Diablo Canyon Power Plant

Long Term Seismic Program Update

Briefing to the California Public Utilities Commission
Independent Peer Review Panel
May 5, 2023

Outline

- Introduction
- SB-846 Seismic Hazard Update Plan
- Update on Selected LTSP Research Activities
- M7.8 and M7.5 Turkey Earthquake Response

SB846 Seismic Hazard Update Plan

Senate Bill No. 846 Language

(13) A covenant that the operator shall conduct an updated seismic assessment.

(14) A covenant that the operator shall commission a study by independent consultants to catalog and evaluate any deferred maintenance at the Diablo Canyon powerplant and to provide recommendations as to any risk posed by the deferred maintenance, potential remedies, and cost estimates of those remedies, and a timeline for undertaking those remedies.

Plan Outline

- Planned approach for seismic hazard assessment
- Potential team members
- Potential topics for evaluation
- Timeline

Updated seismic hazard assessment

- The 2015 Probabilistic Seismic Hazard Assessment (PSHA) study was state of the art:
  - Senior Seismic Hazard Analysis Committee (SSHAC) Level 3
  - Multi-year studies addressing all aspects of hazard
  - Included significant new information on sources and site conditions (e.g., Assembly Bill 1632)
- Refinement of parameters and new studies have been conducted
- Considerations for updated assessment:
  - Completeness of previous study
  - No new ground motion models after prior study:
    - Biggest contribution to uncertainty
    - On the cusp of new modelling approaches

Planned strategy

- Initiate a qualitative approach with flexibility to adjust approach if warranted
- Comparisons made to hazard inputs; not hazard curves
- Start the process of developing a work plan and compiling information
- In parallel, develop a plan for alternative assessment
- Present qualitative hazard assessment results to California Department of Water Resources (DWR) review team
- Potential to elevate to an alternative approach, if necessary; SSHAC 1 study, if so

Basis for incremental approach

- This process starts the work now
- Potentially provides resolution sooner
- Can be modified later based on results
- Documents the changes and provides justification if more work is required

Elevating to a Quantitative Study

- Use the guidance from Payne et. al.
- If “yes” to any of the following, consider elevating the study
  - If any hazard significant discrepancies are found with the previous study
  - If updated inputs are outside of the center, body, and range of the previous study
  - If evaluators do not have confidence in their assessment
- Recommended DWR reviewers

