CITY COUNCIL OTHER BUSINESS

SAN ONOFRE NUCLEAR GENERATING STATION (SONGS) FOLLOW-UP, INCLUDING PRESENTATION REGARDING SONGS' STEAM GENERATORS, AND STORAGE AND SAFETY.

Recommended Action: Receive presentation from Daniel O. Hirsch, Lecturer on Nuclear Policy at the University of California, Santa Cruz, and President of Committee to Bridge the Gap; receive presentation from Southern California Edison representing the San Onofre Nuclear Generating Station; receive public input; and determine whether to take a position regarding the restart of the San Onofre Nuclear Generating Reactors and/or adopt the proposed resolution expressing the City's position.

Reference: Clerk's File No. 1001-3

San Onofre Nuclear Generating Station Steam Generator Failure

Daniel O. Hirsch
Lecturer on Nuclear Policy
University of California Santa Cruz
President of Committee to Bridge the Gap

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SONGS Unit 2 Steam Generators
Wear Depths Summary

Steam Generator SG2E88 (Through-Wall Wear)	Anti-Vibration Bar	Tube Support Plate	Tube-to-Tube Wear	Retainer Bar	Foreign Object	Total Indications	Tubes with Indications (out of 9727 total per SG)
≥ 50%	0	0	0	1	0	1	1
35 - 49%	2	0	0	1	0	3	3
20 - 34%	86	0	0	0	2	86	74
10 - 19%	705	108	0	0	0	813	406
< 10%	964	117	0	0	0	1081	600
TOTAL	1757	225	0	2	2	1984	734*

* This value is the number of tubes with wear indications of any depth and at any location. Since many tubes have indications in more than one depth and location, the total number of tubes is less than the total number of indications.

Steam Generator SG2E89 (Through-Wall Wear)	Anti-Vibration Bar	Tube Support Plate	Tube-to-Tube Wear	Retainer Bar	Foreign Object	Total Indications	Tubes with Indications (out of 9727 total per SG)
≥ 50%	0	0	0	1	0	1	1
35 - 49%	0	0	0	1	0	1	1
20 - 34%	78	1	0	3	0	82	67
10 - 19%	1014	85	2	0	0	1101	496
< 10%	1499	53	0	0	0	1552	768
TOTAL	2591	139	2	5	0	2737	861*

* This value is the number of tubes with wear indications of any depth and at any location. Since many tubes have indications in more than one depth and location, the total number of indiations.

3

SONGS Unit 3 Steam Generators
Wear Depths Summary

Steam Generator SG3E88 (Through-Wall Wear)	Anti-Vibration Bar	Tube Support Plate	Tube-to-Tube Wear	Retainer Bar	Foreign Object	Total Indications	Tubes with Indications (out of 9727 total per SG)
≥ 50%	0	117	48	0	0	165	74
35 - 49%	3	217	116	2	0	338	119
20 - 34%	156	506	134	1	0	797	197
10 - 19%	1380	542	98	0	0	2020	554
< 10%	1818	55	11	0	0	1884	817
TOTAL	3357	1437	407	3	0	5204	919*

* This value is the number of tubes with wear indications at any depth and at any location. Since many tubes have indications in more than one depth and locations, the total number of tubes is less than the total number of indications.

Steam Generator SG3E89 (Through-Wall Wear)	Anti-Vibration Bar	Tube Support Plate	Tube-to-Tube Wear	Retainer Bar	Foreign Object	Total Indications	Tubes with Indications (out of 9727 total per SG)
≥ 50%	0	91	26	0	0	117	60
35 - 49%	0	252	102	1	0	355	128
20 - 34%	45	487	215	0	0	747	175
10 - 19%	940	590	72	0	0	1602	450
< 10%	2164	94	1	0	0	2259	838
TOTAL	3149	1514	416	1	0	5080	887*

* This value is the number of tubes with wear indications at any depth and at any location. Since many tubes have indications in more than one depth and locations, the total number of tubes is less than the total number of indications.

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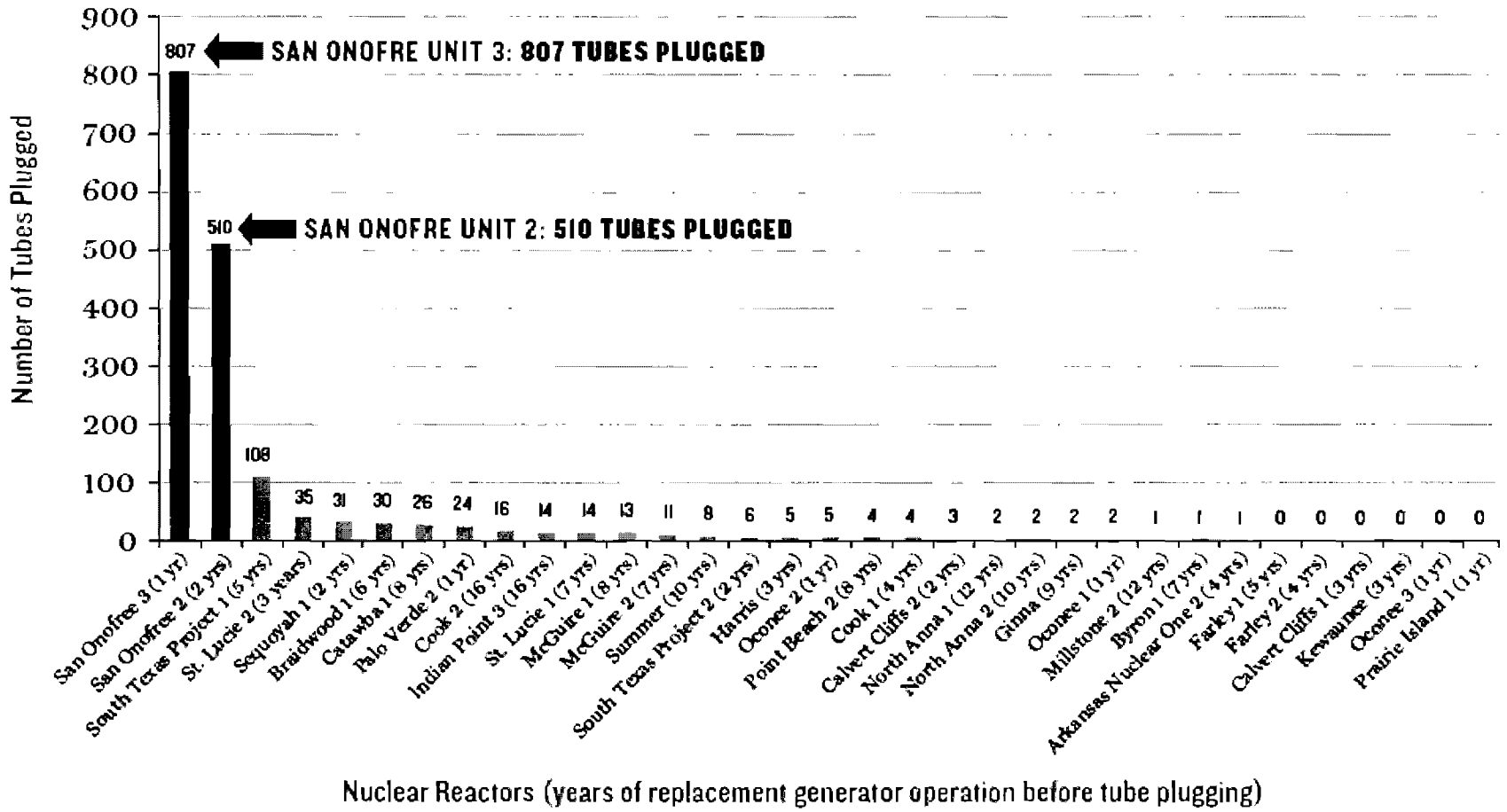
Figure 1

