therefore, I determine composite focal mechanisms, based on the first-motion polarities of all events in three groups: those on the Hosgri fault, those on the southern Shoreline fault (south of 35.23° N), and those on the northern Shoreline fault (north of 35.23° N), with earthquakes assigned to faults according to the OADC results. The northern Shoreline group corresponds to the events that Nishenko *et al.* (2010) hypothesize are actually on the Hosgri fault. Focal mechanisms may allow us to discern which fault these earthquakes are most likely to have occurred on, due to the ~30° difference in fault strike which may be resolvable in the composite mechanisms. First-motion polarities are obtained from the CISN. Take-off angles are found from raytracing in the 3D velocity model of Hardebeck (2010). The focal mechanisms, as well as their uncertainty and quality, are found using the method of Hardebeck and Shearer (2002).

Results

Earthquake Locations and Uncertainty

The relocated earthquake catalogs using hypoDD and tomoDD, while slightly different, both reproduce the basic geometry of the Shoreline fault reported by Hardebeck (2010), a single plane which meets the Hosgri fault at approximately a 30° angle (Fig. 4). The earthquakes along the Hosgri fault appear more diffuse. The average 95% relative location uncertainty is approximately 2 km, both horizontally and vertically. Unsurprisingly, the greatest horizontal location uncertainty is generally in the direction perpendicular to the coastline (Fig. 5). Interestingly, many of the recovered synthetic event locations show systematic offsets from the imposed "true" locations; in particular, the southern Hosgri synthetic events tend to be closer to shore while the northern Hosgri events tend to be further from shore, creating an apparent warp or offset in the recovered locations that is not present in the planar "true" locations. These systematic offsets in the recovered synthetic event locations imply that

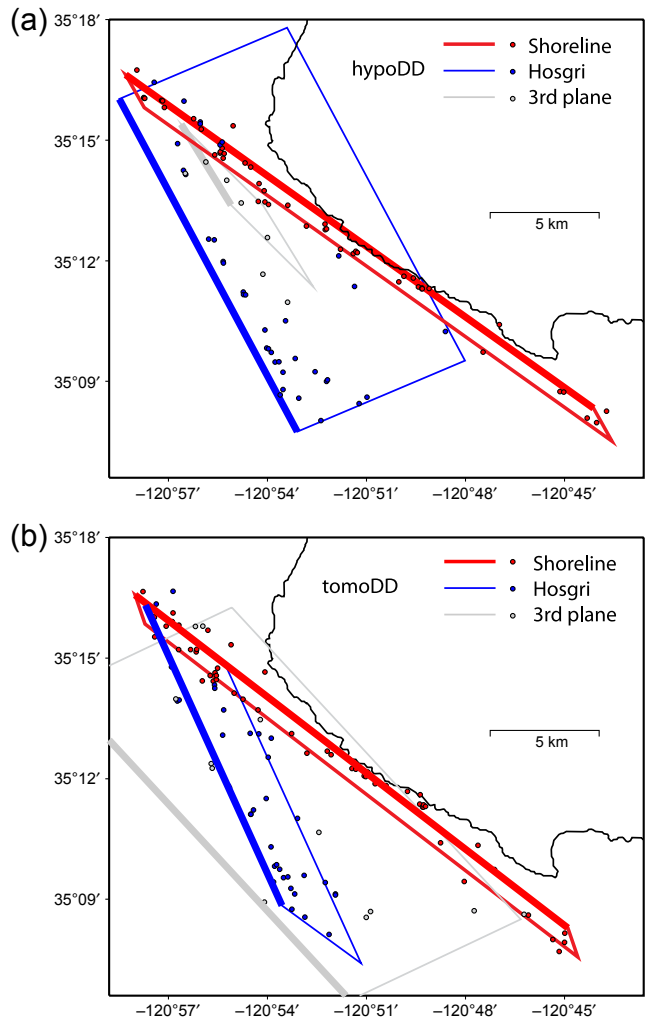

Figure 4. Earthquake relocations and Optimal Anisotropic Dynamic Clustering (OADC) fault plane solutions. The mean fault plane orientation for each of the three planes identified by the OADC algorithm is shown projected into map view, with the top edge indicated by a thicker line. Earthquake locations, circles, with the color matching the color of the plane to which OADC assigns the event. (a) Earthquake locations found using hypoDD. (b) Earthquake locations found using tomoDD. The color version of this figure is available only in the electronic edition.

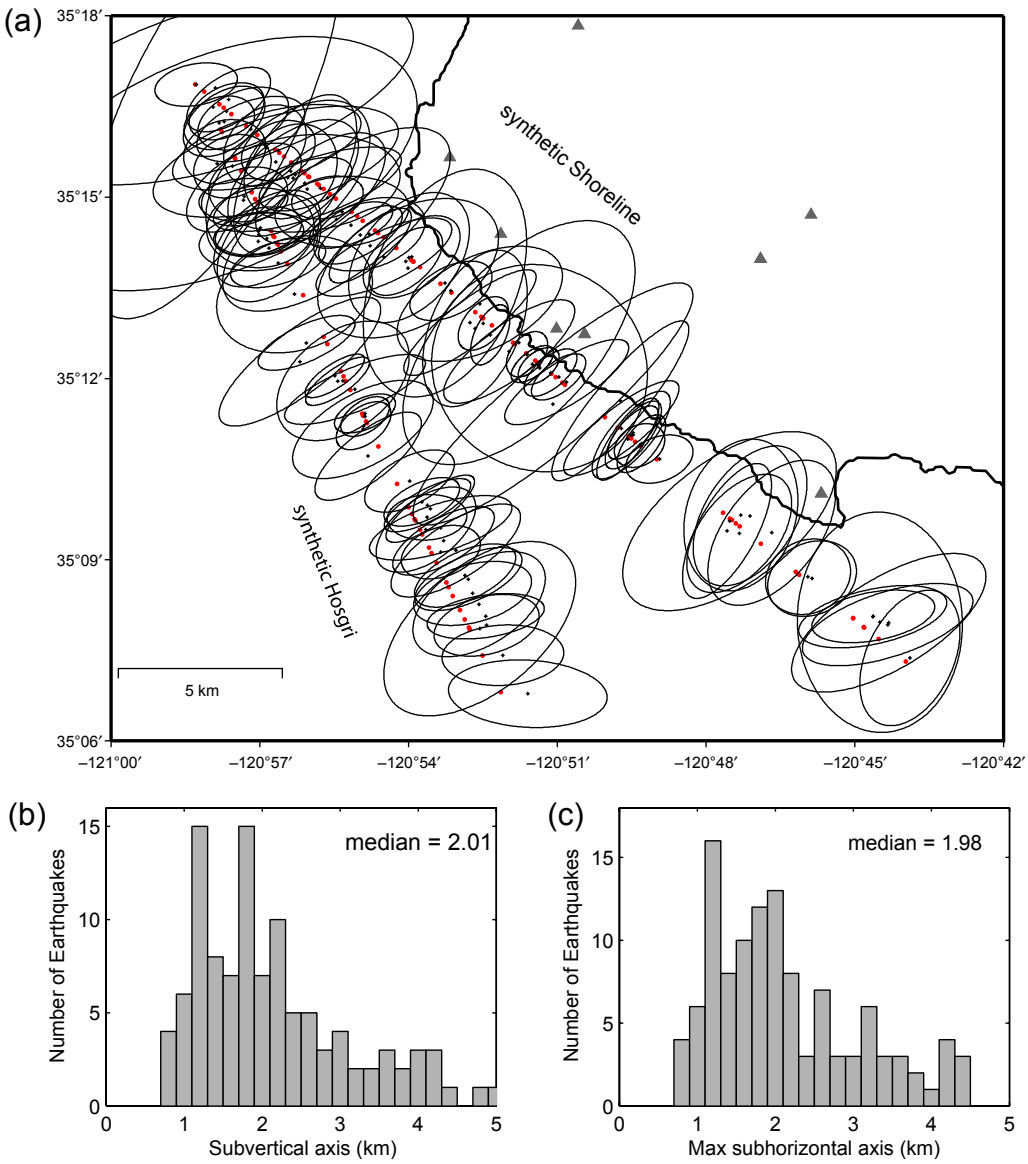

Figure 5. The earthquake location uncertainty, determined from the location errors of synthetic earthquakes. The synthetic earthquakes approximate the real earthquakes, in that each synthetic event is "recorded" at the same stations as the corresponding real event. (a) Dots, the true locations of the synthetic events, defined by projecting the catalog earthquake locations on to simplified planar Hosgri and Shoreline faults; black crosses, the average locations over 300 tomoDD relocation runs with different random arrival time and velocity model errors; 95% confidence ellipsoids (projected into map view) summarize the variability over the suite of runs. Gray triangles; seismic stations. The bottom panels show the distribution of the lengths of the 95% confidence ellipsoid axes, (b) for the most vertical axis (depth uncertainty), and (c) for the largest horizontal axis (horizontal uncertainty). The color version of this figure is available only in the electronic edition.

similar small warps and offsets in the real earthquake locations should not be over-interpreted as they are likely to be artifacts of the poor source-station geometry, and the resulting trade-off between the hypocenter locations and the poorly-constrained velocity model.

OADC

The simplest OADC fault geometry that fits all earthquakes to within their location uncertainty, for either the hypoDD or tomoDD locations, comprises three planes: one clearly corresponding to the Shoreline fault, one corresponding to the Hosgri fault, and a third, unstable, and probably spurious, plane (Figs. 4, 6 and Tables 1, 2). The Shoreline OADC plane is near vertical, and dips very steeply to the southwest. The Hosgri OADC plane dips to the east, towards the Shoreline fault, consistent with the shallow geophysics (e.g., Hanson *et al.*, 2004), although the dip varies greatly between the OADC fits to the hypoDD and tomoDD relocations.

The Shoreline OADC plane orientation is very stable over all solutions, and the northwestern end of the plane extends to the surface trace of the Hosgri fault. The Shoreline

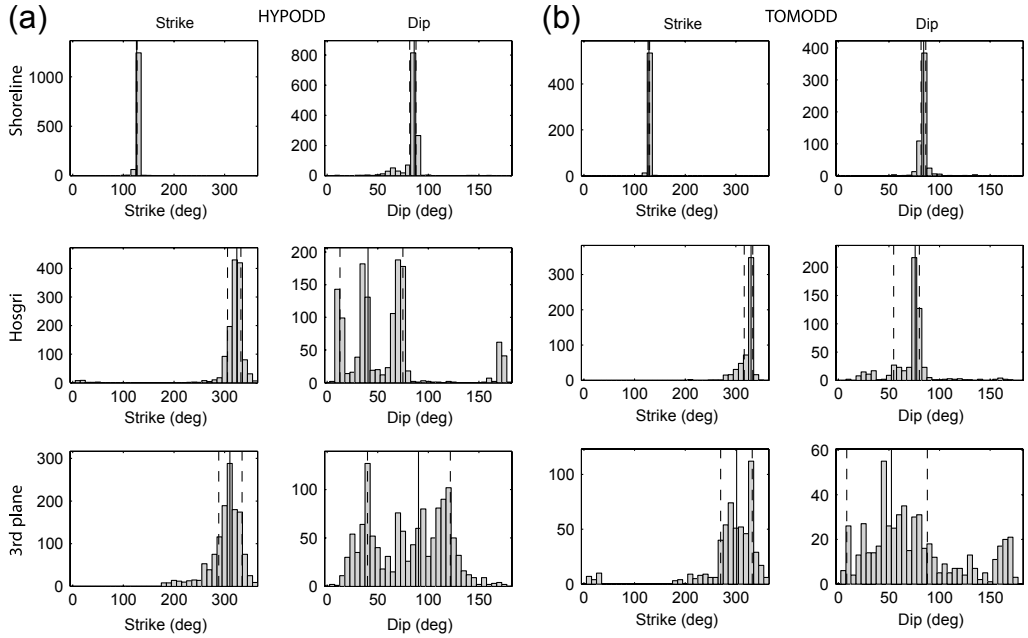

Figure 6. Histograms of the orientations of the three planes identified by the Optimal Anisotropic Dynamic Clustering (OADC) algorithm. The strike and dip of the two planes corresponding in space to the Shoreline and Hosgri faults are shown, along with the strike and dip of the third plane. The fault dips to the right when facing in the strike direction. The circular mean and 1-sigma uncertainty are shown as solid and dashed lines, respectively. The mean plane orientations are shown in Figure 1. (a) For the hypoDD relocated hypocenters, 30,000 runs of the OADC algorithm identified 1317 unique geometries with 3 planes that fit all of the earthquakes to within their location uncertainty. (b) For the tomoDD relocated hypocenters, 30,000 runs of the OADC algorithm identified 552 unique geometries with 3 planes.

OADC plane fits many of the events of the northern Shoreline fault that Nishenko *et al.* (2010) suggest might be on the Hosgri fault and that Watt *et al.* (2011) suggest may be on the N40W fault. The Hosgri OADC plane is less stable, especially in dip, and the northern end does not extend past the intersection with the Shoreline OADC plane. Obviously the Hosgri fault extends north of the intersection, but no seismicity to the north is present in the catalog for the northern continuation to be reflected in the OADC planes. The OADC solutions imply that the Shoreline fault is a single continuous structure that connects to the Hosgri fault.

The third OADC plane is not a robust feature, given that it fits relatively few events compared to the other two planes, and that the plane and the earthquakes assigned to it are different depending on the relocation technique (Fig. 4). The third plane has a location and strike suggesting that it could be a second Hosgri fault strand, which would be consistent with shallow geophysical studies that find two active strands

Table 1
Fault Plane Orientations and Dimensions for the Shoreline and Hosgri Faults*

	Strike (°)	Dip (°)	Rake (°)	Length (km)	Width (km)
Shoreline Fault					
OADC-hypoDD	126 ± 1	86 ± 3		27	11
OADC-tomoDD	128 ± 2	84 ± 2		25	11
FM-South	131 ± 33	86 ± 33	171 ± 33		
FM-North, $d \leq 8$ km	129 ± 32	90 ± 32	178 ± 25		
Hosgri Fault					
OADC-hypoDD	324 ± 13	41 ± 17		17	11
OADC-tomoDD	330 ± 9	76 ± 13		17	9
FM	152 ± 27	73 ± 27	180 ± 24		

*Found from planes fit to the earthquake locations using Optimal Anisotropic Dynamic Clustering (OADC), and from composite focal mechanisms (FM).

Division between northern and southern Shoreline fault at 35.23° N; only events above 8-km depth are used in the focal mechanism for the northern Shoreline fault, because the Hosgri fault or some other structure appears to underlie the northern Shoreline fault (Fig. 9). The strike and dip convention is that the fault dips to the right when facing along the strike direction. The dimensions are given for the mean fault orientation. Uncertainty in OADC plane orientation is the standard deviation from the circular mean.

Table 2
Corners of the Shoreline and Hosgri Fault Optimal Anisotropic Dynamic Clustering (OADC) Planes, for Both the HypoDD and TomoDD Relocated Catalogs

Shoreline OADC plane		Hosgri OADC plane	
HypoDD	TomoDD	HypoDD	TomoDD
−120.9623 35.2635 13.55	−120.9619 35.2641 13.86	−120.8901 35.2966 11.37	−120.9216 35.2478 15.00
−120.9716 35.2771 2.67	−120.9669 35.2761 3.43	−120.9749 35.2670 5.13	−120.9616 35.2719 7.17
−120.7353 35.1388 -1.13	−120.7483 35.1381 0.60	−120.8850 35.1291 3.14	−120.8927 35.1474-0.46
−120.7260 35.1252 9.74	−120.7433 35.1261 11.03	−120.8003 35.1586 9.38	−120.8527 35.1234 7.36

Coordinates are given in: longitude, latitude, and depth in km.

of the fault near the surface (e.g., Hanson *et al.*, 2004). However, rather than the two strands converging at depth into a conventional flower structure, for the hypoDD solutions, the two OADC planes diverge with depth. For the tomoDD solutions, the third plane is subhorizontal, suggesting structures associated with the remnant Farallon subducted slab. However, the third plane consists of earthquakes with an average depth of 5 km, much shallower than the top of the remnant slab, which is at 15–20-km depth in the vicinity of Point Buchon (e.g., Miller *et al.*, 1992). The presence of a subhorizontal plane in the middle of the earthquake depth range is more consistent with the spurious subhorizontal planes recognized by Ouillon *et al.* (2008). Therefore, I consider the third plane to be an artifact, and will not consider it in any further analysis. More than 95% of the earthquakes fall onto either the Shoreline or Hosgri OADC plane in at least one of the two relocated catalogs, indicating that these two planes adequately represent the seismicity to within the location uncertainty and the variability between location methods.

I further validate the Shoreline fault results by demonstrating, using synthetic catalogs, that it is unlikely that multiple fault segments separated by substantial offset could have gone undetected by the OADC algorithm. I generate synthetic "true" earthquake locations by shifting the Shoreline fault earthquakes onto a set of three equal-length vertical planes following the strike of the Shoreline fault but offset horizontally from each other by a variable offset D. The "observed" locations are found by perturbing these "true" locations according to the uncertainty estimates found for the real events. The OADC algorithm is then applied to the "observed" catalog exactly as it was applied to the real earthquakes. The average number of planes found over 3000 OADC realizations is shown as a function of the offset D in Figure 7a. Offsets smaller than ~1 km go largely undetected, but discontinuities smaller than ~1 km are unlikely to be barriers to earthquake rupture (e.g., Harris and Day, 1993, 1999; Wesnousky, 2006, 2008). For $D = 1$ km, at least one offset is detected in >50% of the realization, and this detection ability improves rapidly with increasing D. I also test whether fitting the earthquake locations to within their 95% confidence is appropriate, by repeating the synthetic tests for a range of other confidence levels. Using confidence levels below 95% results in the OADC algorithm typically finding multiple planes when the "true" locations actually lie along a single plane (Fig. 7b). Therefore, attempting to fit the earthquake locations any closer than the 95% confidence level would lead to over-fitting. Any additional planes would be fitting the error in the locations, rather than reflecting the true fault structure.

