Case No.: A.14-02-008

Exhibit No.: A4NR-2

Witness: Douglas H. Hamilton

BEFORE THE PUBLIC UTILITIES COMMISSION OF THE STATE OF CALIFORNIA

Application of Pacific Gas and Electric Company for Compliance Review of Utility Owned Generation Operations, Electric Energy Resource Recovery Account Entries, Contract Administration, Economic Dispatch of Electric Resources, Utility Retained Generation Fuel Procurement, and Other Activities for the Period January 1 through December 31, 2013. (U 39 E)	)	Application 14-02-008 (Filed February 28, 2014)

PREPARED TESTIMONY OF

DOUGLAS H. HAMILTON ON BEHALF OF

THE ALLIANCE FOR NUCLEAR RESPONSIBILITY

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June 20, 2014

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I. Summary and Recommendations

Q1. Please identify yourself and state your professional qualifications.

A.1. My name is Douglas H. Hamilton and my qualifications include BS, MS, and Ph.D degrees, all from Stanford University and more than fifty years of professional experience in engineering and seismic geology. My involvement as a consultant for PG&E's Diablo Canyon nuclear project began in 1971 when I was retained as a consultant to log the geologic features exposed in the foundation excavation for Unit 2 of the power plant, and ended in 1991. In those 20 years, I logged exploratory trenches at DCNPP and advised PG&E of the potential seismic significance of the large (later to be named Hosgri) fault located offshore near the powerplant site in 1972. I subsequently planned and directed offshore seismic reflection geophysical studies of this fault sponsored by PG&E between late 1973 and 1974. In 1978 I prepared most of PG&E's geology testimony for the NRC operating license Atomic Safety and Licensing Board (ASLB) hearing and testified during that hearing. I assisted in formulation of the geology component of PG&E's license-required "Long Term Seismic Program" (LTSP) and thereafter was involved in that program until 1988.

Q2. What is the purpose of your testimony in this proceeding?

A.2. My testimony for this proceeding relating to the Diablo Canyon Nuclear Power Plant (DCNPP) is to review and evaluate the results made public (to date) of the investigation into the seismic hazard posed to the DCNPP by the Diablo Cove fault zone, as the Commission did "expect" them to do per D. 12-09-008. I make no comment on PG&E's assessment of the Inferred Offshore fault and San Luis Ridge fault pending review of the so-called "Final Report" they expect to publish in July 2014. The Diablo Cove fault is of special interest in that it is a zone of north side up right reverse oblique faulting that displaces the Obispo Formation bedrock of the DCNPP Unit 1 Turbine-Generator and Reactor Containment foundations. The real possibility of renewed surface displacement along faults of this zone has the potential consequence of putting the safety of the plant, the electricity it provides to the state power grid, and potentially the health and property of the public at risk.

Q.3. Is there a reason to distrust PG&E's self-determination as to scope, format and analysis of seismic studies?

A.3. Historically, there have been numerous deficiencies and oversights in PG&E's previous seismic investigations, both pre-and post-licensing of the plant. Pre-licensing, PG&E failed to conduct any detailed geologic investigation outside of the DCNPP coastal terrace area. Consequently, much time and effort during construction was wasted when the Hosgri fault was later acknowledged, requiring even more time and costly retrofits. Post-licensing, the best known of the deficiencies from their Long Term Seismic Program findings is PG&E's failure to recognize the Shoreline fault, which they identified in 1988 as a harmless "lineament related to old shoreline" and in a response to an NRC inquiry in 1989 argued that there was no fault along the shoreline. Another significant deficiency was PG&E's defense of its representation of the relationship of the offshore Hosgri to the onshore San Simeon faults as one of separation across the "Cambria Stepover." This misinterpretation was necessary to support PG&E's contention (since proven wrong) that this stepover limited the earthquake potential of the Hosgri fault.

Q.4. Did PG&E's scope of work address the concerns you have expressed in Answer 2 and achieve satisfactory results?

A.4. No. As I will explore in greater detail throughout this Testimony, the results for work purported to address my concerns has been inconclusive, used inappropriate techniques or methods, and did not target the specific geographic zone of interest. Further, beyond the inadequate geoscientific inquiry, the Senior Seismic Hazard Assessment Committee (SSHAC) process PG&E has engaged for evaluating the seismic hazards at DCNPP appears to have been skewed with a cognitive bias against an open-minded and inclusive scientific discussion of the Diablo Cove fault.

Q.5. Did PG&E or its seismic consultants ever ask for your specific input and recommendations regarding any aspect of a survey to address the Diablo Cove zone of faulting?

A.5. No, at no time did PG&E or its consultants seek my input in their investigation design process. I will conclude my testimony with a list of recommendations I would have suggested had my input been sought.

II. Qualifications of Douglas H. Hamilton, Ph.D, C.E.G.

My name is Douglas H. Hamilton and my office and residence address is 2 Bassett Lane, Atherton, California, 94027. I am presenting the following testimony on behalf of the Alliance for Nuclear Responsibility but I am not employed by nor otherwise affiliated with that organization. My qualifications include BS, MS, and Ph D degrees, all from Stanford University and more than fifty years of professional experience in engineering and seismic geology. During my career in this field I have worked on electric generation projects involving some 7600 MW of installed capacity and on proposed but not completed projects with a planned capacity of a further 8000 MW. Electric generation projects for which I have provided geoseismic consultation have included nuclear, conventional thermal, geothermal, and hydroelectric facilities, with regulation variously by the U.S. Nuclear Regulatory Commission, the Federal Energy Regulatory Commission, the U.S. Forest Service, and State agencies in California and Washington. Projects not involving electric power generation have included the Devils Slide Tunnel, numerous water supply dams, and a variety of other projects that entailed engineering geology and seismic issues. My involvement as a consultant for PG&E's Diablo Canyon nuclear project began in 1971 when I was retained as a consultant to log the geologic features exposed in the foundation excavation for Unit 2 of the power plant, and ended in 1991 with a study of the hydrogeologic and geochemical setting of the Diablo Canyon Wastewater Holding Pond facility. During the intervening twenty years I first made geologic logs of three large exploratory trenches at the power plant site and recognized and advised PG&E of the potential seismic significance of the large (later to be named Hosgri) fault located offshore near the powerplant site in 1972, and then planned and directed offshore seismic reflection geophysical studies of this fault sponsored by PG&E between late 1973 and 1974. I also prepared most of the geology sections of the FSAR as submitted to the NRC in 1973 and of supplements to it submitted in 1975, and participated on PG&E's behalf in numerous meetings with NRC staff and before the NRC Advisory Committee on Reactor Safeguards (ACRS). In 1978 I prepared most of PG&E's geology testimony for the NRC operating license Atomic Safety and Licensing Board (ASLB) hearing and testified during that hearing. I was subsequently called on to testify before the NRC Atomic Safety and Licensing Appeals Board (ALAB) in 1981. In 1985, after the low power test license for Diablo Canyon Unit 1 was restored following its having been suspended in

connection with the "Diagram Error" issue between 1981 and 1984, I assisted in formulation of the geology component of PG&E's license-required "Long Term Seismic Program" (LTSP) and thereafter was involved in that program until my participation was terminated by the new PG&E Geosciences Department in 1988. Thereafter I assisted in preparation of PG&E's Rate Case testimony before the CPUC, with that assignment ending when the Rate Case ended with a negotiated settlement in 1989. I have had no involvement with PG&E since 1991 except for having been identified by them, unilaterally, as one of many "Resource" and "Proponent" experts for their SSHAC program.

My interest in the geoseismic issues concerning PG&E's Diablo Canyon project was revived in 2004 by a plot I obtained from the University of Nevada Seismological Laboratory showing earthquake epicenters superimposed on a digital terrain map of the south central coastal region of California where the Diablo Canyon site is located. This plot dramatically illustrated the essentially 1:1 correlation between seismicity and mountain ranges in the region including the Irish Hills-San Luis Range, the site of the DCNPP. Since obtaining this plot I have carried out independent research about the seismic and fault hazard to the nuclear power plant and have submitted interim results at a briefing to the Seismic Advisory Panel of the California Energy Commission and a presentation at the Fall Meeting of the American Geophysical Union, both in 2010. Most recently I was a participant in my capacity as an invited "Proponent Expert" at PG&E's Workshop No. 2 for its SSHAC process review of geologic and seismic issues deemed by PG&E to be relevant to the seismic safety of Diablo Canyon.

I hold California Professional Geologist license No. 56 and am Certified Engineering Geologist No.31, both licenses dating from 1970, and Washington Professional Geologist and Engineering Geologist license No. 1710, dating from 2002.

III. DR. HAMILTON'S CONCERNS REGARDING THE DIABLO COVE FAULT

In February 2012 I submitted Testimony in CPUC A. 10-01-014 wherein I raised several specific concerns with regard to the issue of potential seismic surface displacement along the Diablo Cove fault zone in the Diablo Canyon Nuclear Power Plant Unit 1 foundation, cited as follows:

> "…[O]n the basis of its angle of intersection with the northerly N48W reach of the Shoreline fault, the east-west aligned Diablo Cove fault could have either a branch-splay or less probably, a conjugate structural relationship with the shoreline zone. *That the compression is still active is abundantly demonstrated by the many right lateral mechanism earthquakes along the Shoreline fault, such that the Diablo Cove fault should probably be considered correspondingly subject to potential hazard of future additional movements.* [emphasis added]
>
> A further suggestion of interaction between these faults is provided by a cluster of three epicenters of small earthquakes located 0.5 km NW of the offshore Diablo Cove fault. As determined by Hardebeck (2010) the hypocenters of these events were between 4 and 6 km depth and were slightly east of the surface trace of the vertical Shoreline fault. They were, however, approximately down dip from the surface trace of the north-dipping Diablo Cove fault. *This suggests that ongoing seismic adjustments at depth along the active Shoreline fault may trigger small seismic adjustments along the adjacent part of the Diablo Cove fault.*[1] [emphasis added]
>
> [T]his means that the Diablo Cove fault and the DCNPP are situated above the leading edge of an active thrust fault and that the stress environment in this area is affected by both the San Luis Range/"IOF" thrust and the Shoreline fault. This in turn suggests that the Diablo Cove fault could be classified as "capable" according to the terms of NRC criterion (3), "A structural relationship to a capable fault" (ie, both the underlying San Luis Range thrust and the adjacent Shoreline fault, each of which exhibit instrumentally determined macro-seismicity and are therefore capable according to NRC criterion (3) – "such that movement on one could reasonably be expected to be accompanied by movement on the other".[2] [emphasis added]

In Decision 12-09-008 September 13, 2012, the Commission responded to these concerns:

> A4NR offered the testimony of Dr. Douglas Hamilton, a member of member of PG&E's geoseismic licensing team for Diablo Canyon from 1971 to 1991. Dr. Hamilton's testimony focused on what he considered two major gaps in PG&E's studies:

[1] Hamilton, Douglas. Direct Testimony of Douglas H. Hamilton Before the California Public Utilities Commission, Application No. 10-01-014, Exhibit A4NR-4, February 10, 2012, p. 26.
[2] Ibid p. 23.

- A continued lack of interest in the Diablo Cove Fault, a local fault on the Diablo Canyon Nuclear Power Plant site running from offshore directly under the turbine building and Unit 1 containment foundations.
- The San Luis Range/Inferred Offshore Fault" in San Luis Obispo Bay, which A4NR says falls outside PG&E's target zone for enhanced studies. Dr. Hamilton testified that the existence of this structure is required in order to account for the level uplift of the Irish Hills/San Luis Range.