U.S. Nuclear Reactors Replacement Steam Generators Tubes Plugged to Avoid Generator Failure[3]



FAR OUTSIDE THE NORM:
The San Onofre Nuclear Plant's Steam Generator Problems in the Context of the National Experience with Replacement Steam Generators

by
Daniel Hirsch
and
Dorah Shuey

with a Forward
by
Dale Bridenbaugh

September 12, 2012

http://www.committeetobridgethegap.org

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EXECUTIVE SUMMARY

Southern California Edison (SCE) and the Nuclear Regulatory Commission (NRC) have suggested that the problems experienced in the steam generators of the two San Onofre reactors are fundamentally different and that Unit 2's difficulties are merely "settling in" wear normal for new replacement steam generators. No data have been provided to date by SCE or NRC to support these claims, yet SCE has suggested that for these reasons it expects to request permission to restart Unit 2 and run it at somewhat reduced power, without repairing or replacing the damaged devices.

This report assembles national data from inspections of similar replacement steam generators after one cycle of operation. The conclusion is that both San Onofre Unit 2 and Unit 3 have experienced damage greatly in excess of the typical reactor:

- **The median number of steam generator tubes nationally showing wear after one cycle of operation is—FOUR. San Onofre Unit 2 had 1595 damaged tubes, approximately 400 times the median; San Onofre Unit 3 had 1806.**

- **The median number of indications of wear on steam generator tubes nationally after one cycle of operation is—FOUR. San Onofre Unit 2 had 4721, greater than a thousand times more. San Onofre Unit 3 had 10,284.**

- **The median number of steam generator tubes that were plugged after one cycle of operation is—ZERO. San Onofre Unit 2 had 510; Unit 3 had 807.**

Additionally, the replacement steam generators at San Onofre Unit 2 and 3 suffer from the same fundamental design errors. Indeed, the number of damaged tubes in each unit is approximately the same.

The conclusion is clear: San Onofre Unit 2 and Unit 3 are both very ill nuclear plants. Unit 3's fever is slightly higher, but both are in serious trouble. What they are experiencing is not just normal wear due to "settling in" purportedly experienced with similar replacement steam generators. They are far, far outside the norm of national experience. And Unit 2 cannot be said to be acceptable for restart, any more than Unit 3. Unit 2 has hundreds of times more bad tubes and a thousand times more indications of wear on those tubes than the typical reactor in the country with a new steam generator, and nearly five times as many plugged tubes as the rest of the replacement steam generators, over a comparable operating period, in the country combined. Restarting either San Onofre reactor with crippled steam generators that have not been repaired or replaced would be a questionable undertaking at best.

FORWARD

SAN ONOFRE NUCLEAR GENERATING STATION
REPLACEMENT STEAM GENERATOR PROBLEMS

by
DALE BRIDGENBAUGH
NUCLEAR ENGINEER, RETIRED

As a retired professional nuclear engineer and long time citizen of California, I have followed the recent experience of the San Onofre Nuclear Generating Station with great interest. I am particularly troubled by the extent and causes of the early failures of tubes in the replacement steam generators at both of the San Onofre units (Units 2 and 3) that have not yet been thoroughly explained and reported. As this report makes clear, the conflicting failure data thus far made available by the San Onofre operating utility and the Nuclear Regulatory Commission, along with the lack of specificity detailing the mode(s) of failure, lend little credibility to Southern California Edison's claims that the large number of damaged steam generator tubes and indications of wear on the tubes are in fact completely understood. The data assembled in this report call into question assertions that the San Onofre damage is due primarily to normal "settling in" found commonly in other new replacement steam generators and that no immediate corrective action is needed before the restart of Unit 2.

As dramatically shown in Figures 3, 4, and 5 of this report, the San Onofre experience after only two or less years of operation with replacement steam generators lies far outside the bounds of normality when compared to the experience of other nuclear units with such replaced components. Steam generators, and more specifically the tube boundaries, play a critical role in assuring plant safety and the containment of possible radioactive releases. In spite of Edison's attempt to assert a different level of risk between Units 2 and 3, it seems clear that similar design and failure challenges are present in both units and that future operation of either unit has not been technically justified. It is my opinion that measures necessary for the future safe operation of either of these unit have not been adequately put forth at this time, and that operation with or without reduced power of Unit 2 should not be authorized.

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THE SAN ONOFRE NUCLEAR PLANT'S STEAM GENERATOR PROBLEMS IN THE CONTEXT OF THE NATIONAL EXPERIENCE WITH REPLACEMENT STEAM GENERATORS

Introduction

On January 31, 2012, a steam generator tube in Unit 3 of the San Onofre Nuclear Generating Station burst, leading to a shutdown of the reactor. Shortly thereafter, it was revealed that a previously scheduled inspection of Unit 2, which was down for refueling, had identified hundreds of damaged tubes in that reactor. Subsequent inspections of both units revealed approximately 3,400 tubes were showing indications of wear.

This was surprising because the steam generators in both units were virtually new. Unit 3's steam generators were about a year old, and Unit 2's were approximately two years old. Yet they were showing extensive wear.

Since then, further inspections have revealed serious problems with the steam generators in both units. 1317 tubes at San Onofre have been plugged to date, far more than have been plugged over a similar period of operation in all replacement steam generators in the country combined.

Southern California Edison, which operates San Onofre, has recently conceded that Unit 3 will not be operating anytime soon, if ever, and that the long-term viability of the plant as a whole is now in question.[1] However, the utility continues to suggest it may in the near future request approval from the Nuclear Regulatory Commission to restart Unit 2, even though its steam generators have been neither repaired nor replaced.

Underlying this anticipated action are two assertions: (1) that the problems in Unit 2 and Unit 3 are dramatically different, and (2) that the extent of the wear seen in Unit 2 is nothing out of the ordinary and commonly seen in similar new replacement steam generators, just a routine "settling in" phenomenon that stops soon after installation. The analysis that follows examines those two claims.

What Steam Generators Do and Why Their Proper Functioning is Important

Steam generators are critical components of Pressurized Water Reactors (PWRs) and their failure could lead to serious consequences. In a PWR, the primary coolant is kept under high enough pressure that it remains liquid at temperatures above the normal boiling point. That primary coolant, which picks up significant radioactivity from the nuclear fuel, must transfer its heat to a secondary coolant, which then becomes steam to turn turbines to generate electricity. The steam generators transfer heat from the primary to the secondary coolant and produce steam.