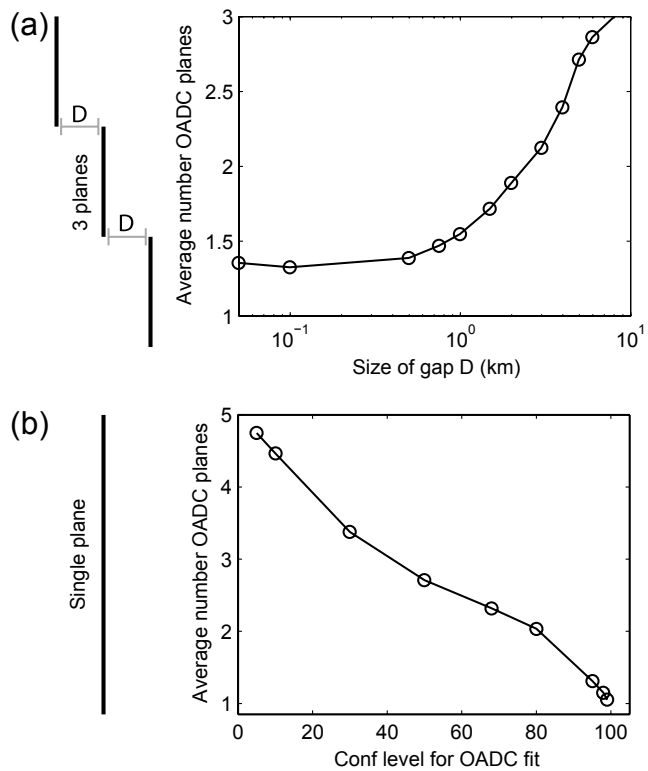

Figure 7. Results from synthetic tests of the Optimal Anisotropic Dynamic Clustering (OADC) algorithm. Synthetic "true" earthquake locations are defined by shifting the Shoreline fault earthquakes onto a series of three vertical planes following the strike of the Shoreline fault but offset horizontally from each other by a variable offset D. The "observed" locations are found by perturbing these "true" locations according to the uncertainty estimates found for the real events. The OADC algorithm is then applied to the "observed" catalog exactly as it was applied to the real earthquakes, for 3000 realizations. (a) Illustration of the fault geometry and the average number of planes found by OADC as a function of the offset D. (b) The average number of planes found by OADC for $D = 0$ (a single plane) when varying the confidence level to which the earthquake locations are fit. More than one plane indicates over-fitting.

Focal Mechanisms

The composite focal mechanism for events along the Hosgri fault is well-constrained, with a quality B solution from the method of Hardebeck and Shearer (2002), and agrees very well with the Hosgri tomoDD OADC plane assuming pure right-lateral strike-slip motion (Fig. 8a). The focal mechanism shows the Hosgri fault dipping to the west, while the Hosgri OADC plane dips to the east, but the first-motion polarities do not constrain the fault plane as well as they constrain the auxiliary plane, and either dip direction would be equally consistent with the polarities. The shallow dip of the Hosgri hypoDD OADC plane is inconsistent with the polarities, so I take the tomoDD OADC plane as the preferred solution. The focal mechanism for the southern Shoreline fault (south of 35.23° N) is not as well-constrained, with a quality D solution, but the mechanism agrees very well with the Shoreline OADC plane, assuming pure right-lateral strike-slip motion (Fig. 8b).

The northern Shoreline composite focal mechanism is made up of the events that both the hypoDD and tomoDD OADC solutions assign to the Shoreline fault, but that Nishenko *et al.* (2010) hypothesize may be on the eastward-dipping Hosgri fault instead. The composite mechanism is marginally well-constrained, with a quality C solution from the method of Hardebeck and Shearer (2002). The composite solution falls in between the OADC planes for the Shoreline and Hosgri faults (Fig. 8c). The Shoreline OADC plane fits the polarities only marginally better, with 6 fewer misfit polarities out of a total of 220 polarities, so this composite mechanism cannot be clearly interpreted as favoring one fault orientation over the other.

Although there are no well-constrained single-event focal mechanisms, the single-event polarities can be used to test whether individual earthquakes are more consistent with the orientation of the Shoreline fault or the Hosgri fault. For each earthquake with ≥8 polarities, I count the fraction of misfit polarities with respect to the Shoreline and Hosgri tomoDD OADC planes, assuming pure right-lateral slip. I quantify the preference for one plane or the other by the difference in the misfit fraction (Fig. 9). For the most part, events along the Hosgri fault agree with the Hosgri OADC plane, and events along the Shoreline fault agree with the

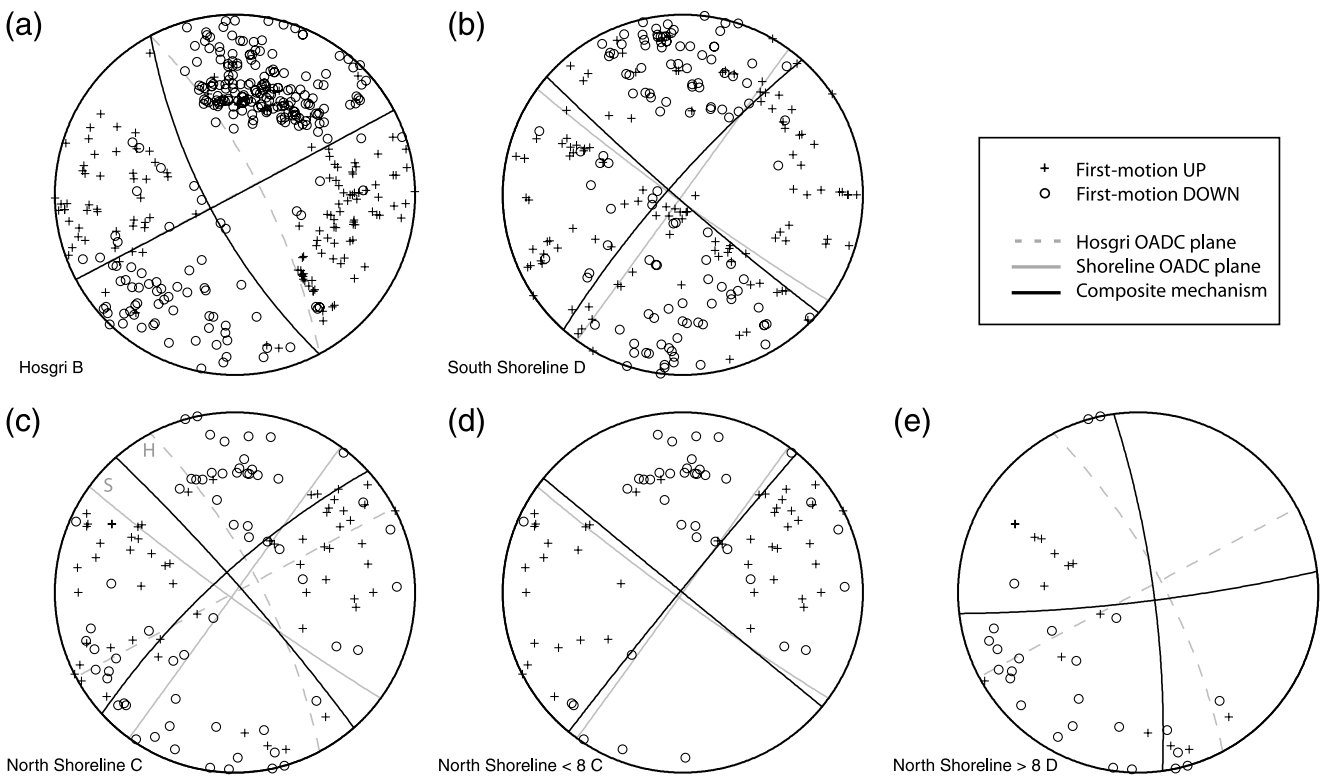

Figure 8. Composite first-motion focal mechanisms. Polarities shown as crosses for upward first arrival; circles for downward first arrival. Black lines: preferred focal mechanism. Gray lines: focal mechanism derived from the OADC plane (tomoDD locations), assuming pure right-lateral rake. (a) All events identified with the Hosgri fault by the OADC procedure, for either the hypoDD or tomoDD locations. The Hosgri OADC solution is shown. (b) All events identified with the southern Shoreline fault (south of 35.23° N) by the OADC procedure, for either the hypoDD or tomoDD locations. The Shoreline OADC solution is shown. (c) All events identified with the northern Shoreline fault (north of 35.23° N) by the OADC procedure, for both the hypoDD and tomoDD locations. The Shoreline OADC solution is shown as solid gray lines; the Hosgri OADC solution is shown as dashed gray lines. (d) Events identified with the northern Shoreline fault by the OADC procedure; only events above 8-km depth. The Shoreline OADC solution is shown. (e) Events identified with the northern Shoreline fault by the OADC procedure; only events deeper than 8-km depth. The Hosgri OADC solution is shown.

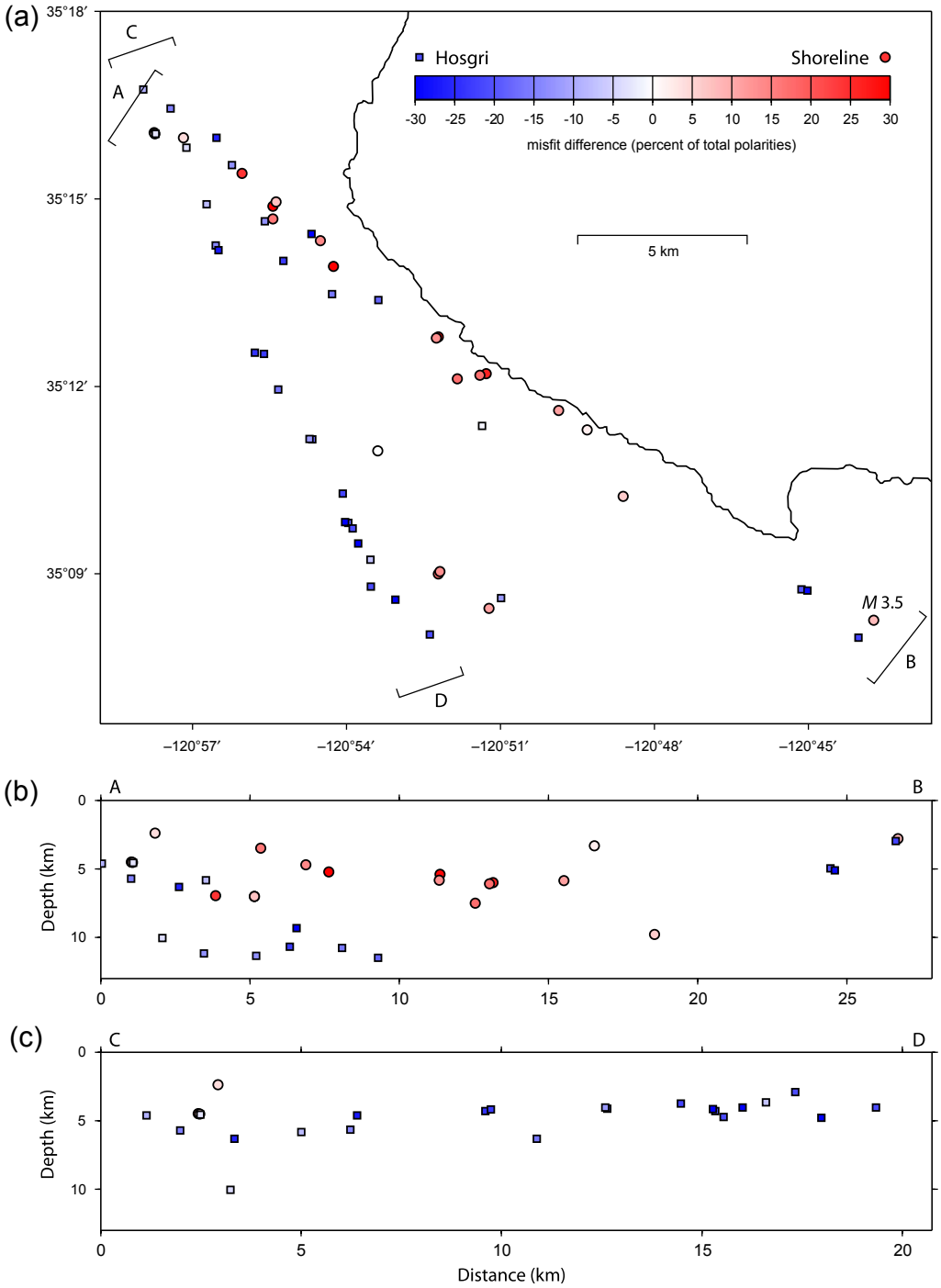

Figure 9. The misfit of single-event first-motion polarities to the focal mechanisms of the Shoreline and Hosgri Optimal Anisotropic Dynamic Clustering (OADC) planes (tomoDD locations), assuming pure right-lateral rake. For each earthquake with at least 8 first-motion polarities, I find the fraction of misfit polarities with respect to the Shoreline and Hosgri OADC planes, and quantify the preference for one plane or the other by the difference in the misfit fraction. Earthquakes shown as circles favor the Shoreline OADC mechanisms, while earthquakes shown as squares favor the Hosgri OADC mechanism. The earthquakes are shown (a) in map view, and in depth sections along the (b) Shoreline, and (c) Hosgri faults. The color version of this figure is available only in the electronic edition.

Shoreline OADC plane, with some exceptions near the southern ends of both planes. The *M* 3.5 earthquake near the southern end of the Shoreline seismicity is better aligned with the Shoreline OADC plane orientation, but some smaller events are not. Most of the shallow to intermediate depth northern Shoreline events are consistent with the Shoreline OADC orientation (Fig. 9). The composite focal mechanism for all northern Shoreline fault earthquakes above 8-km depth also agrees very closely with the orientation of the Shoreline OADC plane (Fig. 8d). However, the deeper events

that fall along the northern Shoreline OADC plane are more consistent with the orientation of the Hosgri fault (Fig. 8e).

Fault Geometry

The OADC results imply that the Hosgri fault dips steeply to the east, while the Shoreline fault is essentially vertical. As the two faults approach their intersection, the Hosgri fault would therefore dip towards and under the Shoreline fault (Fig. 10a). The focal mechanisms generally agree with the planar OADC geometry. The shallow-to-intermediate depth northern Shoreline events are consistent with the Shoreline OADC orientation, implying that the vertical planar Shoreline fault extends to the intersection with the Hosgri fault above 8-km depth. The focal mechanisms of deeper earthquakes, however, suggest a slightly more complicated intersection geometry below 8-km depth. The deeper earthquakes that fall along the northern Shoreline OADC plane are more consistent in their focal mechanisms with the orientation of the Hosgri OADC plane, suggesting they are on the Hosgri fault. This would require a non-planar Hosgri fault to underlie more of the northern Shoreline fault than the planar OADC solution would imply (Fig. 10b). The composite focal mechanism for these deep events (Fig. 8e) implies a more north–south strike than the overall strike of the Hosgri fault, consistent with the deep Hosgri fault locally diverging to underlie the Shoreline fault. Alternatively, the deep earthquakes underlying the northern Shoreline fault may represent an additional fault separate from the Hosgri fault (Fig. 10c), or a zone of distributed deformation.

Discussion

The Shoreline fault as defined by seismicity is 25 km long, and its northwestern end extends to the Hosgri fault. There is no gap between the two faults at seismogenic depths, and it appears that the vertical Shoreline fault sits above the east-dipping Hosgri fault near their intersection (Fig. 10). It is unclear why the intersection of the surface traces has not been observed; it may be that the surface trace of the northern Shoreline fault is difficult to image in the marine environment. Alternatively, the surface traces of the faults may not connect, even though the faults are connected at seismogenic depths, as is the case with the intersection of the Hayward and Calaveras faults in the San Francisco Bay area (Manaker *et al.*, 2005). At the Hayward–Calaveras junction, the end of the surface trace of the Hayward fault runs subparallel to the surface trace of the Calaveras fault, while at seismogenic depths the Hayward fault dips towards and merges with the Calaveras. The Shoreline–Hosgri junction would be exactly analogous if the N40W fault trace were the northern end of the Shoreline surface trace, with the seismicity associated with that trace dipping westward to merge with the Hosgri fault.

The geometry of the Shoreline fault, as well as its intersection with the Hosgri fault, appears more simple at seismogenic depths than at the surface, a common feature of strike-slip faults (e.g., Graymer *et al.*, 2007). The surface trace of the southern Shoreline fault appears to have some minor offsets, as well as differences in expression in the bathymetry (Nishenko *et al.*, 2010; PG&E, 2011), so it would be meaningful to refer to three sections of the fault with differences in surface expression. However, there is

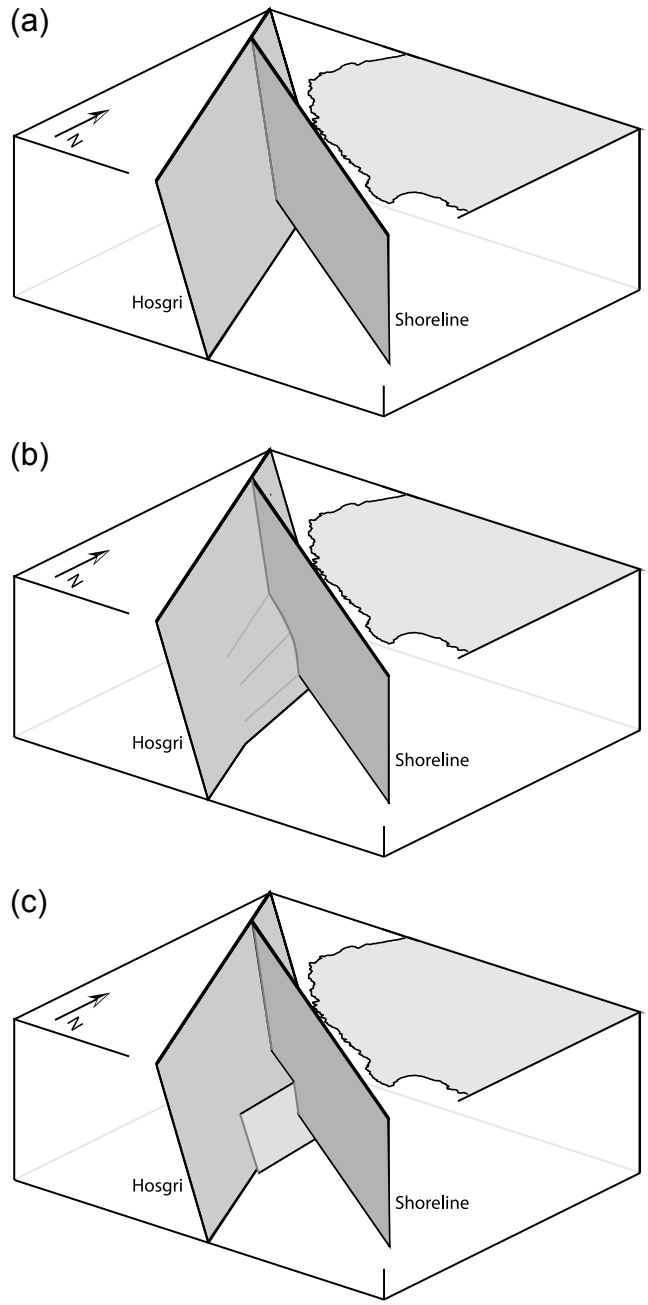

Figure 10. Cartoon of the intersection of the Shoreline and Hosgri faults. Near the intersection, the vertical Shoreline fault lies above the east-dipping Hosgri fault. (a) For the planar Optimal Anisotropic Dynamic Clustering (OADC) geometry. (b) For a similar geometry with a non-planar Hosgri fault underlying the northern Shoreline fault. (c) For a similar geometry with a small north–south trending fault underlying the northern Shoreline fault.

no objective evidence for any discontinuities or segmentation of the Shoreline fault at seismogenic depths, as most earthquakes along its known length fall on a single plane to within their location uncertainty. Discontinuities smaller than ~1 km may be undetected, but would be too small to be barriers to earthquake rupture, as are the < 1 km discontinuities in the surface trace (e.g., Harris and Day, 1993, 1999; Wesnousky, 2006, 2008).