…A4NR recommends that we should direct PG&E to configure its onshore concerning the Diablo Cove Fault and the San Luis Range/Inferred Offshore Fault and their interaction. A PG&E witness testified that PG&E was investigating both the Diablo Cove Fault and the San Luis Range/Inferred Onshore Fault. Therefore, PG&E says we need not take any action other than approving this application in order to implement A4NR's recommendations. We agree with PG&E. PG&E has said it will address the concerns of Dr. Hamilton. We expect PG&E to do so.[3]

IV. WHAT, IF ANY RESULTS WERE ACHIEVED BY PG&E'S SEISMIC STUDY THAT RESOLVE THE CONCERNS RAISED BY DR. HAMILTON?

While definitive judgment on PG&E's attention to the Inferred Offshore fault and San Luis Range fault must await review of its "Final Report" now expected in July 2014, PG&E's 2013 treatment of the Diablo Cove fault—with one exception—does not demonstrate any discernable progress in addressing the concerns of my original Testimony. The following is a summary review of publicly available data, documentation and analysis brought forward by PG&E regarding the aforementioned Diablo Cove fault, and an analysis of its potential as a seismic and surface faulting hazard to the DCNPP.

A. DCPP 2D/3D Seismic-Reflection Investigation of Structures Associated with the Northern Shoreline Seismicity Sublineament of the Point Buchon Region, PG&E Geosciences Department Technical Report, TR Number: GEO.DCPP.TR.12.01

As described by PG&E, this report was intended to:

5.1 Purpose

[3] Decision 12-09-008 September 13, 2012, California Public Utilities Commission, [Application 10-01-014], pp. 7-8.

> The purpose of this technical report is to present initial geologic and geophysical interpretations of the offshore low-energy, high-resolution 3D and 2D seismic-reflection data (referred to here as the 3D/2D dataset) collected in late 2010 and early 2011.[4]

And it concludes with the following caveat before presenting a series of plates and figures:

> 13.0 IMPACT EVALUATION
> The results presented herein may result in changes to DCPP's seismic source characterization of crustal fault sources that are presented in the Shoreline Fault Report (PG&E, 2011b) and the LTSP Report (PG&E, 1988). Depth penetration is limited from a low-energy source that provides only shallow time sections and the small area of coverage limits an overall regional perspective.[5]

My analysis of certain figures within PLATE 3 (***Figure 1***) from PG&E's report notes that the map fails to identify the fault trace of the Diablo Cove fault or the more well known features of their own admission such as the Shoreline and other faults clearly discernable in the Islay shelf area along the shore of Estero Bay northeast of Pt. Buchon.

The marked boundaries (brown lines) of the survey area are indicative that the survey method chosen by PG&E is limited by the natural conditions in the area that do not allow the research vessel to get close enough to shore to properly image the off shore extent of the Diablo Cove Fault to the point of its likely intersection with the Shoreline fault. Imaging structures in the massive Obispo tuft breccia that forms the prominent seafloor outcrop in this area is likely not to be possible in this zone. Seismic energy input in connection with the survey will be reflected back from the rough high velocity surface showing only "hash" in the subsurface.

B. USGS Gravity Station map provided in response to A4NR data request:

> 9. Please provide a map of the Diablo Canyon plant site which identifies the location, ± one meter, of the additional gravity surveys performed on the plant site in 2013.[6]

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[4] DCPP 2D/3D Seismic-Reflection Investigation of Structures Associated with the Northern Shoreline Seismicity Sublineament of the Point Buchon Region, PG&E Geosciences Department Technical Report, TR Number: GEO.DCPP.TR.12.01, December 4, 2012, p. 10,
[5] Ibid. p. 59.
[6] A4NR, A.14-02-008 Initial Data Requests from A4NR, "2013 Gravity Locations"

My analysis of the pattern of gravity stations shown on this map (***Figure 2***)[7] does not indicate stationing that would add to or help satisfy the concerns regarding the Diablo Cove fault. In fact, it is highly unlikely that gravity surveying would detect the Diablo Cove fault—especially as it is known onshore—since there is no density contrast between the rock on the north side and south side of the Diablo Cove fault either onshore or offshore, so it would not register in a gravity survey no matter where the stations were located.

C. Daniel O'Connell/Fugro presentation slides, "2011-2012 AB1632 Onshore Seismic Data," Diablo Canyon SSHAC SSC Working Meeting March 2014

This presentation, given at the third Seismic Source Characterization (SSC) meeting of the Senior Seismic Hazard Assessment Committee (SSHAC) presents results—as of this writing—to a variety of *onshore* seismic research data acquisition projects. Slide 10 (***Figure 3***)[8] shows that targets for the project survey area *did* include the onshore environs of the Diablo Canyon Nuclear Power Plant. The significance of this is that no useful data regarding the Diablo Cove fault was acquired during this survey and *no tomographic or cross section image was shown for the area of the Diablo Cove fault* other than a map of the location of their nodal points and acquisition system (***Figure 4***).[9]

O'Connell's own description of the process and results from application show that no useful data would or could be obtained from that method in the DCPP site area. During his oral presentation accompanying display of these slides O'Connell stated, "You can't see vertical bedding and steep dips and there are aliasing in areas of lower velocity…"[10]

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[7] PG&E Data Response: DR_A4NR_001-Q09Atch01

[8] O'Connell/Fugro presentation slides," 2011-2012 AB1632 Onshore Seismic Data," Diablo Canyon SSHAC SSC Working Meeting March 2014,Slide 10, accessed on June 16, 2014 at: http://www.pge.com/includes/docs/pdfs/shared/edusafety/systemworks/dcpp/SSHAC/workshops/ws3/Day_2_M02_OConnell_onshore_seismic_data_resource_presentation_mar2014_SSHAC_rev1.pdf

[9] Ibid, Slide 3

[10] O'Connell, Daniel, Videotape presentation at Diablo Canyon SSHAC SSC Working Meeting March 26, 2014, at 35 minutes and 29 seconds. Video accessed on June 16, 2014 at: https://www.youtube.com/watch?v=cMGI0zj7uUI&index=3&list=PLta104a5SDQmm8HFTuEyNSbraIOibMP1g

The Diablo Cove fault itself dips 70 degrees in its former sea cliff exposure so given the admission that the study method chosen is ineffective in "vertical bedding and steep dips" they would not have imaged it in any case.

D. PG&E 2011 Onshore Seismic Interpretation Program (ONSIP), Jeffrey Unruh, PG&E SSHAC SSC Workshop #3, 26 March, 2014

The track of vibroseis line 141-142 is shown in ***Figure 5***.[11] The seismic reflection image of this line with interpretation by Dr. Unruh is shown in ***Figure 6***.[12] The trackplot shows the south end of this line terminating on the Diablo Cove north headland about 200 feet short of the trace of the headland crossfault. Dips of bedding along both the Wastewater Holding Pond (WHP) and Diablo Cove seacliff exposures along this headland measured by Jahns in 1966, Hall (USGS) in 1972 and Hamilton in 1991 range between 30 and 70 degrees with highly disturbed Obispo Formation near the end of the vibroseis line. Unruh's interpretation of the line instead shows nearly flat lying Obispo strata, which clearly does not match the observed geology. As to the nearby trace of the Diablo Cove fault, which is some 500-700 feet from but subparallel to line 141, no imaging of this steeply dipping structural discontinuity is evident in the vibroseis image and none would be possible given the character of the geology. Consequently, this line provides no information about the Diablo Cove fault.

E. KelpFly seafloor imaging/bathymetry data

KelpFly data **(*Figure 7*)**[13] shows a bedrock fault in the very place that Professor R.H. Jahns mapped faulting on shore from the Diablo Canyon south headland and foundation rock of unit

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[11] Unruh, Jeffrey, PG&E 2011 Onshore Seismic Interpretation Program (ONSIP), Jeffrey Unruh, PG&E SSHAC SSC Workshop #3, 26 March, 2014, Lettis Consultants International, p. 7. Accessed June 16, 2014 at: http://www.pge.com/includes/docs/pdfs/shared/edusafety/systemworks/dcpp/SSHAC/workshops/ws3/Day_2_M03_Unruh_ONSIP_Presentation_032414.pdf

[12] Ibid, p. 20.

[13] KelpFly Map, Kvitek, Rikk, Sea Floor Mapping Lab, (2009) Cal State University Monterey Bay, 2012 California Sea Floor Mapping Project, 2005-2012 as presented day 2, SSHAC 1, SSC workshop November 2011, P. 52. Accessed on June 16, 2014 at:

1.[14] It also shows the other larger faults of the system that apparently also splay from the Shoreline fault.

The Diablo Cove fault zone is a locally unique structure along the southwest shoreline of the Irish Hills. The KelpFly seafloor imaging reveals what appears to be a master fault that splays rather broadly from a point offshore from the Diablo Cove north headland and which localizes the Diablo and adjacent "WHP" coves. The local erosion of these coves results from this faulting having breeched the rampart of very resistant volcanic breccia that forms the cove headlands to the north and the south, and allowed greater wave attack, which then hollowed out the less resistant rock inboard of that rampart. There are no other large, arcuate coves along the reach of coastline of the Irish Hills between Point San Luis and Point Buchon.

The KelpFly seafloor imaging is the only data likely to exist—absent drilling data—that is useful to define the offshore location and characteristics of the Diablo Cove fault. As noted previously, the location and characteristics of this zone of faulting onshore between the headland outcrop and the DCNPP Unit 1 reactor foundation is precisely known and documented in PG&E's SAR and ASLB Testimony submitted to the NRC.

V. EVIDENCE OF COGNITIVE BIAS TOWARDS INVESTIGATION OF THE DIABLO COVE FAULT:

From very nearly the outset of the process of investigating my concerns regarding the Diablo Cove fault, and in spite of their professed attention to the matter, PG&E and their seismic consultants, Lettis Consultants International (LCI) appear to have shown an increasingly substantial cognitive bias seemingly contrary to fully realizing the goals of said investigation. Over a period of nearly two years, as traced through meetings, presentations and transcripts, their

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http://www.pge.com/includes/docs/pdfs/shared/edusafety/systemworks/dcpp/SSHAC/workshops/source_characterization/SSC_0203_Kvitek_Multibeam_Bathymetry.pdf

[14] Jahns, R.H., 1966, Geology of the Diablo Canyon Power Plant Site, San Luis Obispo County, California: 1967, Supplementary Reports I and II; 1968, Supplementary Report III, Diablo Canyon PSAR, Docket No. 50-275 (Main Report and Supplementary Report I); Diablo Canyon PSAR, Docket No. 50-323 (All reports).

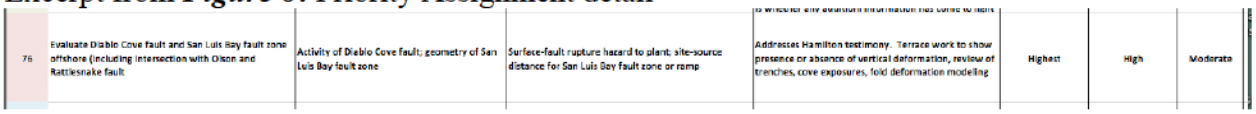
actions appear to have been directed toward minimizing and trivializing legitimate concerns regarding the Diablo Cove fault. I now review these concerns in a chronological outline.

A. From their initial prioritization, as evidenced in an email of May 1, 2012 from Dr. Stephen Thompson of Lettis Consultants International to a redacted recipient ***(Figure 8)***,[15] addressing my concerns was assigned "Priority: Highest" and regarded as "Probability of success: High" while having a "Cost Category: Modest." Subsequent developments suggest that to LCI, "success" meant demonstrating that the Diablo Cove fault either did not exist at all, or if it did, was not significant to the seismic safety of DCNPP.