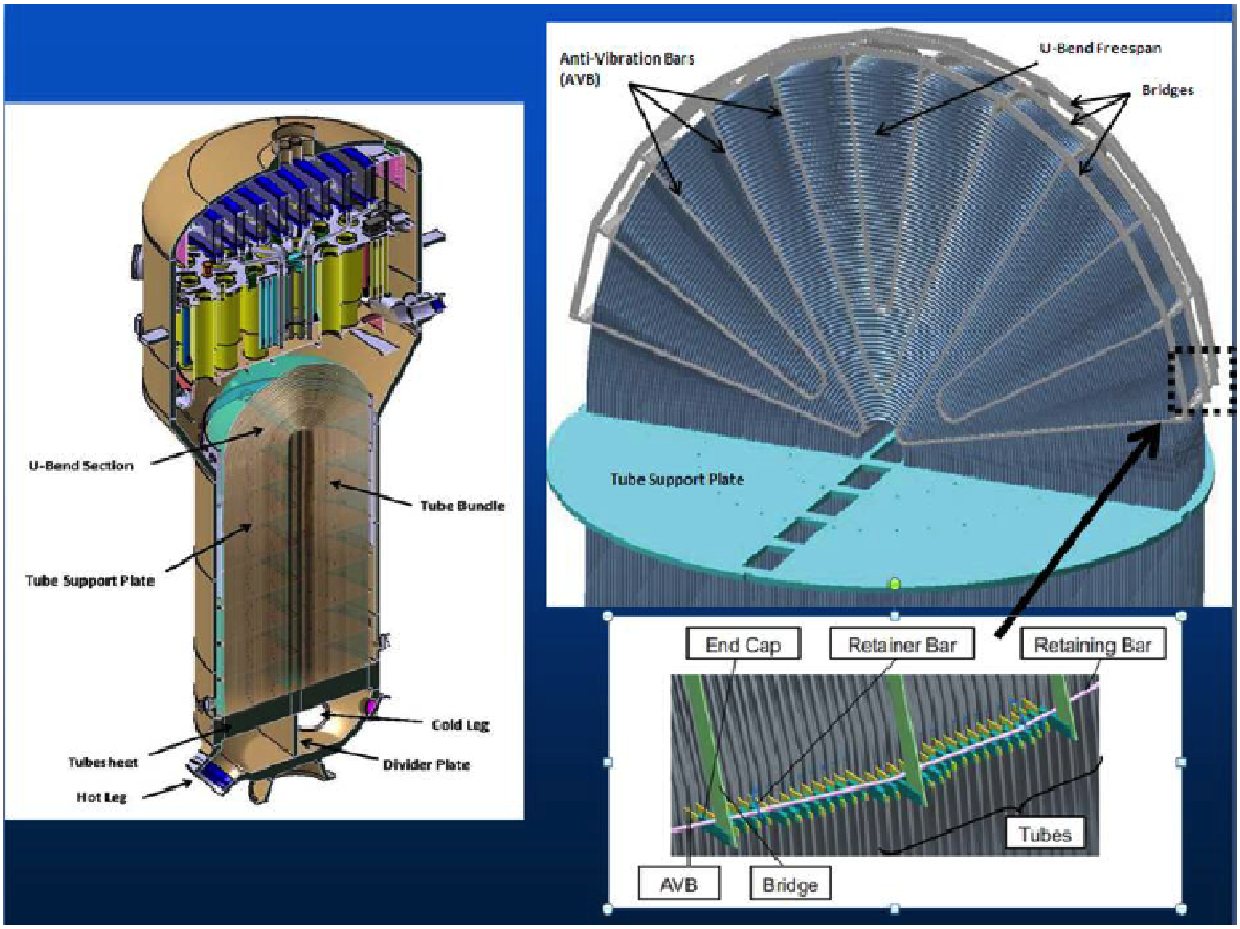
A steam generator is composed of a large number of very thin tubes through which the hot (both thermally and radioactively) primary coolant flows, transferring its heat to secondary coolant on the outside of the tubes. Significantly, while the steam generators are inside the containment structure, the large concrete dome designed to contain radioactivity in case of an accident, the secondary coolant loop/steam line travels outside the containment to run the turbines and generate power.

Therefore, the steam generators are critical because they are the primary coolant boundary that cannot be permitted to be breached significantly. Such a breach could both release radioactivity via a pathway to the outside environment and result in a loss of cooling to the reactor core, leading in some circumstances, if there are other failures, to a potential meltdown. The steam generator tubes must be very thin, in order to effectively transfer heat, and simultaneously very strong, so as to assure they do not burst and cause a loss of reactor cooling and release of radioactivity. Damage to the tubes can thus be problematic. The NRC has described their importance:[11]

> The steam generator (SG) tubes in pressurized water reactors have a number of important safety functions. These tubes are an integral part of the reactor coolant pressure boundary (RCPB) and, as such, are relied upon to maintain the primary system's pressure and inventory. As part of the RCPB, the SG tubes are unique in that they are also relied upon as a heat transfer surface between the primary and secondary systems such that residual heat can be removed from the primary system; the SG tubes are also relied upon to isolate the radioactive fission products in the primary coolant from the secondary system. In addition, the SG tubes are relied upon to maintain their integrity, as necessary, to be consistent with the containment objectives of preventing uncontrolled fission product release under conditions resulting from core damage severe accidents.

Figure 1 below shows a schematic view of the San Onofre replacement steam generators.

Figure 1 San Onofre Replacement Steam Generator Schematic



Source: NRC[iii]

The tubes are in an inverted U shape: in the upper part of the steam generator, the tubes bend to return downward again. There are four key parts of the steam generators for the present discussion: the tube support plates, through which the tubes run; the anti-vibration bars (AVBs), designed to reduce vibration; the retainer bars, which help retain the AVBs; and the U-Bend Freespan, where the tubes bend near the top of the steam generator and have no immediate support.

There thus are at least four locations where steam generator tubes can get damaged: they can rub against the tube support plates, the AVBs, the retainer bars, or against each other in the U-Bend Freespan.[iv] Damage has occurred in the new steam generators at San Onofre at all four locations.

What Happened at San Onofre

The original steam generators for San Onofre Units 2 and 3 were supposed to last for forty years, the design life of the reactors. (Unit 1, a Westinghouse design system, was shut down long ago due in part to extensive steam generator tube degradation.[v]) Therefore, the containment structures were not built with a pre-engineered way to get the old steam generators out and the replacement ones in. The original steam generators, manufactured by Combustion Engineering, began failing earlier than anticipated, and within about twenty years of operation, SCE began planning to replace them.

Mitsubishi Heavy Industries was chosen to construct the new steam generators. It took nearly four years to fabricate the Unit 2 steam generators, and nearly six years for Unit 3's.[vi] They then had to be shipped from Japan and installed. This required cutting large openings into the containment structures, something generally to be avoided both from a cost standpoint and because of the importance of not risking reducing the integrity of the structures designed to prevent release of radioactivity into the environment in case of an accident.

At Edison's request, Mitsubishi made numerous changes to the design of the steam generators compared to those originally at San Onofre, such as using a different tube alloy, Inconel 690, and adding hundreds of more tubes. Yet, by asserting that it was making a "like for like" change, SCE bypassed the normal requirement to apply for a license amendment, which would have entailed a higher degree of scrutiny by the NRC and the opportunity for the public to request an evidentiary hearing. This turned out to be a fateful decision, because it appears possible that the greater degree of review that would have been required with a full license amendment application might have detected the problems that the design changes caused and that have since crippled San Onofre.

Regardless, the changes made from the original design resulted in the replacement steam generators failing within a year or two of installation. Subsequent reviews by NRC and SCE determined that computer modeling errors by Mitsubishi resulted in actual steam flows in parts of the steam generators being four times higher than originally estimated by Mitsubishi, leading to "fluid elastic instability," vibration, and damage to the tubes. *This fundamental problem exists for both Unit 2 and 3.*

Extensive Damage In Units 2 and 3

It has taken considerable effort to get SCE and NRC to disclose fully the number of damaged tubes and the magnitude of their wear. In early February, an NRC spokesman told the news media that 80% of the 9727 tubes in one of the two steam generators in Unit 2 had been inspected, with the following results: Two of the tubes showed more than 30% wall thinning, 69 had 20% thinning and more than 800 had 10% thinning.[vii] *Thus, as of early February, about 11% of the tubes inspected in Unit 2 had 10% or more through-wall wear, after just two years of operation.* This is significant because the full-power plugging limit is 8%, meaning that at the end of forty years of operation of steam generators, one isn't supposed to plug more than 8% of the tubes because of damage and still be able to run at full power. In just two years, therefore,

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San Onofre Unit 2 has suffered damage that normally takes decades.