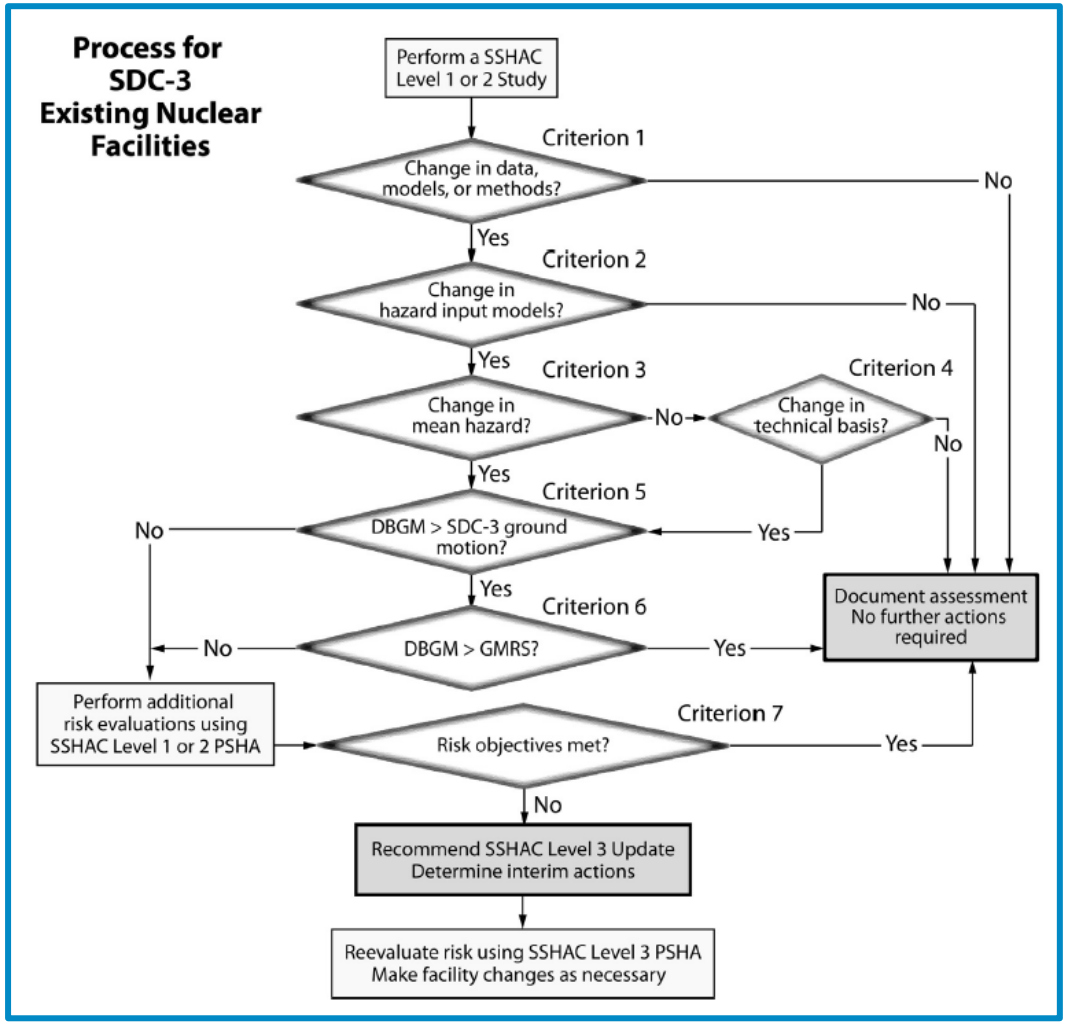
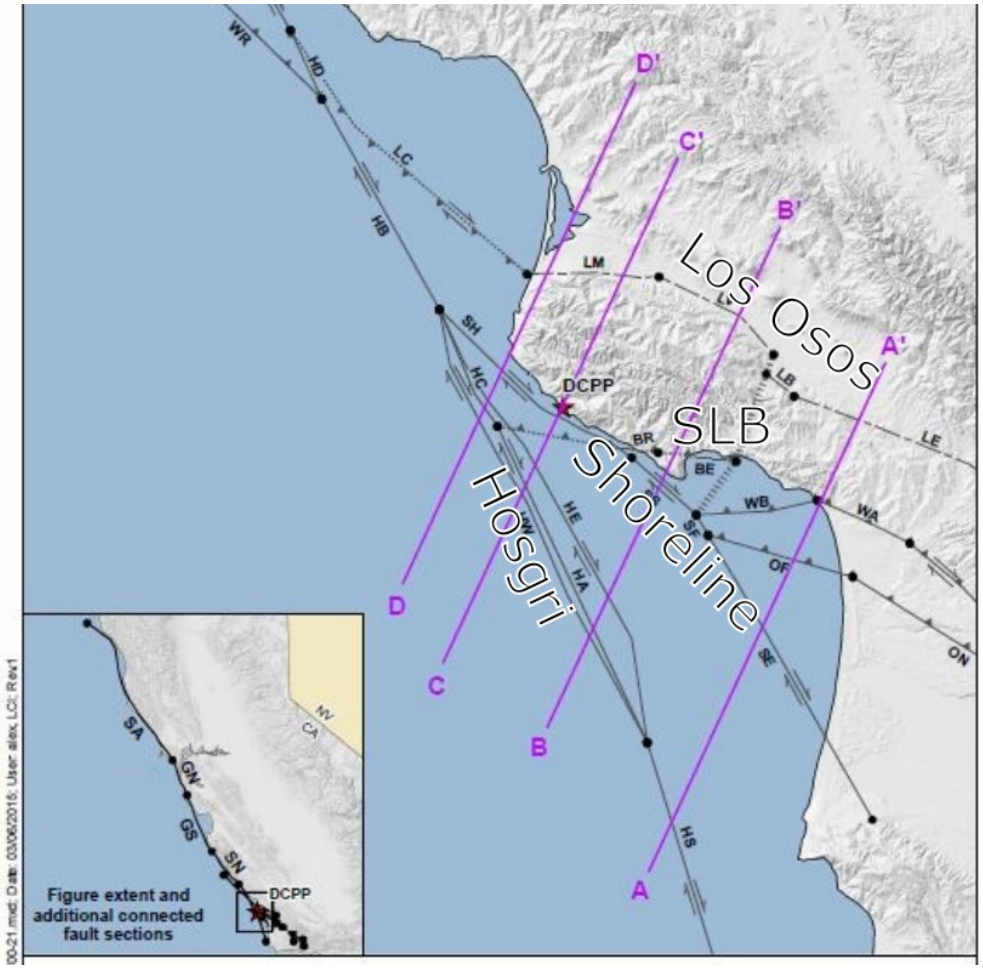


Figure 1 from Payne, et. al. “Assessing the need for an update of a probabilistic seismic hazard analysis using a SSHAC Level 1 study and the Seismic Hazard Periodic Reevaluation Methodology”

