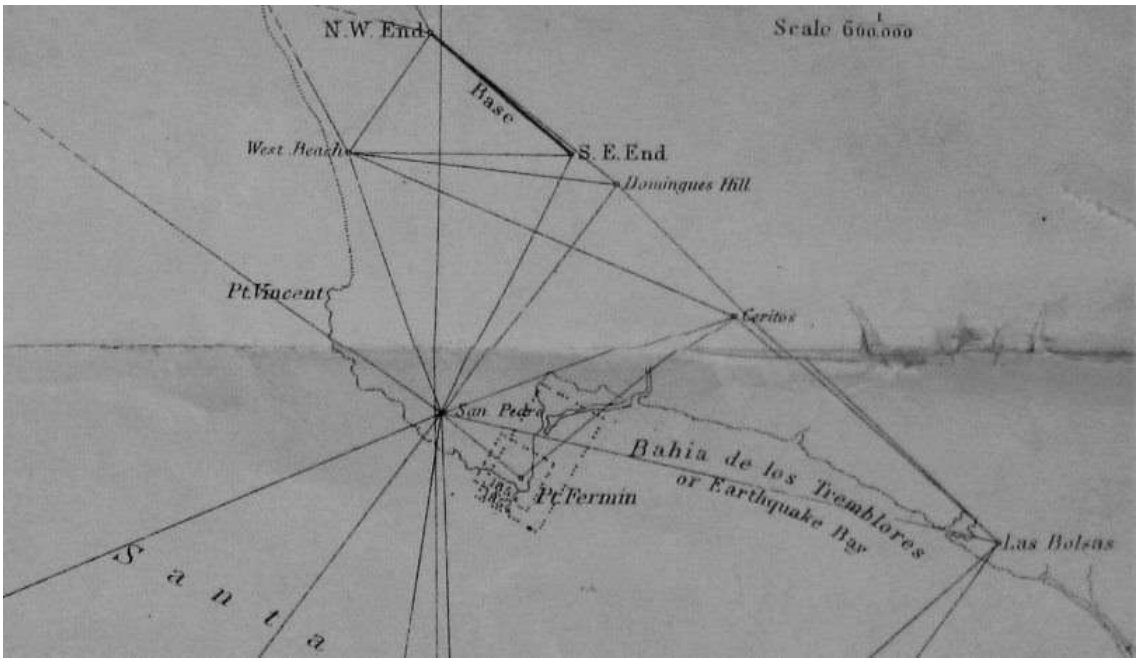
EARTHQUAKE BAY

An evaluation of Geological Risks for Nuclear Waste Hazards at the San Onofre Nuclear Generating Station (SONGS) in San Diego and Orange Counties

THURSDAY FEBRUARY 16, 2017



As recently as 1881, the coastline from Northern Orange County to Central San Diego County was officially known as "Earthquake Bay."

Prepared by : Charles Langley
Executive Director
Robert Pope
Geologist
Public Watchdogs

Overview:

It is the opinion of the authors that with the current trajectory of engineering solutions and public policy, a radioactive release at San Onofre State Beach Park is unavoidable. This document explains why.

History:

On or around mid-March of 2018, Southern California Edison will begin the process of the burial and interment of 3.6 million pounds of spent nuclear fuel generated by the failed San Onofre Nuclear Generating Station (SONGS).

The spent fuel rods contain deadly uranium, plutonium, and other radionuclides, which will be stored on the beach in thin-walled "dry casks" at San Onofre State Park. Although the waste will be stored on the beach on a "temporary basis," the Federal definition of "temporary" is 120 years. [1]

When California was ceded to the United States in 1848, the beach at San Onofre State Park was already known on Spanish maps as "Bahia De Los Tremblores," or "Earthquake Bay," due to seismic activity experienced in the area. Even as recently as 1881 the United States Coast and Geodetic Survey officially referred to this area as "Bahia De Los Tremblores" for obvious reasons.