Repeated requests for the complete data based on inspection of the remaining tubes in Units 2 and 3 were denied for several months. Then, after being pressed for updated figures by the author at a public meeting called by the NRC on June 18 to discuss its Augmented Inspection Team (AIT) review, a senior SCE executive stated:[viii]

> We will get you the specific numbers—I will share the percentages with you tonight... On Unit 3, 9% of the tubes in the Unit 3 steam generators -- so 19,454 tubes in the steam generators, 9% of them showed wear of greater than 10% through-wall indications, 9%. On Unit 2, 12% of the tubes showed wear greater than 10% through-wall indication.

Note that the percentage provided by the SCE official for Unit 2 matches fairly closely with the figures given by NRC in early February when 80% of the tubes in only one of the two steam generators in that Unit had been inspected. After giving the above percentages, the SCE spokesman stated, "Compared to other steam generators in the industry, those numbers by themselves are not alarming. What is alarming and the reason we are here tonight is the unexpected tube-to-tube wear." He went on to assert that problems are far worse in Unit 3 than Unit 2, because there are hundreds of tubes in Unit 3 showing tube-to-tube wear but only two in Unit 2.

Those statements, and others by SCE and NRC, assert that it is only the tube-to-tube wear that is of concern and that the amount of wear other than tube-to-tube wear is comparable to what is generally seen in other replacement steam generators in the industry. This report evaluates those assertions and assesses whether the severity of the problems with the San Onofre steam generators is in line with typical experience nationally.

Weeks passed without the actual tube wear numbers being provided for San Onofre. It took intervention by staff of the Senate Committee on Environment and Public Works before the data were finally posted on the NRC website. The data are critical and can be found below. Table 1 provides data for both steam generators in Unit 2 of the San Onofre Nuclear Generating Station (SONGS Unit 2). Table 2 provides the data for the two steam generators in Unit 3.

Table 1

SONGS Unit 2 Steam Generators
Wear Depths Summary

Steam Generator SG2E88 (Through-Wall Wear)	Anti-Vibration Bar	Tube Support Plate	Tube-to-Tube Wear	Retainer Bar	Foreign Object	Total Indications	Tubes with Indications (out of 9727 total per SG)
≥ 50%	0	0	0	1	0	1	1
35 - 49%	2	0	0	1	0	3	3
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< 10%	964	117	0	0	0	1081	600
TOTAL	1757	225	0	2	2	**1984**	**734***

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< 10%	1499	53	0	0	0	1552	768
TOTAL	2591	139	2	5	0	**2737**	**861***

* This value is the number of tubes with wear indications of any depth and at any location. Since many tubes have indications in more than one depth and location, the total number of tubes is less than the total number of indiations.

Source: NRC[ix]

Table 2

SONGS Unit 3 Steam Generators
Wear Depths Summary

Steam Generator SG3E88 (Through-Wall Wear)	Anti-Vibration Bar	Tube Support Plate	Tube-to-Tube Wear	Retainer Bar	Foreign Object	Total Indications	Tubes with Indications (out of 9727 total per SG)
≥ 50%	0	117	48	0	0	165	74
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Steam Generator SG3E89 (Through-Wall Wear)	Anti-Vibration Bar	Tube Support Plate	Tube-to-Tube Wear	Retainer Bar	Foreign Object	Total Indications	Tubes with Indications (out of 9727 total per SG)
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< 10%	2164	94	1	0	0	2259	838
TOTAL	3149	1514	416	1	0	5080	887*

* This value is the number of tubes with wear indications at any depth and at any location. Since many tubes have indications in more than one depth and locations, the total number of tubes is less than the total number of indications.

Source: NRC[x]

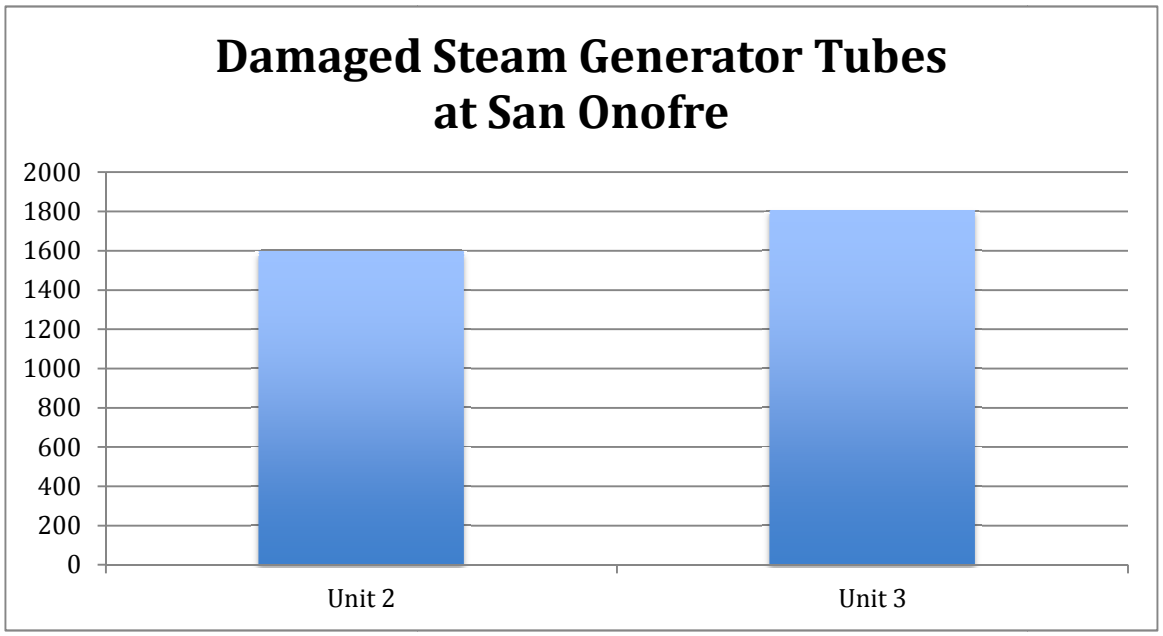
Note that the data tables do not comport with either the numbers given by the either the spokesman for NRC in early February or the spokesman for SCE in June. Whereas NRC indicated in February that, with only 80% of the tubes inspected in one of the 2 steam generators in Unit 2 as of that time, nearly 900 tubes with wear 10% or greater had been detected, the tables NRC posted months thereafter show neither steam generator in Unit 2, after inspection of 100% of the tubes, with more than 565 tubes with wear 10% or greater. And the NRC tables assert at most about 5% of the tubes in Unit 2 had wear of 10% or greater, whereas SCE had said the figure was 12%.

