California's Future Earthquakes: Shake and Bake? By Glenn Barlow

MAJOR RADIOACTIVE MATERIAL SITES • AND EARTHQUAKE FAULTS -----



Table of Contents

Part 1:	The Next Big Quake and the East Bay Nuclear Facilities	page 1
Part 2:	How earthquakes are predicted	page 4
Part 3:	Nuclear Military Sites Are Beyond Local Control	page 6
Part 4:	Surviving the Next "Big One": Southern Californians in Chaos	page 7
	Magnitudes and Continental Drift	page 8



East Bay Nuclear Facilities

by Glenn Barlow

East Bay nuclear facilities were built on active fault zones when the probabilities were considered low for major quakes.

On September 9, 1990, millions of Bay Area citizens received a new federal report predicting "The Next Big Earthquake." This report was prepared by the U. S. Geological Survey (USGS) headquarters in Menlo Park, California and is endorsed by the National and California Earthquake Prediction Evaluation Councils. They say that the Bay Area now has a very high probability of a quake equal to or larger than the October 1989 quake. They predict that the next quake will most likely strike the East Bay Fault zones and could strike at any time, including today."

According to Dr. Karen McNally, Director of UCSC's Seismology Lab, the Hayward Fault in the East Bay "could break in a magnitude 7 at any time. The time scale could be 30 years, 10 years,

or tomorrow." That fault last moved in 1868 with a 6.8 size quake, just three years after a major quake in the Santa Cruz Mountains. Scientists worry that this means the East Bay could have another disaster by 1992. Historically, Northern California's major quakes have frequently occured in pairs.

The next earthquake could add radioactive contamination of drinking water supplies and drifting clouds of radioactive gases to the other problems of post-quake recovery. If the nuclear sites in Alameda County are shaken by a 7 to 7.5 magnitude quake, they could easily be damaged and release radioactive gases into an East Bay that will be without escape routes, water, or electricity. And all insurance policies have a nuclear exclusion clause that denies non-government coverage to victims of nuclear accidents that release radioactivy.

The Bay Area is home to 88 sites licensed to handle radioactive

materials. Nuclear facilities dot the East Bay in Livermore, Berkeley, Concord, Alameda, Sunol, San Ramon and Vallejo. There are nuclear military facilities along the Hayward Fault and along its parallel branches, the Calaveras Fault and the Rodgers Creek Fault.

According to documents debated in recent public hearings, each of these facilities was licensed based on calculations that the largest quake to occur near these nuclear sites in their operating lifetimes would be a magnitude 6 to 6.5 and that the ground motions would be only half of gravity (.5 g) or smaller. The 7.1 Santa Cruz quake caused ground motions equal to gravity (1.0 g).

The U.S. Geological Survey (USGS) significantly revised these calculations in 1988 and 1989.After the October 1989 Santa Cruz earthquake, scientists warned that the East Bay area had a 50 percent chance of the same size quake by the year 2018 and a 36 percent probability of



Most Bay Area nuclear facilities were built in the East Bay

a 7.5 magnitude quake within 30 years. Now in September 1990 that probability has been changed to 67% for a 7 to 7.5 size quake by the year 2020.

By contrast there is only a 1% probability that Santa Cruz would have another quake that size by 2020.

Some scientists argue that the 67% probability is too low. They say that 67% is a minimum. The new report adds that there could be more than one quake size 7 or larger by the year 2020. Numerous quakes of size 6 are also likely. If two fault segments slip during the same quake, the magnitude would likely be 7.5.

The Hayward Fault runs through the UC Berkeley campus, beneath plutonium and other radioactive materials in the Lawrence Berkeley Labs and the UCB nuclear reactor. In spite of quake hazard reduction warnings, the University has persistently asserted its right to operate nuclear reactors, labs, and nuclear weapons facilities on top of active faults in Berkeley, Liver-

more, Santa Barbara, Los Angeles and Irvine.

Lawrence Livermore National Laboratory experienced an earthquake-induced leak of radioactive materials and a damaged nuclear reactor on January 24, 1980. The damage resulted from a mere 5.5 magnitude quake, which caused \$10 million damage and forced the evacuation of 7400 employees.

