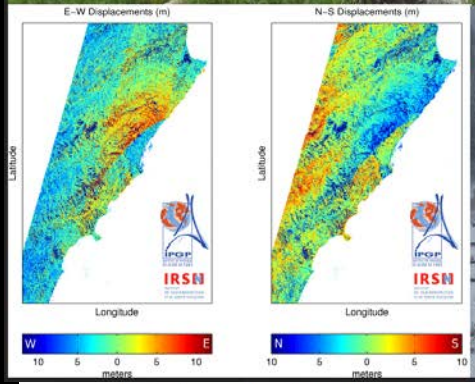
# Fault Displacement Hazards Analysis Workshop

December 8 - 9, 2016

Menlo Park, CA




CGS California Geological Survey

IRSN Institut de Radioprotection et de Sûreté Nucléaire

Istituto Nazionale di Geofisica e Vulcanologia

PEER

USGS science for a changing world

# Introduction to Session II: Perspectives from California

Tim Dawson, CEG
California Geological Survey


Fault Displacement Hazards Workshop, Menlo Park, CA
December 8, 2016

**The 1971 Mw 6.6 San Fernando earthquake was associated with surface fault rupture that damaged or destroyed many structures.**


**Lesson learned**: Damage localized near fault zones, thus an easily avoidable hazard

# The intent of the A-P Act is to prohibit building structures for human occupancy across the trace of an active fault, thus avoiding the hazard of surface fault rupture.