The details of this endeavor, transcribed from "Item 76" of the prioritization chart were:

> 76 Evaluate Diablo Cove fault and San Luis Bay fault zone offshore (including intersection with Olson and Rattlesnake fault;
> **Knowledge gained**: activity of Diablo Cove fault; geometry of San Luis Bay fault zone
> Applicability to defined hazard-significant issues: surface-fault rupture hazard to plant; site-source distance for San Luis Bay fault zone or ramp
> **NOTES (for internal discussion; hide/remove for archive)** addresses Hamilton testimony. Terrace work to show presence or absence of vertical deformation, review of trenches, cove exposures, fold deformation modeling
> **Priority**: Highest **Probability of success**: High **Cost Category**: Moderate

Excerpt from ***Figure 8*:** Priority Assignment detail



76	Evaluate Diablo Cove fault and San Luis Bay fault zone offshore (including intersection with Olson and Rattlesnake fault	Activity of Diablo Cove fault; geometry of San Luis Bay fault zone	Surface-fault rupture hazard to plant; site-source distance for San Luis Bay fault zone or ramp	Addresses Hamilton testimony. Terrace work to show presence or absence of vertical deformation, review of trenches, cove exposures, fold deformation modeling	Highest	High	Moderate

I was not contacted at the time this priority "chart" was created by LCI. Had they contacted me, I would have pointed out that their "Notes" for "Terrace work to show presence or absence of vertical deformation" [emphasis added] *would not have been an unequivocal indicator to seek* because the Diablo Cove fault has a component of horizontal deformation which could be much harder to detect in the data that was available or is possible to get. The only preserved terrace surface left—other than old terrace scarps in back of the plant that have up to 2 meters of

[15] Thompson, Stephen; email of May 1, 2012 and attachments, GRC2014-Ph-I_DR_A4NR_001-Q09Supp01Atch06

uncertainty with regard to their location—is concealed beneath thick alluvial fan deposits and plant facilities.

B. The CPUC Decision 12-09-008 authorizing the funding for the study and including the explicit caveat that PG&E is expected to address my concerns was issued on September 13, 2012. Over four months had passed since the Thompson email (*Figure 8*) of May 1 without any contact from LCI. Coincidence or not, I received an email the following day, September 14, 2013, from Dr. William Lettis inviting me to, "…be a Proponent Expert on the Tectonic Setting of the Irish Hills; in particular to discuss mechanisms for uplift of the Irish Hills, the "Inferred Offshore Fault", and the Los Osos fault."[16] Although my "concerns" had been on their radar since May 1, seemingly it took a decision from the Commission to prompt LCI into actually contacting me.

By telephone, I contacted LCI and replied that I would consider their offer on the condition that I be made aware of all information on the subject area known to LCI in advance in order to avoid being "blind sided" about one or another aspect of the discussion. I also stipulated that I would decline the accompanying offer of a $3000 "honorarium" to (partially) defray the expense of my serving as a "Proponent Expert" for the SSHAC proceeding. Thompson agreed and we arranged for a briefing at their Walnut Creek offices on September 26, 2012. After an introductory tour of the LCI offices, Thompson, Lettis and I moved to a conference room and I was asked about my plans for my SSHAC-SSC2 presentation regarding the Irish Hills geology and tectonics. Beyond the discussion of the Irish Hills, I stated that although it was not depicted on LCI's preliminary but supposedly comprehensive geologic map, I intended to also display and discuss the evidence for the "Diablo Cove Fault," the existence of which had been thoroughly documented in reports and a map prepared by and submitted to PG&E by their consultant, Professor R.H. Jahns. This material had then been included with the PSAR, FSAR and ASLB Testimony documents submitted by PG&E to the NRC between 1968 and 1978.

At this point during the meeting, Thompson and particularly Lettis reacted with apparent annoyance at this prospect. Lettis rather triumphantly activated a projector (which must have had

[16] Lettis, William, email to Dr. Douglas Hamilton, September 14, 2012.

this image pre-loaded in anticipation of this situation) and displayed the high resolution KelpFly multi-beam image of the bedrock outcrop floor of Diablo Cove and the adjacent near shore area including the prominent linear scarp of the Shoreline fault. Lettis and Thomspon had evidently studied this image and with a "Gotcha" flourish noted a prominent lineation that extended across the outer northern half of the cove. This lineation was formed by the discontinuity truncation of the approximately east-west aligned bedrock structure that extended into the cove from the structure observable in the sea cliff opposite the power plant from the outlet structure to the south headland of lower Diablo Canyon. This lineament aligned with a fault exposed in the above north headland that had originally been mapped by Jahns in 1966 but not projected offshore, and was subsequently shown on maps in PG&E's Shoreline Fault Final Investigation Report as continuing offshore into Diablo Cove (called Discharge Cove in current PG&E usage) and then bending to a north-northeast trend and crossing the Shoreline fault at nearly a 90 degree intersection. However, the KelpFly data which only became available after both PG&E's 2011 Shoreline Fault Investigation Final Report and my 2012 Testimony to the CPUC, showed that rather than bending to a high angle intersection with the Shoreline fault, the onshore fault crossing the north headland and its prominent seafloor lineament offshore continuation, extended straight across the outer part of the cove, directly across any possible offshore projection of the onshore Diablo Cove fault. To Lettis and Thompson, *this cross fault lineament precluded any possible seaward extension of the Diablo Cove fault, and with that, removed any increased hazard associated with a splaying or intersection relationship of this zone of faulting with the nearby Shoreline fault*.

Upon returning to my office and examining my newly acquired high quality KelpFly sea floor imagery, it almost immediately became evident that the Diablo Cove and two other faults that had previously been mapped onshore, aligned with well defined sea floor lineaments that apparently had been etched out by erosion along fault-line shear zones. Also at the point where the lineament aligning with the Diablo Cove fault onshore intersected the cross lineament identified by Lettis and Thompson, the cross lineament appeared to be displaced right laterally by roughly 5 meters. This data in my opinion convincingly demonstrates the existence of a branching pattern of faults in the sea floor bedrock between the shoreline sea cliff where faults had been recognized during onshore mapping, and the offshore Shoreline fault towards which

this pattern was converging where the sea floor rock outcrop becomes obscured by sea floor sediment.

C. The Senior Seismic Hazard Assessment Committee (SSHAC) Workshop #2 Seismic Source Characterization (SSC) Presentation

Subsequent to the aforementioned meeting at the LCI offices in Walnut Creek, I received an email from Dr. Stephen Thompson on September 28, 2012:

> Also, we will be sending you (in a separate email) your letter to participate as a Proponent Expert in the SSHAC Workshop. The questions we'll ask you to address are based on our conversation yesterday. As you'll see, the questions allow you some latitude to discuss interpretations you consider to be technically defensible and relevant to the seismic hazard assessment at the plant. After you have had some time to digest and interpret the 11x17 images we gave you of the multibeam bathymetry and LiDAR data from the plant site and Diablo Cove, *please let Bill and me know if you plan to include in your presentation a discussion of faulting in Diablo Cove and at the DCPP site. As we discussed on Wednesday, an important part of the SSHAC process is to have alternative viewpoints presented at the meeting so that we can evaluate the range of technically defensible interpretations*.[17] [emphasis added]

In spite of Dr. Thompson's assertions that "an important part of the SSHAC process is to have alternative viewpoints presented at the meeting so that we can evaluate the range of technically defensible interpretations" it appears from his and Dr. Lettis' actions at the preceding meeting (and later at the SSHAC) that their viewpoint dismissive of the Diablo Cove fault had been predetermined. Thompson's communication to me appears to imply that my review of the multibeam image might lead me to acknowledge the insignificance of the Diablo Cove fault. This was clearly not the case, as my study of this imagery instead enabled me to develop a precise interpretation showing the pattern of faulting in and adjacent to Diablo Cove.

My presentation at the SSHAC SSC # 2 Workshop took place on November 6, 2012.

[17] Thomspson, Stephen, email to Dr. Douglas Hamilton, September 28, 2012

I was told to "wrap up" my presentation by Dr. Thompson just before I could finish displaying my final map slide where I had marked and indicated the 5 meter offset of the cross-fault crucial to my interpretation (but antithetical to the view Lettis and Thompson had proffered in their office in September). Additionally, I was not able to present and explain my three remaining "Summary and Conclusion" slides.[18] A "Question and Answers" session followed immediately, in the remaining 6 minutes of my allotted time period. After questions from Dr. Thompson regarding a variety of issues from my talk, a question was raised by Dr. John Caskey, a member of the SSHAC Technical Integration (TI) team. The TI team to which Dr. Caskey belongs "…consists of Evaluator Experts with PSHA and/or SSC experience that are responsible for conducting the evaluation and integration process and development of the SSC model."[19]

The following exchange took place during the Q & A period. Dr. Caskey addressed his questions to me and at points was interrupted by Dr. Thompson of LCI. During this exchange Dr. Caskey was seated at the dais table between Dr. Lettis and Dr. Abramson-Ward, also on the staff of LCI.

> JOHN CASKEY: (technical integrator team) Doug, that fault that you're referring to, on a couple of the slides it looked like it was a bedding parallel fault, and it's in an area where the Obispo is going from overturned bedding to kind of upright. So you're in kind of a change from an older anticline syncline. So you might expect a lot of flexural slip.
> DOUG HAMILTON: Should we go back to my hand-drawn cross-section?
> JOHN CASKEY: Yes, it was a plan view, map view slide toward the end, I think. Continue on, though. Well, there's that and then...
> STEVE THOMPSON: But this shows it's interpreted to be roughly a bedding plane fault within the Obispo that goes to...
> DOUG HAMILTON: That's this one here. But it actually, that's sort of an artifact to the projection because it actually creates a discordance of about 70 degrees so that on the footwall side it is close to but slightly cross-cuts the bedding in the now advanced shoreline headland exposure. On the opposite side the bedding strike rotates to a very high angle at that fault, and it's that going on out to that point of apparent cross- fault as well.
> JOHN CASKEY: Could you advance a couple slides? I think it's—keep going.
> DOUG HAMILTON: More?

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[18] Videotape of the presentation is accessible at: http://www.youtube.com/watch?v=n0oK8UQY4Lc&feature=youtu.be

[19] Lettis, Dr. William R., Technical Integrator Team Lead, "Diablo Canyon SSC Model Update Using SSHAC Level 3 Methodology Project Plan for the Diablo Canyon Seismic Source Characterization (SSC) Model Update, July 18, 2012, p. 7.

JOHN CASKEY: Yes, I think it was in the map view. I think so. Oh, go back one. Right there.
DOUG HAMILTON: There or the next one?
JOHN CASKEY: Yes, those east-west striking faults that you were talking about? It looks like that's that area...(***Figure 9***)[20]
DOUG HAMILTON: This is the east-west to what I call the Diablo-Cove fault. The bedding, you can actually see the bedding out here.
JOHN CASKEY: Right. That's what I was wondering about.
DOUG HAMILTON: And the footwall side but the bedding over on the hanging wall side is more like this. It's at a very high angle to the bedding on this side. So although it looks like the displacement is rather small, Jahns thought it was larger by the time it got to the Shoreline fault, which is not that far away. And it seemingly is even bigger by the time it gets to where it looks to me like this cross-fault is displaced at the point of intersection.
JOHN CASKEY: That's where it's parallel to the layer. See the strikes? The strike of the layering comes right in.
STEVE THOMPSON: Let's move on if we can.
DOUG HAMILTON: Here are the strikes. Jahns' strikes and there.[21]

Dr. Thompson of LCI's request "Let's move on if we can" brings the presentation to an abrupt halt and video documentation ends. The recording lasts 28 minutes, indicating that a full two minutes of my allotted 30 minute window still remained. Dr. Caskey's comments and abruptly terminated line of discussion appears to have been an affirmation of my interpretation of the Diablo Cove fault's continuity of displacement of its onshore expression, and its extension offshore towards the Shoreline fault. I believe it is not coincidence, and indeed further evidence of LCI's cognitive bias against an interpretation that differs from that initially expressed by Lettis and Thompson in their office when they first displayed the enhanced KelpFly seafloor image and summarily declared that my Diablo Cove fault could not cross the north-south crossfault evident in the image.

It is equally significant that Dr. Caskey is seeking further elaboration of my interpretation, and that his inquiry was curtailed. According to the SSHAC methodology plan authored by Dr. Lettis in 2012, in which the various members of the TI Team were vetted for consideration, this was written of Dr. Caskey, the only scientist listed as having no cognitive bias in the matter, "Dr.

[20] Hamilton, Douglas; SSC 5: Irish Hills and San Luis Range fault model, Presentation SSC5, SSHAC SSC Workshop #2, November 6, 2012, slide 21; accessible at: http://www.waterenergysavings.com/courses/SSHAC3_WS2_Day01_12_Hamilton.pdf
[21] Transcript, SSHAC SSC Workshop #2, November 6, 2012, pages 104-105.