The area has seen minimal seismic activity in the last 170 years, making it pregnant with the probability of earthquakes to come.

[1] See Nuclear Regulatory Commission, August 26, 2014: *CLI-14-08 MEMORANDUM AND ORDER* https://www.nrc.gov/reading-rm/doc-collections/commission/orders/2014/2014-08cli.pdf

Broadly speaking, there are two key considerations that make the storage of spent nuclear fuel at San Onofre a hazardous proposition.

The first is the fact that the beach is located in the center of a seismically active region known as "Earthquake Bay" to early residents. Second, careful examination of publicly available records shows that the construction of the casks and the concrete silos that will house them are not designed to withstand significant seismic activity. Third, the spent fuel pools and other infrastructure necessary for keeping the spent fuel cool in the event of a cask leak have been approved for removal, taking away vitally need safety measures in the event of a cask failure of any magnitude. Finally, the casks are located in a tsunami inundation zone and in close proximity to several earthquake faults, most notably the Offshore Newport-Inglewood Fault

Part One: Known geological risk factors

The Newport–Inglewood Fault is a right-lateral strike-slip fault that extends for 47 miles from Culver City through Inglewood and other coastal communities to Newport Beach, where it extends into the Pacific Ocean immediately offshore from the planned San Onofre Nuclear Waste Dump. It then descends east-southeast into the Pacific, where it joins the Rose Canyon Fault; also a right-lateral strike-slip fault.

Swarms of low-intensity earthquake activity were recorded in 1981 and 2000 offshore at San Onofre, consisting of more than 20 individual seismic events. These mapped clusters of earthquakes, together, illuminated the connection and relationship between the Newport Inglewood Fault and the Rose Canyon Fault. [2]

1. **Helium-3 data suggests the Newport-Inglewood Fault is as deep as the San Andreas,** extending all the way to the mantle of the earth. Helium-3 has been detected in the Newport Inglewood Fault.[3] This data indicates

[2] LB Grant, PM Shearer, Bulletin of Seismological Society of America, Vol 94, No2, April 2004

[3] See *Boles, J. R., G. Garven, H. Camacho, and J. E. Lupton (2015), Mantle helium along the Newport-Inglewood fault zone, Los Angeles basin, California: A leaking paleo-subduction zone, Geochem. Geophys. Geosyst., 16, 2364–2381, doi:10.1002/2015GC005951.*

that the fault, where structurally similar, could deliver a seismic event comparable to the San Andreas Fault.

Helium-3 (^{3}He) is stable at high temperature and high pressure, deep below the earth's crust. It is a light, non-radioactive isotope of helium with two protons and one neutron and can only be found in abundance below the Mohorovičić discontinuity (known as the "Moho") more than 22 miles below the boundary between the Earth's crust and its mantle.

Helium-3 increases the potential magnitude of an earthquake by acting as a lubricant. Recent studies of South Pacific earthquakes demonstrate that the presence of Helium-3 can cause earthquakes to release more energy than predicted by the geology alone. Seismic motion, once it begins, is essentially lubricated with explosive force by the presence of Helium-3. Given the confirmed presence of Helium-3 within the Newport-Inglewood Fault (at levels greater than those measured in the San Andreas Fault), it is possible that the magnitude of an earthquake on the Offshore Newport-Inglewood Fault could exceed that which is estimated by the geologic environment alone.

2. **Critical faults are on the move**.
   The Newport-Inglewood Fault and Rose Canyon Fault are both seismically active. Numerous studies have cited movement of up to 0.5mm or more per year along the Newport-Inglewood Fault in Los Angeles County, and up to 2mm per year along the Rose Canyon Fault offshore of San Diego County. Movement in the area that connects these faults, offshore of Orange County and North San Diego County, near San Onofre, was only detected in two clusters of micro-seismic events during the last half century. The data from these incidents validate our concern. We cannot continue to observe movement along these two faults in Los Angeles and San Diego Counties without comparable seismic activity in the offshore Orange County area that connects them.