A magnetic anomaly observed along the Shoreline fault implies the presence of serpentinite (Watt *et al.*, 2009; Sliter *et al.*, 2010), which is often associated with weak or creeping faults (e.g., Irwin, 1990). Serpentinites in laboratory experiments at room temperature can exhibit very low coefficients of friction and velocity-strengthening behavior that leads to stable sliding or creep (e.g., Reinen *et al.*, 1994). However, at higher temperatures and pressures representative of seismogenic depths, the strength of serpentinite increases to nearly that of characteristically strong rocks (Moore *et al.*, 1997). Serpentinites can exhibit velocity-weakening behavior at higher slip velocities (Reinen *et al.*, 1994), implying that earthquakes nucleating elsewhere on the fault could continue propagating through the serpentinite. The non-zero fault strength ensures that there would be shear stress on the serpentinite patches to drive continued rupture, even if they were usually creeping. Serpentinites also tend towards velocity-weakening behavior at higher temperatures (Moore *et al.*, 1997), implying that earthquakes could potentially nucleate in serpentinite at depth. Nucleation clearly can occur on the Shoreline fault, given the observed seismicity on the fault, including an M 3.5 earthquake. Therefore, the Shoreline fault should be considered capable of nucleating and propagating large earthquakes.

The size of the Shoreline fault plane determined by the OADC algorithm can be used to estimate the magnitude of a hypothetical earthquake rupturing the entire fault (Table 3). The OADC plane is 25 km long with a width of 11 km, and comes within at least 0.5 km of the surface (Table 2), consistent with the expression of most of the fault on the seafloor. Assuming a 3 MPa stress drop, the moment magnitude would be 6.7. Scaling relationships with either rupture length or rupture area for a strike-slip fault (Wells and Coppersmith, 1994) give moment magnitudes of 6.4–6.5. Extending the southern end of the Shoreline fault to the coast adds 10 km to the southeastern end of the fault, increasing the moment magnitude to 6.8 for the constant stress drop approach, and to 6.6 for both scaling approaches. Given the connection between the Shoreline and Hosgri faults at seismogenic depths, it should be possible for a hypothetical earthquake nucleating on the Shoreline fault to continue rupturing to the north onto the Hosgri fault. Examples of earthquakes starting on a smaller fault and continuing onto a nearby larger fault include the 2002 M 7.9 Denali earthquake (e.g., Eberhart-Phillips *et al.*, 2003) and the 2001 M 7.8 Kokoxili (or Kunlun) earthquake (e.g., Klinger *et al.*, 2005). This scenario could extend the rupture length an additional ~100 km to the WGCEP (2008) northern termination of the Hosgri fault near Big Sur. This hypothetical earthquake would have a moment magnitude of 7.2–7.5 (Table 3), compared to a magnitude 7.3–7.7 if the entire WGCEP (2008) Hosgri fault were to rupture.

Given that rupture directivity can greatly influence the spatial distribution of ground shaking (e.g., Aagaard *et al.*, 2010), it is important to consider also whether a southward-propagating earthquake on the Hosgri fault could branch onto the Shoreline fault. Kame *et al.* (2003) present a generic model of dynamic rupture on a main fault with a splay fault. They find that whether or not a rupture branches onto the splay fault depends on the stress orientation. Unfortunately, the stress orientation at the Shoreline–Hosgri intersection is unknown. The single event focal mechanisms do not have the quality or quantity necessary for a stress inversion. The composite mechanisms constrain only the quadrants of the principal stresses (McKenzie, 1969), and so the maximum compressive stress could be oriented anywhere from 0° to 60° to the Hosgri fault strike, in the sense to drive right-lateral slip. McLaren and Savage (2001) find that the average orientation of focal mechanism P axes over a larger region is ~43° to the strike of the Hosgri fault, but do not invert for

Table 3
Fault Dimensions for Four Different Hypothetical Earthquakes

	L (km)	W (km)	M_w ($\Delta\sigma = 3$ MPa)	M_w (W&C length)	M_w (W&C area)
Shoreline, seismicity	25	11	6.7	6.4	6.5
Shoreline, to coast	35	11	6.8	6.6	6.6
Shoreline + Hosgri	130	11	7.2	7.5	7.2
Hosgri, WGCEP segment	170	11	7.3	7.7	7.3

Four scenario earthquakes: a rupture of the Shoreline fault as defined by the seismicity; a rupture of the Shoreline fault continued southeast to the coastline; a rupture of the Shoreline fault along with the section of the Hosgri fault from the Shoreline–Hosgri junction to the northern WGCEP (2008) fault endpoint near Big Sur; and a rupture of the whole WGCEP (2008) Hosgri fault length. The fault width is taken from the Optimal Anisotropic Dynamic Clustering OADC fit to the Shoreline fault. The moment magnitude is determined either from assuming a 3 MPa stress drop and the appropriate stress drop equations for a strike-slip fault (e.g., Lay and Wallace, 1995), or using the moment-length and moment-area regressions from Wells and Coppersmith (1994).

stress orientation. The World Stress Map (Heidbach *et al.*, 2008) includes only two borehole breakouts nearby: one near San Luis Obispo with a maximum compressive stress axis oriented 53° to the strike of the Hosgri fault, and one west of the Hosgri fault with maximum compressive stress oriented 81° to the Hosgri strike, which is obviously not representative of the Hosgri–Shoreline junction because it predicts left-lateral motion on the Shoreline fault.

The Kame *et al.* (2003) model shows that a compressive branch oriented ~30° from the main fault, such as the Shoreline fault branching off of the Hosgri fault, is favored in the prestress field if the maximum compressive stress is at an angle < 45° to the strike of the main fault, which is plausible. Dynamic rupture in this case branches onto the splay fault, but the rupture on the splay fault is arrested by the stress shadow from continued rupture on the main fault under most conditions. This suggests that southward directed rupture on the Hosgri fault would probably not successfully branch onto the Shoreline fault.

However, there are several simplifications in the Kame *et al.* (2003) model that may make the results inapplicable to the specific case of the Hosgri and Shoreline faults. First, the model is 2D, meaning that any effects from 3D structure are not modeled. The Hosgri–Shoreline intersection has a complicated 3D structure, with the splay fault sitting above the dipping main fault, and a possible non-planar Hosgri fault, or another structure, at depth (Fig. 10). Second, the fault strength in the Kame *et al.* (2003) model follows a simple slip-weakening law, and the main and splay faults are assumed to have the same strength. The Hosgri and Shoreline faults could have very different constitutive properties, as there appears to be serpentinite along the Shoreline fault. The assumed slip-weakening strength evolution in the Kame *et al.* (2003) model is quite different from the laboratory constitutive properties of serpentinite, which exhibits depth-dependent strength, and velocity- and temperature-dependent transitions from velocity strengthening to velocity weakening behavior (Reinen *et al.*, 1994; Moore*et al.*, 1997). Third, the timing and effects of prior earthquakes on each fault are not considered. Modeling by Duan and Oglesby (2007) shows that prior earthquakes have a significant effect on the stress around the branch point. Schwartz *et al.* (2012) conclude that the relatively longer time since the most recent event was the primary factor that caused the 2002 M 7.9 Denali, Alaska, earthquake to branch onto the Totschunda fault rather than continuing on the main Denali fault.

When considering the interaction between the Shoreline fault and other faults, it is important to remember that the primary mode of deformation in the San Luis Obispo area is strike-slip faulting. The Hosgri fault slip rate of 1–3 mm/yr (Hanson and Lettis, 1994; Hanson *et al.*, 2004) is an order of magnitude greater than the 0.1–0.2 mm/yr uplift rate of the Irish Hills (Hanson *et al.*, 1994). Given that the Shoreline fault is connected to the Hosgri fault, it most likely functions as part of the dominant strike-slip system. The slip rate and cumulative offset of the Hosgri fault are thought to diminish to the south, reaching zero offshore of Lompoc (Hanson *et al.*, 2004; Jachens *et al.*, 2009), and so its slip must be transferred eastward to other faults of the plate boundary system. The Shoreline fault most likely transfers some of this strike-slip motion southeastward. The current configuration of the Shoreline and Hosgri faults is inherently unstable for large amounts of slip, despite the apparent lithological contrast across the Shoreline fault (Nishenko *et al.*, 2010) that suggest non-negligable vertical or horizontal offset. The fault junction could be maintained through dip-slip faulting, deflection of the fault planes, and/or distributed deformation. Alternatively, the Shoreline fault could be a reactivated preexisting fault.

The Shoreline fault may interact with the system of reverse faults bounding the Irish Hills (Lettis *et al.*, 1994). The Shoreline fault possibly crosses and perhaps truncates the reverse San Luis Bay fault, and runs subparallel to the reverse Los Osos, Wilmar Avenue, and Oceano faults (Fig. 1). The geometry of the Shoreline fault with respect to these faults is not consistent with that of a tear fault, which would strike perpendicular to and connect offset reverse faults. The Shoreline and Hosgri faults may instead accommodate some of the uplift of the Irish Hills block relative to the offshore Santa Maria Basin. Because the uplift rate is an order of magnitude smaller than the strike-slip rate of the Hosgri fault, the motion of the Hosgri fault would still be strike-slip with only minor obliquity. The Shoreline fault is a logical candidate for a bounding fault for the Irish Hills, given the steep topography along the very straight coastline. It is such a logical candidate based on the geomorphology, that prior to the discovery of the Shoreline fault by Hardebeck (2010) a reverse fault was hypothesized in its exact location (Nitchman and Slemmons, 1994). If the Shoreline fault has accommodated some vertical motion, its current strike-slip rate must be greater, given that the focal mechanisms are strike-slip.

Some bounds can be placed on the current ratio of the vertical to horizontal slip rate of the Shoreline fault. The greatest amount of reverse slip encompassed by the confidence bounds of the southern Shoreline fault composite focal mechanism is a rake of 138° (Table 1). This rake bounds the ratio of vertical to horizontal slip to be $v/h \leq 0.9$. An upper bound can be put on the vertical slip rate, $v \leq 0.2$ mm/yr, the uplift rate of the Irish Hills. Unfortunately, these bounds cannot place any meaningful constraints on the horizontal slip rate, h, without a non-zero lower bound on either v/h or v.

The approximately 50 $M \leq 3.5$ recorded earthquakes on the Shoreline fault are inadequate to extrapolate to the rate of larger events, especially without knowing whether or not there are characteristic large earthquakes that occur more frequently than extrapolation of smaller events may suggest (e.g., Schwartz and Coppersmith, 1984; Parsons and Geist, 2009). However, this extrapolation may provide an approximate lower bound, without having to resolve the existence or non-existence of characteristic earthquakes. In the characteristic earthquake model (e.g., Schwartz and Coppersmith, 1984), the extrapolation of the rate of smaller events would

by definition underestimate the rate of larger events. In the alternative model, earthquake occurrence follows the Gutenberg–Richter law over all magnitudes, but temporal earthquake clustering leads to different earthquake rates over different time scales (Page *et al.*, 2008). In such a model, a short earthquake catalog would usually underestimate the total earthquake rate, as it is unlikely to capture a period of intense earthquake clustering (Page *et al.*, 2008). The recorded earthquakes on the Shoreline fault do not exhibit strong temporal clustering, so it is reasonable to assume that an extrapolation of the current rate would provide a lower bound on the long-term earthquake rate.

A rough lower bound is placed on the rate of $\mathbf{M} \geq 6.7$ earthquakes on the Shoreline fault by extrapolating from the events that the OADC algorithm identified with the Shoreline fault. The EMR method (Woessner and Wiemer, 2005) is used to identify the magnitude of completeness of 1.6, the Gutenberg–Richter *a*-value and *b*-value are fit using maximum likelihood, and the Gutenberg–Richter distribution is extrapolated to larger magnitudes (Fig. 11). From this extrapolation, the rate of $\mathbf{M} \geq 6.7$ earthquakes is constrained to be $\geq 1.5 \times 10^{-5}$ events/yr, which corresponds approximately to a slip rate bound of ≥ 0.04 mm/yr, assuming most of the slip is accommodated in $\mathbf{M}$ 6.7 earthquakes. An upper bound can be found from the assumption that the Shoreline fault, functioning as part of the Hosgri fault system, would not slip faster than the Hosgri fault north of the junction. This places a bound on slip rate of ≤ 3 mm/yr, corresponding to $\leq 1.0 \times 10^{-3}$ events/yr assuming $\mathbf{M}$ 6.7 earthquakes. The possible slip rate ranges across two orders of magnitude, which is too uncertain for meaningful hazard estimates. Slip rate is therefore a key parameter that must be more tightly constrained in order to include the Shoreline fault in probabilistic seismic hazard assessment.

Conclusions

The geometries of the Shoreline fault at seismogenic depth, and of the adjacent section of the Hosgri fault, are constrained from seismicity relocations and composite first-motion focal mechanisms. The OADC method, which objectively determines planar fault geometry from the seismicity locations, identifies the Shoreline fault as a single continuous structure that connects to the Hosgri fault. The Hosgri fault dips steeply to the east, while the Shoreline fault is essentially vertical, so the Hosgri fault dips towards and under the Shoreline fault as the two faults approach their intersection. The focal mechanisms generally agree with pure right-lateral strike-slip on the OADC planes, but suggest either a non-planar deep Hosgri fault or some other structure underlying the northern Shoreline fault (Fig. 10b).

These results support the interpretation of Hardebeck (2010) that the Shoreline fault is a continuous planar fault at seismogenic depth, rather than the interpretation of Nishenko *et al.* (2010) and PG&E (2011) that the fault is divided into three segments by boundaries that would act as barriers to earthquake rupture. The results also support the interpretation of Hardebeck (2010) that the northern Shoreline fault connects to the Hosgri fault. The hypothesis of Nishenko *et al.* (2010) that the earthquakes that appear to be on the northern Shoreline fault are actually on an east-dipping Hosgri fault may be partially correct, as the deep events underlying the northern Shoreline fault could be on the Hosgri fault. However, the earthquakes above ~8-km depth delineate the northern Shoreline fault extending to the Hosgri fault. The Shoreline fault most likely accommodates the transfer of strike-slip motion between the Hosgri fault and other faults of the plate boundary system to the east.

The geometry of the Shoreline fault can be used to estimate its earthquake potential, although the probability

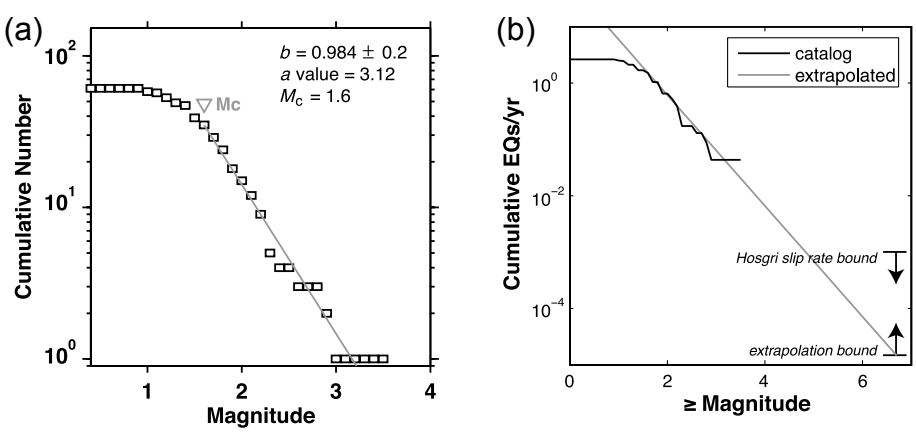

Figure 11. Magnitude frequency distribution for earthquakes on the Shoreline fault. (a) Cumulative distribution of magnitudes for earthquakes identified by the Optimal Anisotropic Dynamic Clustering (OADC) algorithm as being on the Shoreline fault. Magnitude of completeness, M_c, and Gutenberg–Richter distribution parameters, *a* and *b*, found using the ZMAP software (Wiemer, 2001) and the EMR method of Woessner and Wiemer (2005). (b) Number of events per year, black line from the catalog and gray line from extrapolation using the Gutenberg–Richter parameters. The extrapolation to $\mathbf{M}$ 6.7 provides a lower bound on the rate of $\mathbf{M} \geq 6.7$ earthquakes. An upper bound is estimated by assuming that the Shoreline fault does not slip faster than the Hosgri fault.

of a large earthquake cannot be reliably estimated because the slip rate is unknown. A hypothetical earthquake rupturing the entire known length of the Shoreline fault could have a moment magnitude of 6.4–6.8. Because the Shoreline and Hosgri faults are connected at seismogenic depths, a rupture nucleating on the Shoreline fault could continue propagating onto the Hosgi fault. A hypothetical earthquake rupturing the Shoreline fault and the section of the Hosgri fault north of its junction with the Shoreline fault could have a moment magnitude of 7.2–7.5. Generic 2D modeling of dynamic rupture on fault branches suggests that a rupture on the Hosgri fault should not branch onto the Shoreline fault, but this type of modeling does not capture the 3D geometry of the Shoreline–Hosgri intersection, the complex constitutive properties implied by the apparent presence of serpentinite in the Shoreline fault zone, or the unknown earthquake history of both faults.

