CALIFORNIA LEGISLATURE

STATE CAPITOL
SACRAMENTO, CALIFORNIA
95814

INFORMATIONAL HEARING
JOINT LEGISLATIVE COMMITTEE ON EMERGENCY MANAGEMENT

California's Next Mega-Quake: Assessing the State's Preparedness and Response Strategy

July 19, 2017
1:30 p.m.
State Capitol, Room 3191

Background Paper

Introduction

Living with the threat of earthquakes is a part of life in California. Every day, dozens of small earthquakes rattle beneath our feet – most of them too small to notice. However, both geologic and recorded history tell us that infrequent, large-magnitude earthquakes, or "mega-quakes," are just as much a part of California's seismic reality as the smaller-intensity earthquakes that many Californians have grown accustomed to. Unlike the small earthquakes that are part of our daily lives, large-magnitude quakes can shatter our cities and bring about widespread devastation.

The 7.0 magnitude Haitian Earthquake of 2010, for example, destroyed or damaged beyond repair some 250,000 residences and 30,000 commercial buildings, and killed between 100,000 and 160,000 people. As one of the poorest countries in the Western Hemisphere, Haiti was ill-prepared to handle a disaster of this magnitude. In the aftermath of the earthquake, much of the vital infrastructure needed to respond to a significant disaster was severely damaged or destroyed, including hospitals, transportation and communication systems, and utility networks. Years later, tens of

thousands of people affected by the 2010 earthquake continue to experience food insecurity and limited access to clean water, adequate sanitation, and health care.

In contrast to the Haitian Earthquake, a pair of earthquakes that rocked New Zealand in 2010 and 2011 resulted in significantly less injury and destruction. In 2010, a 7.1 magnitude earthquake - known as the Canterbury Earthquake - and in 2011, a 6.3 magnitude earthquake, both struck in the vicinity of Christchurch in the south of New Zealand. Remarkably, despite the weakened infrastructure from the first temblor, this pair of quakes resulted in the deaths of only 185 people, and the destruction of 10,000 homes.

While similar in intensity and relative proximity to urban areas, the impact on the human environment differed dramatically between the Haitian and New Zealand earthquakes. Emergency services in and around Christchurch were able to reach impacted areas relatively rapidly, damaged utilities were quickly repaired, and the resulting death and destruction from the New Zealand quakes were a mere fraction of that experienced in Haiti. Planning, preparation, and mitigation - particularly the use of modern building standards - were significant factors accounting for the different outcomes of these two large earthquake events.

California's own experience with large quakes has left an indelible mark on our state's history. The 7.8 magnitude 1906 San Francisco Earthquake and Fire, which killed approximately 3,000 people and destroyed 80 percent of the City of San Francisco, remains the largest natural disaster to have struck California in terms of loss of life. Following the 1906 quake, Governor George Pardee ordered an investigation into earthquakes in California, which materialized as a commission led by Andrew Lawson, chairman of the geology department at the University of California at Berkeley, and produced the first integrated, government-commissioned earthquake investigation in the United States.

Large earthquakes in California and elsewhere in the world have directly influenced how our state plans for disasters, including not only post-event efforts by first responders to aid the wounded and limit property damage, but also pre-event efforts to mitigate the impacts of a disaster before it strikes. Today's hearing is the first in a two-part series on mega-quakes - those with a magnitude of 8.0 or greater - and will focus on California's seismic risk for such events, as well as state and local mitigation efforts to minimize the impact of the next mega-quake. The second hearing in this series will focus on post-event response and recovery efforts following a mega-quake in California.

Seismic Risk

California's west coast sits along the eastern edge of the "ring of fire" -- the name given to a tectonically active region encircling the Pacific Ocean where approximately 90 percent of the world's earthquakes occur. California's west coast can be divided into two predominant tectonic zones, each of which produces characteristically different earthquakes. The more familiar San Andreas Fault Zone extends for about 750 miles through the southern half of the state from the Salton Sea to Mendocino County. This fault zone marks the boundary between the Pacific Plate and the North American Plate, and was first identified by Andrew Lawson, the U.C. Berkeley professor who led the 1906 San Francisco earthquake commission. The San Andreas Fault Zone is characterized by strike-slip, or horizontal, movement between the Pacific and North American tectonic plates and averages about 20-35 millimeters of movement per year.