3. **Southern California Edison appears to have ignored key data.**
   Although $64 million in public money was budgeted at the request of Edison,[4] to conduct its geological studies, it appears that it may have

[4] See San Diego Union Tribune, Edison Seeks $64 million for Seismic Studies.

focused its analyses and conclusions on evaluating risks from faults that many geologists believed presented a significant risk in the first place. It prompts skeptics to ask if Edison replaced assessments of major risk, with an analysis of risks known to be the trivial.

The partial results of the $64 million study were published three days ago at the SONGS Community Website on February 13, 2017. [5] The research appears to have ignored the full threat of the Newport-Inglewood Fault in favor of -discrediting questionable risks related to the Oceanside Blind Thrust Fault (OBT). In doing so, Edison may be focusing on the wrong issue.

4. **Contradictory reports:** The last sentence of the conclusion of Edison's 2015 study published in *Marine Geology*[6] suggests that the Newport-Inglewood Fault has not moved since the melting of continental ice during the last ice age (MWP1b). This is a conclusion the authors fail to mention in the report from *Applied Geology* published three days ago at the SONGS Community Website.

5. **Alarming similarities to the New Zealand Kaikoura Earthquake.** New Zealand's recent seismic activity represents a comparable model of what's possible for Southern California. Both the South Island of New Zealand and coastal California are in transform plate boundaries exhibiting a network of onshore and offshore strike-slip faults.

   Last November's New Zealand magnitude 7.8 quake with over 3000 related quakes exhibited movement on at least six faults, and surface ruptures on four faults, including one fault that was previously unknown or non-existent. In all, more than 40 miles of surface rupture occurred during the seismic event, including more than 20 miles of surface rupture on land and 20 miles of additional surface rupture offshore. While earthquakes are predictably more frequent on New Zealand's South

---

[5] See Southern California Edison February 13, 2017, Press Release*: San Onofre Community Engagement Panel to Discuss New Seismic Research*

[6] See Songs Community Web site *Continental shelf morphology and stratigraphy offshore San Onofre*, http://www.songscommunity.com/docs/Pre-ReadNewportInglewoodandRoseCanyonFaulManuscriptcontinentalshelf.pdf
The report above conflicts with conclusion from the report published in Applied Geology.
See http://www.songscommunity.com/docs/Pre-ReadChapter36_Segmantation.pdf

Island, the scenario that played out last November is something USGS warned us about on March 9, 2015, for Southern California stating "the result could be multiple faults rupturing in a simultaneous mega-quake." [7]

USGS warns that there is a 75% probability of a magnitude 7.0 or greater earthquake for Southern California in the next 30 years, a 93% chance of a 6.7 or greater, and a 100% chance of 6.0 or greater.[8]

6. **Evidence suggests greater risks further South.**
According to University of Southern California Geologist James Dolan, the Newport Inglewood fault is more dangerous the further south it goes.

Dolan states the fault is capable of generating earthquakes of magnitude 7 and above, "The 20-mile stretch from Baldwin Hills to Long Beach is composed of several smaller cracks that run loosely parallel to one another… They have not coalesced into a basically smooth, single crack like the San Andreas, where seismic waves have a much easier time rippling through the earth for longer distances causing larger quakes," said Dolan.[9]

History demonstrates this with magnitudes of about 4 in the vicinity of Culver City, 6.2 in the 1933 Long Beach Earthquake, and a predictable future quake of 7 or greater along the Offshore Newport-Inglewood Fault.