Data and Resources

The merged CISN/CCSN phase catalog 1984–2010 was obtained from the Northern California Earthquake Data Center (NCEDC; http://www.ncedc.org/ncedc/catalog-search.html, last accessed January 2011). The CISN/NCSN waveforms are also obtained from the NCEDC, and CISN/SCSN waveforms are obtained from the Southern California Earthquake Data Center (http://www.data.scec.org/research-tools/index.html, last accessed January 2011). Waveforms from the CCSN stations were obtained through the NCEDC for events after 5 September 2006. Waveforms from CCSN stations for events prior to 5 September 2006 were obtained from PG&E. The WGCEP UCERF3 report can be found online at http://pubs.usgs.gov/of/2007/1437/ (last accessed May 2012). The Sliter *et al.* USGS Open File Report can be found online at http://pubs.usgs.gov/of/2009/1100/ (last accessed May 2012). Lowman's thesis was downloaded from http://digitalcommons.calpoly.edu/erscsp/2 (last accessed May 2012). PG&E's report on the Shoreline Fault was downloaded from http://www.pge.com/myhome/edusafety/systemworks/dcpp/shorelinereport (last accessed May 2012).

Acknowledgments

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Appendix G

Dr. William Lettis Email

From: Lettis, Bill [FWLA] <w.lettis@fugro.com>
Sent: Tuesday, May 10, 2011 12:16 PM
To: [redacted]
Subject: Budget estimate for SSHAC
Attachments: SSHAC_Budget.xls

Hi [redacted]

I have put together a spread sheet to track costs for the SSHAC process. I have NOT added the time/budget needed for Norm and the GM TI group and hazard analyst to prepare for the kickoff meeting and Workshop 1. I have left a space – Norm – please provide this estimate.

My biggest fear is that we have not allowed enough prep time for Workshop 1. However, this is the first year of the program, and we are building off of an existing model, so we may be okay.

I have tried to be as realistic as possible. However, I included all participants in the budget, including PG&E employees, consultants, academia, state employees, etc. If the budget for PG&E employees (Page, Steinberg, Abrahamson, Wooddell, etc) is already accounted for elsewhere, then this can be subtracted.

Also, I have assumed an AVERAGE billing rate of $1600/day for all people – some will be lower and some will be higher. I am a bit hesitant to simply offer a flat rate of $1,500/day to all of the PPRP. Coppersmith, Campbell and Donahue may be higher as consultants, while Weldon, Rockwell, Day, and Bommer may be lower as academia, and Chiou may be free ? as Caltrans. The average rate for the PPRP might be less than $1500. I will leave this up to you and Norm.

The budget estimate as it currently stands on the spreadsheet is approaching $1 million for 2011. This is a very rough first cut estimate to try to capture all of the elements of the program. I have listed the assumptions – please check to see if some costs can be trimmed (or if I am too light). Just for comparison, Coppersmith and I put together cost estimates from all of the completed, ongoing and proposed SSHAC Level 3 studies, and the average is about 3 to 4 million for a SSC SSHAC and 1 to 2 million for the GM SSHAC (PEGASOS as a Level 4 GM went much higher), for a 4 to 6 million effort. For DCPP SSHAC, some issues will make this less expensive (Pros below) and some issues may lead to higher costs (Cons below) depending on how we manage the effort

Pros

(1) We already have an existing model with significant existing effort, documentation and pedigree
(2) We are only performing an "update" of this existing model versus a complete new model
(3) PG&E, SCEC and PEER are performing many studies under separate budget that will help reduce uncertainty and feed directly into the SSHAC models

Cons

(1) The study is 4 to 5 years instead of typical 3 year – although this may lead to lower annual budget, any time extension on a project typically leads to higher costs
(2) DCPP is highly visible among state and federal regulators and public, with many complex, possibly controversial issues.
(3) Our PPRP consists of 8 members, many with significant SSHAC experience, and may asks for greater participation, additional analyses, etc of unknown budget and effort. Many SSHAC studies only have a 5-member PPRP
(4) The ongoing PG&E, SCEC and PEER studies will generate an enormous amount of new data and analyses. These results may lead to a more streamlined modeling effort or a more complex effort, especially if the TI team becomes involved in the analyses/interpretations.

I am available to have a conference call, or if you have email feedback, I am happy to modify the spreadsheets through many iterations

Thanks
Bill

Appendix H

May 9, 2011 SSHAC Project Plan

SSHAC Level 3 Methodology

PG&E DCPP SSHAC Study

DRAFT - Project Plan for Diablo Canyon Seismic Source and Ground Motion Characterization SSHAC Studies

Prepared by:

May 9, 2011

TABLE OF CONTENTS

LIST OF FIGURES

Purpose

A seismic hazard update will be performed for the DCPP Site, using an updated Seismic Source Characterization (SSC) and updated Ground Motion Characterization (GMC) as basic inputs to a site-specific probabilistic seismic hazard analysis (PSHA). The SSC describes the future earthquake potential (e.g., magnitudes, locations, and rates) for the region surrounding the DCPP site, and the GMC describes the distribution of the ground motion as a function of magnitude, style-of-faulting, source-to-site geometry and site condition. For this project, both of these models will be developed following the guidelines of the Senior Seismic Hazard Analysis Committee (SSHAC) Level 3 process (Budnitz et al., 1997). The SSC logic tree model will involve a comprehensive review and update of the existing DCPP Logic Trees developed by PG&E (1988, 2011). The GMC logic tree model will incorporate results from numerical simulations into the available empirical ground motion prediction equations (GMPEs). This Project Plan outlines our approach for conducting the SSC and GMC SSHAC studies. The Project Organization is shown on Figure 1; the Project Schedule is shown on Figure 2 and described in Table 1. Both the project organization and schedule are described further below.

A SSHAC Level 3 process is a formal process for developing SSCs and GMCs that has been identified in NRC regulatory guidance (RG 1.208) as an acceptable process for use in performing PSHA for nuclear sites. The SSHAC process provides guidelines for how all aspects of the SSC and GMC development should be conducted, including: (a) identification and evaluation of key data; (b) identification and solicitation of expert opinions; (c) evaluation and integration of interpretations, opinions, and hypotheses; (d) documentation of the model development; and (e) participatory peer review of the technical results and process. As described within the SSHAC guidelines, the goal of following a SSHAC process is to provide reasonable assurance that the center, body and range (CBR) of the Informed Technical Community (ITC) in the SSC or GMC models have been adequately captured. The purpose of this document is to describe the SSHAC Methodology in general and how the SSHAC Level 3 process will be applied to develop the updated DCPP SSC and GMC models.

The LTSP SSC and GMC models were originally developed in 1988 as part of the first PSHA performed for Diablo Canyon (PG&E, 1988). Outstanding technical issues with significant uncertainty identified at that time included the sense of slip and down-dip geometry of the Hosgri fault, sense of slip, slip rate and down-dip geometry on the Los Osos fault, and 3-D fault interactions at depth beneath the San Luis Range. Since that time, the SSC model was updated for the ISFSI project in 2003 (PG&E, 2003) and again for the Shoreline fault study in 2011 (PG&E, 2011). The 2003 update primarily involved revising the Hosgri fault characterization to be primarily strike slip based on new data that rejected the reverse and

reverse-oblique alternatives that were included in the SSC logic trees in the 1988 LTSP study. The 2011 update involved including the Shoreline fault zone in the model, reassessing the down-dip geometry on the Hosgri fault and Los Osos fault, and reassessing the existence and offshore continuation of the Rattlesnake and Olson traces of the San Luis Bay fault. Since 1988, the LTSP GMC model has been frequently updated using updated empirical GMPEs and near fault ground motion data that became available over the past two decades. The SSHAC update will re-examine parameters of the GMC and SSC models in light of recent and ongoing studies to develop new, updated GMC and SSC models that capture the center, body and range of the informed technical community.

The DCPP SSHAC Level 3 study will meet all of the SSHAC Level 3 processes of a traditional Level 3 study, but will differ in several important aspects. First, all of the proposed workshops will be open to the public and will include a “public comment” session at their conclusion. The attending public will be observers and will help to achieve transparency in the technical proceedings of the SSHAC process. Second, the DCPP SSHAC study will constitute an “update” of the existing Long Term Seismic Program (LTSP) SSC Logic Tree model and GMC model through “hazard-informed” sensitivity analyses. Although all aspects of the models will be considered, discussed, and updated based on current scientific understanding and concepts, the intent of the sensitivity analyses will be to inform the SSHAC participants of those issues of greatest significance to the hazard results and to focus further evaluation and integration of data and information on characterizing the uncertainty in these model parameters. An important aspect of the LTSP update, therefore, will be to avoid being anchored to the pre-existing characterizations and to be open to new data, evaluations, and alternative interpretations. Third, a number of significant studies will be performed during the course of the SSHAC study. These studies include onshore and offshore field investigations performed by PG&E and the ongoing USGS CRADA program, and empirical and numerical ground motion simulations by PEER, SCEC, and other researchers. Because of the significant amount of new data that will progressively become available, several of the traditional SSHAC Level 3 Workshops will be repeated in order to fully evaluate and integrate the newly available data and models into the SSC and GMC models. The intent is to capture improvements in the science and to develop updated SSC and GMC models that are current with our best knowledge and understanding, even for those parameters that are not significant to hazard. Important milestones in the ongoing studies relative to the SSHAC process are shown on Figure 2 and described in Table 1.

In part because of the ongoing field studies and ground motion research, the DCPP SSHAC Level 3 study will be performed over a four-year period, with a final report prepared during 2015. As described below, the project will include formal workshops, working meetings, and interface opportunities between the SSHAC project team and the ongoing PG&E field programs. A goal of the SSHAC process, therefore, in

addition to developing an updated SSC and GMC model, will be to identify important data needs for reducing uncertainties in significant SSC and GMC parameters that can be fulfilled by the ongoing PG&E field program and ground motion research. Through the iterative process of SSHAC workshops and directed field studies, the intent of the SSHAC Level 3 study is to develop a fully hazard-informed SSC and GMC model for use in updating the PSHA for DCPP.

Description of SSHAC Methodology

In 1997, the Senior Seismic Hazard Analysis Committee (SSHAC) published NUREG/CR-6372 (Budnitz et al., 1997) that detailed a methodology for capturing the epistemic (i.e., non-random) uncertainty in input parameters for PSHAs. Factors motivating the development of this methodology were the observations that: (1) different PSHA studies (e.g., EPRI, 1986-1989; 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 adequately characterize the uncertainty within those characterizations. Recognizing the importance of characterizing uncertainty, the SSHAC spent approximately four years developing a methodology for characterizing uncertainties in SSCs and GMCs. 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). The following summary of the SSHAC methodology and the proposed DCPP SSHAC 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 earthquake magnitude for a fault. In this case "center" can be thought of as the average (i.e., median) magnitude, "range" can be thought of as the extreme upper and lower magnitude limits, and "body" can be thought of as the shape of the distribution of potential 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. Following the SSHAC methodology is meant to provide reasonable 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, and stable (i.e., if someone else were to conduct a similar study they would not get significantly different results).

The SSHAC methodology defines four different levels of study that can be conducted to achieve this goal. The four study levels, Level 1 through level 4, are distinguished by the increasing level of sophistication, resources, and participation by technical experts, with a Level 4 study being the most intensive. As described within the SSHAC guidance, the higher-level studies (Level 3 or 4) should be used for projects with complex assessments, the potential for significant public impact, and significant regulatory scrutiny. The basis for using high-level studies for these projects is that the higher-level studies provide the greatest assurance that uncertainties within the SSC and GMC are adequately characterized.

A SSHAC Level 3 study will be conducted for the DCPP site because of both technical and regulatory issues. On the technical side, the SSC and GMC for the DCPP site will involve complex assessments due to the location of the site within an active tectonic region of the US. On the regulatory side, the seismic safety at DCPP will be subject to significant public and regulatory scrutiny. In addition to providing a robust characterization of the uncertainty in the SSC and GMC, a Level 3 study, in comparison to a Level 1 or 2 study, will provide the greatest assurance that the SSC and GMC will be accepted by the NRC, interested stakeholders, and the public.

For the DCPP 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 ITC. Integration refers to the assessment process where the various datasets, models, and interpretations are combined into a cohesive representation of the CBR for the SSC and GMC. Participatory peer review refers to the participation in the evaluation and integration by a peer review panel capable of reviewing and providing feedback on technical aspects of the project and whether the SSHAC Level 3 process was followed appropriately. Documentation refers to the final reports produced by the project that document the technical results (i.e., the SSC and GMC), how they were reached, and how the SSHAC Level 3 process was implemented. The SSHAC Level 3 methodology formalizes the process of interaction between the ITC, the project participants, and the peer review panel through a series of workshops. To fully understand these different components and the workshops, one must first understand the different roles that are defined within a SSHAC Level 3 study.

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. For the DCPP SSHAC study the roles listed below will be explicitly designated and documented as shown on Figure 1.

Project Sponsor – The project sponsor provides financial support and "owns" the results of the study in the sense of property ownership. PG&E is the Project Sponsor for the DCPP SSHAC study. [redacted] will be the Project Manager for the project on behalf of PG&E.

Technical Integrator Team (TI Team) – The TI Team is a team of technical experts with PSHA experience that are responsible for conducting the evaluation and integration process. The TI Team may also have a staff of experts that are not officially part of the TI Team but assist the team during the project. Ultimately, the TI Team "owns" 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 datasets, models, and interpretations of the ITC are considered in the evaluation; and (2) that the final SSC and GMC capture the center, body and range of the ITC. For the DCPP SSC study, Dr. William Lettis will be the TI Team Lead, and for the DCPP GMC study, [redacted] will be the TI Team Lead. Separate TI Teams, including Evaluator Experts (see below) will be selected for each study. Members of each TI Team are shown on Figure 1.

Project Technical Integrator (PTI) – The PTI is a technical expert with knowledge of the SSHAC process and both GMC and SSC studies. The PTI is responsible for ensuring coordination and compatibility between the GMC and SSC studies and for providing oversight of the overall DCPP SSHAC process. [redacted] will be the PTI for the DCPP study.

Evaluator Expert (EE) – An EE is an expert with PSHA experience capable of evaluating the relative credibility of multiple alternative hypotheses to explain observations. EEs use their professional judgment to objectively quantify uncertainty based on evaluations of the data, knowledge, and alternative models presented by the Resource and Proponent experts. EEs support the TI Team in their evaluation and integration and will be included in the TI Team's staff. For the DCPP studies, specific EEs will be identified as needed during the project.

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. For the DCPP studies, REs will be identified as needed during the project

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. For the DCPP studies, PEs will be identified as needed during the project

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. For the DCPP studies, Dr. Nick Gregor and [redacted] will be the Hazard Analysts.

Participatory Peer Review Panel (PPRP) – The PPRP is a panel of experts with SSHAC methodology and 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 views of the ITC are captured and documented through proper implementation of the SSHAC process. Members of the PPRP generally are involved in all of the workshops either through actively participating in the workshop or through reviewing meeting summaries. For the DCPP studies, there will be one PPRP for both the SSC and GMC to provide consistent reviews. During the concurrent SSC and GMC sessions at the workshops, the PPRP will divide into two groups. Members of the PPRP are shown on Figure 1.

Outside Observers – Outside observers are not explicitly defined within the SSHAC guidance (Budnitz et al., 1997), but may include regulatory officials or other interested parties outside of the project. 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 sponsor. All Workshops will be open to the public and time for public comment will be accommodated at the conclusion of each workshop. In addition, we anticipate that at least one observer from the NRC and other interested State agencies will attend each SSC and GMC SSHAC workshop.

For a SSHAC Level 3 study, the process of evaluation, integration, documentation, and review occurs in a series of workshops, working meetings, and internal work. These process components are described below.

Evaluation – The process of evaluation includes, but is not limited to, the: (a) identification of hazard-significant issues; (b) compilation of relevant data, models, and interpretations (e.g., published research papers, geologic and geophysical data); (c) collection of new data as needed; and (d) evaluation of the data, models, and interpretations with respect to their impact on either the SSC or GMC. The overall goal of the evaluation process is to compile and evaluate all of the data that is relevant to the characterization being developed (i.e., SSC or GMC). For this study, a Project Data base will be developed and will be made publically available for review. The existing LTSP database will provide the basis for the initial project database, and will be updated progressively as new information becomes available. The data evaluation process will be led by the TI Team, who are assisted by Evaluator, Resource, and Proponent Experts. Many of the interactions between the experts and the TI Team occur at official project workshops, but various experts may also be called upon by the TI Team as needed in other settings (e.g., working meetings). Because the DCPP SSC Logic Tree model will be an update to the existing LTSP SSC Logic Tree model, an important part of the evaluation process will be to avoid being anchored to pre-existing characterizations. Through sensitivity analyses, those parts of the SSC logic tree that are most significant to hazard will be the focus for evaluation and update. Those parts of the LTSP 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 sensitivity analyses. The primary focus of the GMC evaluation process will be on (1) the applicability of the NGA-West2 empirical models to the DCPP site conditions, (2) the use of recordings at DCPP to make site-specific modifications to the GMPEs, and (3) the applicability of the ground motions based on numerical simulations to the fault/site-specific geometries at DCPP. The PPRP is involved in the

evaluation process through attending workshops and/or reviewing interim project documentation. Outside observers may be invited to observe parts of the evaluation process.

Integration – Following the evaluation process, the TI Team will integrate the relevant data, models, and interpretations to develop an updated SSC logic tree and an updated GMC logic tree that captures the center, body, and range of the ITC. The process of integration commonly includes: (a) development of a preliminary SSC logic tree (version SSC 1) and a preliminary GMC logic tree (version GMC 1); (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 initial SSC logic tree, initial GMC logic tree, and hazard sensitivity; and (d) the development of the next version of the SSC logic tree and GMC logic tree. This process is iterated until a final SSC logic tree and a final GMC logic tree are developed.

For the DCPP SSC logic tree update, we anticipate four iterations of the logic tree (SSC V1 to V4) before development of the final logic tree (SSC V5). Initial versions of the SSC logic tree will be full Earth Science logic trees that capture the CBR of the ITC. The Draft (V4) and Final (V5) versions of the logic tree will be simplified “Hazard-Informed” logic trees that eliminate non-significant branches based on sensitivity analyses, but still capture the CBR of the ITC.