This disturbing incident occurred less than ninemonths after the Three Mile Island nuclear disaster. The timing helped spark media interest in this event. When CBS News asked Lab spokespeople if Walter Cronkite was furious to find out that his news team had been misled by a public university. Lab officials later admitted that there had also been two leaks of plutonium dust soon after the quake in 1980. The facility is licensed to handle up to 495 pounds of deadly plutonium at a time. It has had 18 serious radiation leaks since 1960.

Before that earthquake, the Lab had been barraged by criticism from environmentalists, neighbors, and politicians. Thirteen active earthquake faults had been mapped underneath and adjacent to the Lab, including the ancient plate boundary on the Hayward and Calaveras Faults.

At the request of the Alameda County Board of Supervisors, independent structural engineers examined the integrity of the Livermore plutonium facilities and found that they were not



Livermore Lab is near 13 active faults including several mapped beneath it.

there were any radiation leaks, they were assured that none had occurred. The next day the media learned that they had been misled, just as they had been lied to about leaks of radiation at Three Mile Island.

Radioactive liquids began pouring out of a 30,000 gallon tank immediately after the quake, and the Lab's nuclear reactor was so badly damaged that it had to be permanently shut down.

designed to withstand the ground motions in foreseeable quakes. Yet nothing changed because the Lab, managed for the federal government by the University of California, is not subject to local governmental control.

The Lab is still handling almost 500 pounds of plutonium at a time in unsafe buildings. According to Dr. John Gofman, a UCB Professor who was the first director of the Livermore Lab's



Livermore Valley has had many quakes.

Biomedical Division, one pound of plutonium is enough to give millions of people lung cancer if it is spread by winds in dust form and inhaled.

As a result of this debate over the safety of the Lab, members of the Bay Area congressional delegation requested that the federal government immediately remove all plutonium from Livermore because of the extreme earthquake hazard. The congressmen suggested that the plutonium work could be moved to the vast Nevada Test Site (NTS), which is already permanently contaminated with plutonium dust.

Livermore's plutonium research is tested at NTS and the deadly materials are continually being trucked back and forth between the two sites.

But 1980 was an election year, and Ronald Reagan's victory quashed hopes of federal approval of the congressional request. The 1989 quake and 1990 predictions of an East Bay quake may encourage Californians to try again to get the University and the federal government to remove the plutonium from Livermore before the next "Big One" hits. One East Bay environmentalist, Paula Pelot, told her Congressman, "Now that the Berlin Wall is down. Do we really need plutonium in Livermore. After all, the site was chosen in the fifties to sooth Edward Teller's ego by giving him a separate lab in which to compete with Oppenheimer and the Los Alamos team. Together the two labs exploded over 700 bombs at NTS near Las Vegas by the 1990's.

Just a few miles west of the Livermore Lab is the Vallecitos Nuclear Center, owned and operated by General Electric (GE). As you drive by on an idyllic country road, you pass close to three shiny nuclear reactor domes, another reactor in a building, and a plutonium laboratory that were sited here in 1956 as the world's first privately owned nuclear complex.

In 1976 the USGS discovered that three earthquake faults (including the Calaveras Fault) form a triangle around the Vallecitos reactors. GE claimed that these were old, dead faults. They hired experts to testify that the area was not due for a quake for hundreds or thousands of years. Yet in 1979, 1980, and 1984, significant quakes proved them wrong. Still, GE insisted that Vallecitos was safe to operate. The largest reactor at Vallecitos was shut down in 1977 when local environmnetalistsand several members of Congress challenged the relicensing by the NRC. During the next five years, Friends of the Earth pursued the issue in NRC hearings.