Source characterization topics

- Changes in data, models, and methods since 2015
- Slip rate and geometry of local faults:
  - Hosgri
  - Shoreline
  - Los Osos
  - San Luis Bay
- Deformation models
  - Geodesy
  - Kinematics
  - Hosgri fault transpression
- Earthquake catalog
- Background model



Ground motion topics

Note:
Ground motion models dominated uncertainty in the 2015 study

- Review of ground motion models
  - Median
  - Variability
  - Uncertainty
- Updates to earthquake catalog; focused on controlling events
- Non-ergodic models and their potential application

M<4 Events Near DCPP from 2014 - 2022

Timeline

April 2023	May 2023	June 2023	July 2023	Aug. 2023	Sep. 2023	June 2024
• Regulatory and stakeholder feedback	• Data collection begins	• Small initial team begins evaluation and reporting	• Identify if additional assessment is required	• Contract additional team members for SSHAC 1, if required	• Complete qual. Report **OR** Kick-off SSHAC 1, if required	• Deliver SSHAC 1 study, if required

Update on Selected LTSP Research Activities

Source Characterization Publications

- **Hosgri Fault Slip Rate**
  - Manuscript published in Marine Geology: “Subaqueous clinoforms created by sandy wave-supported gravity flows: Lessons from the Central California shelf” by Medri et al
  - Manuscript submitted to Geosphere: “High-Resolution Geophysical and Geochronological Analysis of Relict Shoreface Deposit Offshore California: Implications for Slip Rate Along the Hosgri Fault” Kluesner et al

- **Coastal Uplift**
  - Manuscript submitted to The Seismic Record: “Hosgri Fault Transpressional Slip Rates Reproduce Observed Central California Coast Uplift” O’Connell et al

Ground Motion Publications

- Published in Seismological Research Letters: “Automated Detection of Clipping in Broadband Earthquake Records” by Thompson et al.
- Published in Earthquake Spectra: “A DesignSafe earthquake ground motion database for California and surrounding regions” by Cabas et al.
- Published in Bulletin of Earthquake Engineering: “Evaluating the performance of nonergodic ground motion models in the Ridgecrest area” by Macedo et al
- Published in SoftwareX: “Seismo-VLAB: An open-source finite element software for seismic meso-scale simulations” by Asimaki et al.
- Published in Journal of Geotechnical and Geoenvironmental Engineering: “What Spatial Area Influences Seismic Site Response: Insights Gained from Multiazimuthal 2D Ground Response Analyses at the Treasure Island Downhole Array” Hallal and Cox

Other publications

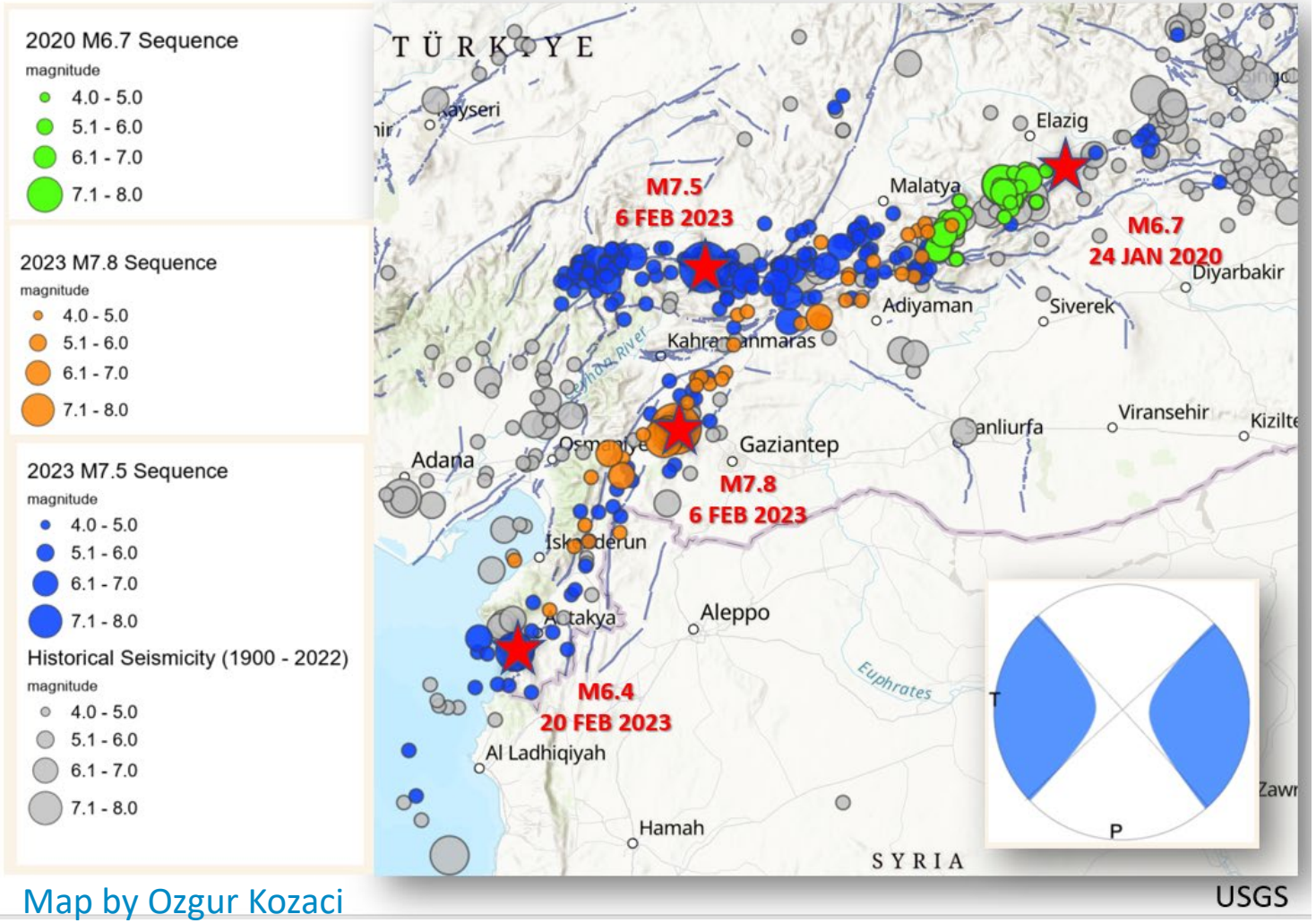
- **Precariously balanced rocks**
  - Manuscript submitted to Seismica: “Virtual Shake Robot: Simulating Dynamics of Precariously Balanced Rocks for Overturning and Large-displacement Processes” Chen et al