For the DCPP GMC Update, we anticipate three model iterations (versions GMC V1 to V3) before development of the final logic tree (GMC V4). The first version (GMC V1) will be based on the preliminary updated NGA-west2 models. The second version (GMC V2) will incorporate the final NGA-west2 models including near fault directivity effects and initial results from numerical simulations. The third version (GMC V3) will incorporate the final numerical simulation results. The final logic tree (GMC V4) will be developed based on the feedback from the Resource experts and PPRP members.

The TI Team will lead the integration process, and the Hazard Analysts will conduct the sensitivity analyses. The Evaluator, Resource, and Proponent Experts are less active in this process, but they can be called upon by the TI Team as needed to provide clarification, resolve new issues, and provide feedback on the preliminary model. The majority of the integration process occurs through informal working meetings and internal work. Workshops are generally used to present the models and sensitivity results, and to

collect feedback. The PPRP is involved in the integration process through attending workshops and/or reviewing interim project documentation.

Peer Review – Participatory peer review is an integral component of the DCPP SSHAC Level 3 study. The overall goals of this review are to ensure that the SSHAC process is adequately followed and that the technical results adequately characterize the center, body, and range of the ITC. The review is participatory in that it is a continuous process that occurs throughout the study, not a singular review that occurs at the end of the study. As such, the PPRP is kept abreast of project developments through a combination of attending workshops and reviewing interim project documents and the TI team has the opportunity to address the PPRP comments and make modifications during the project.

Documentation – Documentation is also an integral component of a SSHAC Level 3 study in that it provides a record of the final technical results (i.e., the SSC and GMC), 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 of the DCPP SSHAC Level 3 study also will provide the basis for the next PSHA update for Diablo Canyon.

DCPP SSHAC Studies

As described above, a SSHAC Level 3 study will be performed for the DCPP PSHA update. The SSHAC study will consist of both a seismic source characterization (termed the SSC Study) and a ground motion characterization (termed the GMC Study). [redacted] will act as the PTI and provide coordination and oversight of both studies. One PPRP will be convened for the overall SSHAC study (both SSC and GMC). Given the different fields of technical expertise required for developing SSCs and GMCs, each study will necessarily involve different professionals for the TI Team and experts (e.g., RE, PE). All SSC and GMC Workshops will be co-convened at the same time and location. Each meeting will have first a joint session followed by separate technical meetings for the SSC and GMC. This will allow the sensitivity analyses to be presented to both groups and allow for integrated feedback. As shown on the project schedule (Figure 2), the final GMC model will be completed (9/14) prior to completion of the Final SSC Model (3/15) so that it can be used to perform the final sensitivity analysis for use in developing the final SSC model.

For the DCPP project, both the SSC and GMC studies will follow a hazard informed approach in developing the center, the body, and the range of technical interpretations of the SSC and GMC. By “hazard informed” we mean that the level of effort put into characterizing certain parameters (e.g., a fault

100 miles from the site, the sensitivity of the site hazard to rupture directivity, etc) will be gauged by how significant the parameter is to hazard at the site. We will determine the hazard significance of, and thus the level of effort expended on, the various parameters of the SSC and GMC through a process of iterative sensitivity analyses that are built into the evaluation and integration components of the SSHAC study. An initial sensitivity analysis will be performed based on the existing 2011 LTSP SSC and GMC logic trees to identify those parameters that are significant to hazard at the site. Subsequent evaluation will be focused on improving the characterization of these hazard sensitive parameters and capturing the CBR of the ITR for those parameters.

Key tools that will be utilized in the SSHAC study are study-specific databases for both the SSC and GMC studies. These databases will be developed as the study progresses and will dynamically evolve as the project progresses in response to data needs identified by the TI Team, the PPRP, and experts (RE and PE) queried by the TI Team. As described above, because of the ongoing LTSP at Diablo Canyon, a comprehensive SSC data base currently exists and is actively maintained. The database includes publications, maps, a variety of digital data (e.g., digital topography, gravity data), and compilations of faults and tectonic features. This data base will become the SSHAC project database and will continue to be updated and augmented with new data from the ongoing PG&E field studies. The GMC database will be the PEER NGA-west2 data base with the addition of results from suites of numerical simulations computed using the SCEC broadband platform. The actual databases formed for the GMC and SSC studies will become part of the SSHAC documentation and will be made publically available. All of the relevant database content that contributes to the final SSC and GMC (either directly or indirectly by informing the evaluation and integration process) will be described within the final SSHAC documentation for the respective studies.

The four process components of each 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 each SSHAC study. All GMC and SSC workshops will be co-convened, with an opening joint session followed by break-out meetings of each group, and concluding with a joint summary session to discuss mutually important technical issues identified at the workshop. All workshop materials and presentations will be documented and made publically available.

DCPP SSHAC Level 3 Study Tasks

General Tasks

Task 1: Preparation of Draft Project Plan and Initial Sensitivity Analysis

The initial task for the SSC project will be to prepare the Draft project Plan and prepare for Working Meeting 1 (Task 2). Preparation for the working meeting will include reviewing the 2011 LTSP SSC Logic Tree model (SSC V0) and Ground Motion model (GMC V0), conducting sensitivity analyses using the V0 model, and establishing contractual relationships with the PPRP, TI staff, and Hazard Analyst.

Task 2: Kickoff Meeting for SSHAC Training, Project Plan Review, and Workshop 1 Preparation

This meeting will be attended by the PTI, the SSC and GMC TI team and staff, the PPRP, and the Hazard Analyst. The meeting will last one day. The meeting objectives are to: (a) present and explain the SSHAC methodology (i.e., SSHAC Training), (b) present the draft project plan and schedule for the study; (c) discuss the interaction between the SSHAC GMC and SSC studies; (d) present the 2011 LTSP Version V0 sensitivity analysis to identify key parameters and features most significant to hazard at the site; and (e) identify resource and proponent experts that will be used in the study to address the significant parameters and features. A review of the LTSP program from initial development of the LTSP SSC and GMC models in 1988 (PG&E, 1988) to the current Version V0 SSC and GMC model developed as part of the Shoreline Fault Study (PG&E, 2011) will be provided. The results of the meeting will be to finalize the Project Plan and to identify the initial set of Resource and Proponent Experts for Workshop 1. The PPRP will provide a letter documenting their observations and comments on the Draft Project Plan. Important data needs identified during the meeting will be submitted to PG&E for integration with the ongoing PG&E field program.

Task 3: Preparation for Workshop 1 and Database Development

Following the Kickoff Meeting, additional data developed by the ongoing PG&E field program will be gathered and input into the project database. Results from the ongoing field program will be considered and evaluated. These studies will include

- Initial 3-D Tectonic Model Results
- Initial Low Res 3D Seismic Results
- Initial Los Osos/Edna Fault Map Results
- NGA-west2 ground motion data base
- Comparisons of NGA models and updated data sets (residuals of V0 models)
- Validation of finite-fault simulations
- Updated methodology for inputs to dynamic rupture models

This work will be conducted by the TI Team and staff, and may involve interaction with REs and PEs. The database will be continually updated throughout the project as relevant data are compiled and will provide the fundamental data from which the TI Team will conduct the

evaluation and integration processes. Based on the sensitivity analysis performed for the Kickoff Meeting, key parameters of the LTSP SSC and GMC logic trees that are significant to hazard will be identified for further evaluation and to query the resource and proponent experts during WS1. Prior to the Workshop, letters will be sent to all or selected Resource and Proponent Experts identifying directed topics and issues to assist in their preparation for the meeting. The letters will help focus the workshop discussion on key issues related to a particular data set or to an alternative interpretation or model, including quality and resolution of data, expected use of data, uncertainty in the data or interpretations, etc.

Task 4: Workshop 1 – Data Needs and Alternative Models Workshop

Workshop 1 (WS1) will last for three days and be attended by the PTI, the TI team and staff, the PPRP, the Hazard Analyst, Resource Experts, and Proponent Experts. At this time, we anticipate the need to repeat the traditional SSHAC Level 3 Workshop 1 because of the significant amount of new data, analyses and interpretations being developed by the ongoing PG&E field program and USGS CRADA program studies. Thus, we have scheduled Workshops 1a and 1b six months apart. This will allow the TI staff, REs and PEs to be aware of and benefit from the new data, evaluations and interpretations in the workshop discussions. In addition, data needs identified during the course of Workshop WS1a will be used to help define the scope of further PG&E field investigations. The primary goal of Workshops WS1a and 1b is to interactively use the Proponent and Resource Experts, to explore the center, body, and range of SSC and GMC for the DCPP region, with a focus on those parameters of the LTSP model that are most significant to hazard. In addition, the RE and PE may identify other alternative models or technical issues that are not currently captured in the LTSP Logic Trees. These alternative models or technical issues will be identified during the workshop for future evaluation by the TI Team and added to the updated SSC Logic Tree model and GMC model as appropriate. This goal is accomplished through exploring alternate interpretations of data and alternate hypotheses derived from the data in a series of presentations and structured dialog between the various experts and the TI Team. The information gained from these interactions will, combined with information within the database, form the basis for defining the center, body, and range of the ITC and be used to update the LTSP SSC and GMC models. The workshops also will be used to identify additional data needs and/or analyses that may be performed to further evaluate alternative models or key model parameters and uncertainties. The proceedings of each workshop will be documented in a brief workshop summary for distribution to the Project Sponsor and members of the PPRP, and the PPRP will submit a letter to the TI Team Lead documenting their observations of the workshop. The workshop summary and PPRP letter will be publically available and become part of the final documentation of the SSHAC Level 3.

Task 4a: Workshop 1a

The topics to be addressed at Workshop 1a will include the following:

- Introduction and review of SSHAC procedures
- Present sensitivity analysis on SSC and GMC Version V0
- Interactive discussion with Resource Experts (selected presentations)
- Interactive discussion with Proponent Experts (selected presentations)
- Explore key parameters, data uncertainties, and alternative models
- Identify additional data needs and/or analyses

Task 4b: Data Evaluation and Integration for SSC and GMC Model V1 Development

Following Workshop WS1a, the SSC and GMC TI Teams will develop Models SSC V1 and GMC V1, respectively, through a series of working meetings and internal work. The SSC TI Team will collect and evaluate any additional relevant data identified in Workshop WS1a, and perform the initial Integration of the data and alternative interpretations into Version V1 of the updated LTSP Logic Trees. These working meetings may include combination of the TI Team, PPRP, and Hazard Analyst. SSC models V1 and the basis for the characterizations (e.g., earthquake magnitudes, rupture geometries, earthquake rates) will be documented within the source characterization database (i.e., database sheets detailing all of the parameters of the seismic sources including faults and areal sources) and logic trees. These source characterization database sheets and logic trees will ultimately become part of the documentation of the SSC. The GMC TI Team will evaluate the updated GMPEs developed as part of the ongoing PEER NGA-West Project and develop Version V1 of the GMC model. The SSC V1 and GMC V1 logic trees will be transferred to the Hazard Analyst for implementation and will be used in a set of hazard sensitivity calculations to provide hazard feedback for the TI team. The source characterization database sheets and logic trees will be provided to the PPRP prior to Workshop WS1b so that the PPRP will be able to fully evaluate the SSC and GMC V1 models before workshop 1b. Development of the SSC and GMC V1 models and the V1 hazard calculations will be completed using preliminary work products and will not be required to meet PG&E QA requirements .

Task 4c: Workshop 1b

The topics to be addressed at Workshop 1b will include the following:

- Introduction
- Present sensitivity analysis on SSC and GMC Version V1

- Present new data and information gained from ongoing PG&E, USGS CRADA, PEER, and SCEC programs
- Interactive discussion with Selected Resource Experts (selected presentations)
- Interactive discussion with Selected Proponent Experts (selected presentations)
- Explore key parameters, data uncertainties, and alternative models
- Identify additional data needs and/or analyses

Task 4d: Data Evaluation and Integration for SSC and GMC Model V2 Development

Repeat the evaluation and integration process described under Task 4b.

- Evaluate new data, interpretations and alternative models
- Integrate new information into development of SSC and GMC model V2.
- Perform sensitivity analysis on Model V2
- Identify key parameters and additional data needs, as needed
-

Task 5: Workshop 2 – Preliminary Model and Hazard Feedback Workshop

Similar to Workshop 1 (consisting of two Workshops 1a and 1b), we envision that Workshop 2 will consist of a series of iterative workshops at six-month intervals to develop a “hazard-informed” updated LTSP SSC and GMC models. Each Workshop 2 will last one to two days each and be attended by the PTI, the TI team and staff, the PPRP, the Hazard Analyst, and selected Resource and Proponent Experts that are identified by the TI Team, as needed. In contrast to Workshops 1a and 1b, which consisted primarily of evaluation of new information from RE and PEs, the primary focus of the Workshop 2 process will be for the TI Team to integrate information into models that represent the CBR of the ITC. The early updated versions (V1, V2) of the SSC logic tree model based on the Workshop 1a and 1b process will be “Earth science based” in that they will include the alternative scientific interpretations. In Workshop WS2c, the "earth science based" logic tress will be simplified into “hazard-informed” logic tree (V4) that eliminates non-significant branches from the logic tree model through a series of hazard sensitivity analyses that progressively identify those issues most significant to hazard.

During each workshop 2, subsequent iterations of the updated Logic Tree model will be presented to the PPRP and selected Resource and Proponent Experts, as needed. The workshops provide an opportunity for the RE, PE, and PPRP to review and challenge the TI team's evaluations and the technical justifications used to develop the structure of the SSC and GMC logic trees and weights on branches of the logic trees (e.g., whether any significant interpretations are missing, how the TI Team has integrated the alternative models and data

uncertainties into a single SSC, etc.). The TI Team will use this feedback in developing the new versions of the SSC and GMC logic trees.

At each workshop, the Hazard Analyst will present the results of the hazard sensitivity analyses to the TI Team and the PPRP to provide the TI team with feedback about the implications of their preliminary SSC models and GMC assessments on hazard. The hazard sensitivity will also be used to focus the discussion by the RE, PE, and PPRP on the technical issues and parameters that have the greatest effect on the hazard at the DCPP site..

The proceedings of each workshop will be documented in a workshop summary report. The PPRP will submit a letter to the Project Sponsor documenting their observations of the workshop. The workshop summary and PPRP letter will become part of the documentation of the SSHAC process.

Task 5a: Workshop WS2a

The topics to be addressed at Workshop 2a will include the following:

- Common Session
  - Present SSC V2 logic tree
  - Present GMC V1 logic tree
  - Present sensitivity analysis of Model SSC V2 and GMC V1 to identify hazard significant issues and parameters
- Concurrent sessions
  - Review and challenge TI team logic trees (SSC V2 and GMC V1)
  - Identify short-comings of TI logic trees
  - Identify key models and parameters requiring further evaluation
  - Identify data needs and additional analyses to better constrain logic trees
  - Integrate with ongoing programs

Task 5b: Develop Version SSC V3 and GMC V2 Models

- SSC
  - Evaluate new information from ongoing studies (can we list the expected studies that will be complete at this time?)
  - Integrate new information into Model SSC V3
- GMC

    - Include near-fault directivity and fling models into GMC
    - Based on feedback from WS2a, develop GMC logic tree V2
- Hazard Analyst
    - Perform hazard sensitivity analysis

Task 5c: Workshop WS2b

The topics to be addressed at Workshop 2b will include the following:

- Common Session
    - Present SSC V3 logic tree
    - Present GMC V2 logic tree
    - Present sensitivity analysis of Model SSC V3 and GMC V2 to identify hazard significant issues and parameters
- Concurrent Sessions
    - Review and challenge TI team logic trees (SSC V3 and GMC V2)
    - Identify short-comings of TI logic trees
    - Identify key models and parameters requiring further evaluation
    - Identify data needs and additional analyses to better constrain logic trees
    - Integrate with ongoing programs

Task 5d: Develop Version SSC V4

- Evaluate new information from onging studies
- Integrate new information into Model SSC V4
- Perform sensitivity analysis (using SSC V4 and GMC V2)

Task 5e: Workshop WS2c

The topics to be addressed at Workshop 2c will include the following:

- Common Session
    - Present SSC V4 logic tree
    - Present GMC evaluation of numerical simulations
    - Present sensitivity analysis of Model SSC V4 and GMC V2 to identify hazard significant issues and parameters
- Concurrent Sessions
    - SSC
        - Review and challenge TI team logic trees (SSC V3)

- Identify short-comings of TI logic trees
- Identify key models and parameters requiring further evaluation
- Identify data needs and additional analyses to better constrain logic trees
- Integrate with ongoing programs

- GMC
  - Review and challenge TI team evaluation of numerical simulations
  - Identify subset of numerical simulations to be used for evaluating need to adjust the GMPEs

Task 6: SSC Final Model V5 and GMC Final Model V3 Development

Following Workshop WS2c, the TI Team will revise the SSC V4 model and GMC V2 model in response to the PPRP comments, expert comments, and any additional information that is collected or discovered as part of the SSHAC process and ongoing PG&E field program. The model developed during this stage will be the final model developed as part of the SSHAC Level 3 process barring any significant comments by the PPRP on the model. To develop the model, the TI Team will hold a series of working meetings to discuss significant issues that were raised by the PPRP and/or experts on the SSC V4 and GMC V2 models. The TI Team may also utilize Resource and Proponent Experts, as necessary, to further refine alternate interpretations within the characterizations. As part of finalizing the model, the TI Team will finalize the source characterization database sheets and updated LTSP Logic Trees for all sources considered in the SSC. The SSC logic tree V5 and GMC logic tree V3 will be transferred to the Hazard Analyst for implementation and use in calculating the V5 hazard results. The V5 hazard calculations will be subjected to PG&E QA requirements. The source characterization database sheets will be provided to the PPRP prior to Workshop WS3 so that the PPRP will be able to review the technical content of the SSC V5 logic tree and the GMC V3 logic tree prior to the workshop.