Today, GE still operates the Vallecitos plutonium lab and one of its four Vallecitos reactors just 17 miles from San Jose where GE has its world headquarters for nuclear reactor design and export. The other three reactors at Vallecitos are still radioactive and hazardous. Now scientists are concerned that the Calaveras Fault may have a magnitude 7 to 7.5 quake because there has been a significant increase since 1979 in the

Some of the Members of Congress from the Bay Area who have requested shutdown of East Bay nuclear sites; from left top, Pete Stark, Don Edwards, George Miller, and Norman Minetta. they were joined by Ron Dellums, John and Phil Burton, and Republican Pete McCloskey.



number of magnitude 5 to 6.5 quakes along the Calaveras near San Jose. Many environmentalists and citizens groups believe that the Vallecitos nuclear complex should be decommissioned and all radioactivite wastes removed.

The members of Congress who signed a letter to the NRC in 1977 requesting federal action and hearings were the John and Phil Burton, Pete Stark, Don Edwards, George Miller, Norm Mineta, Ron Dellums, and Republican Paul (Pete) McCloskey. The Burtons and Dellums participated in NRC hearings for four years.

Also on May 10, 1979, five of the same group of Congressmen requested the DOE to end plutonium handling at the Livermore Lab due to quake hazards. They said, "As elected Federal officials from this immediately affected area, we request that plutonium operations be suspended immediately, that all plutonium be removed from this site, and that this operation be relocated to an appropriate site...During the DOE hearings on the LLL EIS, many geologists, seismologists, and structural engineers testified that indeed surface ruptures are possible ... and the plutonium buildings could not gurantee structural safety against surface rupture. ... the possibility of plutonium contamination of the Hetch Hetchy Aqueduct and the South Bay Aqueduct as well as direct radiation or plutonium exposure to these (4.5 million) residents in the event of a severe earthquake is catastrophic."

The East Bay also has other facilities licensed to handle radioactive materials, including a nuclear reactor on the Calaveras Fault in San Ramon owned and operated by Aerotest Corporation.



How Earthquakes Are Predicted

Scientists can predict earthquakes with a variety of tools, including historic records of foreshocks, seismic gaps, and quake patterns. Occasionally, timely predictions result in preventative measures which save lives. In China, a 1975 prediction may have saved the lives of three million people evacuated from collapsible structures less than 24 hours before a 7.3 magnitude quake demolished their region. In Mexico in the 80's a magnitude 8 quake was predicted and happened but no public warnings were issued and no lives were saved.

In California, the Santa Cruz Mountains had been shaken by foreshocks twice in the 14 months prior to October 17. The June 1988 quake measured 5.3 and the August 1989 quake measured 5.1.on the Richter scale. In 1988 seismologists estimated a 30 percent probability of a 6.5 magnitude quake striking Santa Cruz by 2018.

After the August 1989 foreshock, Dr. Karen McNally, Director of UCSC's Richter Seismological Lab, said that it was a "wake-up" call and that a quake as big as a magnitude 7 could follow at any time—which it did, just two months later. Dr. McNally also cautioned the public that there is about a 40 percent likelihood of aftershocks in the 5 to 5.5 range over the next several years. During the two weeks following October 17, there were thousands of aftershocks, only two of them 5.0 or larger.

"We have had sort of a seismic honeymoon...after the 1906 event," states William Ellsworth, a seismologist with the USGS in Menlo Park. "The terrifying part is that we are underestimating the magnitudes that can come out of these fairly short segments," notes Allan Lindh another USGS seismologist.

Now for the good news: Dr. McNally and most other scientists agree that the Santa Cruz Mountains will probably not have another major quake for 100 to 150 years. Also, the probability that the San Francisco Bay Area will experience another 1906-size (8.2) quake in the next 100 to 200 years is low.

The Los Angeles region, however, has the highest probability of a major quake within the next 30 years. The southern segment of the San Andreas fault is overdue for a "Big One" (a magnitude 8.0 or larger quake). The last time the southern San Andreas had a Big One, in 1857, the Fort Tejon quake left a 225-mile-long scar in the Earth's crust.

According to Dr. McNally of UCSC, "in California...we have several other locations in the state that could produce magnitude 7 and larger earthquakes." She points out that Southern California could have quakes ranging from magnitude 7.5 to 8 in the near future. In Northern California, the Hayward Fault "could break in a magnitude 7 at any time," according to McNally. "The time scale could be 30 years, 10 years, or tomorrow." She concludes that "It is critical for us to know in advance something about these large earthquakes in California to better prepare and help give us some warning of those expected events in the future."