North of the San Andreas Fault zone is the Cascadia Subduction Zone, a 620-mile long zone that runs from Mendocino County to Vancouver Island in British Columbia. The Cascadia Subduction Zone marks the boundary between the North American and Juan de Fuca tectonic plates. Unlike the San Andreas Fault Zone, the Cascadia Subduction Zone is characterized by a thrust fault where one tectonic plate (Juan de Fuca) is pushed underneath another (North American) at an average rate of 40 millimeters per year. Thrust faults such as this are capable of producing megathrust earthquakes - the most powerful in the world - which can exceed magnitudes of 9.0. Since megathrust earthquakes deform the ocean floor, they often generate a significant series of tsunami waves. A megathrust earthquake tsunami was generated in 2011 by the Great East Japan earthquake, which created a tsunami wave of 133 feet in height that travelled up to 6 miles inland and led to the ultimate meltdown of the Fukushima Daiichi Nuclear Power Plant. The north coast of California is capable of generating similar megathrust earthquakes and tsunamis.

According to a 2014 U.S. Geological Survey (USGS) earthquake forecast for California, the state is nearly certain to experience an earthquake as strong as the 6.7 magnitude 1994 Northridge Earthquake in one of these two zones during the next 30 years. The same USGS forecast also found that California's risk for a mega-earthquake (magnitude 8 or larger) during the same time period stands at about seven percent, and identifies the southern San Andreas Fault as having the greatest threat for earthquake activity of any region in California. An earlier 2008 report from USGS projected that a magnitude 7.8 earthquake along the southern San Andreas Fault would result in approximately 1,800 deaths and $213 billion in economic losses.

Further north, researchers at Oregon State University have predicted based on historical averages that the southern end of the Cascadia Subduction Zone – from Northern California to Newport, Oregon – has a 37 percent chance of producing a mega-quake in the next 50 years. Officials at the Oregon Department of Geology and Mineral Industries have predicted a 10 to 14 percent chance of a magnitude 9.0 or greater earthquake along the Cascadia Subduction Zone over the next 50 years, which could generate a tsunami up to 100 feet in height. (*See* Lori Tobias, *Big Earthquake Coming Sooner Than We Thought, Oregon Geologist Says*, The Oregonian [Apr. 19, 2009]).

California's Earthquake Response Plan

Within California, the Governor's Office of Emergency Services (OES) serves as the lead agency for managing statewide earthquake readiness. As part of this mission, OES has developed three response plans for a mega-quake scenario: the Cascadia Subduction Zone Earthquake and Tsunami Response Plan; the Bay Area Earthquake Plan; and the Southern California Catastrophic Earthquake Response Plan. Each plan provides a framework outlining how local, tribal, state, and federal governments and private and nongovernmental organizations will respond and coordinate following a catastrophic earthquake in California, focusing on delivering a rapid and effective response to meet the needs of survivors in affected areas. While each plan differs, all three plans anticipate immediate and devastating impacts to the human environment, including:

- **Damage to infrastructure** – Damage to transportation, water, wastewater, industrial, power, public safety, medical, and housing infrastructure will result in the need for significant support in all impacted areas.

- **Loss of transportation capacity** – Damage to transportation networks could cause large population areas to become isolated and the supply chain serving residents to become degraded.

- **Loss of water and wastewater services** – A severe earthquake will damage water utility pipelines and facilities, resulting in interrupted sources of supply and ultimately loss of service.

- **Damage to petroleum infrastructure** – In a severe earthquake, petroleum refining and distribution infrastructure may not be fully operational. Partial or complete failure of storage tanks is possible in areas of peak ground acceleration or liquefaction. Oil pipelines might rupture through displacement at points where

pipelines cross faults, and may be damaged by ground shaking in liquefaction areas. Interruption of public fuel supplies through commercial gas stations is also probable due to power failure and degraded infrastructure. Although retail gas stations may have fuel in underground tanks, they will be unable to pump fuel without electric power.