- **Fault displacement**
  - Report published by the UCLA Garrick Institute for Risk Sciences: “Comparison of Fault Displacement Hazard Initiative Models” Sarmiento et al.
  - Manuscript submitted to BSSA: “A Probabilistic Displacement Hazard Assessment Framework for Coseismic Distributed Fracturing from Strike Slip Earthquakes” Padilla and Oskin
  - Manuscript accepted by Geosphere: “Evaluating How Well Active Fault Mapping Predicts Surface Rupture” Scott et al.

M7.8 and M7.5 Turkey Earthquake Response

Turkey Earthquake Sequence

Sequence of Large Magnitude Earthquakes along the East Anatolian Fault Zone



Map by Ozgur Kozaci

LTSP Earthquake Reconnaissance Program

- Large earthquakes happen infrequently in California
- Observations of earthquake effects and impacts on utility infrastructure improves PG&E's seismic preparedness

Earthquake	Lessons Learned	PG&E Application/Action
1992 Landers 1999 Hector Mine	Multiple faults can rupture together to produce large earthquakes. Static stress triggering	Tuned earthquake magnitudes in source models
1999 Turkey Earthquake	Ruptures can end at big steps in fault systems	Tuned earthquake magnitudes and displacements
2004 Sumatra Earthquake/2012 Tohoku Earthquake	Tsunami hazard Maximum magnitude	Triggered tsunami hazard assessment Led to DCPP seismic studies and hazard re-assessment
2016 Kaikoura Earthquake	Rupture can be very complex above subduction zones	Updated models for fault rupture in Humboldt area
2018 Hokkaido Earthquake	Shallow landslide potential during rainy season	Updated understanding of potential hazard in volcanic terrain
2019 Ridgecrest Earthquake Sequence	Static stress triggering Unknown active faults in remote areas.	Led to development of potentially active fault identification and assessment program

PG&E Post Earthquake Activities

- Coordination with GEER and EERI reconnaissance teams to understand initial lessons learned and identify research focus areas relevant to PG&E and DCPP
- Coordination and information sharing with Southern California Edison and SoCal Gas
- Coordination with USGS and Turkish researchers to identify research targets that fill knowledge gaps in earthquake science
- Planning for late reconnaissance trip to understand earthquake process and impacts

Photo by O. Kozaci

Initial Lessons Learned and Questions

- Initial findings by GEER and EERI reconnaissance teams
  - Earthquake sequence produce strong ground shaking, fault rupture and liquefaction. Few landslides
  - Buildings and utility infrastructure that incorporated seismic design elements generally performed well
  - The M7.8 earthquake began on a short secondary fault

- Research questions
  - What is the relation between the secondary fault where the M7.8 epicenter occurred and the East Anatolian fault?
  - How predicable is static stress triggering, as occurred between the M7.8 and M7.5 earthquakes?
  - How did ground motion models perform?
  - What are the takeaways on infrastructure and building performance?

Thank You