Efforts to have NRC clarify which of the three sets of data—NRC's summary from early February, SCE's from June, or the tables posted on NRC's website in July—is correct, and describe what is the cause of the discrepancies, have been unsuccessful to date. NRC personnel responsible for the San Onofre investigation indicated they do not know.[xi] For the purposes of this analysis, the NRC data tables above are employed, resulting in the use of the smallest estimate of damaged tubes. Should either the earlier NRC or SCE summaries be more accurate than the data tables used here, the disparity with the national experience with replacement steam generators would be even greater than shown in the discussion that follows.

Steam Generator Tube Damage is Not Dramatically Different Between San Onofre Units 2 and 3

The data tables posted by NRC show similar numbers of damaged tubes in the two units. Unit 2 has 1,595 tubes with wear, Unit 3 has1,806.

Figure 2



Additionally, as will be seen in Table 3 and Figure 5, the number of steam generator tubes that have had to be plugged in each reactor is in the same approximate range: 510 in Unit 2 and 807 in Unit 3. As this report shows, these numbers are dramatically higher than the national experience. Each San Onofre unit has had to plug many times more tubes than all reactors with new steam generators in the country, over a comparable operational period, combined.

Unit 3 has a somewhat greater number of wear indications than Unit 2 (i.e., tubes showing wear on more than one location per tube) and more tubes in the higher ranges of through-wall wear. And Unit 3 has hundreds of indications of through-wall wear due to tube-to-tube rubbing whereas Unit 2 has only two.

However, tube-to-tube wear represents less than 10% of the wear indications in Unit 3. The great majority of tubes that are in trouble in either unit are experiencing tube-to-AVB wear or tube-to-tube-support-plate wear. And both reactors are faced with thousands of such wear indications.

The focus by SCE and NRC on tube-to-tube wear and the effort to thus distinguish Unit 2 from Unit 3 is misplaced. By far, the majority of tubes showing wear are evidencing it from other kinds of wear and exist in large numbers in both units.

Furthermore, and most critically, both Unit 2 and 3 suffer from the same fundamental design defect. The computer model employed by Mitsubishi, coupled with the design changes inherent in the steam generators in both San Onofre reactors, resulted in considerably higher steam flows than predicted, causing vibrations resulting in rubbing and damage to the sensitive, very thin tubes.[xii] The same fundamental problem is crippling the steam generators in both reactors.

The Steam Generator Tube Wear at San Onofre Is Far Worse Than the National Experience

The NRC's AIT report dismissed all but the tube-to-tube wear (which is primarily in Unit 3) and four wear indications at retainer bars in Unit 2 as common in new steam generators. The report stated that, with those exceptions, "*the wear indications found are similar to those found at other replacement steam generators after one cycle of operation*."[xiii] (emphasis added)

However, at other times NRC has stated the opposite. For example, the *Los Angeles Times* quoted an NRC spokesman on July 14: "Other large steam generators have exhibited wear after one cycle of operation which resulted in tube plugging...but not to the extent seen on San Onofre steam generators." Another NRC spokesperson was quoted as saying, "It is accurate to say San Onofre's demonstrated wear is unprecedented for the length of time the steam generators were used."[xiv]

Also, SCE has made assertions similar to the statement in the NRC AIT report. In a July press statement about the release of the tube wear tables, for example, SCE stated, "The majority of this wear is related to support structures. *The nature of the support structure wear is not unusual in new steam generators and is part of the equipment settling in.*"[xv] (emphasis added)

So where does the truth lie? How does San Onofre compare to the national experience with new replacement steam generators?

Efforts to get NRC to provide data supporting the claim in its AIT report have not been successful. NRC staff in Region IV responsible for the San Onofre steam generator investigation stated that they believed the number of wear indications in Unit 2 was comparable to other similar steam generators. When asked for the basis for that belief, they said they had no data but had heard it anecdotally.[xvi] Obviously, a matter important for determining whether San Onofre Unit 2 should be permitted to restart should be based on more than an anecdote.

NRC regional staff indicated they would attempt to get supporting data on the national experience from NRC headquarters. NRC headquarters staff reported NRC had not compiled any such data.[xvii] This report, in the following sections, assembles and evaluates available data on replacement steam generator tube wear and describes where San Onofre falls within that national experience.

The Only Similar Replacement Steam Generators—at Fort Calhoun—Had NO Damaged Tubes

The claim has been made that San Onofre experience is comparable to that of reactors with similar replacement steam generators. However, the only similar steam generator in the country is found at the Fort Calhoun reactor; it has the only Mitsubishi steam generators in the U.S. outside of San Onofre. The number of steam generator tubes showing any wear at Fort Calhoun after one cycle of operation: zero. The number of wear indications: zero. The number of tubes that had to be plugged due to operation: zero.

San Onofre Unit 2, by contrast, has 1,595 damaged tubes, with 4,721 wear indications, and 510 tubes plugged. That is obviously not anywhere in the range of what the only similar steam generators in the country experienced. Furthermore, an assessment of the experience of replacement steam generators of other designs yields a similar disparity, as shown below.

As of 2002, the Majority of Replacement Steam Generators Had NO Damaged Tubes

How does San Onofre compare with the experience with replacement steam generators (RSGs) more generally? A January 2002 article in *Nuclear Engineering International*, entitled "Replacement Steam Generators," answers that question:

> Of the 30 RSGs now in operation, 26 have received 100% eddy current inspection during in service inspection. Of these, 12 have experienced limited fretting wear. The other 14 RSGs have no evidence of any wear. ECT [Eddy Current Testing] indications have resulted in 23 plugged tubes out of a total population of 176,282 in the 26 inspected SGs.

Thus, when the article was written, the majority of replacement steam generators showed "no evidence of any wear." The remaining minority showed limited wear—so limited, that a total of only 23 tubes had to be plugged out of 176,282 tubes in the 26 inspected steam generators. Unit 2 of San Onofre, the reactor asserted to be far healthier than Unit 3, had plugged more than twenty times as many tubes as the 26 replacement steam generators considered in that 2002 review, combined.

Analysis of Most Current National Replacement Recirculating Steam Generator Tube Wear Data Shows San Onofre Is Far Outside the Norm

Perhaps it could be argued that the data from the 2002 article are old and more recent replacement steam generators are having more trouble than was identified a decade ago. NRC staff, in stating that the agency has no compiled data on national experience with replacement steam generators, indicated that data for each individual plant should be found in each plant's first In-Service Inspection (ISI) report submitted to the NRC after installation of the replacement steam generators. The analysis that follows is based on reviewing the data from those ISI reports and numerous related documents for replacement recirculating steam generators that are available to the public through NRC's Agencywide Documents Access and Management System (ADAMS).

NRC staff provided a list of all replacement steam generators in the country and identified which, like San Onofre, are of the recirculating type and use Inconel 690 alloy tubes, and which few (a small minority) are once-through designs or use Inconel 600.[xviii] This analysis compiles the data for all recirculating replacement steam generators using Inconel 690 in the U.S., going back to ones installed around 1998 (data for earlier years are not available in the NRC's ADAMS database.) The results are striking, and are summarized in Table 3 and Figures 3 through 5 below. In short, the damage experienced by the replacement steam generators in both San Onofre reactors is far out of the norm of other comparable nuclear plants, even when taking into account the minor variation in the number of steam generator tubes at each plant.*

* SCE has attempted to compare its steam generator experience to St. Lucie 2, in order to assert that what is happening at San Onofre is typical for new replacement steam generators and is simply a "settling in" process common to them. These assertions are clearly misplaced. St. Lucie 2's steam generators are having great trouble, and as the data show, not in any fashion the norm. Indeed, St. Lucie 1 had only 17 damaged tubes at its first ISI. The serious problems at St. Lucie 2 have resulted in its operators having to conduct a root cause analysis which concluded that "the root cause was that the U-tubes were not effectively supported during SG [steam generator] manufacture, which caused the tubes to sag into the AVBs and led to slight AVB deformation that closed the tube-to-AVB gap at specific locations. This exacerbated tube wear in those locations."[xix] NRC's Advisory Committee on Reactor Safety concluded that the St. Lucie 2 tube wear is "different than the form of degradation reported to have occurred at San Onofre. There are a number of design differences between the SGs installed at San Onofre and those at St Lucie 2."[xx] Thus the problems at St. Lucie 2 are not standard "settling in" but due to a serious manufacturing error and unrelated to San Onofre's problems. Even with all the troubles St. Lucie 2 has, it had to plug only 14 tubes, compared to the hundreds plugged at San Onofre.