Caskey provides earthquake geology and fault characterization expertise and has conducted research on faults in central coastal California, including the San Gregorio fault. *Dr. Caskey has no prior experience working on SSC for Diablo Canyon, and thus provides a fresh perspective with no cognitive bias*."[22] [emphasis added]

This contrasts with Dr. Lettis, who as described, "…has familiarity and expertise with the LTSP SSC model and significant updates to the Diablo Canyon LTSP model including for the ISFSI study and the Shoreline fault zone study."[23] In fact, Dr. Lettis' association with the LTSP began in 1985, and was actively involved when the 1988 LTSP document classified the now prominent and active Shoreline fault as merely a "lineament related to old shoreline."[24]

As the SSHAC SSC Workshop # 2 proceeded, it became increasingly evident that the precepts for intellectual openness and cognitive bias elaborated by Dr. Lettis in his SSHAC methodology proposal were being circumvented. In that document, he wrote:

> Because there are recent SSC studies available for DCPP, an important aspect of the update will be *to avoid cognitive bias (e.g., anchoring) to the pre-existing characterizations and to be open to new data, evaluations, and alternative interpretations*. This will be accomplished by including discussion of cognitive bias at the start of each workshop and working meeting by the Technical Integrator (TI) Lead, and by conscious reminders by the TI Lead or other TI team members or staff during each Workshop and Working Meeting if apparent cognitive bias arises.[25] [emphasis added]

However, as demonstrated in his own subsequent presentation—and in spite of Dr. Caskey's curiosity—Dr. Lettis was already developing a case for precluding further discussion of my Diablo Cove fault analysis:

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[22] Lettis, Dr. William R., Technical Integrator Team Lead, "Diablo Canyon SSC Model Update Using SSHAC Level 3 Methodology Project Plan for the Diablo Canyon Seismic Source Characterization (SSC) Model Update, July 18, 2012, p. 8.
[23] Ibid.
[24] PG&E, "Onshore-Offshore Geologic Correlation Map of the Southwestern Boundary Zone of San Luis-Pismo Structural Block." Original Edition LTSP, July, 1988, Plate 19
[25] Lettis, Dr. William R., Technical Integrator Team Lead, "Diablo Canyon SSC Model Update Using SSHAC Level 3 Methodology Project Plan for the Diablo Canyon Seismic Source Characterization (SSC) Model Update, July 18, 2012, p. 4.

> LETTIS: This is the Diablo Canyon area with the Kelp Fly data offshore. These are the marine terraces mapped through the Diablo Canyon region, the 5A terrace which maintains a consistent elevation of ten meters. This is the 5E terrace at an elevation of 31 meters or so. The stage seven marine terrace and the stage nine marine terrace. So any potential fault, and this is the Kelp Fly data as opposed to Doug Hamilton's interpretation, we don't see any fault in the interpretation of the offshore bathymetry and clearly any fault that would be present is not displaced in the marine terrace, the local marine terrace sequence back to an age of 320,000 years. So it does not appear that there—if there is bedrock deformation, the bedrock is folded as Doug showed and which we also have mapped. There are also are small bedrock faults on the order of a meter, a few meters of offset that occur throughout Diablo Cove area, and none of these faults appear to deform the marine terrace sequence*, and therefore we're quite confident there's no recent activity that can be associated with the current tectonic setting*.[26] [emphasis added]

My analysis of "Slide 18" accompanying the above transcript of Lettis' description (***Figure 10***) reveals scant "hard evidence" upon which to base his conclusions.[27]

- Lettis' Slide 18 only shows shoreline angles of the present and progressively older series of uplifted shoreline angles
- Only for the area labeled "Terrace 5E" directly in the plant area, is there any continuous documentation of the terrace shoreline angle (where it was mapped during Professor Jahns' original trenching program)
- The stages 7 and 9 are each defined by *only two points of observation* 100 or more meters apart in this area, and for those two points the indicated resolution of vertical continuity is identified as *plus or minus 2 meters*

Thus, faulting observed in the plant foundation where it does not exceed one meter of vertical displacement could pass unnoticed or undetected through the older shoreline angles upslope from the plant where resolution is plus or minus 2 meters.

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[26] Transcript, SSHAC SSC Workshop #2, November 6, 2012, p. 117.
[27] Lettis, William R., SSC 7: Geometric and kinematic alternatives for the Los Osos and San Luis Bay faults, SSHAC SSC Workshop #2, November 6, 2012, accessible at: http://www.pge.com/mybusiness/edusafety/systemworks/dcpp/SSHAC/workshops/ws2.shtml

I subsequently attempted to rectify my growing sense of cognitive bias during the "observer comment" period on the afternoon of the third and final day of the SSHAC SSC Workshop #2.

> DOUGLAS HAMILTON: Going on to my last point, it seems to me that the matter of this feature that I described which I've referred to as the Diablo Cove fault seemed I gathered to have been dismissed out of hand, at least in a remark that Bill Lettis made. But that fault has been well known in the onshore. It was identified and described in submittals that PG&E made to the AEC and the NRC up through the time of the licensing here in 1978 and '79. And so it's a pretty well documented component of the local geologic structure, and I believe that I saw the seaward end of that as it's seen in the sea floor outcrop pattern on the actual geologic map that was displayed here kind of showing the offshore geology out to and including beyond the Shoreline and toward the Hosgri.
> So you seem to have documentation of either end of it, and at least to my eye it's clearly seen in the outcrop between the original Shoreline exposure and the tail end going seaward where it approaches at least the projection of the Shoreline fault. So that being the case, I might add that it looks like I can identify some seismic events and the downward projection of that fault and some of the data that has been informally provided to me by Dr. Hardebeck.
> So I think it's premature to just dismiss that feature out of hand, because it has a reasonable capability of a co-seismic rupture I think, even though it seems not to have done that onshore in the period of time of about 80,000 or so years that's recorded in the terrace deposits. So that nonetheless, if we're looking at something that's right there in the foundation in the roots of unit one, I tend to think that more consideration should be given to what the potential implications to seismic hazard of that structure are.
> So that's what I had to say, but I would be interested in any comments about how these issues may be addressed, if they are to be addressed if they are to be addressed further by the SSHAC process. So thank you for the opportunity.
>
> BILL LETTIS: Thanks, Doug. Just this is time for comments from observers, not really a time for rebuttal, but I will just say all of your comments are being addressed by the SSHAC Committee. I don't know if you were here for my talk or not. The uplift of the Irish Hills is a primary focus of our investigation and addressing the mechanism for uplifting those Hills is a major point of evaluation. I presented models that included potential thrust faults beneath the range including your inferred offshore fault as well as wrapping the San Luis Bay fault in to accommodate it. So uplift of the Irish Hills is a clear observation and any of our models that we present have to accommodate that. And as you well know, it's been a focus, a primary focus of our work since 1986. So for almost 30 years we've been looking at that.
> The fault that you've inferred in the Diablo Cove, you also may have missed my slide but that fault has not had any displacement in 320,000 years and there's no evidence that we observe it in the offshore. But we're clearly looking at it. You've brought it up and we're definitely looking at it. Anyway, just to let you know that everything you just brought up we are actively addressing…[28]

[28] Transcript, SSHAC SSC Workshop #2, November 6, 2012, p. 121.

Dr. Kevin Coppersmith, present during these proceedings, also chairs the SSHAC's Participatory Peer Review Panel (PPRP). The role of the PPRP is described in his by Dr. Lettis SSHAC methodology plan as:

> The PPRP is a panel of experts with SSHAC methodology and/or PSHA experience that provide participatory peer review of the SSHAC methodology implementation process and technical judgments of the TI Team. The PPRP assures that the range of TDI is captured and documented through proper implementation of the SSHAC process.[29]

Given this description, it is well worth noting that chair Coppersmith raised the following points with regard to my "Proponent" comments on the treatment of my model and presentation:

> KEVIN COPPERSMITH: I'm chairing the PPRP….[A]nd I want to make a comment that relates back to what Doug said, that the issue of limiting the models up front, limiting the range of what's considered is a real problem. If it is not made clear that in fact the models that are being considered are broad, then you start with a narrower set of considerations and the model ultimately would not include those considerations.
> So I just want to express on the part of the PPRP, we are following the process closely and comments like Doug's will raise flags, that we will want to be sure going back that all of these hypotheses have been considered.[30]

Dr. Coppersmith's warning was prescient. In retrospect, it appears that the Diablo Cove fault as a seismic hazard source had been discounted by the principal TI team leaders Lettis and Thompson, and that any spirit of open inquiry was precluded, as evidenced by the curtailed discussion that was instigated by TI team member Dr. Caskey. As Dr. Lettis noted in his SSHAC methodology:

> The current SSHAC Level 3 update will re-examine parameters of the SSC model in light of recent and ongoing studies with the objective of developing an updated SSC model that captures the center, body and range (CBR) of the technically defensible interpretations (TDI). As described in NUREG 2117 (NRC, 2012),

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[29] Lettis, Dr. William R., Technical Integrator Team Lead, "Diablo Canyon SSC Model Update Using SSHAC Level 3 Methodology Project Plan for the Diablo Canyon Seismic Source Characterization (SSC) Model Update, July 18, 2012, p. 7.
[30] Transcript, SSHAC SSC Workshop #2, November 8, 2012, pp. 122-123.

> TDI are defined as the development, assessment, and weighting of the scientifically justifiable and defensible interpretations of earth science and geotechnical data by appropriate experts in these fields using a structured process of Evaluation and Integration with full access to all available data.[31]

From the treatment it received before and during Workshop #2 it appears that a bias against my Diablo Cove fault model was present. This abdication of SSHAC's intellectual precepts is more disturbing in that Workshop # 2 is the last stop before the models are combined into the "logic trees" that will inform the final probabilistic seismic hazard model arising from Workshop # 3:

> The primary focus of Workshop 3 will be for the TI Team to integrate information into models that represent the CBR of TDI. However, given the large amount of new information and data that will be collected over the duration of the project, the preparation for Workshop 3 will include an evaluation of the new data and information, followed by integration of the new data and information into the model.[32]

The results of the above described bias are evident in the outcome of Workshop # 3, which was held March 25-27, 2014: There was no mention of the Diablo Cove fault in any source model, logic tree or hazard evaluation presented during the entire workshop. Nor was there any evidence presented in public as to why this model had been effectively "disappeared" from the process. The "flag" that PPRP Chair Dr. Coppersmith raised appears to have gone unnoticed or was suppressed by Lettis and company, and with it, the intellectual credibility of the SSHAC process for Diablo Canyon.

VI. WHAT SHOULD HAVE BEEN DONE TO ADDRESS CONCERNS OF DR. HAMILTON…IF PG&E HAD ASKED?

Although I was invited to participate as a proponent expert in the SSHAC SSC Workshop #2 in November, 2012, at no point since Decision 12-09-008 was issued on September 12, 2012 was I contacted by PG&E or its consultants for my input on the best and most efficient manner with which to resolve my concerns. During my meeting with Lettis and Thompson at their office on

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[31] Lettis, Dr. William R., Technical Integrator Team Lead, "Diablo Canyon SSC Model Update Using SSHAC Level 3 Methodology Project Plan for the Diablo Canyon Seismic Source Characterization (SSC) Model Update, July 18, 2012, pp 2-3.
[32] Ibid., p. 20.