Task 7: Workshop 3 – Presentation of Final SSC Model (V5), Final GMC Model (V3) and Hazard Results (V5)

Workshop 3 (WS3) will be attended by the PTI, the TI team and staff, the PPRP, and the Hazard Analyst. The goals of the workshop are for the TI Team and Hazard Analyst to present to the PPRP: (1) a review of the SSHAC Level 3 process that was used to develop the SSC; (2) the final SSC V5 model and final GMC V3 model; and (3) the resultant hazard (V5 hazard results) at Diablo Canyon from the combination of the final SSC and GMC models. The intent of these presentations is to provide the PPRP with a clear representation of how the TI Team integrated

the center, body, and range of the ITC into the SSC or GMC and how these characterizations impact seismic hazard. The dialogue and interaction with the PPRP will be used to help refine the presentation of the SSC and GMC in the final documentation of the SSHAC study. The proceedings of the workshop will be documented in a brief workshop summary for distribution to the Project Sponsor and members of the PPRP, and the PPRP will submit a letter to the project sponsor documenting their observations of the workshop. The workshop summary and PPRP letter will become part of the SSHAC documentation.

Task 8: Develop Final SSC V5 and GMC V3 Models

Following Workshop WS3, final comments from the PPRP will be resolved and incorporated into the SSC logic trees and the GMC logic trees, as needed. A final review of all new information, if any, from the completed PG&E offshore 3-D survey and SCEC and PEER studies will be performed and incorporated into the final SSC and GMC models, as needed.

Task 9: Report Preparation

Following Workshop 3 and development of the Final SSC and GMC models, the TI Team will develop the final documentation of the SSHAC Level 3 study. This documentation will be comprised of a Final report and calculations developed under the PG&E Geosciences QA program. The documentation will include complete documentation of the development of the SSC and GMC models and all of the parameters included within the models. Specifically, the documentation of the SSC will include LTSP logic trees of alternative models representing epistemic uncertainty, descriptions of aleatory uncertainty in appropriate parameters, the source characterization database sheets, and documentation of the workshops (e.g., workshop summaries, participant lists, presentations by Resource and Proponent Experts). The documentation for the GMC will include GMC logic trees of the alternative rock site median GMPEs (including directivity), site-specific amplification at DCPP, near fault fling effects, and single-station sigma. The final report will also be provided to the PPRP for their review. Upon completion of their review, the PPRP will provide a letter documenting their evaluation of the SSHAC Level 3 process. This letter will be included in an appendix of the final report.

Task 10: Final Briefing Meeting

The Final Briefing will be attended by the PTI, the TI team, the PPRP, and the Hazard Analyst. The goals of the meeting are for the TI Team and Hazard Analyst to present to the PPRP the final versions of the SSC (V5) and GMC (V3) models, and resulting hazard results at Diablo Canyon, as presented in the Final Report. Significant remaining uncertainties in model parameters

important to hazard and/or outstanding technical issues will be identified for further evaluation during the next LTSP hazard update.

Schedule

The schedule for completing the Diablo Canyon SSHAC Study is presented in Table 1 and Figure 2. The project will commence with the Kickoff Meeting in June 2011, and will be completed in mid 2015, a 4 year duration. Workshops are anticipated to be held at 6 month intervals every June and November during the project. As described above, the goal of following the SSHAC methodology is to have reasonable assurance that uncertainties in the SSC logic trees and GMC logic trees have been adequately captured for use in an updated PSHA for Diablo Canyon. Accurately capturing these uncertainties is essential to developing an SSC and a GMC that will: (1) be accepted by the NRC, and (2) provide a robust characterization of the hazard at Diablo Canyon. This goal is accomplished by following the formal SSHAC process of data collection, evaluation, integration, participatory peer review, and documentation. While the process is formal, in that the required process steps are defined within the SSHAC documentation, (Budnitz et al., 1997), the process is very dynamic. For example, the discovery of new data during the collection stage can trigger additional evaluation steps, attempts to integrate unexpected alternative models identified and/or supported by experts can slow the integration process, and comments by the PPRP and experts can trigger the need for unexpected analysis and revisions to the SSC or GMC. All of these dynamic events are part of the SSHAC process, and the unexpected work they trigger needs to be conducted to ensure that the uncertainties in SSC and GMC are appropriately characterized.

The target schedule for the DCPP SSHAC study envisions the development of new data, the complex tectonic setting of the site region, and possible requests or need to develop new information to address specific SSC or GMC parameters and uncertainties. In particular, the schedule incorporates the known schedule for the ongoing PG&E field program, USGS CRADA Program, and the PEER and SCEC ground motion studies. However, because of possible unexpected events, we view the schedule as dynamic. We will adjust task durations and start dates throughout the course of the project to accommodate these unexpected events to the extent possible, but attempt to maintain the target completion date for 2015.

Quality Assurance

Quality Assurance for the development of the SSC and GMC models is the SSHAC process itself and the peer review. These two tasks will not be required to follow the PG&E Geosciences QA procedures.

Implementation of the SSC and GMC models into hazard inputs will be required to follow the Geosciences QA procedure. The translation of the SSC and GMC models into PSHA inputs will be documented in Hazard Input Documents (HIDs) and the HIDs will be part of the QA documentation. Any changes to the hazard code that is required to implement the SSC and GMC models will require that the revised hazard program be verified under the QA program. The final PSHA calculations will be conducted under the Geosciences QA program.

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Table 1 - Schedule for LTSP Update Using SSHAC Level 3 Process

(*Italics show Interface with PG&E, PEER and SCEC Activities*)

** This should be separated into SSC and GMC parts. Need to put into chronological order. It is too confusing with the dates moving back and forth.

June 2011 (1 day meeting)	**Kickoff meeting.** Review Project Plan, SSHAC Training, coordination with ongoing PG&E, SCEC and PEER programs, and Workshop 1 objectives (issues, experts). <u>Attendees</u>: TI Team, PPRP, TI staff.
July/Oct 2011	Prepare Sensitivity Analysis for Seismic Sources 200 mi radius and LTSP logic trees.
June/Oct 2011	Evaluate/Integrate information from ongoing PG&E, PEER and SCEC studies into LTSP GMC and SSC models (Version V0)
Oct 2011	Perform Sensitivity Analysis of V0 models.
May 2011	*Updated NGA data set*
Aug 2011	*Initial 3-D Tectonic Model results available*
Aug 2011	*Initial Low Res 3D seismic results available (North).*
Oct 2011	*Initial Los Osos/Edna Fault Map results available*
Oct 2011	*Validation of Finite-fault simulations*
Oct 2011	*Update method for inputs to dynamic rupture models*
Nov 2011 (3 day meeting) (+1 day PPRP)	**Workshop 1a.** Data needs/alternative models. Version V0 sensitivity results. Identify data required to test alternative models significant to hazard, identify additional alternative models, if any. <u>Attendees:</u> TI team, PPRP, Resource and Proponent Experts
Dec/May 2012	Collect/analyze additional data, as required.

April/May 2012 Evaluate/Integrate new information into GMC and SSC Version V1 models

May 2012 Perform Sensitivity Analysis of V1 logic trees.

*** Bill: This will not work. THe NGA model are availabe in May. We can't start on developing GMC V1 until these models are ready. We can't run the sensitivity in May. The June 2012 workshop will have to be late June or July **

Dec 2011 ***Final low res 3D seismic results available (South)***

May 2012 *Initial NGA – West 2 Models available*

June 2012 (3 day meeting) (+1 day PPRP) **Workshop 1b.** Data needs/alternative models. Version V1 sensitivity results. Identify data required to test alternative models significant to hazard, identify additional alternative models, if any.

Attendees: TI team, PPRP, Resource and Proponent Experts

July/Oct 2012 Collect/analyze additional data, as required.

Sept/Oct 2012 Evaluate/Integrate new information into SSC Version V2 model

Oct 2012 Perform Sensitivity Analysis of SSC V2 and GMC V1 models.

June 2012 *Finite fault Simulations (FFS) for Hanging Wall (HW) effects*

June 2012 *Complete library of dynamic rupture sources*

Aug 2012 *Results from onshore 2D seismic survey available.*

July 2012 *Fling models based on old FFS.*

Sept 2012 *Final NGA-west2 models available, including Median Horizontal (w/HW effects), V/H ratios, Sigma, and Directivity*

Nov 2012 (2 day meeting) **Workshop 2A.** Version V2 Model and Hazard Feedback Workshop. Version SSC V2 sensitivity results. Identify data/additional analyses to test alternative models or

reduce uncertainty significant to hazard.

Attendees: TI team, PPRP, selected Resource and Proponent Experts.

Dec/April 2013 Collect/analyze additional data, as required.

April/May 2013 Evaluate/Integrate new information into GMC V2 and SSC Version V3 models

May 2013 Perform Sensitivity Analysis of GMC V2 and SSC V3 models.

Dec 2012 *Inputs to kinematic FFS simulations complete.*

Dec 2012 *SOM method complete (epistemic uncertainty space covered by GMPEs).*

May 2013 *Initial results of paleoseismic studies*

May 2013 *Final results of onshore fault mapping complete*

June 2013 (2 day meeting) **Workshop 2B.** Version V3 SSC Model and Hazard Feedback Workshop. Version SSC V3/GMC V2 sensitivity. Identify additional data needs, incorporate new data.

Attendees: same as Workshop 2A. (Down select experts based on issues.)

July/Sept 2013 Collect/analyze additional data, as required.

Sept/Oct 2013 Evaluate/Integrate new information into SSC Version V4 models

Oct 2013 Perform Sensitivity Analysis using GMC V2 and SSC V4 models.

July 2013 *Finite fault simulations complete*

June 2013 *Results from offshore 3D HESS survey available*

Nov 2013 (1 day meeting) **Workshop 2C.** Version V4 SSC Model and Hazard Feedback Workshop. Version SSC V4/GMC V2 sensitivity. Identify additional data needs, incorporate new data. Identify additional data needs.

Attendees: same as Workshop 2B.

Dec/Sept 2014	Collect/analyze additional data, as required.
Sept/Oct 2014	Develop Final Earth Science and Hazard-informed SSC Model (V5)
June 2014	Develop Final GMC V3 model
Oct 2014	Perform Sensitivity Analysis using GMC V3 and SSC V5 models.
July 2014	*Final results of paleoseismic studies*
Aug 2014	*Final results of offshore fault mapping studies*
Aug 2014	*Final results of 3-D tectonic model available*
Sept 2014	*Final results from HESS 3D survey available.*
Nov 2014 (1 day meeting)	**SSC & GMC Workshop 3.** Version 5 SSC V5 and GMC V3 Final Models and sensitivity analyses Attendees: TI team and PPRP
Dec/May 2015	Incorporate Final PPRP comments, develop final Hazard-informed logic trees (working meeting).
Dec/May 2015	Incorporate new information from Hess 3D seismic survey, as appropriate
Mar/Oct 2015	Prepare report, final data compilation, documentation.
Nov 2015 (1 day meeting)	**Final Briefing Meeting** (as required). Version SSC V5 and GMC V3 Final Models Attendees: TI team, Hazard Analyst and PPRP.

Figure 1: DCPP SSHAC organizational structure.

Figure 2: DCPP SSHAC GMC and SSC schedule and interaction points with ongoing programs

Appendix I

Excerpt from PG&E Transcript of 2011 SSHAC Workshop

KATHRYN HANSON: I recall stopping. I recall it not being necessarily that definitive or clear. Jerry Webber did map and I think he did identify in his report that there was a possible displacement there. I think that some additional reconnaissance and mapping north of Moro Bay across the Cambria fault is certainly warranted for this study.

BILL LETTIS: Yes, I was just going to ask that follow-up. So a potential data need would be at least a reconnaissance of the marine terraces in that area. Webber, by the way, is a potential resource expert that we may want to contact. Any other questions? Otherwise we are cutting into our lunch break, which I thank you all for. I know lunch is important, but we will reconvene at 1:00. It will be a merged session with the GMC group, the ground motion group. So I invite you all back at 1:00. Thanks.

[LUNCH]

NORMAN ABRAHAMSON: We'll get started with our summaries. Is this microphone on now? Yeah, great. I'm just waiting for a plot to be updated, but I can get started to review where we are. I'm going to run through the ground-motion section, so we're back together. I don't know if Bill mentioned it to the source characterization group. Moving forward, we have decided not to try to run concurrent sessions for future workshops. There's too much that people want to see in both of these workshops as what's going forward, so we will make them so you are welcome to stay for the entire week when we try to do that. It's going to take more time, but I think it will give us a better integration moving forward. And I'm going to pull up—so I have some general slides, and then we'll run through the summary of where we ended up on the ground-motion data needs.

First off, as a reminder what we're trying to do here is, one, we're looking at hazard sensitivity; what matters most in current models. The hazard sensitivities were intended to guide us as to what's important. These were not comprehensive yet. Okay. There's going to be other features that are brought in. An example was brought up the first day. What about a renewal behavior on the Hosgri Fault? Well, that hasn't been evaluated, and each time before the workshop, we'll be redoing these hazard sensitivities to, again, re-evaluate what is the most important factors and largest impacts on the uncertainty. We're then trying to put out here for Diablo Canyon, we are running both deterministic and probabilistic analyses. So when we're thinking about what matters, we've been showing you sensitivity and probabilistic space hazard, but we need to also be keeping track of what is important for the deterministic analysis as well. So the next time we show the tornado diagrams at the next workshop, we will be having one for probabilistic impacts and one for deterministic impacts so that we can keep track of both of those going forward. As well, we're now looking at identifying in the ground motion side what is our ability data for addressing the hazard sensitive issues and what are the gaps and how will we fill those gaps. I just got this one hot off the presses, so it should be at the top. There it is. Trying to—is that visible? Yes.

So summarizing just what we're going to be looking at this hour, in terms of the impacts on this short-period motion, this will change as you look at longer periods, but this is just as a reminder. We want to be looking at the things that are going to be most sensitive to the hazard in terms of our uncertainty, and we have to be sure that we don't miss these. Okay? That's really

the key. As we move down onto these other features, so on the ground motion for us, sigma model is really most important and next is the ground motion—is it the ergodic assumption approach, and we'll talk a bit about that, and the ground-motion prediction equations with this additional epistemic uncertainty are really driving it for us on the ground motion side, issues like down here the hanging wall effect, on or off. For probabilistic standpoint wasn't as big of a deal, and as we went to the issue of, are we truncating at four or three or six sigmas was not as significant of an issue. So for our main ones, they're going to be up here as well. I don't see directivity on here because we didn't do that for peak acceleration. It will affect us for long periods.

Our main interest—the frequency band that's most important in nuclear power plants is sort of the 2.5 to 30 Hz range sort of captures it; however, our characterization is going to go, you know, broadband to long periods as well. There are some features or systems that are sensitive to longer period motions, not the key ones critical for safety, but we want to be getting a comprehensive characterization. So you will see on the ground motion side some other things, for example, directivity may start to become more important at the longer periods, and next time when we show this, we'll start to do it. Remember on these types of tornado plots, they're intended to focus your attention on things near to the top, so on the source characterization, these items here are more important at least in the way we currently characterize the model than these items are down here. And that's really simply trying to focus our attention. Okay? What is going to, as we collect new data, actually impact our results and evaluation. Okay. So thank you, Katie, for putting that together quickly for us.

The—so I'm going to start with—so an overview of where we were on ground motion. So I've tried to here put into some columns what are our uncertainties that we were looking at in the order of—that we were talking about. So, sigma and then the ground-motion model were—those were the biggest players for us in terms of hazard sensitivity for the probabilistic results. For the hanging wall and partially ergodic assumptions as well, those are—partial ergodic is important both for probabilistic. The hang wall effect is mainly—is more important for us in the deterministic analysis because that can change quite a bit depending on, for example, for the Los Osos Fault. Directivity and fling become more important for us just at the longer periods. So, really, in our priority list, that is a less critical issue to be taking on. And then we'll talk about a couple other factors that we're considering which will help us later on when we go to the probabilistic risk analysis. How are we going to get ground motions into the structure? And I'll talk a little bit about that.

So the gaps and needs, one is expanding the empirical database with additional worldwide ground motions. So I think I mentioned on the first day, our focus has been—or we are working with the PEER center. There's a large effort updating the NGA ground-motion models, and new NGA West 2 ground-motion model will be done next year. It has a significantly expanded database, but it still doesn't have everything that we need to be capturing, so we want to be bringing in extra data that will not go into that database for the development of the new NGA model, but we can use that data to check those models to make sure that we are capturing a broad enough range and not just limited to what was in that set. Our focus is going to be in the five-and-a-half to seven range and short distances. Down to five-and-a-half, the

reason we're going that low is we want to really be able to start to understand things like how the hanging wall effect will begin to taper out and diminish at smaller magnitudes.

Hard-rock classification project, this is actually something that our discussion—this will probably turn into a broad project tied—needing to partner with other groups doing this, in particularly, the NGA East work; that is, we really haven't had a really good way of classifying hard-rock size other than drilling them. Most of our sites, we still don't go out and actually drill through them. A lot of the—or to get the shear wave velocities, many of the estimates are based on inferred values, correlations with surface geology, topography, and so forth. And these really need to be recalibrated for hard rock. They haven't—they work well in a soil range, but we need to get them to do that. Ours—Diablo Canyon is a hard-rock site, and so, we need to focus on that. That's going to be affecting, again, the basic ground-motion model and the way we're getting at the hang wall effect.

The third one here is finer sampling of spectral values in the 20 to 30 Hz range. This is not a ground motion issue for us; like, we need to collect new data. It's just, when we have been running the response spectral values before, the original NGA models, for example, had pretty sparse sampling. We'll go 20, 30 and 50, and then we jump to 100. We need to get a few more frequencies in there to better define that part of the spectrum because for hard-rock sites, we do have high frequencies there. So that's really just—that affects the way that we'll build the median GMPEs at the high frequency end.

Completing the California small magnitude data, this is really focused on the sigma value for us. We're using an approach called single-station sigma that needs—to do that, we have to have recordings at sites—or at sites with multiple recordings to be able to take out the site, the actual side effect from that. The data that has currently been available and used has not had enough data from California, in particular, sampled at many different frequencies. And we're also looking at updating this on a worldwide basis where we have at least five recordings per station. So that will help us constrain this—our standard deviation model. Part of the issue though with that data is, for the smaller magnitudes, our metadata, like the location, is generally not as accurate as it has been for the larger ones. Errors in the location accuracy affect the distances close in. That translates into standard deviation effects. And so, we have been seeing empirically, when we just ignore that and move forward, a larger standard deviations from small magnitudes at short distances compared to big magnitudes, and that may well be simply an artifact of the metadata. So we need to go back and re-evaluate those metadata. It may be relocating the earthquakes or filtering through them to take out the ones that don't have reliable metadata.