Lack of seismic movement portends higher risk.
Edison's costly studies validate our point about the risks associated with the Newport-Inglewood fault. Because the Newport Inglewood is as deep as the San Andreas Fault, the relative lack of movement shows an

---

[7] See *Los Angeles Times*, March 10, 2105, *Risk of 8.0 earthquake in California rises, USGS says.*
http://www.latimes.com/local/lanow/la-me-ln-chance-of-80-earthquake-in-california-rises-usgs-says-20150310-story.html

http://www.latimes.com/local/lanow/la-me-ln-chance-of-80-earthquake-in-california-rises-usgs-says-20150310-story.html

[8] United States Geological Survey Web site: https://earthquake.usgs.gov/earthquakes/eventpage/us1000778i#executive

[9] *Los Angeles Times*, May 19, 2009: *Northern segment of Newport-Inglewood fault less prone to large quakes than southern portion, professor says.* http://articles.latimes.com/2009/may/19/local/me-quake-explainer19

increase, not a decrease in risk factors.

7. **Additional evidence of tsunami and earthquake hazard.** A study by Gerald G. Kuhn[10] documents late Holocene tsunami deposits in Northern Coastal San Diego County at 100+ meters above sea level with corresponding paleoseismically deformed sediments, likely caused by a magnitude 7+ seismic event. The paleoseismic events impacted late Holocene Indian middens and burial sites, indicating they occurred within the last one to three thousand years. Perhaps they are even records of the earthquakes of Nov 22, 1800, or May 27, 1862. Regardless, data presented in the study demonstrate tsunami and earthquake events have occurred, in recent time, with a magnitude that could overwhelm and devastate the infrastructure at SONGS.

Part Two: The ISFSI and cask design increase seismic risk

There are a number of practical reasons why the Independent Spent Fuel Storage Installation (ISFSI) is unsafe.

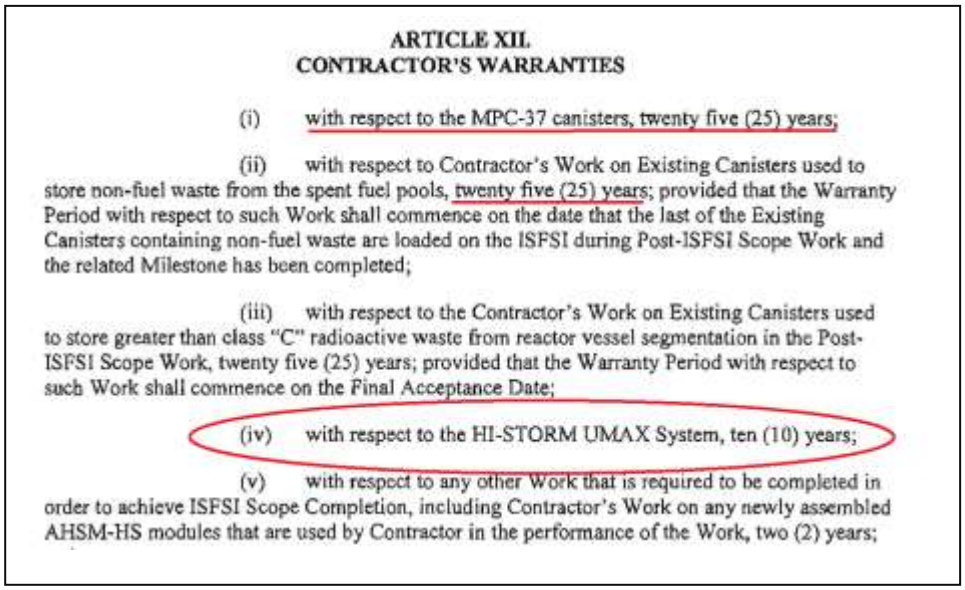
1. **The fuel is deadly for billions of years**.
   The spent fuel rods, which are rich in Plutonium, have a "half life" of more than 24,100 years,[11] meaning in 24,100 years, half of the mass of deadly Plutonium will have decayed into other deadly radioactive isotopes, making Plutonium deadly to humans for hundreds of thousands of years. Additionally, the Uranium 238 in the spent fuel has a half life of 4.46 billion years.[12] For practical purposes, the spent fuel rods can be considered eternally deadly to Life.