USGS seismologists have estimated a 60 percent probability of Los Angeles having an 8 to 8.3 quake in the next 30 years and a 70 percent probability of the region having a 7.5 quake by 2018. In the East Bay, there is a 67 percent chance of a magnitude 7 to 7.5 quake striking by 2018 . "These forecasts are serious and reliable," according to CalTech geologist Kerry Sieh, one of the co-authors of the USGS report predicting future quakes.

"This is a warning," cautions Professor Walter Alavarez of UC Berkeley. "Right now, I think the Hayward Fault is really scary. If we ignore it, and our cities are seriously damaged, it is nobody's fault but our own." A 1980 Federal Emergency Management Agency (FEMA) report estimated that a size 7.4 quake on the Hayward Fault could kill 3,000 to 7,000 people, injure 27,000, and cause \$44 billion in damages. Several seismologists have pointed out that the most damaging earthquake to hit Oakland was in 1868, just three years after the last major quake hit the Santa Cruz segment of the San Andreas. That would seem to indicate that the next East Bay quake is more likely to occur in three years than in 30.

The Oakland quake of June 1836 was followed two years later by a size 7.0 quake on the San Francisco Peninsula. Because of the stress shift from the 1989 quake, the USGS has raised the probability of the same size quake striking the Peninsula to 30 percent over the next 30 years. A magnitude 7 quake along the Hayward Fault or on the Peninsula "would be much more devastating than the [Santa Cruz] earthquake," states USGS geophysicist Jim Dieterich.

The use of seismic recurrence intervals to predict earthquakes often relies on what are called "seismic gaps." Seismic gaps are segments of major fault zones where no major quake has occurred for a long time, despite the rupturing of other segments of that fault. The East Bay area along the Hayward Fault Zone is a seismic gap it last ruptured in 1868, following several massive quakes in the prior century. When enough stress builds up on a seismic gap, it has to move.

The seismic gap technique was used to predict the Mexico earthquake of 1985, which measured 8.1 and killed nearly 10,000 people hundreds of miles away from the epicenter. That fault zone had been previously identified as a seismic gap that was overdue for a size 8 or greater quake.

Today, Southern California has two seismic gaps capable of a 7.5- to 8.3-magnitude quake, and the East Bay has a seismic gap waiting for a 7 to a 7.5 quake. "The predicted quake for Southern California will be significantly larger than what we had in the Bay Area, with ground motions on the order of 10 times larger and with durations of one to several minutes of violent ground motions as compared to only 15 seconds in the Santa Cruz quake," according to USGS seismologist Lucile Jones.

"Everybody who lives in California should be ready for an earthquake at any time, and that means tomorrow," warns Don Anderson, director of CalTech's seismological lab.



The San Francisco Bay Area is in a seismic plate boundary fracture zone that has been active for millions of years. The East Bay is waiting for a 7 to 7.5 size quake in the midst of nuclear weapons, military reactors, plutonium labs and radioactive wastes.

Nuclear Military Sites Are Beyond Local Control

An estimated 1200 nuclear weapons are stored at 12 bases in California. Because the military refuses to acknowledge the presence of these bombs, it will not cooperate with state and local emergency planning officials to plan for the possibility of earthquake damages and accidental radiation releases. The military and its contractors transport radioactive wastes and bombs on highways that cross fault zones on a daily basis.

The Navy uses California's harbors as home ports for 19 ships and submarines powered by 29 nuclear reactors. The radioactive waste, or spent fuel, from these ships is removed at Mare Island in Vallejo. Some people at the state Office of Emergency Services (OES) call it Nightmare Island because of the potential for a major radioactive disaster there. The OES has tried to develop an emergency plan for the facility, but the Navy refuses to provide information or cooperate. Many civilian workers have already been contaminated with radiation during routine accidents there.