Table 3

Nuclear Plant	# of Wear Indications	# of Damaged Tubes	# of Tubes Plugged	Total Tubes
South Texas 1	0	0	0	31,540
South Texas 2	0	0	0	30,340
Kewaunee	0	0	0	7,184
Shearon Harris	0	0	0	18,921
Ft. Calhoun	0	0	0	10,400
Farley 1	0	0	0	10,776
Farley 2	0	0	0	10,776
Diablo Canyon 1	1	1	0	17,776
Diablo Canyon 2	1	1	0	17,776
Comanche Peak 1	1	1	0	22,128
Braidwood 1	1	1	1	26,532
Beaver Valley 1	2	1	1	10,776
ANO 2	3	3	0	21,274
Palo Verde 1	4	4	0	25,160
Watts Bar 1	9	6	7	20,512
Sequoyah 1	11	11	11	19,932
St. Lucie 1	19	17	11	17,046
Palo Verde 2	81	48	15	25,160
Prairie Island	104	67	6	9,736
Palo Verde 3	140	68	4	25,160
Calvert Cliffs 1	189	166	0	16,942
Calvert Cliffs 2	200	170	29	16,942
Callaway	214	36	0	22,144
Salem 2	1,567	591	10	20,192
San Onofre 2	**4,721**	**1,595**	**510**	19,454
St. Lucie 2	5,994	2,174	14	17,998
San Onofre 3	**10,284**	**1806**	**807**	19,454

Figure 3

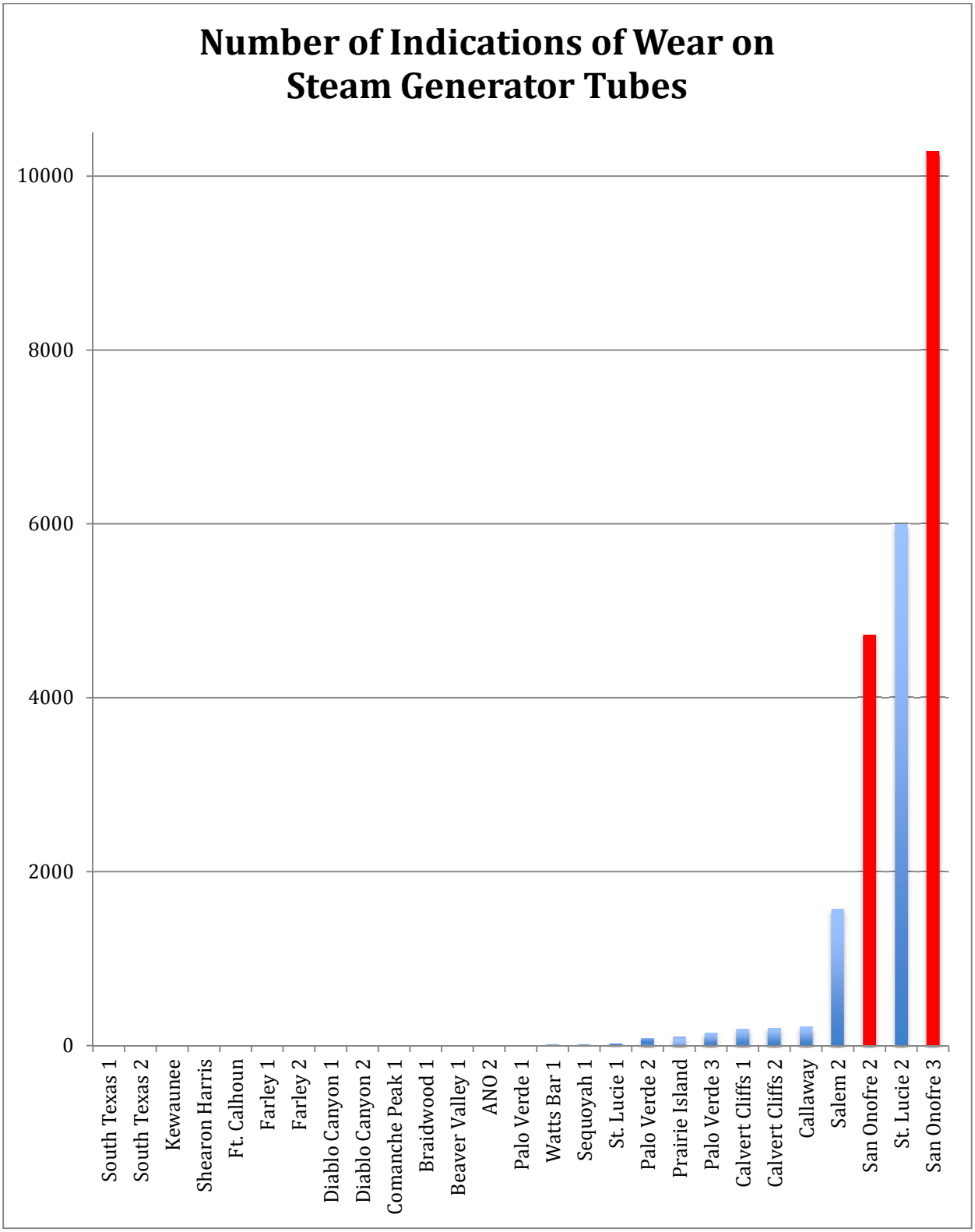

Number of Indications of Wear on Steam Generator Tubes
10000
8000
6000
4000
2000
0
South Texas 1
South Texas 2
Kewaunee
Shearon Harris
Ft. Calhoun
Farley 1
Farley 2
Diablo Canyon 1
Diablo Canyon 2
Comanche Peak 1
Braidwood 1
Beaver Valley 1
ANO 2
Palo Verde 1
Watts Bar 1
Sequoyah 1
St. Lucie 1
Palo Verde 2
Prairie Island
Palo Verde 3
Calvert Cliffs 1
Calvert Cliffs 2
Callaway
Salem 2
San Onofre 2
St. Lucie 2
San Onofre 3