---

[10] See *Engineering Geology*, *Paleoseismic features as indicators of earthquake hazards in North Coastal, San Diego County, California, USA,* Gerald G. Kuhn, Volume 80, Issues 1–2, 8 August 2005, Pages 115–150 *http://www.sciencedirect.com/science/article/pii/S0013795205000785*

[11] See "*Plutonium*" on Wikipedia, https://en.wikipedia.org/wiki/Plutonium

[12] See Institute for Energy and Environmental Research, "*Summary of Uranium Isotopes*," http://ieer.org/resource/factsheets/uranium-its-uses-and-hazards/



ARTICLE XII
CONTRACTOR'S WARRANTIES

(i) with respect to the MPC-37 canisters, twenty five (25) years;

(ii) with respect to Contractor's Work on Existing Canisters used to store non-fuel waste from the spent fuel pools, twenty five (25) years; provided that the Warranty Period with respect to such Work shall commence on the date that the last of the Existing Canisters containing non-fuel waste are loaded on the ISFSI during Post-ISFSI Scope Work and the related Milestone has been completed;

(iii) with respect to the Contractor's Work on Existing Canisters used to store greater than class "C" radioactive waste from reactor vessel segmentation in the Post-ISFSI Scope Work, twenty five (25) years; provided that the Warranty Period with respect to such Work shall commence on the Final Acceptance Date;

(iv) with respect to the HI-STORM UMAX System, ten (10) years;

(v) with respect to any other Work that is required to be completed in order to achieve ISFSI Scope Completion, including Contractor's Work on any newly assembled AHSM-HS modules that are used by Contractor in the performance of the Work, two (2) years;

2. **The dry casks are only designed to last 60-years.**
   Legal documents secured by San Onofre Safety (www.sanonofresafety.org) reveal that "the design life of the HI-STORM UMAX system is sixty years."[13] Given that it is likely the waste will remain on the beach for at least 120 years, and the material inside is eternally deadly, Southern California Edison's decision to use HI-STORM casks with a "design life" of sixty years seems imprudent.

3. **The dry cask storage system is only guaranteed for 10-years.**
   Southern California Edison (SCE) argued that the warranty for the Holtec brand of dry casks should be kept a secret, and now we know why: It is an embarrassment to SCE and the manufacturer. According to the warranty provided to SEC by Holtec, the dry casks are guaranteed to last 25 years, while the concrete silos that will store them carry an alarmingly short 10-year warranty.[14]

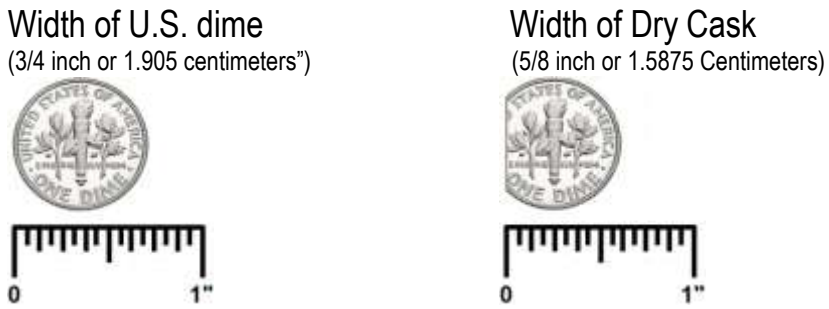
---

[13] See *Response to Question 10, Supplemental*, page 7 of 9, *Data Request Set A.14-12-007 Gilmore-SCE-001 Follow-Up 2,* https://publicwatchdogs.org/wp-content/uploads/2016/09/sce-dr-response-w-attachment-to-a-14-12-007-gilmore-sce-001-follow-up-2-q-09-q-12-OCRd.pdf

[14] Again, see *Data Request Set A.14-12-007 Gilmore-SCE-001 Follow-Up 2, page 3 of 9 (79),* https://publicwatchdogs.org/wp-content/uploads/2016/09/sce-dr-response-w-attachment-to-a-14-12-007-gilmore-sce-001-follow-up-2-q-09-q-12-OCRd.pdf

4. **The Dry Casks are only 5/8" thick**

The "walls" in the thin-walled stainless steel casks that will be used at San Onofre are 5/8" thick. This thickness is slightly less than the width of a dime as illustrated below.