- **Loss of electrical power** – A severe earthquake could damage much of the affected area's electrical power infrastructure. Electrical transmission lines and towers will likely fail as a result of ground shaking; gas pipeline breaks and leaks will occur, creating hazardous conditions and fires; and power could be out to communities for weeks, due to lack of repair parts caused by high demand and manufacturing delays.

- **Loss of communications capabilities** – Extensive damage to existing communications infrastructure would result from a severe earthquake—damage that could take several weeks or months to repair. Neither landline nor cellular telephone systems will work for at least the first day post-event, probably longer, due to system overload and damage to cell phone towers. Loss of communications capabilities will impact the response and needed communication with the public.

For the northern part of the state, the Cascadia Subduction Zone Earthquake and Tsunami Response Plan acknowledges the likelihood of 1,000 or more immediate fatalities, an additional 1,500 persons injured, and 28,000 structures damaged or destroyed as a result of a major earthquake and tsunami event. Modeling for a 7.8 magnitude earthquake in the Bay Area indicates that of the 7.7 million people who reside there, approximately 2,550 would be killed, 13,357 buildings would be destroyed, over half of all households in the affected area would lose power and water service, and economic losses could total up to $60.5 billion.

State, Regional, and Household Mitigation

Emergency managers, government officials, private sector and non-profit groups, communities, and individuals across the state are working to mitigate the impacts of California's next mega-quake before it occurs. Since 2006, the State of California has been part of a multi-jurisdictional effort to develop an earthquake early warning system. Earthquake early warning systems provide seconds to minutes of advance warning that an earthquake is coming, allowing people to take actions to protect life and property from destructive shaking. When an earthquake occurs, seismic waves—

including compressional (P) waves, transverse (S) waves, and surface waves—radiate outward from the earthquake's epicenter. The faster but weaker P waves trip warning system sensors, causing alert signals to be transmitted to recipients almost instantaneously through modern communications infrastructure, giving people and automated electronic systems some time to take protective actions before the arrival of the slower but stronger S waves and surface waves.

Once deployed, an early warning system could cause elevators to open at the next floor in a building, sparing occupants from being trapped, alert surgeons to remove scalpels from patients during surgery, and halt the flow of oil or natural gas through major pipelines, preventing catastrophic fires and spills. According to a recent article in the *Los Angeles Times*, an early warning system in California could provide more than a minute's warning before a magnitude 7.8 earthquake that starts at the Salton Sea reaches Los Angeles, 150 miles away, traveling on the San Andreas Fault. (*See* Rong-Gong Lin II, *Defying Trump, House Panel is Expected to Propose Restoring Funding for Earthquake Early Warning System*, Los Angeles Times [Jul. 11, 2017].) Indeed, a prototype early warning system already in place provided San Francisco with eight seconds of warning before shaking from the magnitude 6.0 Napa Earthquake in 2014 reached the city.

Regionally, cities like Los Angeles have implemented "Resilience by Design" programs to reduce earthquake vulnerabilities through such measures as building retrofitting and the securing of water supply and communications infrastructure. Resilience by Design represents a holistic effort to strengthen a city's physical, social, and economic foundations, and in Los Angeles has led to the nation's first citywide ordinance to mandate retrofitting of non-ductile reinforced concrete buildings.

At the household and individual level, Californians are taking steps to protect themselves and their families before the next mega-quake occurs. Through programs like the spanish-based *Listos* training curriculum, Californians are learning how to operate fire extinguishers, assemble disaster supply kits, shut off damaged utility systems, and form family reunification and communication plans before disaster strikes.

Conclusion

The most recent earthquake forecast for California states with near certainty that an earthquake as strong as the 6.7 magnitude 1994 Northridge Earthquake will occur

during the next 30 years, and that the state's chance for experiencing a mega-quake of magnitude 8.0 or greater over the same time period is about seven percent. Either of these earthquake scenarios would result in a significant loss of life, widespread damage to our state's infrastructure, and economic losses in the billions of dollars. This hearing will provide members of the Joint Committee on Emergency Management and the public with the latest information on both California's seismic risk profile, and on efforts at the state, local, and individual levels to make our residents and infrastructure more resilient to mega-quakes.