Figure 4

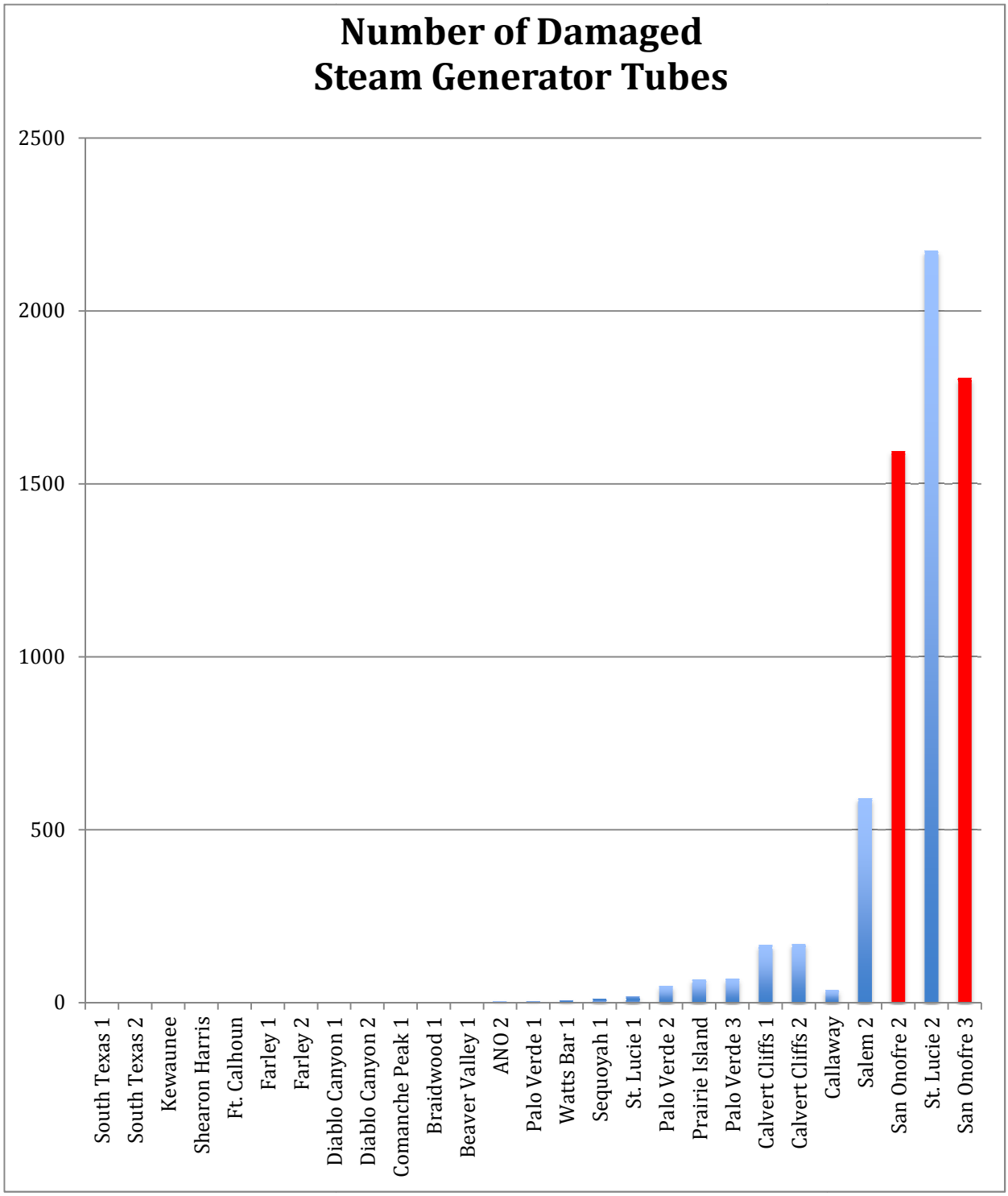
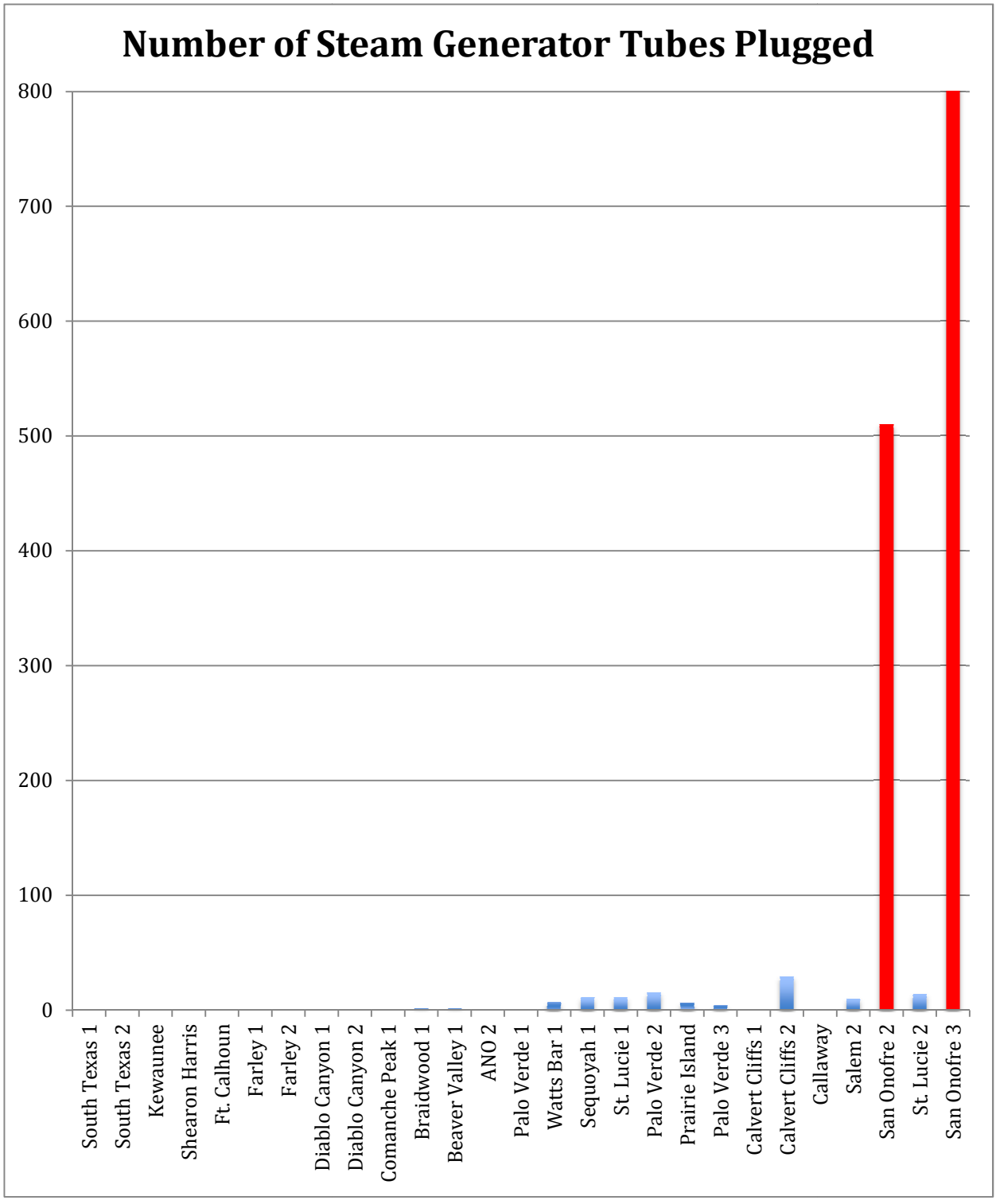

Number of Damaged
Steam Generator Tubes
2500
2000
1500
1000
500
0
South Texas 1
South Texas 2
Kewaunee
Shearon Harris
Ft. Calhoun
Farley 1
Farley 2
Diablo Canyon 1
Diablo Canyon 2
Comanche Peak 1
Braidwood 1
Beaver Valley 1
ANO 2
Palo Verde 1
Watts Bar 1
Sequoyah 1
St. Lucie 1
Palo Verde 2
Prairie Island
Palo Verde 3
Calvert Cliffs 1
Calvert Cliffs 2
Callaway
Salem 2
San Onofre 2
St. Lucie 2
San Onofre 3