September 26, 2012, *their* agenda focused on *their* perceptions regarding the irrelevance of the Diablo Cove fault; I was never once queried for my thoughts on what investigations would or could be suggested to further explore my interpretation of the available data. For this Testimony, therefore, I have outlined a program that if completed, could answer my concerns.

a. Review reports of Jahns, ASLB Testimony, Hamilton 2010 report and Hamilton SSHAC SSC Workshop 2 figures and conclusions

b. Use seafloor diver/geologists with remote vessel observations and sampling along fault traces visible on Multibeam and Kelp Flyer Multibeam images in and seaward of Diablo Cove and "WHP" Cove and follow fault traces out toward their projected intersection with the Shoreline fault.

c. Drill a slant core boring through the down dip plane of the Diablo Cove fault from a rig setup on the Diablo Cove north headland, on the hanging wall side of the Diablo Cove fault near its sea floor trace. Obtain as nearly continuous core as possible and down-hole oriented bore hole digital photo scans in the fault zone interval. Install continuous recording strain metering instrumentation in boring.

d. Drill slant core boring through downdip planes of faults mapped in DCNPP Unit 1 foundation from a rig setup in the bottom of the reach of lower Diablo Canyon adjacent to the DCNPP, sample image borehole walls and install instrumentation in boring as with Task 3 above.

e. Collate data from Tasks b-d with data from Task a, develop overall 3-D model of Diablo Cove fault including its adjacent splays. Evaluate potential for near surface/surface displacements in and near the DCNPP foundations. ALSO: Evaluate potential DCNPP damage scenarios involving right reverse fault displacements of up to 0.5 meters along fault traces documented as existing in the plant foundations.

For purposes of estimation, I provide herewith a preliminary, approximate budget, based on consultation with current contractors and experts for the scope of work proposed above. Estimates of time and labor for coring and drilling work are based on work done for the Devil's Slide tunnel (2001-2004) where I was a project geologist.

ITEM	DESCRIPTION	COST
a.	Office review 5 days at $3000 per day	$15,000
b.	Diver geologist $3000 per day x 10 days	$ 30,000
	2 support people at $1500 each x 10 days	$ 30,000
	Boat @ $500 per day x 10 days	$ 5,000
c.	Core drilling carefully logged and imaged 500 feet x $150/ft.	$ 75,000
d.	Core drilling carefully logged and imaged 300 feet x $150/ft	$ 45,000
	Supervision for core and drill 16 days x $3000/day	$ 48,000
e.	Project Administration & Overhead @ 25% above costs	$ 62,000
TOTAL		$310,000

Note that this estimate does not include possible costs of dealing with various regulatory agencies, especially the NRC and California Coastal Commission.

VII. CONCLUSION

From my examination of data made publically available by PG&E since D. 12-09-008 was issued by the Commission, I can conclude that PG&E has not satisfactorily or thoroughly resolved my concerns regarding the potential seismic hazard posed by the Diablo Cove fault. Further, the SSHAC process by which this issue was to have been explored in an open and peer reviewed process appears to have been subverted by cognitive bias on the part of PG&E Technical Integration team leaders and consultants.

If past is prologue, then the Commission and all concerned with the potential reliability of energy produced at Diablo Canyon would be wise to observe the following precedent: PG&E produced

a seafloor map projection from the 1988 LTSP (***Figure 11***)[33]. This indicates a feature of the fourth order described as a "lineament related to old shoreline" but was evidently considered a benign feature and never further explored in the LTSP. Two decades later, it was recognized through the research of Dr. Jeanne Hardebeck of the USGS as being the *active* Shoreline fault. On this same 1988 map, and with the greater importance (second order) description of "moderately defined lineament" are the approximate traces of the Diablo Cove zone of faulting, now more accurately depicted on the KelpFly sea floor imaging. These traces appear to be heading for a merge with the Shoreline fault. Given the importance and severity of consequence for underestimating the seismic hazard at a nuclear power plant, it is my hope that due consideration is given the hazards posed by Diablo Cove fault, and that a further two decades will not need to pass before investigation and evaluation of *this* "moderately defined lineament" is given more conscientious attention than PG&E's current, ineffectual effort.

[33] Pacific Gas & Electric, "Onshore-Offshore Geologic Correlation Map of the Southwestern Boundary Zone of San Luis-Pismo Structural Block." Original Edition LTSP, July, 1988, Plate 19

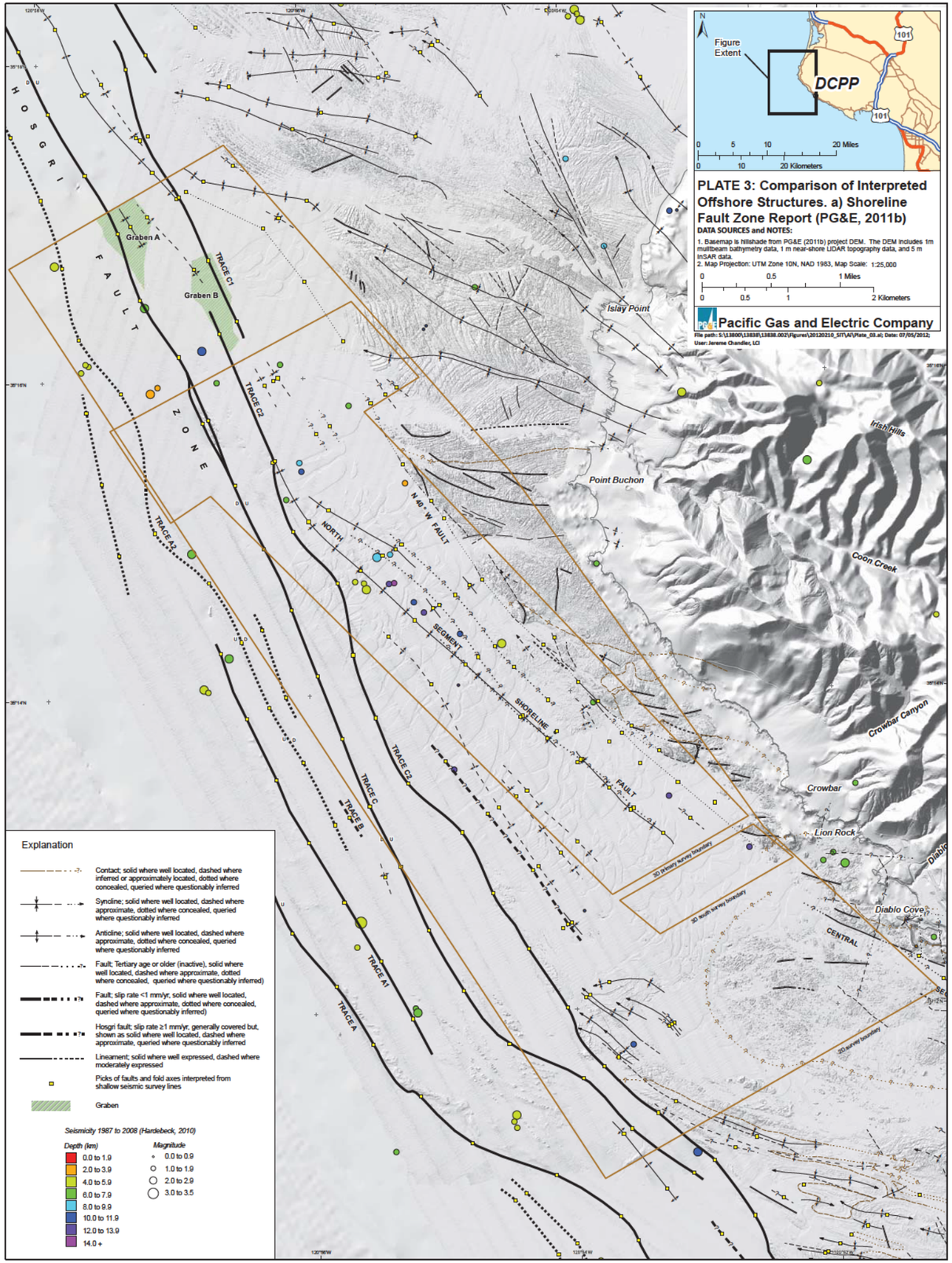

PLATE 3: Comparison of Interpreted Offshore Structures. a) Shoreline Fault Zone Report (PG&E, 2011b)

DATA SOURCES and NOTES:

1. Basemap is hillshade from PG&E (2011b) project DEM. The DEM includes 1m multibeam bathymetry data, 1 m near-shore LiDAR topography data, and 5 m InSAR data.
2. Map Projection: UTM Zone 10N, NAD 1983, Map Scale: 1:25,000

0 0.5 1 Miles
0 0.5 1 2 Kilometers

Pacific Gas and Electric Company

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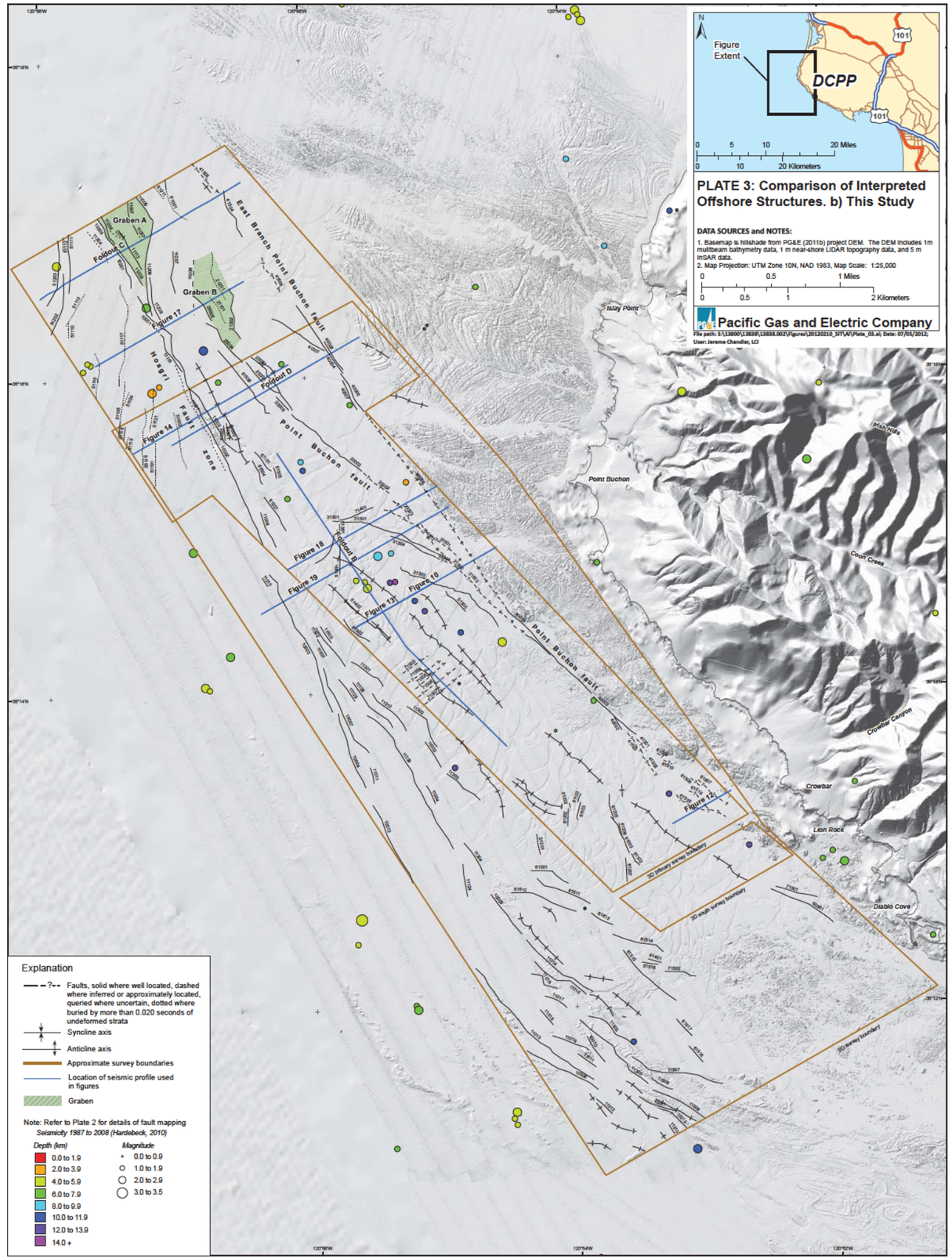

PLATE 3: Comparison of Interpreted Offshore Structures. b) This Study

DATA SOURCES and NOTES:

1. Basemap is hillshade from PG&E (2011b) project DEM. The DEM includes 1m multibeam bathymetry data, 1 m near-shore LiDAR topography data, and 5 m InSAR data.
2. Map Projection: UTM Zone 10N, NAD 1983, Map Scale: 1:25,000