Compilation of path azimuth to allow treatment of correlation of path effects, so I'm now getting you into some statistical details on how we do things. The issue fundamentally here is, with the single-station sigma approach, we are taking out a side effect, but if I have all my earthquakes coming at me or a bulk of them from one direction, like an aftershock sequence, and they're all coming from one direction, those will end up having a similar path. And so, they may get a reduced variability because the path was all the same, not just because the site was the same. So we need to be sure we are not mapping path similarity into side effects because that's

not what is part of single-station sigma. So all of those are sigma and probably our highest priority of topics for moving forward in terms of our tornado plot.

Next, moving to finite-fault simulation, so in addition to the empirical data sets, we're looking at numerical simulation efforts. We need to expand our view beyond just the limited data. Even as those have grown, they're still not, I would say, comprehensive in the large magnitude, short distance range. So the first part of this is validations of these simulation methods. This is an important thing that we've done in the past, but probably not as comprehensive as it needs to be, and I'll go through more details of that. That effects our GMPE and particularly the uncertainties. Part of our approach will be to take, say, the NGA models and broaden the epistemic uncertainty, that's the FE term here, to capture differences, for example, PCC, different scaling from the numerical simulations. We need that to be captured in the range of models that we've created so we can broaden that range out. And in particular, this will be important for us for hanging wall effects. It's probably—what we—I will cover that as we go forward in more detail.

Finite-fault simulation methods for the inputs, so once we have a procedure working, we still need to have a way to get the inputs for that procedure. Okay. So how do we specify now what our thousands of input parameters that may go into a finite-fault simulation. This, again, is primarily affecting our epistemic uncertainty in the GMPE, if I can get a mouse, here and the hanging wall effect. And then, we're going to turn the crank on these things. So that's when we'll just start creating a large suite of finite-fault simulations. This is not hundreds. This is tens or hundreds of thousands because the whole purpose is to start to get robust answers or results and well-planned experiments as opposed to what we get with the empirical data. So that's, again, in our median values, our hanging wall effects, and this will also now be helping us in directivity and fling studies.

The other, then, moving on to regional data from the Deer Canyon earthquake sequence. So the Deer Canyon earthquake was a small earthquake that happened about four kilometers away from Diablo Canyon of magnitude 3.4, and it was recorded at the site, and so we've been using that to help characterize the site condition, those of you know the kappa value, or, really, what is the high frequency damping that we think is in the Diablo Canyon site area. But we haven't looked at the other recordings from around that earthquake, so that should be recorded by the regional network, and we can go and better understand the source properties of that to help us constrain how we are interpreting that earthquake in terms of its shaking at Diablo Canyon as well because—and this is affecting for us two parts. It's, one, it affects the GMPE part, the median ground motion because we're using that as part of our kappa estimation, so it's helping control the high frequencies. And if we can get regional data, we can now have more than five stations recording that site, and it now can become one of the points that we use in our partially ergodic data set. We are now working with two recordings, and that will get us up to three which is a 50-percent increase, so that's progress.

As well, really, ideally for this partially ergodic approach, this δS2S; that's our site term. If you think of it, that's the correction that we add for the specific amplification that's seen at Diablo Canyon; that's empirically based. So we're looking at installing some additional accelerometers in Diablo, an area there with lower trigger thresholds than what we currently

have if we can find some quiet enough sites on the same geologic material but still close to the power plant because we don't want to be getting away from it. And so, that we can start to get earthquakes, let's say, in the magnitude 3 range that would be triggered, and then we could use those as well to build up the number of data sets. Part of the—one of the issues that we've got on our—back to our kappa value is that Diablo Canyon is showing up at—currently interpreted as a high velocity site, 1200 meters per second, yet high kappa. Okay. Kappa, meaning it's still attenuating the high frequencies more like a soft-rock site. So it's, how can you have a high velocity and a high kappa? So our data is indicating that, but this could be because of Q in the crust if—while we're only about—the hypocentral distance is about eight kilometers or so, so there's not a lot of time or path for Q to have an effect. If there's a low Q path that the waves are taking, then that might be influencing this, so if we could benefit from any of the 3D crustal structure models that you're guiding from the source characterization part, that would help us interpret that data as well. So that's, again, helping us on the GMPE and the epistemic uncertainty of that.

Then we're also then moving to the issue of fault branching. What is the ground motion when you have a fault branch? And let's say that you're next to the branch. If we have the case with the Hosgri rupturing and the San Luis—or, excuse me, Shoreline Fault ruptures as a splay fault, what is the combined ground motion from the—through going rupture and the splay rupture? So we're looking at, one, using dynamic rupture simulations to help you look at that effect so that you can model it and see how much the ground motions would change with and without the splay fault there. Then as well, one [inaudible] here falling into the other category. This starts to help us down the line for what do we do in the risk calculation; how do we specify inputs to the power plant; is dynamic ground rupture simulations for extreme ground motion. This is a topic that was dealt with in the DOE/PG&E Extreme Ground Motion Project for Yucca Mountain. And this really is after, what do unusually large ground motions look like, because it's not simply a scaled-up version of a regular earthquake. Okay? And so, we want to push the simulations to try to give us a better way of specifying realistic unusually large cases because they're going to be different.

Then a topic that we didn't talk about here but I have put on that we will get to next—for our next workshop is going to be identifying and characterizing fragile geologic features in the region. This is a topic we've called unexceeded ground motions, but can you—to try to extend our basically short-observation period, looking at the geology, can we use the existence of a particular geologic feature that is fragile, would break if it was shaken in a strong earthquake, and you can figure out how long it's been there. It can help you, here, look at alternative ways or weighting of your epistemic uncertainties. So this was—that's one thing that was really—made a lot of progress with the DOE work on the Extreme Ground Motion Project. The other couple—two here are on directivity and fling that we talked about today, reprocessing of static displacements for the record, so we're finding a way—the new processes and techniques are allowing us to pull back these static displacements in the ground motion records, and there's a broader set that we can work with.

And then, finally, at the end, how good, it says here, evaluating the station distributions in the empirical data compared to random sites. What we're trying to get at is, how—as our data set has expanded and it's got bigger and bigger, are effects of fling and directivity now just simply

captured in our data sets so that we don't have to try to model them specifically, but they're in our medians and in our standard deviation, and we need to see what we have now. How well is that capturing what is—what would be if we had, you know, thousands of recordings from that. All right.

So that's our overall summary. And, again, things pretty much that were in the left-hand most columns we will put as our highest priority; things in the right-hand columns are probably our lowest priority sites. If I go through a little more detail then, so I'm going to do this a little bit quickly. So I'm not going to read all these things up here. You can try to read them yourselves, but I'll just, again, highlight them.

The first part is back to expanding the empirical database as we talked about, particularly the data sets in Japan. There's quite a large increase here. Our focus is on hard-rock sites, magnitude five-and-a-half to seven at short distances. In particular, we're also looking for sites where we have recordings on dipping faults. We have recordings on both the hanging wall and the foot wall. If you have them just on the hanging wall and nothing on the foot wall or just on the foot wall and nothing on the hanging wall, we can't get the effect of the difference. So we need to try to find any cases where they're there and going to smaller magnitudes, because right now that is really the poorly controlled part of the data set. We're looking in addition to just thinking about Japan is, what about other regions? So, Turkey, Taiwan, New Zealand, and China, the key to all of that is getting data with reliable metadata. If you just get the ground motions and you don't know the site conditions or the magnitude is not well controlled or the location is not good, that's not going to be too valuable for us. Okay? That we did identify some additional near-fault data from the Duzce earthquake. Ralph Archuleta said that he knew of a temporary array that had been put in, so we're going to go and pull those data in.

As well the data from Diablo Canyon that we have right now, we will—so that is some of the hard-rock site data. We will now put that into the NGA data set, so that will become part of the full data set that's evaluated. There were questions if anything has been recorded at Songs [ph]. I'm not sure about that. They're not a hard-rock site, but for the Songs [ph] people, if you have any recordings there, I think is valuable now to bring those into the data set so they're also evaluated in a consistent way. And then, are there other sites that have this feature of a high shear wave velocity and high kappa, so normally, higher velocities, the lower the kappa value. Okay? And there was a comment about—it's very well detailed here. It's station A64 from the Canadian earthquake, so we're going to the east. Appears to be having that same kind of behavior, so we're going to take a look at that as well.

So the database that we're using right now for NGA, there's been a significant increase in the number of records with reliable low-frequency content. This was work that Pacific Engineering and Analysis has done, but we need—so we're almost getting two-to-three times as many recordings that are good at low frequencies than what they were before, and we're after—we need documentation as to what happened in terms of the changing of the processing and why. The higher frequency limits is still an issue for us; that is, how high can we push the recordings; how much is the—any low paths filtering impacting us in response spectral space. We know it has a big effect in [inaudible] spectra, but we want to check this on response spectral space, particularly for hard-rock sites. Again, the current data set, I talked before about

we just need to add higher, more fine sampling of how we characterize the response spectral values in the high-frequency range.

The additional epistemic uncertainty in the medians then, really, we said the expanded data set from NGA1 to NGA2 is having—just because we have a lot more data now, we are expecting a reduction in the statistical uncertainty; that is, you know, it's almost sort of a [inaudible] reduction. As I get more and more data, my median becomes more and more accurate, but there's other methods that we're looking at. Frank Scherbaum has put forward some concepts as to how to visualize how the uncertainty or differences between ground-motion models in a set of space. If any of you have seen, these are these Sammon's maps, and so forth. It's a very clever concept. Those of you who have dealt with Frank as well is, it is very high on the sophistication approach. So, unfortunately, Frank was not able to do this work for us. We had tried to contract him under the PEER work, so we need to find somebody else that can try to do it, and what data is needed to make that method work. And part of what we're doing on this epistemic uncertainty here, I said, is we're going to be using this as a way to capture the range of what the data or models would be from other areas of the world, and what the data would be from, say, simulations. So this is really the thing that gives us a way to say our models are this close, but, really, we need to broaden out that uncertainty to capture everything that's out there.

Metadata, again, this whole problem of hard-rock sites, there—one, you know, so we're looking—are there some key hard-rock sites that it really makes sense to go spend the money and drill and find out what's there, and that we should measure instead of infer, and, again, this need for a comprehensive characterization project on hard-rock sites. And this fits really well with what's going on in the eastern U.S. work. There's a lot of—we're looking how many hard-rock sites have measured VS30 values. Really, the answer was very few, I think; although, most of—because we have few small number, most of those have been characterized, but a key issue is how many of the sites that have been characterized as soft rock using inferred methods really were a harder site, and are there some out there like that. So we need to start to—one way is to look at a—just, there's a pilot study. Pick a subset of those that we've used inferred methods and see, if we do a detailed characterization, are, you know, ten percent of them wrong or is it 50 percent of them wrong, and so forth.

Finite-fault simulation, so in all of this, you know, while we have a large expanded empirical data set, as I mentioned earlier, we are still short in, you know, robust large numbers of recordings at large magnitudes and short distances or large numbers of recordings over the hanging wall versus the foot wall of even a magnitude six-and-a-half earthquake. So part of our issues, though, is that in the past when we have used some different simulation methods, we haven't been getting—in some cases, we get consistent results; in some cases, we get inconsistent results. Here, it says get to the bottom in the differences. And we've had difficulty really isolating what is causing that, but one of our approaches here is to move from modelers individually running their models for us to having them produce—take their concepts, turn them into algorithms that are implemented as a module on the SCEC broadband platform, and then we can run them in a very controlled way and say, let me do parametric studies, and so forth, and really understand if we're getting a difference, what is causing it. We need to go beyond what's just being done in simulations in California or at SCEC, and the Japanese have been doing

simulations for quite a long time, and so, we're looking to trying to bring the Japanese methods into this SCEC broadband platform as modules. It's really a nice place to put things because it naturally can accept an approach, and we just build a module, and then you can hook up different modules to get your simulated results.

We do need to go back and re-optimize how we choose—you know, how we're going to do our simulations in terms of where do we put the sites, how many sites we're doing, the number of realizations, and so forth. For Diablo Canyon, it's short distances, right? I think the first day we were trying to emphasize this for you. From what we know now currently, we've got four faults that matter. Okay? The other faults we will include, but they are not the key background zone. I didn't mention the first day. We included a background zone, even double—we know we're double-counting events, and it still doesn't matter. So our four faults are really what we have to get at. We need to go to smaller magnitudes than what we have used before in our simulation, down to get to hanging wall effects, and we need methods that work or validated here for high frequencies. So a lot of the work earlier on in the simulations have been focused on the long-period range. That's where the science is mainly working, and we've got to be sure we're using methods that are intended for high frequencies, high frequencies being 25-to-30 Hz. Okay? So high frequencies isn't 1-to-3 Hz. All right.

Hanging wall effects, so this is mainly—again, as I mentioned in that early summary, its biggest impact is on deterministic values. The current data set that we have empirically is really sparse. If you start to lump it all together and squint your eyes, you can start to see trends coming through, but it's really difficult to just simply have an empirical model. There's only a couple of earthquakes. It would be really Northridge, Chi-Chi, and I think Wenchuan is the other better one that start to have enough data, both on the hanging wall and foot wall sides so that you can reliably see what a difference is. So we're trying to expand that, in particular if we can, with the Japanese data. In the last ten years, there's quite a bit—a lot of sort of moderate-size earthquakes, and we may have some good chances to get data on both sides of the set. Paul Somerville mentioned a study the Japanese have shown just some—or some pictures of some of their data showing some very strong hanging wall/foot wall differences. And so, we need to understand how they did that, how they classified their stations, but then also going to other regions, back to the, you know, Taiwan, you know, New Zealand, Turkey, and wherever they are. We need to search the world for hanging wall/foot wall pairs to be comparison. Because this data will likely come after the NGA West 2 models are developed—there's no time to build them into that data set—we will use these data to compare the models, and with the NGA West models or other candidate models, and again, C, do we need to be making an adjustment to that model or broadening our uncertainty to capture that.

Hanging wall effects keep going on. The simulations, really, the great news here is that with the simulations that we have existing currently that were done for the NGA project in 2004, they show broad agreement this time as opposed to what we've seen in other cases. They all are showing a very strong hanging wall effect. They differ in the amount, in the size of the effect, but they in general were good, and that really makes us believe that this effect is there even though, from the empirical side, it's not compelling, but from the numerical simulations, it makes sense and should be there, and that really tells us we have to start to consider this effect. Simulations in the past were focused on big magnitudes, seven-and-a-half or, you know,

7.8, and so forth, for hanging wall effects. We need to be moving this back to smaller magnitudes as well, again, all the way down to picking up the smallest magnitude where we can see the hanging wall effects going away. Right now, the current simulations stop at six-and-a-half, and they show strong hanging wall effects. So do they die at six; do they die at five-and-a-half? You know, how are they attenuated?

As well, we need to be looking at the same effect for strike-slip. That wasn't done at all, so a dipping strike-slip fault, if the Hosgri is dipping as much as 70 degrees, then we need to be looking at hanging wall effects from strike-slip faults. One issue we talked about, well, what are the source characterization people going to come up with. The Los Osos Fault currently may be—you know, the dip could be 45, but could you now shift it to being a strike-slip mechanism. If so, then we need to start to think about that, so we want to try to capture these now before—and not at the end, have you come up with a case we're not ready to implement.

Dynamic rupture models, most of our approach for the simulations is on kinematic models to get to the high frequencies that we're after. But in a small enough volume, so if we're looking at 15-by-15-by-15 kilometer cube, we may get a small enough volume that we can take now the more sophisticated dynamic rupture models and push them up to five Hz. Okay? At that point, we can start to then see what's happening. The dynamic models give us big advantages. They would be different for reverse and normal; whereas, the kinematic models, it's just a flip of the sign, and that's all it is. So they don't pick that up, and they would have, again, differences in strike-slip, so that would be good for us if we can get it to work. The indications from the people involved is—are, who know dynamic ruptures models is, they think they can get there if we can limit the volume to something manageable. All right. That was day 1 for us. Okay?

Day 2. Okay. So single-station sigma. So for many of the people in the room, they've been working on this for several years. There's a whole lot of happening on this topic around the world, and the good news is it's really been well-integrated around the world. We're all cooperating. The key, though, again, is we need to be looking at expanding the worldwide data set. Stations with at least five recordings per station and each earthquake that they're using, we need at least five recordings for that earthquake to get what we call the event term. Was that earthquake systematically high or low so that we can start to identify the—what is our site term. A particular site may be more—have larger amplification or lower amplification at a specific period than a typical site with that VS30. So we need to be adding the California data to that. These are what we talked about in particular; that the new Japanese data may triple the size of what we've been using. The current studies from around that are being compiled around the world to deal with this stopped at 2005 for the compilation, so we need to deal with that. For this, for the Japanese data, there's an issue for us. We need to separate out crustal and subduction earthquakes. We can't just throw them together because they'll have different median ground motions. We're back to this issue of sampling of the path azimuth, as I said, so that we don't map repeatable path effects and assume that was a repeatable side effect. Okay.

And then, when we talked about here comparison of class 1 and class 2, so if you haven't known, this is our new terminology in the ground motion world. To have peace with the seismologist, we are not talking about aftershocks and mainshocks. We are talking about class 1

and class 2. For us, a class 1—or a class 2 event is an aftershock that occurs along the rupture plane of the mainshock. So if you're—the new—if it's a rupture that—an earthquake that occurs right off the ends, or as you move away, for us that is not class 2; it's class 1. So class 1 is all things you would have called mainshocks or not ruptures on the mainshock plane. The reason for that is, the whole issue of aftershocks and before-shocks and triggered events starts to create an inconsistency, so we are using class 1 and class 2, and you should not hear us ever saying the word aftershock and mainshock. All right. The issue here again is, does this affect our standard deviations. Are they the same for those groups, because we may get areas where there's a whole lot of class 2 events because of an aftershock sequence is happening. So I guess I can say it that way. But we don't—we want to make sure that that standard deviation is applicable to our class 1 events.

