Findings and Recommendations

from the

Ridgecrest Earthquake Sequence of July 2019



CALIFORNIA SEISMIC SAFETY COMMISSION

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November 22, 2019

California Seismic Safety Commission

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November 12, 2019

California Seismic Safety Commission -

I would like to take this opportunity to say thank you for the meeting you held in Ridgecrest. It was very helpful to hear others speak of lessons learned. You went above and beyond and we are most appreciative!

What made it more important and helpful, was that most attendees heard all of what each person/entity had to say for the first time. Things some of us did not fully recognize - all from a different set of eyes and experiences - became even more focused for future unforeseen events.

The deficiencies of various public entitles' responses can almost solely be attributive to the number of responders and that being determined by local budgets. State and federal funds are available for additional training and perhaps funding positions. Identification of that potential will be much needed.

FEMA funding was one of the most important. The funding is determined on a flawed finding, I believe. You stated: "Finding 4 Regarding Eligibility for Post-Disaster Government Funding: The Federal Emergency Management Agency's threshold of \$56 million in public damage was not met for local government agencies to become eligible for Federal Public Assistance after this sequence of earthquakes. While the Navy's losses are now reportedly approaching \$4 billion at the China Lake Naval Air Weapons Station, those losses do not count toward local government, non-profit or individual disaster funding eligibility even though indirect effects from these losses impacted nearby communities. The State of California is authorized to provide assistance if a requested Federal declaration of an emergency is not issued and when a local authority's capability to respond is inadequate to cope with the emergency." However, the determination is made as each incident happens, what one can only ask for is a fair assessment. A percentage of an economic basis i.e. gross economic output or perhaps using that plus a factor of the economic impact (value) of the economic entities.

We needed this opportunity to see deficiencies and learn and you made that possible!

Thank you,

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Peggy Breeden Mayor City of Ridgecrest

Findings and Recommendations 11-22-2019

The Ridgecrest Earthquake Sequence of July 2019: Lessons Learned

Executive Summary

The Ridgecrest earthquake sequence struck Ridgecrest and Trona on July 4 and 5, 2019. The largest earthquakes were a magnitude 6.4 (moment magnitude scale M_w) on July 4 and a M_w 7.1 on July 5. Thousands of aftershocks were recorded and still continue to occur. Fortunately, damage to the City of Ridgecrest was relatively localized and limited considering the magnitudes and proximity of these earthquakes. The town of Trona experienced similar levels of damage. However, facilities at the China Lake Naval Air Weapons Station were severely damaged. Total damage was estimated to be approximately \$4 billion.

A State Emergency was declared for Kern and San Bernardino Counties. A Federal Emergency was also declared largely due to damage to military assets.

On September 11, 2019, the Commission held a hearing in the Ridgecrest City Hall with testimony from approximately 25 individuals representing many different organizations and the public. During the hearing, commissioners asked the presenters questions that focused on their experiences during the earthquakes and lessons learned that could be passed on to local governments who will ultimately face damaging earthquakes in the future.

During public testimony it was made clear that the Ridgecrest and Trona communities came together to support each other during and after these damaging earthquakes. Ridgecrest and Trona are rural, remote and minimally populated communities with a culture of self-sufficiency and resiliency. Rural communities can also face difficulties receiving immediate emergency assistance due to their remote locations. This can also be compounded by a lower level of emergency response training and resources that are common in more urbanized areas. While this report reflects similar recommendations presented in prior reports, the Commission would like to emphasize in this report the need for smaller and/or rural local jurisdictions to be supported by their larger counterparts to ensure accurate and appropriate emergency response is expedited.

After considering the facts independently gathered by the Commission and the public testimony, the Commission adopted the following recommendations in no order of priority for consideration by the Governor and the Legislature:

Priority Recommendations

<u>1.</u> Increase Local Government Capabilities to More Effectively Respond to Disasters:

1a. Enhance Safety Assessment Program (SAP) Evaluator and Coordinator training opportunities for jurisdictions in rural regions of California. Step up efforts to provide table-top training exercises to expedite and improve the quality and priorities of safety assessments for damaged buildings and other structures. Re-evaluate the comprehension and effectiveness of structural assessment training curricula. Train appropriately-qualified local government personnel to conduct rapid safety assessments of all potential locations for emergency shelter centers after future earthquakes so that shelter deployments are in safe facilities without undue delays. Ensure, through training or mutual aid, that each local government has at least one trained SAP Coordinator on staff.