0 0.5 1 Miles
0 0.5 1 2 Kilometers

Pacific Gas and Electric Company

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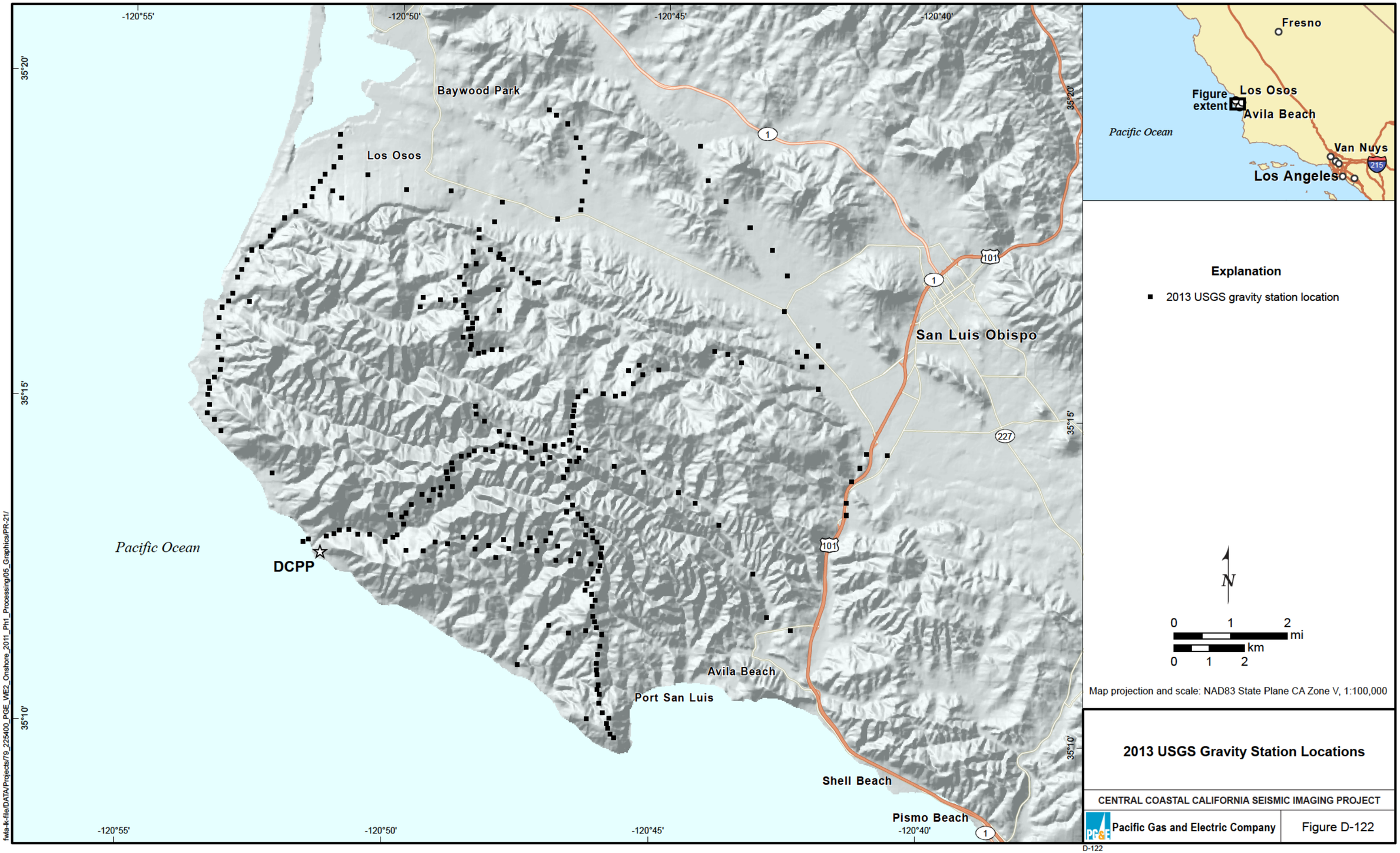
-120°55'
-120°50'
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35°20'
35°15'
35°10'
Baywood Park
Los Osos
San Luis Obispo
Pacific Ocean
DCPP
Avila Beach
Port San Luis
Shell Beach
Pismo Beach
1
101
227
Fresno
Figure extent
Los Osos
Avila Beach
Pacific Ocean
Van Nuys
215
Los Angeles
Explanation
2013 USGS gravity station location
N
0 1 2 mi
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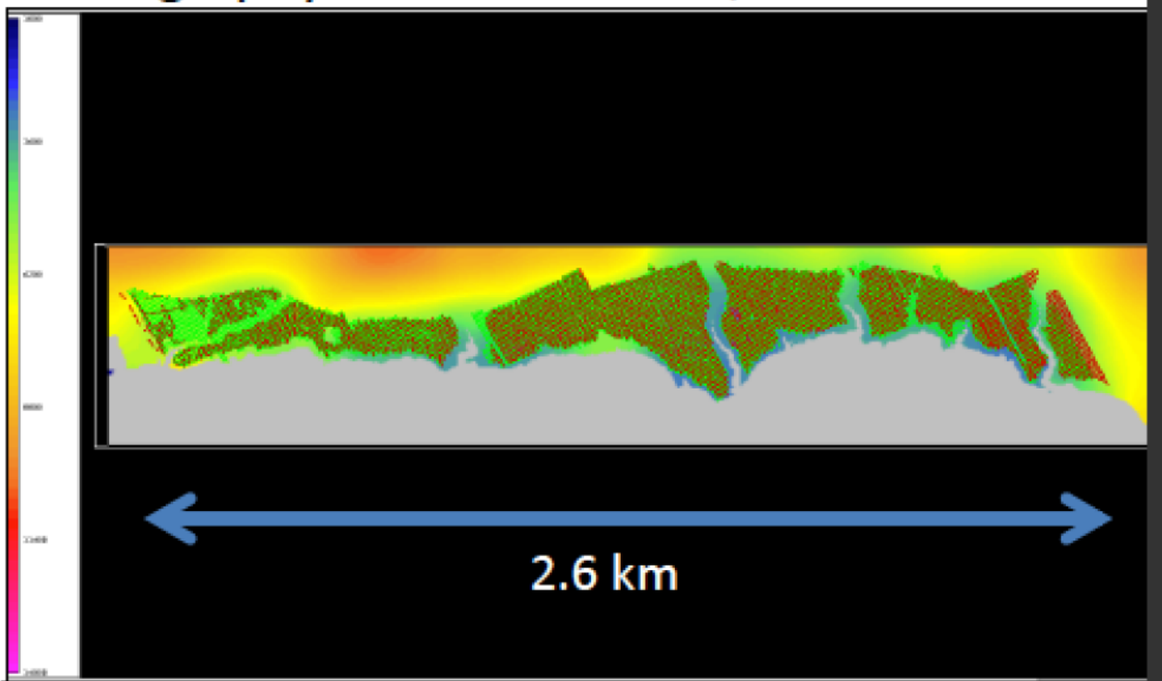
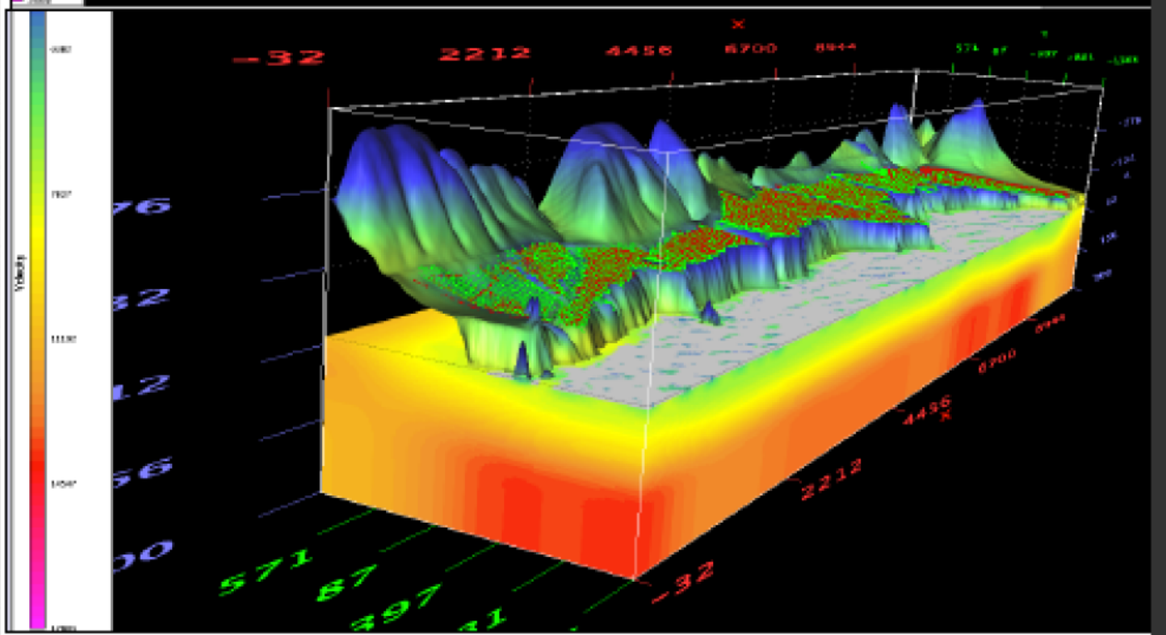
Map projection and scale: NAD83 State Plane CA Zone V, 1:100,000
2013 USGS Gravity Station Locations
CENTRAL COASTAL CALIFORNIA SEISMIC IMAGING PROJECT
Pacific Gas and Electric Company
Figure D-122
fvda-k-file/DATA/Projects/79_225400_PGE_WE2_Onshore_2011_Ph1_Processing/05_Graphics/PR-21/

CCCSIP Onshore: 2012 Terrace 3D Seismic Data

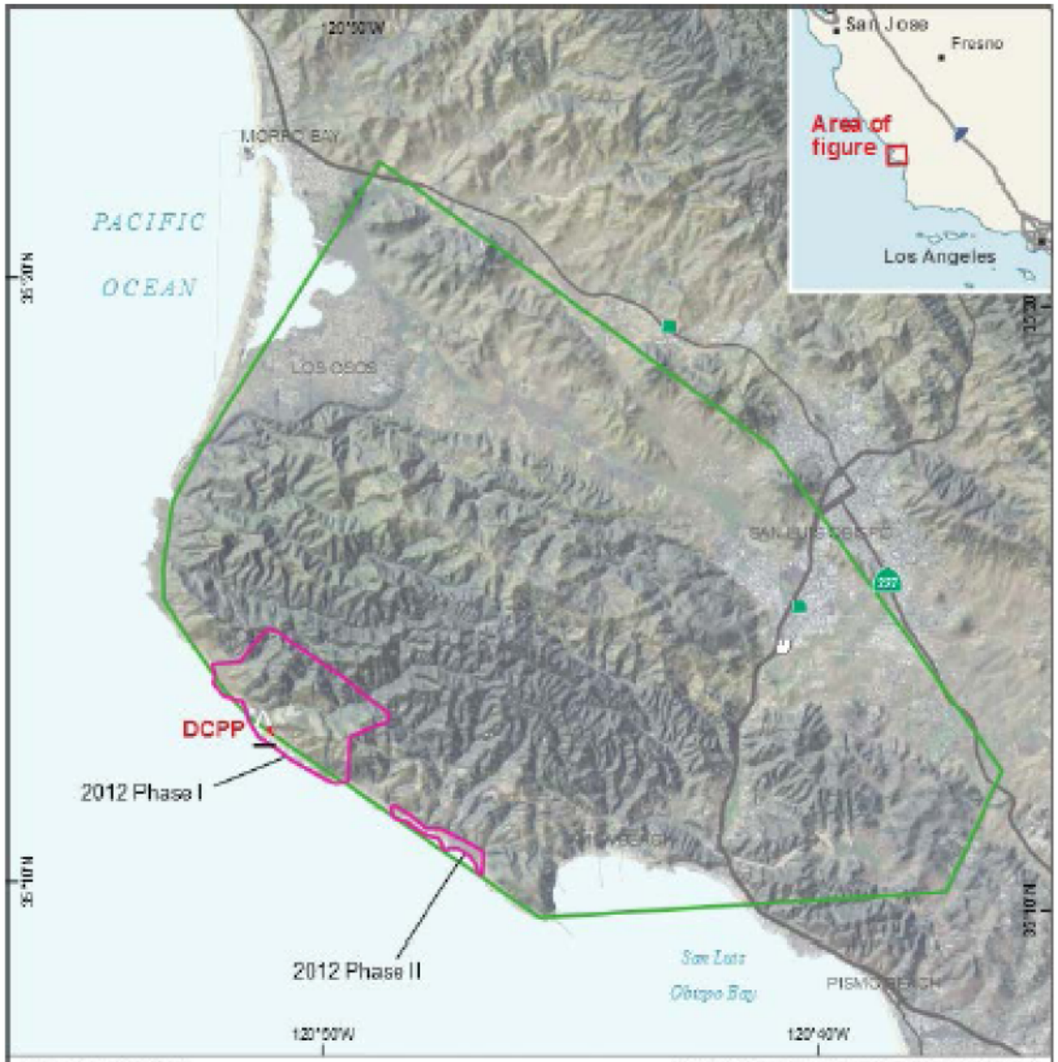
Reflection: 2.4x4.8x0.6 m bins, Z < 300 m