So to be able to get data, enough recordings at our sites, to be able to estimate an average site turn; that is, I can see how my site response is different than what the model was predicting and in a stable way, we need to get—this is as I said here, we're after five or more recordings per earthquake. To do that, you've got to go small. Okay? We can't wait at a site and say I need five magnitude 7s. That's not going to happen for us. So we're now working under an assumption that our site, that the differences in the amplification we get from magnitude—small magnitudes, say magnitude 4s, is the same as what we would be getting for magnitude 7s, and this needs to be checked and really worked through. As well, you know, if there's nonlinearity in the amplification, that would start to affect that value as well. We're also looking, as I said, the quality of the data from small metadata, particularly the location could be leading to significant errors in the short distance part, and we're seeing—there's an indication that, again, we see a very large standard deviation, increase in the standard deviation at, say, magnitude 4 to 5 in the zero- to 15-kilometer range. Well, that's where an error in location could really change the prediction by quite a bit, and then, we may simply be mapping location errors into what we call aleatory variability, and that's not right. That's not where it should be.

There's another concept here. I don't—I'll try to explain a little bit. So we get to, now, the concept of a single-station sigma. Okay. PhiSS is the within-events single-station sigma, so after I've taken out whether my earthquake is systematically high or low, how—what is the variability at my site. But now, if I go to a site where I have, let's say, stronger 3D effects in my subsurface, then that site may find that it's more sensitive to the amplification changes depending on how the waves are coming into the site. If I had area in the flat zone, it may be very similar. But what we're seeing is, there is—as we now have enough data, we can see the standard deviation is not the same for all sites, and we can actually see how that varies. This is a source of epistemic uncertainty that has never been considered in probabilistic seismic hazard analysis before. Okay. It's got to be there. It's the right thing to do to include it, but now this is something new that we're going to have to work through. Increasing epistemic uncertainty, those of you who have done hazard, you know always now flattens out your hazard curves, so we will—almost surely, this will lead to an increase in the hazard as compared to ignoring that effect, but we need to work out how to treat that. And then, the same—I guess this is a repeat—that we are combining small and large magnitude datas to try to get our site terms. That's the δS2S.

The Diablo Canyon site conditions, so, really, where Diablo Canyon is a hard-rock site, again, 1200 meters per second. We have old measurements from when at the power block when they—when construction was going on, there was also new measurements from the [inaudible] about a half kilometer away, but on the same geologic unit. We're looking to see, can we find another spot closer to the power block where we can do geophysics or measure what that shear wave velocity is to confirm that that's there. Easy places like the parking lots or on a different geologic unit unfortunately, so there's some trade-off there that we're working through, but it looks like there's a potential for some spot. So the recordings at Diablo Canyon for site kappa, so, again, I mentioned the Deer Canyon earthquake recording; that's the one that shows us that, while this is—we're measuring the high shear wave velocity, it gets a kappa value or a behavior in the high-frequency amplification that looks like a softer rock site. Part of the, I would say, arm-waving interpretation is that we are on a hard piece of material in a more fractured area so that the fracturing in the Franciscan is damping out the higher frequencies like a soft-rock site would do. But we do need to look at this one. There's several other methods for doing kappa. We have done one. You can—based on response spectra, you can look at [inaudible] spectra. We can look at the verticals because we have focused on the horizontals, and then back to, can we find some other explanation? Can you find a way to get a Q effect through a particular zone? You know, is it from Deer Canyon to Diablo Canyon that it is running through a low Q that's attenuating it; whereas, if the ground motions were coming from the Hosgri or somewhere else, it wouldn't be there. So that's where we could really use help on—with the—probably the velocity models and information that's coming out of the active geophysics that's going on.

Our δS2S, so in our terminology, that is our modification, how much we change the generic ground- motion model for a hard-rock site to apply to Diablo Canyon. Okay. And the only way you get this is data or real detailed geotechnical models of such an effect. So we've had our two earthquakes that we've used. Parkfield and San Simeon were recorded here, and we're able to use those to get our first estimate. I will tell you that those two earthquakes actually gave us—were consistent in what their term was. So even though I only have two recordings, two samples, at least they are not going in opposite directions. They are showing a similar trend. The third one we can try to bring in is Deer Canyon, but to do that, we need to understand that earthquake more. We can't do this kind of a calculation with one recording. You must have multiple recordings so that we can understand, well, if the whole earth—if the stress drop was higher, the whole earthquake is more energetic than normal. That's not a side effect. That's an earthquake effect. Or if it was less energetic than normal, I don't want to map those source terms into the side effects. So this is really looking at the regional data, what's out there, to help us constrain that, probably seismological mauling of these events to really understand them and make sure that the stress drops that come from the seismology are consistent with stress parameters we're getting from simplified point source [inaudible] models.

Back to collecting additional data, so I think all of us will say more data is good. How do we do that? Again, probably trying to push in some areas where we can get an instrument and try to collect more at Diablo Canyon; however, that doesn't help me unless I got this thing recorded at five other stations in the approximately same distance range. If I had a recording at Diablo Canyon from an earthquake ten kilometers away, and now I have five other recordings but they're 100 kilometers away, that doesn't help me. Okay. So I need to be able to constrain

the attenuation and try to take out the source term so I'm not mapping that into side effects. We'll go—the one issue came up, after we've done this new δS2S is applying site corrections, does our standard approach of applying a vertical-to-horizontal ratio still work? Okay. So our normal way, we've develop a horizontal spectrum in detail, and then we'll use scale factors to go from the horizontal to the vertical. Do those scale factors still work if we've applied all of these other corrections? And so, we're going to look at just the simple trial application with Parkfield and San Simeon to see how that goes. That will be two samples, though, so we really want to have more to try to get something robust.

Validation of the simulation methods, so we're validating against past—two ways to do it. Validate against past earthquakes. How well you predict individual observed recordings, let's say from Loma Prieta, you can say, did I match the recording at Saratoga, and so forth, or—and then, we can go to a different earthquake and see how well the simulations are working. And the other way to do it is to say, let me just check that my model, simulation model, works for—is consistent with our empirical ground-motion models where they're well-constrained. Like 10 to 30 kilometers from a magnitude six-and-a-half earthquake, we have quite a lot of data. Well, the simulations on average ought to be similar to those values. The—in our discussion, the primary method for checking against the—or evaluating the simulations was strongly supported; that that be comparing observed ground motions, but the problem with just that is, we need a way to check the whole process of how the simulation works. And that whole process involves setting up how you do the inputs for future earthquakes. And the way you can check then—a good way to check the whole process is going back and saying, let me take my method for producing thousands of inputs, run them all. Does it work at least where I believe my empirical models are well-constrained? And so, we'll be looking at running both of those approaches. We're looking at getting numbers like 20 earthquakes that we validate against. In the past, these have been numbers sometimes 3, 4, or 5 earthquakes, 7 earthquakes. That's not enough to start to get really robust stable results. And this is some of the issues of—we want to get as many earthquakes as we can. Mainshock/aftershock pairs would also be useful for some cases. Some of this work is being done as the NGA East validation effort, but we're going to expand it to a larger set.

And let's see, we'll go to inputs to the kinematic finite-fault simulations. So, again, once we've got the whole thing working back to how do we get the inputs, one of the key issues that we've had is these finite-fault inputs have—they require—finite-fault simulations require a lot of inputs. At every point on the grid that you're going to have the fault slip, you need to specify how much it slips, the direction of the slip, the rise time, when it slips, and the correlation of these parameters and where the hypocenter is, is the key issue. So in the past, quite a bit of work has been done using marginal statistical distributions of these parameters, and we need to be tracking correlations. So the new methods are all starting to deal with, what is the correlation? If the rise time is longer or the rupture velocity is faster, does something else adjust? If the slip is high, is another piece adjusting so that we keep physically realizable realizations happening; otherwise, with kinematic models, it will run whatever you tell it to run, and you can create physically unrealizable combinations. So part of this—so we're using dynamic rupture models which are then at least physically consistent when they create what the source models are to build, what is effectively, artificial earthquakes. We can make hundreds of artificial earthquakes, or a catalog of those, and now evaluate how all the parameters are correlated, and then turn those into kinematic ruptures. We don't simply turn on the dynamic

rupture model straightforward because we have to get to higher frequencies than they can currently get us with.

There is an issue of subshear and supershear velocity, so some of the work so far has dealt with this correlation, but only for the subshear case. We have to deal with the potential of very energetic ground motions. Well, supershear is a way that you create more—you know, above average ground motion, so we can't have those left out. We need to have those included. But once you've said, I'm going to use dynamic models to build my kinematic inputs, how do you get the inputs for your dynamic models? Okay. You have—that problem has not gone away. You've just pushed it further down the line. We're doing—that work has been going on with SCEC and the USGS for the last, I guess, year-and-a-half to two years on this. And we're trying to work with them in sort of a broad community review of this and workshops that come up with some models. Right now, we're into iteration 2. I expect we're going to need a third iteration in a year as we start to see how all this works. The question then is, how do you check that that was right, that you got the right distribution? So one way we're looking at this is, if I start to run my dynamic models for a suite of earthquakes, I should start to get the variability in my single-station sigma which now has taken out the variability of the site [inaudible] that is similar to that number from the empirical data. And one of the great things that we're finding is this PhiSS term is very stable around the world, much more stable than our standard deviation was in old values. And so, I'm ready to call it soon our ground-motion universal constant of what PhiSS is. But this tells us—gives us a way to really start to make sure the dynamic rupture model had—we need some way to check the whole thing and not just say, well, I built in statistical properties and here's what comes out. Okay.

So the data—the other way of getting at kinematic simulation in inputs has been to look at, what do we see from source models from past earthquakes? So it's now routine process. When a big earthquake happens, people will take the recordings, either teleseismic data or local data. They'll do inversions of that data and say, here's what happened on the fault. Here's what the slip was; here was the rupture times; here was the slip time function, and so forth. And so, we're starting to build up catalogs of a lot of these things that now can be used to try to look at the correlation. There are not as many as what we can crank out with dynamic ruptures, but now we're back to data that is a good place to be. Martin Mai had been building a database of these, but his database stopped adding data in 2005. A lot more models have happened, as this, again, is becoming a routine process, so we need to look, one, to see is there an update to this model database that somebody else has taken on, and if not, we've got to start to bring those in and see what's happening. Here's a very specific thing. So detailed particular calculation, and that is one way we specify the inputs within the wave number domain and particularly the slope of the fall-off with wave number. All right.

So, and one issue has been that the—some of the times we do these inputs—these inversions, three people will do an inversion for Parkfield, and they're not going to be the same. And you can say, well, one found the patches the PEER; another found a similar patch, but then another one on a different part of a fault. Well, that's why—you know, that's going to be differences, but are the characteristics that we're after, the statistical properties which are captured in the wave number spectra, the same. So we may find that these things are actually more similar than we thought. These wave number spectra, basically, are telling you the

dimensions and numbers of asperity is the way to think about it, and how they're separated. And so, if you had asperities, but in one case they were in two spots, in another case they were in two different spots, you'd look at those in a map of the fault and say, wow, those are different. But from a statistical point of view, they may be very similar.

Fault branching, as we talked about before, how do you get ground motions from fault branching? Our ground-motion models are not geared to produce this. Empirically, they're not set up for that case. The dynamic rupture models, then, are something that can be used to try to work that problem out. There is an effort underway right now to do what we call code validation, taking multiple people's dynamic rupture models and seeing, if we give them the same inputs and same fault branching case, can they get the same output so that we can at least have some confidence that the simulations are working right. And it looks like some initial issues are that these really may be very sensitive to small changes, and how you deal with inputs or model the details numerically of how you're building up fault branching. We need robust results. So if things are moving tremendously back and forth, we won't be able to rely on this type of an approach. If we can find, no, there's some places where it is stable and we can see what's happening, we can do that.

There's also a couple—you know, we're down to—around the world, we found two, I guess, recordings near a place where we had a branching fault rupture as well. Okay. One is from Imperial Valley, station EO7, and a couple others nearby, near the Brawley Fault, and the second one is Kobe University site from the Kobe Fault where there was a little fault branch. So we can look at that and see those were modeled numerically where they've now done simulations with and without the fault branch, so we can then see the seismogram if the fault branch wasn't there and the seismogram with it there and see what the impact is. Does this increase the ground motion 10 percent; Is it 20, whatever? We can then, from that way, build at least an empirical correction factor for when we have a branching case in the source characterization.

Extreme ground motions, this is back to the idea of, one, you can try to get bounds on distributions. How big can it be? It's similar to the effects of sigma as use truncation. Katie showed this earlier. This isn't a real big topic for us. Yucca Mountain, this matters when you're pushing probabilities down to 10-to-the-minus-8, 10-to-the-minus-9. This becomes one of the key factors. But at the probabilities in the minus four, five, and six, that we're mainly after here, then this is not as important of an issue. But it does help us on this bottom piece, characterizing what large, rare ground motions look like. Okay. So that we can put realistic ground motions into the structure and not be taking ground motions that are just scaled up from something else and saying, I'll make this really large ground motion by taking a small one and bumping it up into the structure. So we're looking at our new approaches in our seismic PRA to really describing our initiating events. So these are, something happens, well, it's an earthquake; we want to get actually suites of scenarios that are realistic, but when I put this whole suite together, I recover the hazard, and I recover the uniform hazard spectrum. And a lot of work is going on on that topic. That's the end of day 2. All right. We're almost there.

So day 3, was—we were looking at near-fault effects of directivity and fling. So directivity, we are—a lot is happening on that topic. In the current NGA databases that are being used, several different directivity parameters have been tabulated. We know that there's a

bunch—there's other candidate directivity parameters that haven't been included. Bodie—and I would butcher his last name so I'm not even trying to put it up there—Jack Baker and then Jennie Watson-Lamprey have different parameters that we need to be including to see what's happening. We want to, on directivity, come back to the case of, is the data now broad enough and complete enough that directivity effects are simply captured when we model the data. When we get the average and the standard deviation, we have some forward directivity; we have some backwards, and they're in there so that we wouldn't have to be trying to tinker with the model to add directivity effects to it. The question then becomes, is the distribution—if we look at these directivity parameters, so those of you who have known this, you may have been before of X cos (theta) and terms like that, we're now looking at some different ways of doing directivity, but does our sample capture what we would have got if we had had uniform distribution of stations? Okay. So, ideally, that's what would be the case. We would be getting something that is not bias by the sample size. And so, we need to check that.

The existing 2004 simulations for numerical simulations were also used to evaluate directivity. This was a part where we did not get robust or consistent results between the different methodologies. This could simply reflect some of the methods were not good at producing directivity effects, or they work great for high frequencies, but they didn't create the right directivity effects, or—you know, so we need to figure that out. On my side on the TI team, I want to see multiple numerical simulations producing similar answers before I'm going to jump onto that train. Okay? So one person or one model or approach that is giving me an answer and hearing that that is the correct value or "believe me," you know, I can talk to different people, and they all say believe my model. So we need to have models where we're getting similar results. This discrepancy might not occur with the current methods that are on the SCEC broadband platform. We're now into the period range where a lot of science has been happening, a lot of research is going on on long period, so we think even taking the existing methods on a SCEC broadband platform, running in a—this—I said 2004-type suite of cases, now we're going to crank that, turn the crank for, you know, thousands of realizations out, then we should be able to see if we're getting robust results. If these three methods now are in agreement, now we're in a much better place to start to rely on what those trends are.

The other part that we talked about at the bottom is, once we have directivity or pulses back to—sometimes this leads to a large velocity pulse in the ground motion, we're back to talking about, how do we get realistic inputs into our PSA, into our PRA? These are correlated between epsilon, so this is now epsilon is how many standard deviations you are above the median. The higher you are in epsilon, the more rare it is; that is, it's a more severe earthquake. It's still a big earthquake, but I can have severe, you know, big earthquakes, and I can have more benign big earthquakes. And we're trying to see what is, not only a large nearby earthquake, but one that's above-average. What would it be doing? And that's what those high epsilons are. This will help us try to get back to more realistic inputs that we use for the evaluation of a plan.

Fling is the last part. This is the part of the ground motion associated with the permanent tectonic deformation so that the fault is moved. Your site has physically moved during the earthquake. You know, if you did your GPS, you'd see it in one spot and another spot location later on, and that took a finite amount of time. So in the NGA, the question comes back to,

again, is this already captured in the empirical data? It turns out that now—what was surprising to me on—so 60 to 80 percent of the large magnitude data at short distances have now the fling effect in it. Before, we didn't—we had so few that we were not confident we were capturing the effect. We are now looking at finishing this up by adding static. Static processing means processing the ground-motion data to preserve that static displacement for some other near-fault regions with the potential for fling so that we can keep this number up nice and high. So this is really indicating we've got pretty good coverage. There are, though, at the same time in 2004 time frame, a set of simulations was run for the tectonic offset, the fling effects, and if we compare those to the existing empirical data, they are not consistent. Part of the inconsistency may be on, let's say, features of how the kinematic inputs were specified back then, and that process has changed quite a bit. And so, we need to update those simulations so we can see if we're getting consistent results from the empirical and simulation, as well as we can look at any geodetic measurements that may be nearby to help constrain those values.

That's the end of day 3. So I am finished. Not too bad. Any comments? So we've got—I guess we're about how far behind? We're a half an hour late. Only half an hour, so not bad. I will open up comments from any of you. I mean, this is a lot. If you're not into ground motion, this may just seem like gobbledygook, but there is a method to our madness. Again, as I said, we are focusing on things that matter. So if I went back to our plot that we're talking about here, this is where we're at. We are—most of what we have listed for you is addressing things in those top three red lines there. The other ones down here are going to be less important. But, again, hanging wall effects will be mainly showing up on the deterministic analysis. Any comments? None whatsoever? Okay. Did you understand it? I know at least this side of the room got it. I can see a few hands coming up. Any broad questions as to—I mean, it's fine if you want to, what the heck are you guys talking about? No? All right. If you're all satisfied, then that means you are saying fund all of this, and we'll move forward. But, Bill, are you ready, or do I need to stall a little bit?

Okay. 15-minute break. All right? Let's start up at 2:45, and we'll be on to the source characterization part. Thank you.

[BREAK]

BILL LETTIS: Okay. Could we have everybody take their seat for the next session, please. Thank you. First of all, I'd just like to extend my thanks to everyone here for a great workshop and, you know, for your attendance, your participation. Those who gave presentations, I know on the SSC side, they were outstanding presentations. I—and a lot of great ideas were presented, so I just want to say thanks before I say anything else. And so, we went through quite a bit of discussion, a lot of presentation of data, how that data might relate to significant issues, and we came to the conclusion geology doesn't matter. Norm Abrahamson. But, seriously, I do want to go back to the tornado plot that shows geology matters. I don't want to be overwhelmed by the ground-motion plot, but once again, there's quite—the significant—

- Bill, point out that this is a different scale than their scale.