- 1b. Advise local government to modify the basic SAP placards to include information deemed pertinent to local responders and emergency managers.
- 1c. Advise local governments to pre-establish multiple potential shelter and emergency command center sites including pre-planning of grounds and facilities within those sites for respective purposes.
- 1d. Examine the strengths and weaknesses of jurisdictions relying solely on building owners' requests for safety assessments of damaged buildings rather than systematic safety assessments of entire neighborhoods.
- 1e. Examine the strengths and weaknesses of relying on mutual aid with neighboring jurisdictions for building safety assessment personnel rather than requesting safety assessors and coordinators through the state Office of Emergency Services' SAP.
- 1f. Determine lessons learned including the need for a single, coordinated point of contact to address the public's questions about safety assessments of damaged buildings.
- 1g. To help minimize duplication of entering data in multiple forms, develop a consistent digital data format to retrieve pre-existing information and capture new information about each applicant for disaster assistance.
- 2. <u>Mental Health Services:</u> Continue to improve the delivery of mental health services to both emergency responders and the public at large after future disasters.
- 3. <u>Businesses Emergency Response and Recovery Capabilities</u>: Encourage businesses, including hotel owners and managers and food providers to better train their employees for disasters and support their rapid return to work following disasters such as by participating in the state's *Outsmart Disaster* Program.
- 4. <u>Eligibility for Post-Disaster Government Funding</u>: Reexamine federal and state eligibility thresholds as they apply to rural communities to provide more Public Assistance Grants and Individual Assistance Grants after future disasters. Propose basing the thresholds on a percentage of a jurisdiction's annual gross economic product.
- 5. <u>Nonstructural Retrofits</u>: Encourage building owners and occupants, especially in schools, to undertake seismic retrofits of nonstructural components and contents during future maintenance, repairs, and alterations. Update and reissue the Division of the State Architect's and the Office of Emergency Services' advice on nonstructural bracing to public and private school facility personnel.

A list of other topics raised by local government officials, first responders, local citizens and others at Commission hearings is in the Appendix.

Introduction

The Ridgecrest earthquake sequence struck the cities of Ridgecrest and Trona on July 4 and 5, 2019. The largest earthquakes were a magnitude (moment magnitude scale M_w) 6.4 on July 4 and a M_w 7.1 on July 5 and caused no serious injuries or deaths. Thousands of aftershocks have been recorded and continue to occur. Fortunately, damage to the City of Ridgecrest, population 30,000, was relatively localized and limited considering the magnitudes and proximity of these earthquakes. The town of Trona, population 2,000, experienced similar levels of damage and facilities at the China Lake Naval Air Weapons Station were most severely damaged. (See Map, Figure 1)

The great majority of the nearly \$4 billion in dollar losses occurred at the China Lake Naval Air Weapons Station, the region's largest employer, where 84 buildings are proposed to be replaced out of 230 buildings damaged. So far, \$585 million was earmarked by Congress to begin recovery on the base. The Department of Defense is evaluating the effects of these earthquakes to determine if its facility management and emergency response practices need improvements.

In San Bernardino County, the Searles Valley Mineral Company is the largest impacted employer with three brine-processing industrial plants and 700 employees. Damage is in the millions, but boilers and soda ash production were restored in mid-September. No employees were laid off at the plants.

On July 8, 2019, the Alfred E. Alquist Seismic Safety Commission (Commission) deployed a team to view the damage in Ridgecrest and Trona and helped staff the California Earthquake Clearinghouse. Working with the Clearinghouse and the City of Ridgecrest better enabled the Commission field team to identify areas to view damage and observe teams from the U.S. Geological Survey and the California Geological Survey in the field. Every evening the field teams reported findings to the Clearinghouse, which helped the Commission gain information on the impacts the earthquake sequence had on the region. The Clearinghouse remained open and active for seven days and held nine briefings.