Tomography: 3x3x0.6 m cells, Z < 100 m

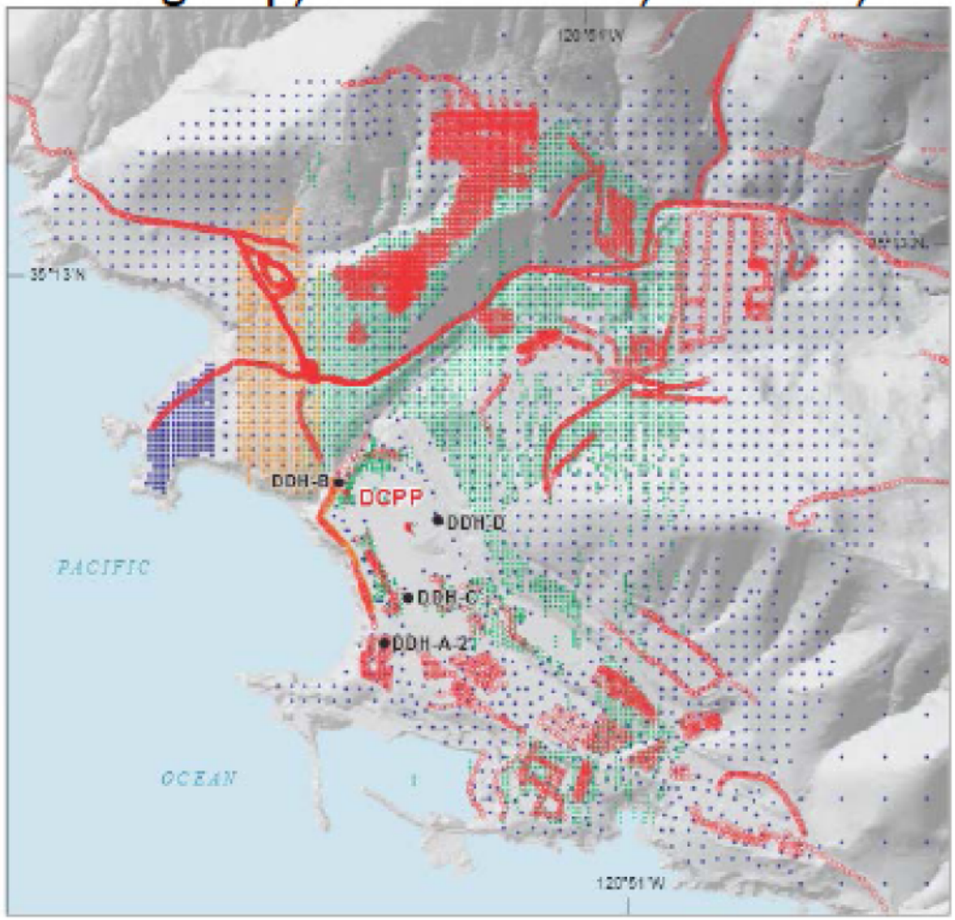




CCCSIP Onshore: 2012 DCPP 3D Seismic Data



5-30 m group, 5-20 m source, 9 m bins, <3 km



8000 Receiver Positions, 8000 Source Points

LEGEND

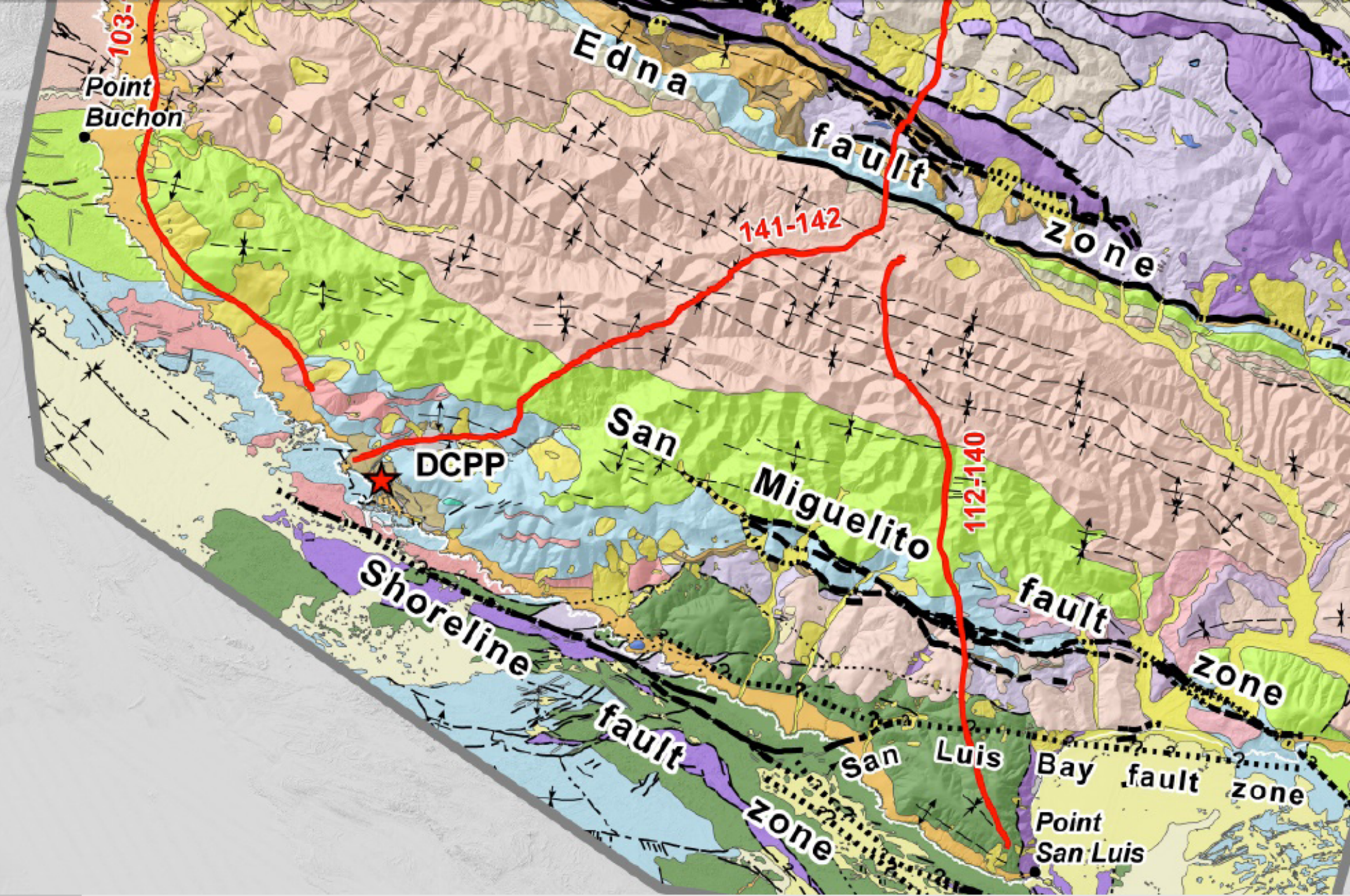
2012 Phase 1 Data

- Zland receiver locations
- Sigma receiver locations
- Seismic receiver locations
- Vibroseis source locations
- DDH-C ● Borehole location of the 1978 investigations

2012 Phase 1 DCPP 3D Survey Sources and Receiver Layouts Detail

CENTRAL COASTAL CALIFORNIA SEISMIC IMAGING PROJECT

Pacific Gas and Electric Company | Figure D-026


Point
Buchon
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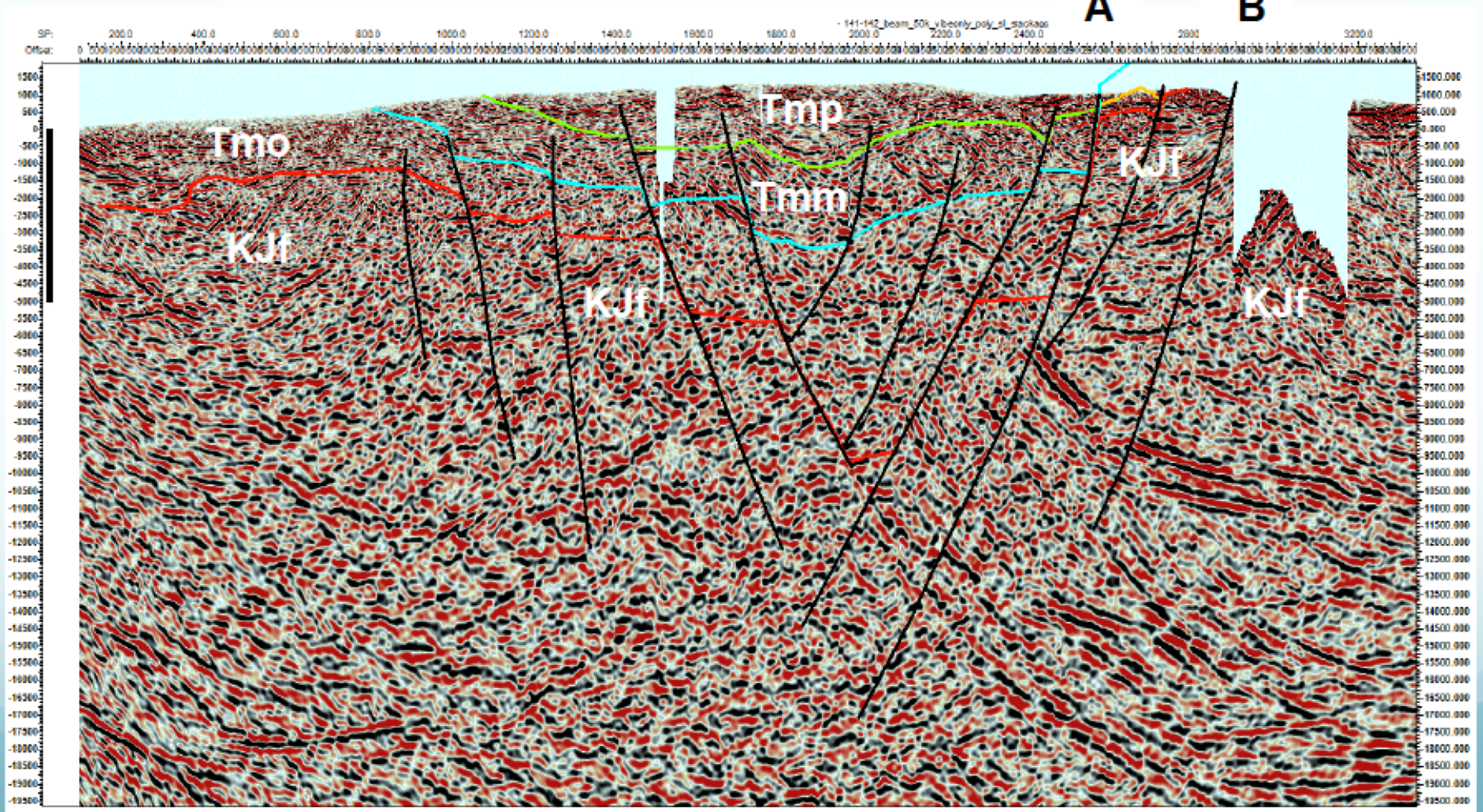
fault
zone
103-
141-142
DCPP
San
Miguelito
fault
zone
112-140
Shoreline
fault
zone
San Luis
Bay
fault
zone
Point
San Luis