5. **Government Regulations Allow for 75% Through-Wall Cracks**

The Nuclear Regulatory Commission, the Federal agency responsible for nuclear safety, allows the cracks in a dry cask to penetrate up to 75% of the width of the cask wall before it is considered unsafe. In the case of the San Onofre dry casks, this means that the allowable thickness of a cracked cask wall is reduced to 00.156 inches, or 79/500th of an inch

This remaining cask wall,-- less than 1/5th of an inch -- is considered "safe" under NRC regulations.

In the event of a stress crack, the allowable width of the remaining cask wall is a dangerously narrow 79/500th of an inch, or less than 1/5"

6. **The casks are not secured in the event of an earthquake.**
   When the dry casks are newly interred they can reach temperatures of up to 750 degrees Fahrenheit – hot enough to vaporize human hair.[15] Moreover in order to provide passive cooling for the hot radioactive waste, there is significant air space between the steel casks and their concrete enclosures. While this air space allows for the benefits of passive cooling, it also allows for movement of the casks in the event of an earthquake.

   Each of the casks can weigh up to 500,000 pounds, and is subject to cracking from a drop of only a few inches. In the event of an earthquake greater than M7, the casks could be violently thrown and broken open, releasing millions of curies of deadly radiation and potentially contributing to a chain-reaction criticality event.

7. **The infrastructure required to transfer and repair leaking casks is scheduled for demolition.**

   Edison has applied for, and been granted permission, to remove the spent fuel pools at San Onofre. The spent fuel pools and related infrastructure are required to perform overpacking of casks for transport offsite. Spent fuel pools are also necessary for many engineering solutions that may be required in response to even the most minor cask failure incident.

SUMMARY

Edison's conclusions are faulty.

In summary, the "preferred conclusion" in the report funded by Edison appears to be one that favors the financial interests of Edison's shareholders, and sidesteps the enormous number of other logical conclusions one could draw from the abundance of data.

A clear and simple conclusion one could draw is that the offshore geology exhibits complex folding and faulting caused by tens of thousands of years of seismic

[15] Human hair spontaneously ignites at 452 degrees.

activity. What is predictable is tens of thousands of more years of seismic activity for our future.

Although not a "preferred conclusion," another obvious conclusion is that the Newport-Inglewood/Rose Canyon Fault is seismically active throughout the offshore region, and minor deformation of shoals along the transgressive surface are the product of strike-slip faulting, with minimal vertical displacement. This conclusion is consistent with seismic data recorded for nearly 100 years in the Los Angeles County and San Diego County regions of the same fault system.

Large-magnitude earthquakes will happen again in a strike-slip motion along one or more fault lines or transpressional structures.

Let us not forget, also, the study by Kuhn that documents late Holocene tsunami deposits in Northern Coastal San Diego County at 100+ meters above sea level with corresponding paleoseismically deformed sediments, likely caused by a magnitude 7+ seismic event. Data presented in the study demonstrate tsunami and earthquake events have occurred, in recent time, with a magnitude that could overwhelm and devastate the infrastructure at SONGS.

We remind the reader that this is the most seismically active coastline in the contiguous 48 States. Once the waste is buried on the beach, it will likely remain there for at least 120 years. The probability of a significant seismic event occurring during that time period is nearly 100%, making a nuclear waste disaster at San Onofre unavoidable.

30