On September 11, 2019, the Commission held a hearing in the Ridgecrest City Hall with testimony from approximately 25 individuals who represented many different organizations and the public. During the hearing, commissioners asked the presenters questions that focused on their experiences during the earthquakes and what lessons learned could be passed on to local governments who will ultimately face damaging earthquakes in the future.

The Commission wishes to express its gratitude to the City of Ridgecrest, Kern and San Bernardino Counties, and the town of Trona for their assistance in helping organize the September 11 hearing. Mayor Peggy Breeden and Police Chief Jed McLaughlin are particularly thanked for their dedication to the people of Ridgecrest during such a stressful time and their assistance in helping the Commission conduct a very informative and valuable hearing.

The findings and recommendations below are similar to those in Commission reports after the 2014 M_w 6.0 South Napa, 2010 M_w 7.2 El Mayor Cucapah, 2003 M_w 6.6 San Simeon, 1994 M_w 6.7 Northridge and 1989 M_w 6.9 Loma Prieta Earthquakes.



Figure 1. Map showing the locations of Ridgecrest and Trona in relation to the northeast-southweststriking fault that ruptured in the M_w 6.4 foreshock and the northwest-southeast-striking fault that ruptured in the M_w 7.1 mainshock. (Miyamoto 2019)

Findings and Recommendations:

<u>Finding 1 Regarding Local Government Capabilities:</u> Building Department personnel in Ridgecrest were not trained and certified as Safety Assessment Program (SAP) Evaluators or Coordinators. Even though California has over 7,000 SAP Evaluators, 140 trainers, and 50 training sessions annually, gaps exist throughout the state where hundreds of jurisdictions do not have trained personnel, particularly in rural areas.

Red Cross personnel commented that delays in setting up the emergency shelter center at the Kerr McGee Community Center occurred because of delays in completing safety assessments of the buildings. Key responsibilities of SAP Coordinators are to identify and request resources to meet priorities for safety assessments of critical facilities including emergency shelters.

Ridgecrest, in cooperation with the Kern County Building Department, decided to respond only to owners' requests for safety assessments rather than conduct systematic, block-by-block safety assessments. Some building owners were not available or opted to not contact the Building Department despite experiencing severe damage and, in some cases, collapses or near collapses. Some occupants and other members of the public were exposed to unsafe building conditions due to actions or inactions by owners and regulators. By comparison, San Bernardino County conducted a systematic safety assessment of all buildings in its region of strong shaking.

Ridgecrest in cooperation with the Kern County Building Department decided to delay its request for additional building damage safety assessment personnel from Kern County's Emergency Operations Center (EOC) to supplement Ridgecrest's safety assessment capabilities. The EOC eventually received a request and responded by providing mutual aid from neighboring local governments, volunteers from the American Council of Engineering Companies, and a volunteer from the California Earthquake Clearinghouse. Requests were not made for trained SAP Coordinators. Some owners reported receiving conflicting information about safety assessments. (For a map of safety assessments, see Figure 2)

Owners and occupants of damaged facilities were confronted with forms to fill out that were difficult to complete and multiple requests to fill out duplicate information on multiple data forms when applying for recovery assistance. Local, State and Federal recovery efforts could be expedited, and paperwork could be reduced by streamlining applications and relying on parcel and occupant data collected from and shared by multiple government agencies before and after disasters.

<u>Recommendation 1: Increase Local Government Capabilities to More Effectively Respond to</u> <u>Disasters:</u>

1a. Enhance Safety Assessment Program (SAP) Evaluator and Coordinator training opportunities for jurisdictions in rural regions of California. Step up efforts to provide table-top training exercises to expedite and improve the quality and priorities of safety assessments for damaged buildings and other structures. Re-evaluate the comprehension and effectiveness of structural assessment training curricula. Train appropriately-qualified local government personnel to conduct rapid safety assessments of all potential locations for emergency shelter centers after future earthquakes so that shelter deployments are in safe facilities without undue delays. Ensure, through training or mutual aid, that each local government is prepared to have at least one trained SAP Coordinator on staff.