141-142 vibroseis

South

North



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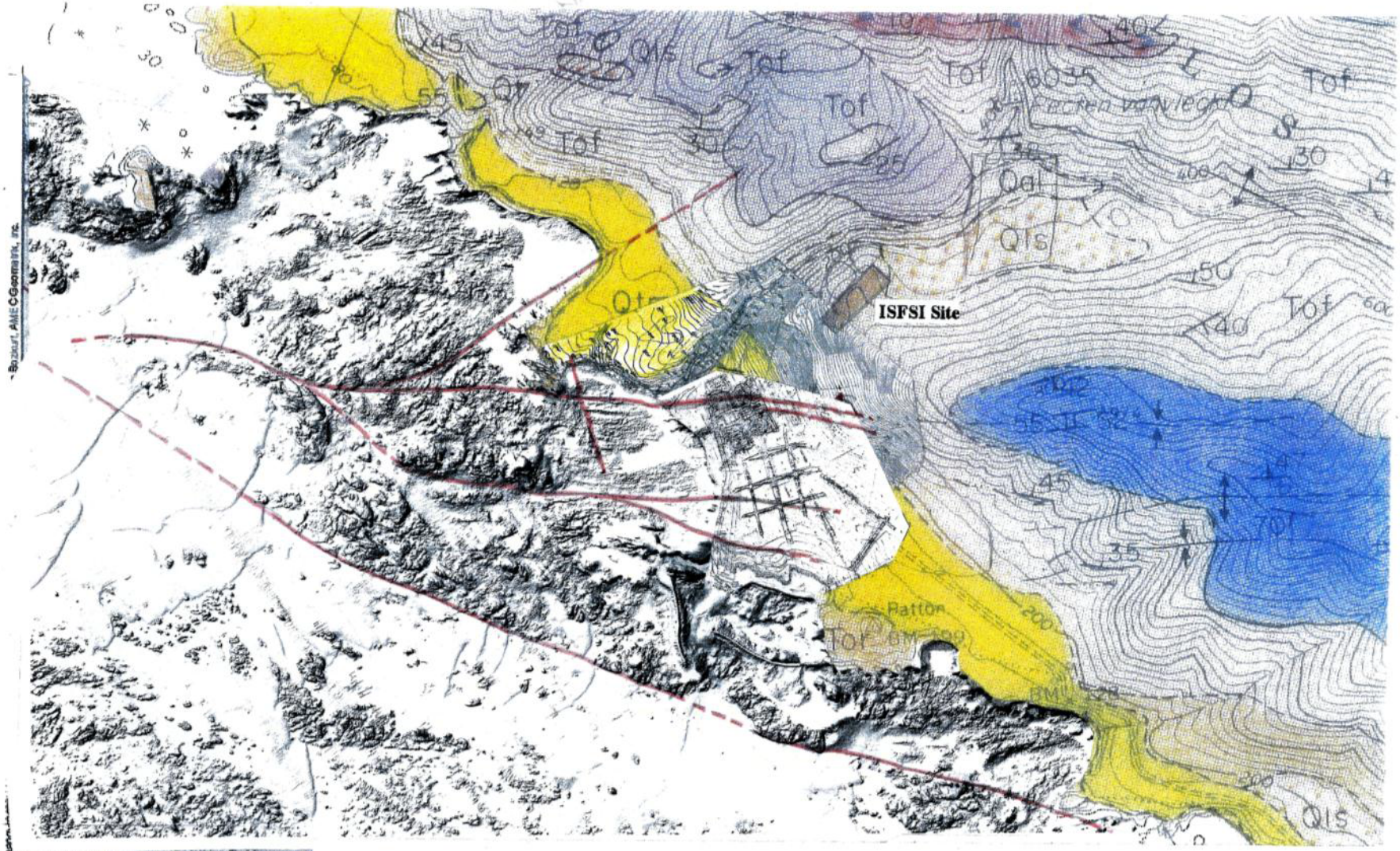
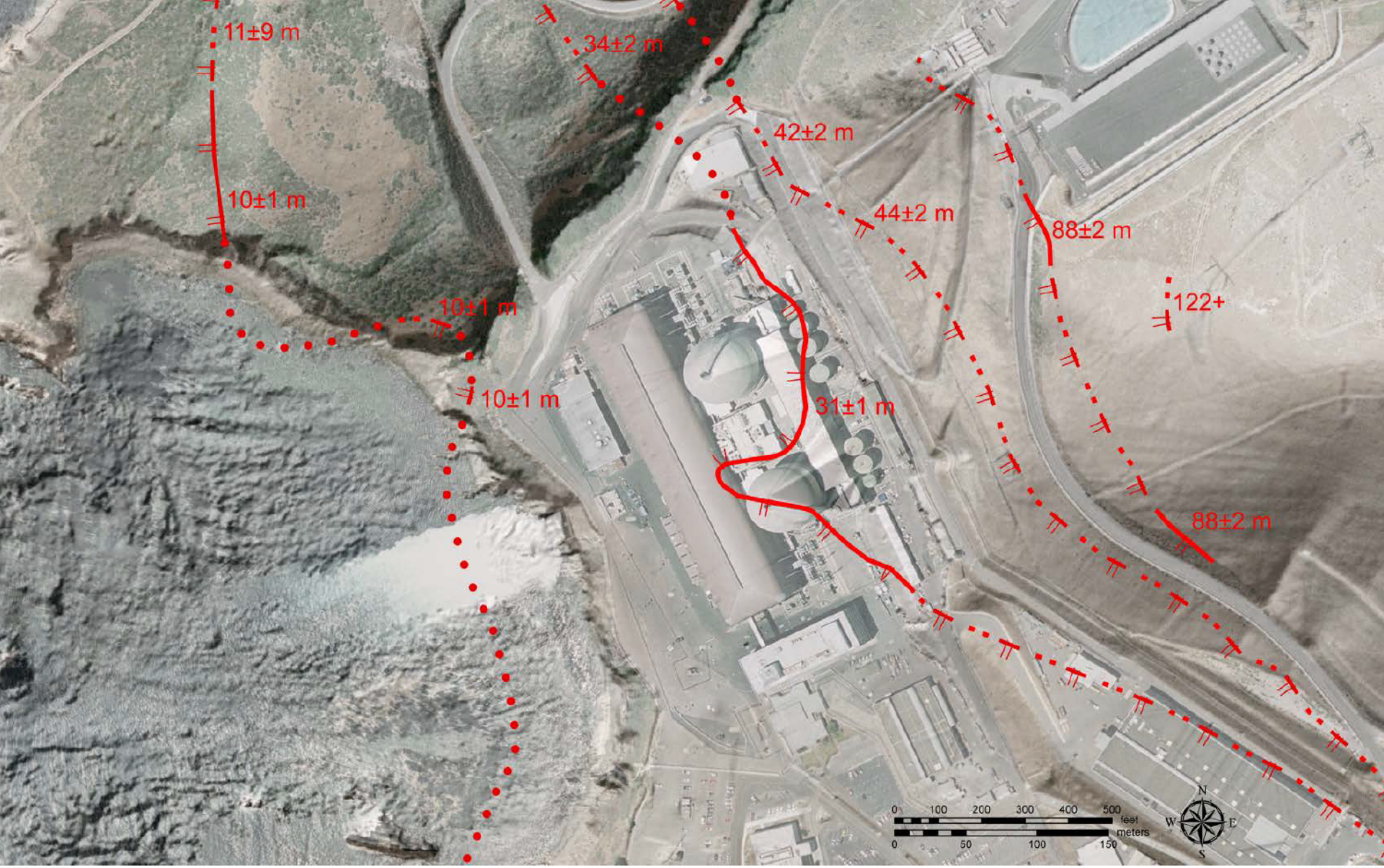
20 "Kelp Flyer" Multibeam image of the sea floor outcrop between the Diablo Cove shoreline and the Shoreline fault.

Item ID	Proposed Data Gap/Needs - Action Items	Knowledge Gained	Applicability to defined hazard-significant issues	NOTES (for internal discussion; hide/remove for archive	Priority	Probability of Success (column E)	Cost Category	Budget, $k (est.)	AB1632	LTSP	SSHAC	CRADA (LTSP)	Schedule
45	Low Energy (high-resolution) 2D/3D surveys in Estero Bay	Shallow high-resolution imaging in area of offshore Los Osos and seismicity lineaments	Location, geometry and sense of slip on Los Osos fault; insights into geometric relations of intersecting offshore faults; and potential for identifying non-V_0 fault sources in Estero Bay (e.g., along seismicity lineaments?)	Not an explicit line item in AB1632. Potential site for low energy 2D survey included in AB1632	Highest	Moderate	High	$0	X (flexibility?)				Q4, 2012 or Q1, 2013 (depending on HESS schedule, scope)
66	Evaluate Pt San Luis tide gauge and determine record for uplift rate; NOAA survey uplift rate information	Secular uplift rate of Pt San Luis and areas interior	Useful for evaluation of processes driving uplift of Irish Hills - may be used with elasic models?	Ray Weldon Postdoc already working on SONGS tide gauge data. GPS does not give vertical, so this is key. Although it is just one point, we should know how far inland the leveling loops go. Will focus attention on mechanisms for uplift and how to model.	Highest	Moderate	Low	$20		X			
70	Utilize local fault pull-apart basins to estimate fault slip rates. Phase 1: Feasibility study	Alternative model for slip rate on faults	Slip rate on Hosgri fault (limiting constraints)	Gary Greene presentation on Pt. Buchon fault 2/13/2012 referenced Rodgers. Hanson developed this in RAI Responses	Moderate	Moderate	Low	$50	?	X			Q2, 2012 (prior to WS2)
71	Evaluate time since most recent significant ground shaking event (e.g., Mission Records)	Constraint on most recent event	MRE on Hosgri or other area faults for renewall model	Marcia to scope this out this year; define scope. LTSP report has section on historical earthquakes. Question is whether any additionl information has come to light	Highest	High	Low	$20		X			
76	Evaluate Diablo Cove fault and San Luis Bay fault zone offshore (including intersection with Olson and Rattlesnake fault	Activity of Diablo Cove fault; geometry of San Luis Bay fault zone	Surface-fault rupture hazard to plant; site-source distance for San Luis Bay fault zone or ramp	Addresses Hamilton testimony. Terrace work to show presence or absence of vertical deformation, review of trenches, cove exposures, fold deformation modeling	Highest	High	Moderate	$150		X			Q2-Q3, 2012
53	Conduct geologic and geophysical strip mapping along onshore seismic-reflection survey cooridors	Surface geologic and geophysical control for interpretation of high-energy seismic reflection data	Los Osos and San Luis Bay down-dip geometry and 3D crustal structure (supports item 42)		High	High (for input to Item 42)	Moderate	$400	X				Q1, 2012 (prior to Item 42)
						TOTALS		$2,150	$850	$1,085		$215	



21 **Faulting mapped onshore in sea cliff outcrops, exploratory trenches, and the DCNPP Unit 1 foundation excavation. Offshore fault extensions are as interpreted from the "Kelp Flyer" multibeam image of the sea floor outcrop**



Marine terrace shoreline angles at DCPP (data from Hanson et al., 1994)

PLATE 19: PG&E "ONSHORE-OFFSHORE GEOLOGIC CORRELATION MAP OF THE SOUTHWESTERN BOUDARY ZONE..." LTSP, JULY 1988