At Mare Island, submarines are put into drydock on top of the Calaveras and Franklin Faults. Cranes store and remove plutonium, strontium, cesium, and other poisons that could contaminate the nearby Central Valley. Before the 1906 quake, the Mare Island Quake of 1898 was the most expensive disaster in the state's history. Now up to six refuelings take place every year with the submarines suspended five feet off the ground on blocks that could collapse in a quake.

Near Vallejo, the Concord Naval Weapons Station stores nuclear bombs next door to suburban homes—and atop several active fault zones. The Alameda County Board of Supervisors was given a chilly reception by the Navy when they attempted to develop an earthquake preparedness plan.

Also located in the East Bay is the Alameda Naval Station, home to nuclear vessels including the USS Enterprise, equipped with eight nuclear reactors and numerous bombs. The Naval Station is constructed on the same landfill that liquified in the 1989 quake and collapsed a section of the nearby Nimitz freeway. Moffett Field on the Peninsula, where nuclear weapons have been stored at times, is also built on landfill.

The military also stores nuclear weapons in Southern California atop active fault zones in Long Beach, Ventura, Fallbrook, and San Diego. The Naval Nuclear Weapons Station at Seal Beach is built on the fault zone that devastated Long Beach (and Seal Beach) in 1933.

The San Diego sites are on North Island and in Pt. Loma where numerous nuclear powered military vessels dock and unload their nuclear weapons for maintenace. The Newport-Inglewood Fault passes beneath North Island's nuclear arsenal.



Surviving the Next "Big One": Southern Californians In Chaos

During the past 35 years, over 2000 facilities in California have been licensed to handle radioactive materials. Dozens of nuclear reactors, plutonium labs, and nuclear weapons depots are sited dangerously close to some of the most powerful earthquake faults in the world, most of them built before nearby fault zones were adequately mapped or understood. Consequently, the next major temblor could contaminate California with lethal radiation.

What would happen if a future quake caused radiation releases from the three San Onofre nuclear reactors halfway between LA and San Diego? Ten million refugees could flood Northern California after evacuating a permanently radioactive Southern California, according to government reports. Various government agencies paint a grim picture of Southern California after a nuclear accident:

• A 1980 report by the state of California's Office of Emergency Services (OES) estimated that the aftermath of a San Onofre meltdown (without an earthquake) would involve evacuation of eight to ten million people and emergency health care for hundreds of thousands of radiation victims. The accident could contaminate 16,000 square miles. The report attempted to place a value on the loss of life—at \$180 billion.

• Even without damage to San Onofre, a magnitude 7.5 quake on the Newport-Inglewood Fault could kill 23,000 people, injure thousands more, and cause \$70 billion in damages, according to 1980 FEMA (Federal Emergency Management Agency) estimates.

• According to a 1981 Nuclear Regulatory Commission (NRC) report, a meltdown at San Onofre without a quake could cause 130,000 early deaths and 300,000 latent cancers in people living within 50 miles of the accident. More than one million people would be exposed to more than 25 rems of radiation—10,000 times the "safe" dose.

• In 1980, following the Three Mile Island (TMI) accident, the President's Council on Environmental Quality attempted to predict the effects of a nuclear reactor meltdown on the surrounding population. They concluded that the radiation could produce thyroid tumors in children within a 100-mile radius, and recommended that children and pregnant women be evacuated immediately following a nuclear accident.

But in the event of an earthquake-caused accident, chances of a successful evacuation seem extremely remote. The quake would probably have damaged freeways, airports, and all avenues of escape. If mountain passes were blocked by landslides or other quake damage, most people in Southern California would be trapped. San Onofre is located on Interstate 5, the main road to the south. Eight to ten million people would be exposed to radiation and eventually evacuate the area, many going to Northern California.

In December 1980, the NRC issued a new report on earthquake hazards at the site. The report confirmed the existence of an entirely new fault zone branching beneath the reactors. It also upgraded the maximum possible jolt for the Newport-Inglewood Fault to 7.0.

One month later, a new U.S. Geological Survey (USGS) report stated that the Newport-Inglewood Fault could generate a 7.5 quake, an ominous increase from earlier estimates. Two new San Onofre reactors were almost completely built, and they had been designed to withstand only a 6.5 quake.