- **1b.** Advise local government to modify the basic SAP placards to include information deemed pertinent to local responders and emergency managers.
- 1c. Advise local governments to pre-establish multiple potential shelter and emergency command center sites including pre-planning of grounds and facilities within those sites for respective purposes.
- 1d. Examine the strengths and weaknesses of jurisdictions relying solely on building owners' requests for safety assessments of damaged buildings rather than systematic safety assessments of entire neighborhoods.
- 1e. Examine the strengths and weaknesses of relying on mutual aid with neighboring jurisdictions for building safety assessment personnel rather than requesting safety assessors and coordinators through the state Office of Emergency Services' SAP.
- 1f. Determine lessons learned including the need for a single, coordinated point of contact to address the public's questions about safety assessments of damaged buildings.
- 1g. To help minimize duplication of entering data in multiple forms, develop a consistent digital, data format to retrieve pre-existing information and capture new information about each applicant for disaster assistance.



Figure 2. Map showing the red (unsafe) and yellow (limited access) safety assessment placards for damaged buildings and other structures in Ridgecrest, Kern County, Trona and San Bernardino County.

<u>Finding 2 Regarding Mental Health Services:</u> Aftershocks between the M_w 6.4 and M_w 7.1 earthquakes were numerous and unsettling to the public. After the mainshock, aftershock frequency and severity slowed down, but the fear of future earthquakes continues to adversely affect the mental health and sleep cycles of many in the region of significant shaking. After the Ridgecrest sequence, local and county mental health services were deployed. After recent fires elsewhere, the state's Department of Mental Health Disaster Assistance Program was deployed after counties determined that mental health needs exceeded local resources.

<u>Recommendation 2: Mental Health Services:</u> Continue to improve the delivery of mental health services to both emergency responders and the public at large after future disasters.

<u>Finding 3 Regarding Business Emergency Response and Recovery Capabilities:</u> Hotels and restaurants had difficulty maintaining their operations despite the lack of damage because some of their staff did not come to work in the days following the earthquakes. Many other businesses were also faced with cleaning up fallen building contents and repairing structural and nonstructural damage. Those businesses with prior emergency plans and trained employees were more effective in their response.

<u>Recommendation 3: Businesses Emergency Response and Recovery Capabilities</u>: Encourage businesses, including hotel owners and managers and food providers to better train their employees for disasters and support their rapid return to work following disasters such as by participating in the state's *Outsmart Disaster* Program.

<u>Finding 4 Regarding Eligibility for Post-Disaster Government Funding:</u> The Federal Emergency Management Agency's threshold of \$56 million in public damage was not met for local government agencies to become eligible for Federal Public Assistance after this sequence of earthquakes. While the Navy's losses are now reportedly approaching \$4 billion at the China Lake Naval Air Weapons Station, those losses do not count toward local government, non-profit or individual disaster funding eligibility even though indirect effects from these losses impacted nearby communities. The State of California is authorized to provide assistance if a requested Federal declaration of an emergency is not issued and when a local authority's capability to respond is inadequate to cope with the emergency.

<u>Recommendation 4: Eligibility for Post-Disaster Government Funding:</u> Reexamine Federal and State eligibility thresholds as they apply to rural communities to provide more Public Assistance Grants and Individual Assistance Grants after future disasters. Propose basing the thresholds on a percentage of a jurisdiction's annual gross economic product. <u>Finding 5 Regarding Nonstructural Retrofits:</u> Damage to ceiling systems, partitions, plumbing, mechanical, and electrical equipment in buildings was experienced throughout the region of strongest shaking and resulted in significant interruptions of building usage and economic losses. Several school buildings were unable to be reoccupied quickly because of nonstructural losses. The Division of the State Architect's and the Office of Emergency Services' advice on nonstructural bracing for public and private school facility personnel is currently out of date.

<u>Recommendation 5: Nonstructural Retrofits:</u> Encourage building owners and occupants, especially in schools, to undertake seismic retrofits of nonstructural components and contents during future maintenance, repairs, and alterations. Update and reissue the Division of the State Architect's and the Office of Emergency Services' advice on nonstructural bracing to public and private school facility personnel.