1992 Mw 7.3 Landers Earthquake

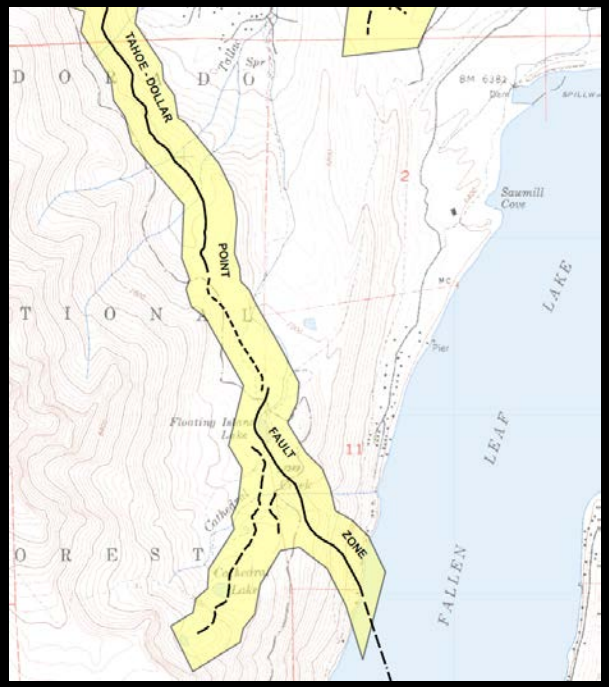

1999 Mw 7.4 Izmit (Turkey) Earthquake

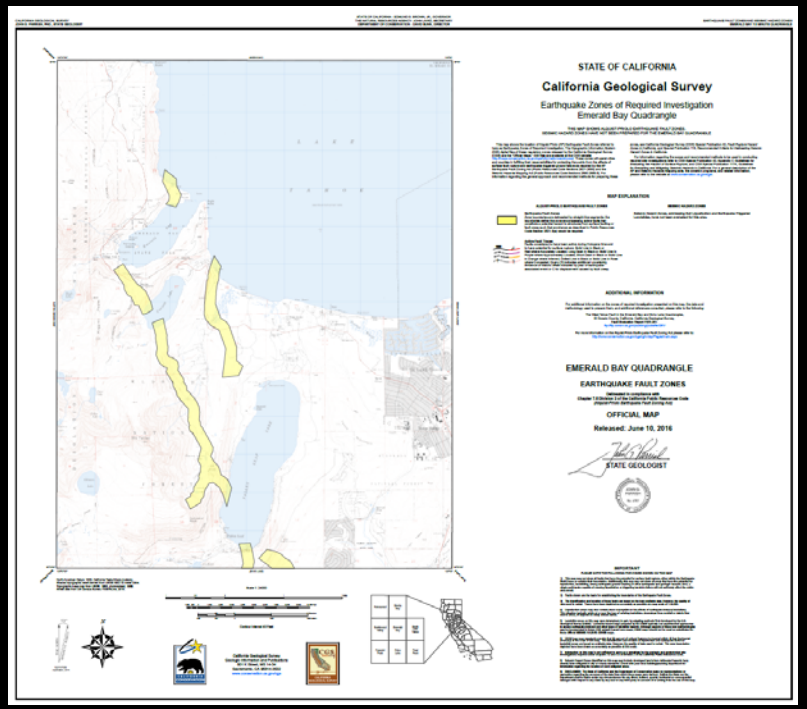

1999 Chi Chi (Taiwan) Earthquake


2016 Kaikoura Earthquake

# California Approach Under the Alquist-Priolo Act

- Earthquake Fault Zones of Required Investigation (EFZs) are established by the State Geologist
- Criteria used for zoning is “sufficiently active” (Holocene) and “well-defined”
- EFZs typically 500 feet wide



# California Approach Under the Alquist-Priolo Act

- California approach to mitigation is by avoidance
- Local jurisdictions (Cities and Counties) require geologic investigations for “projects” within EFZs
  - Investigations typically include local geomorphic mapping, trenching, boring transects, etc.
- Structures for human occupancy prohibited from being constructed across traces of active faults
- Permits issued after local jurisdiction reviews geologic site investigation report to ensure it addresses fault rupture hazard.

# Success of A-P Act

- A-P Act provides effective management of the hazard, providing reduced risk.
- Uses a mitigation option that works!
- Characterization approach (identification of active faults) is simple and effective
- Uniform State-wide minimum standard.
- Review process by jurisdiction is simplified – No design recommendations to argue about or review.
- Several thousand A-P related site investigations conducted in past 40 years
- Many large developments have therefore avoided building structures across traces of active faults – Setback zones are sometimes turned into greenspace and homes adjacent to these setbacks have higher value due to perceived amenities (See Toké et al. (2014)

# Fault Characterization Issues

The A-P Act's "mitigation-by-avoidance" approach to fault rupture mitigation is perceived to be in conflict with current approaches to fault characterization and mitigation by design.

While engineering practice can handle ground displacements, the more challenging aspect are reliable estimates of surface displacement at a site-specific level

Uncertainties in paleoseismology

- Dating Uncertainties
- Stratigraphy may not allow for event resolution or identification of faults
- Lack of consensus on what dating methods are appropriate in different circumstances

# Fault Characterization Issues

Paleoseismic resolution may be lacking

- Soils and young deposits may not be present, or stripped away. Inability to prove faults are not Holocene active.
- High deposition rates – Trenching may be impossible or cost prohibitive.

Holocene criteria may not capture faults that are potentially active – e.g. faults with MREs at or beyond average reoccurrence

# Fault Characterization Issues

How to deal with “secondary faults” or faults with perceived “minor” displacement?

- A-P Act does not distinguish between principal and secondary faults that rupture with small displacements
- Engineering community feels they can mitigate by design for small displacements
- How do we characterize “secondary faults”/
  - Is recurrence behavior well-understood?
  - Are single displacements representative of long term and future behavior?

Engineered mitigation is possible. Fault characterization at a site-specific level may be the greater challenge to implement in a practical way that serves owners, jurisdictions, and society.

# A Path Forward

Above issues may penalize property owners with sites not amenable to traditional approaches to fault characterization that meets local and State regulations

Possible improvements/standards:

- If fault can be characterized and meets A-P criteria for an “active fault”, mitigation by avoidance is best option.
- Alternative options for “faults of undetermined activity” and “minor” faults should be considered – if data and approaches support the characterization and recommendations

However, in most cases site-specific data is not available

- Alternative interpretations and uncertainties in site-specific geologic data often lead to conflicts between developers and regulators

# A Path Forward

## Probabilistic Fault Displacement Analysis

- Offers an alternative approach less reliant on site-specific data that may or may not be available.
- Captures uncertainties in a more consistent way.  Perhaps easier to review with a standardized knowledge base and less professional judgment/opinion.
- Cast in a probabilistic framework, buildings could be designed based on risk category relative to structure type, service life, occupancy.

# A Path Forward

## User Needs

- Should be vetted by research and user community
- Should be easy to use (e.g. USGS ground motion calculator, commercial PSHA software)
- Not black box, and easy to review (minimize tunable parameters that are generally accepted)
- Testable and updatable on an as-needed basis