Many federal and state agencies have drafted disaster plans for use when the next powerful quake strikes. In the aftermath of the

NUCLEAR LOS ANGELES



Three Mile Island accident, they also began making separate plans for major nuclear accidents. However, no one bothered to combine the two plans in California, Where most of America's quakes occur. A nuclear meltdown can result from breaks in cooling water pipes (called a Loss of Coolant Accident), an event which seems possible during a major temblor.

A magnitude 7.5 quake could destroy the cooling pipes that bring water to the San Onofre's radioactive core, triggering a meltdown that could permanently contaminate Southern California. Consultants hired by San Onofre's owners testified that the probability of a 7.5 quake hitting the Newport-Inglewood Fault during the 30 year life of the reactors was low. However, since the October 1989 quake, some scientists believe this probability has increased.

In 1980, the Reagan Administration changed federal rules to prevent legal interveners in federal hearings (in this case Friends of the Earth and an insurance executive from La Jolla) from blocking the licensing of San Onofre because of quake hazards. In 1982, the NRC granted fullpower operating licenses for the new reactors, despite the quake hazards. (Like San Onofre, Diablo Canyon nuclear power plant was licensed on the basis of earthquake predictions calculated by utility company consultants).

The latest federal reports estimate a 60 to 70 percent chance that the region will experience a 7.5 to 8.3 magnitude quake during the 30-year operating lifetime of the San Onofre reactors. The NRC license was based on a much lower probability.

San Onofre is not Southern California's only radioactive threat. General Atomic operates several research reactors in La Jolla, within sight of the UC San Diego campus. The University of California operates nuclear reactors in fault zones on its Los Angeles, Irvine, and Santa Barbara, and Berkeley campuses. Northrop Corporation operates a reactor in Hawthorne (near Los Angeles). Cal State University at San Luis Obispo has a reactor which has been shut down since 1980.

The San Fernando Valley is perhaps the worst potential disaster area. Atomics International operates plutonium labs and reactors 35 miles north of downtown Los Angeles in Santa Susana. In 1959 the site suffered a reactor meltdown and released 200,000 curies of radioactive gases.

Today the facility's owner operates five sites in and around Los Angeles County that handle radioactive materials. The largest is the 290-are Santa Susana site, licensed by the NRC to handle 1500 kilograms of bomb-quality uranium and 3.5 kilograms of plutonium. Just after the Santa Cruz quake of 1989, Atomics International announced that it was bowing to public pressure and voluntarily shutting down part of its nuclear research facility in the San Fernando Valley.



MAGNITUDES AND CONTINENTAL DRIFT

Scientists believe that the surface of the earth consists of gigantic plates that are gradually colliding or sliding past each other. These movements cause earthquakes. The North Pacific Plate is moving toward Alaska and is sliding against the North American Plate. This has created the San Andreas fault system.

The maximum possible earthquake on the San Andreas Fault is assumed to be 8.5 on the Richter magnitude scale. (The 1906 quake which destroyed San Francisco measured 8.2.) The Richter scale is logarithmic, so an increase of one number means a tenfold increase in the magnitude of the tremors, and a 30-fold increase in the amount of energy released. An 8.5 quake could release an explosive fury equal to 1500 Hiroshimasize atom bombs, according to the California Division of Mines and Geology.

Less powerful quakes in other countries have killed more people than the October temblor due to less stringent building codes. In 1988, a magnitude 6.9 quake killed 25,000 in Soviet Armenia. Another 6.9 quake in Iran in 1972 killed over 5,000. During the 1980's, quakes measuring from 7.1 to 7.3 each killed thousands in Turkey, Italy, and Algeria.



7,1

Glenn Barlow has written about earthquakes and California's nuclear hazards in the book <u>Nuclear California</u>, published in 1982 by the Center for Investigative Reporting and Greenpeace. He has also written extensively on the same subjects for monthly magazines and other publications by Friends of the Earth, the Nuclear Weapons Freeze, and the California Public Interest Group. Sixona Club