Geology

Local geology within the Ridgecrest region includes alluvial fans, a dried lakebed and granitic outcrops. The area contains several short faults, including the Little Lake -Airport Lake faults and two unnamed faults that are related to the July 4 and 6 M_w 6.4 foreshock and the M_w 7.1 mainshock. These two earthquakes and accompanying fault rupture highlight the complexity of the region. Near Ridgecrest, four faults bound the area. They are the Wilson Canyon, the Garlock, the Sierra Nevada and the Panamint Valley faults. Each fault can produce major earthquakes.

Earthquake, ground motions and faulting

The unilateral rupture propagation in this sequence of earthquakes in the Ridgecrest area caused most of the severe ground motion to occur miles away from populated regions. (See the red regions in Figure 3). As of November 2019, there have been over 110,000 aftershocks and they are still occurring. Many of the foreshocks and aftershocks as well as ground deformation occurred near the unnamed faults and has produced an image of two faults intersecting like a lower case "t" (see Figures 4 and 5). This kind of fault pair is known as a conjugate fault pair. Such pairing of faults has occurred in the past as shown by the Superstition Hills Elmore Ranch earthquakes in 1987 and the Landers Big Bear earthquakes in 1992. This is not unusual. The nearness of the M_w 6.4 foreshock is likely to have triggered the M_w 7.1 mainshock by changing the state of stress locally. The seismicity pattern from the mainshock diminishes near the Garlock and tends to drop off at the Garlock fault. This means that the fault segment south of the unnamed fault may be more stressed than other nearby segments. The reason for the drop-off in seismicity near the Garlock fault is unknown. The complexity of the region and the proximity to the Garlock fault indicates that the seismic hazard for the region should be further evaluated.

Garlock fault

The Garlock fault is about 160 miles long and extends from Frazier Park to Death Valley making it one of longest faults in California. The Garlock fault has ruptured in numerous earthquakes based on paleoseismic evidence. However, none of the larger earthquakes occurred in historic time. The last significant earthquake was a M_w 5.7 in 1992 after the Landers earthquake, near the town of Mojave. The Garlock fault is a boundary between the Sierra Nevada and the Mojave Desert geologic provinces. The left-lateral movement of the fault is opposite of many other large faults in the state. The larger unnamed fault of the Ridgecrest earthquake sequence appears to be in a cross-cutting relationship with the Garlock fault to the south. In turn, the Garlock fault appears to form a cross-cutting fault pair with the San Andreas fault near Frazier Park to the west.

Using satellite imagery and data from seismometers, researchers from California Institute of Technology and NASA's Jet Propulsion Laboratory recorded localized post-Ridgecrest earthquake sequence movement on the Garlock fault. Although the implications of this movement along the Garlock fault are unknown at this time, seismic monitoring of this feature should be continued and the implications of any continued movement should be considered for the seismic risk to the region.



CISN/sc ShakeMap : 17.6 km (11.0 mi) W of Searles Valley, CA Jul 6, 2019 03:19:53 AM UTC M 7.1 N35.77 W117.60 Depth: 8.0km ID:38457511

Scale based upon Wald, et al.; 1999

Figure 3. Map depicting the shaking distribution and fault rupture from the M_w 7.1 mainshock. (USGS 2019)



Figure 4. Seismicity pattern from Ridgecrest July 4, 2019 M_w 6.4 foreshock. Epicenter location (green star) and aftershocks, including M_w 4.9 (orange star) prior to Mw7.1 mainshock. The geologic map shows the area is underlain by granitic bedrock (pink polygons) surrounded by younger alluvial valley deposits in yellow. Bright yellow polygons surrounding faults are Alquist-Priolo fault zone boundaries for Holocene faults (Hernandez, 2019).



Figure 5. Seismicity pattern from post-Mw 6.4 and one-week post-Mw 7.1 earthquake events. Surface rupture from both large earthquakes occurred on faults that were either not previously mapped, or on faults with discontinuous mapped traces (Hernandez, 2019).

Appendix: Other Topics Raised at Commission Hearings

- a. **Cross-Fault Interaction:** Document lessons learned and develop policies regarding the evaluation and communication of the potential for cross-fault triggering of additional earthquakes in future earthquake sequences
- b. **Early Warning of Aftershocks:** Improve the state's use of temporary, localized installations of ground motion networks to aid in providing earlier warnings to help advise and protect emergency response and recovery personnel extricating victims in collapsed structures and repairing damaged structures.
- c. Share Locations of Ground Motion Recording Stations with the Clearinghouse: Researchers should promptly share the locations of ground motion recording stations in strongly-shaken regions with the Clearinghouse so that the response of nearby structures can be reviewed by Structural Engineers.
- d. **Road-clearing Equipment:** Evaluate deployment of heavy equipment to clear roads impacted by rock slides, determine if estimated response times are adequate, and consider whether changes to staging of equipment and personnel and reductions in response times are warranted.
- e. **Sewage Treatment Facilities:** Evaluate the need to deploy strike teams or a more formal mutual aid protocol to expedite the evaluation and restoration of damaged sewage treatment facilities after future earthquakes.
- f. **Hospital Evacuations:** Examine the response to hospital damage and the voluntary evacuation of patients. Evaluate if changes to emergency response protocols, personnel training, state regulations, and building standards are warranted.
- g. School Fire Sprinklers and Ceiling Systems: Ask the Division of the State Architect to evaluate the performance of fire sprinklers and their interaction with ceiling systems, and pendulum light fixtures with irregular configurations particularly in the Gateway Elementary School and Cerro Coso Community College Learning Center Building. Advise school district facility managers on lessons learned.
- h. **Informational Videos for Emergency Management:** Train local emergency personnel to use informational videos and social media after future disasters to communicate more effectively with the public.
- i. **Public Information from Utilities:** Improve the public's situational awareness and preparedness for protecting themselves from additional harm by enhancing the sharing of critical information with the public by government agencies and key utilities.
- j. **Personal Emergency Preparedness Plans:** Continue to support Red Cross volunteers, government staff, and the public in the development of personal emergency preparedness plans.
- k. **Engage Families of First Responders in Support Roles:** Formalize a post-disaster program to engage families of first responders to assist in emergency support and recovery support roles.

- Expedite Deployment of Emergency Response Resources: Ask FireScope (FIrefighting RESources of California Organized for Potential Emergencies) to consider developing and providing training for predesignating deployment of emergency response and staging protocols based on different thresholds of PAGER estimates (Prompt Assessment of Global Earthquakes for Response) to reduce response times after future earthquakes.
- m. **Military-Civilian Mutual Aid:** Review relationships between military facilities in California, nearby local jurisdictions and state agencies to improve mutual aid and sharing of information after natural disasters.
- n. **Manufactured Homes:** Assess California's manufactured home program and regulations to ensure effective earthquake resistance of future manufactured home installations, relocations, repairs and alterations, as well as effective post-disaster response to expedite safety assessments and permitting of repairs for damaged manufactured homes.
- o. **Earthquake Information Clearinghouse Outreach:** Improve Clearinghouse outreach to local officials to inform them about the role of post-earthquake information clearinghouses and how their gathered information can add value during emergency and recovery phases.
- p. **Expedite Mission Tasking for State Agencies:** Support the Department of General Services Emergency Services 3 Construction and Engineering Team (ESF3) in collaboration with OES, HCD, and DSA to develop prescriptive mission tasks to expedite the deployment of state resources following future disasters.
- q. **Rural Mutual Aid Agreements:** Reevaluate and consider expanding predesignated mutual aid zones between neighboring rural counties, cities, and special districts to expedite emergency response times and resources.
- r. **Ambulance Mutual Aid:** Reevaluate emergency medical services needs after disasters and strengthen mutual aid of ambulance services.
- s. **Federal Funds:** Explore the potential for using Federal Building Resilient Infrastructure in Communities (BRIC) funds to enhance California's resilience.
- t. **Increase Ground Motion Instrumentation and Fault Monitoring:** Add new or replace existing instruments to measure ground motions and displacements, including early warning instruments, and increase monitoring of known active faults in the region of strongest shaking and along the Garlock fault.

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