Figure 5


Number of Steam Generator Tubes Plugged
800
700
600
500
400
300
200
100
0
South Texas 1
South Texas 2
Kewaunee
Shearon Harris
Ft. Calhoun
Farley 1
Farley 2
Diablo Canyon 1
Diablo Canyon 2
Comanche Peak 1
Braidwood 1
Beaver Valley 1
ANO 2
Palo Verde 1
Watts Bar 1
Sequoyah 1
St. Lucie 1
Palo Verde 2
Prairie Island
Palo Verde 3
Calvert Cliffs 1
Calvert Cliffs 2
Callaway
Salem 2
San Onofre 2
St. Lucie 2
San Onofre 3

The Damage at Both San Onofre Units Greatly Exceeds That at Typical Reactors

The data for replacement recirculating steam generators nationally indicate:

- **The median number of steam generator tubes showing wear after one cycle of operation nationally is—FOUR. San Onofre Unit 2 had 1595 damaged tubes, approximately 400 times the median; San Onofre Unit 3 had 1806.**

- **The median number of wear indications on steam generator tubes after one cycle of operation is—FOUR. San Onofre Unit 2 had 4721, greater than a thousand times more. San Onofre Unit 3 had 10,284.**

- **The median number of steam generator tubes that were plugged after one cycle of operation is—ZERO. San Onofre Unit 2 had 510; Unit 3 had 807.[xxi]**

CONCLUSION

The conclusion is clear: San Onofre Unit 2 and Unit 3 are both very ill nuclear plants. Unit 3's fever is slightly higher, but both are in serious trouble. What they are experiencing is not just normal wear due to "settling in" purportedly experienced with similar replacement steam generators. They are far, far outside the norm of national experience. And Unit 2 cannot be said to be acceptable for restart, any more than Unit 3. Unit 2 has hundreds of times more bad tubes and a thousand times more indications of wear on those tubes than the typical reactor in the country with a new steam generator, and nearly five times as many plugged tubes as the rest of the replacement steam generators, over a comparable operating period, in the country combined. Restarting either San Onofre reactor with crippled steam generators that have not been repaired or replaced would be a questionable undertaking at best.

ENDNOTES

[i] Edison International, "Southern California Edison Announces Intent to Downsize Staffing at San Onofre Nuclear Generating Station," August 20, 2012, http://www.edison.com/pressroom/pr.asp?id=7986, last accessed September 9, 2012.

[ii] NRC Draft Regulatory Guide DG-1074, *Steam Generator Tube Integrity,* Dec 1998, ML003739223.

[iii] http://www.nrc.gov/info-finder/reactor/San Onofre/San Onofre-steam-generator-internal-diagram.pdf last accessed September 9, 2012.

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[iv] There is a fifth potential damage mechanism, damage by foreign object (i.e., loose parts). Only two tubes at SAN ONOFRE showed this type of damage.

[v] Kenneth Karwoski, Leslie Miller, and Nadiyah Morgan, U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, "Regulatory Perspective on Steam Generator Tube Operating Experience," in *Ageing Issues in Nuclear Power Plants* (undated).

[vi] NRC AIT report, p. 3-4.

[vii] Esmeralda Bermudez, "San Onofre nuclear power plant incidents draw attention: A radiation leak, the discovery of tube damage and a worker falling into a reactor pool all happened within days of one another," *Los Angeles Times,* February 5, 2012. See also the *Wall Street Journal*,. Rebecca Smith, "Worn Pipes Shut California Reactors," February 4, 2012.

[viii] The NRC meeting was videotaped and the answers by the senior SCE executive to questions about the tube data can be viewed at http://www.youtube.com/watch?v=VPxDYWa0b8o and http://www.youtube.com/watch?v=8tCQWeEauHo. last accessed 9/6/12.
The question asked was for the number of tubes in each SAN ONOFRE Unit that had greater than 10% through-wall wear, and also the total number of tubes showing any indication of wear. SCE provided data about the former.

[ix] http://www.nrc.gov/info-finder/reactor/songs/songs-unit-2-steam-generator-tube-wear-data.pdf last accessed September 9, 2012

[x] http://www.nrc.gov/info-finder/reactor/songs/songs-unit-3-steam-generator-tube-wear-data.pdf last accessed September 9, 2012.

[xi] email, Hirsch to Elmo Collins, July 13, 2012; response July 17; teleon with Tom Blount, Ryan Lantz, Michael Bloodgood, July 18.

[xii] NRC AIT report, pp. i, 46-56

[xiii] NRC AIT report, p. 10

[xiv] *North County Times*, "SAN ONOFRE: Rate of tube wear at nuke plant 'unprecedented,' NRC says," April 4, 2012

[xv] SCE press release, "Southern California Edison Releases Steam Generator Tube Wear Data," July 13, 2012

[xvi] Conference call July 18, *supra.*

[xvii] emails from Tom Blount, June 17, 2012; from Ryan Lantz, July 31; from Kenneth Karwoski, August 7.

[xviii] August 7 and 9, 2012, emails from Ryan Lantz, Chief, Reactor Projects Branch D, NRC Region IV.

[xix] Advisory Committee for Reactor Safeguards, NRC, July 23, 2012, letter to R.W. Borchardt, Executive Director for Operations, NRC, "SUBJECT: Final Safety Evaluation Report Associated with the Florida Power and Light St. Lucie, Unit 2, License Amendment Request for an Extended Power Uprate," p. 3

[xx] *ibid.*, p. 4

[xxi] Arnie Gundersen, in a July 2012 report, "San Onofre's Steam Generators: Significantly Worse Than All Others Nationwide," previously pointed out the high number of plugged tubes at San Onofre compared to plugging rates nationally, based on data in a 2006 NRC report. SCE tried to dismiss the significance of those findings by saying the data were old and that many tubes plugged at San Onofre were plugged preventively. The present study examines more current data, finding the same trend for plugged tubes, but also determines that this is not due to preventive plugging, since the number of damaged tubes and wear indications on tubes at San Onofre far exceeds the national median.

APPENDIX A

PLANT-BY-PLANT DESCRIPTIONS OF REPLACEMENT RECIRCULATING STEAM GENERATOR TUBE WEAR EXPERIENCE

A) PLANT-BY-PLANT DESCRIPTIONS OF REPLACEMENT RECIRCULATING STEAM GENERATOR TUBE WEAR EXPERIENCE

Arkansas Nuclear One, Unit 2: 2 replacement steam generators installed in 2000.
0 tubes plugged during first InService Inspection (ISI) of the steam generator tubes after installation, 1 tube plugged prior to service.

3 wear indications in 3 tubes identified during 1st ISI. Source: April 2002 ISI report, NRC Agencywide Documents Access and Management System (ADAMS) Accession Number ML031080421, pg 4 of PDF/pg 2 of attachment & pg 6 of PDF/pg 4 of attachment. (Note, hereafter NRC ADAMS Accession numbers will be given just by their ML #. Also note that the PDF page number is often different from the document's page number due to how pages are numbered in the cited documents). See also ML031820241, the 2003 NRC review of the licensee's ISI report.

The 2 replacement steam generators are Westinghouse model Delta 109,
pg 3 of PDF/pg 1 of attachment of April 2002 tube inspection ML031080421.

The total number of tubes is not explicitly stated in those reports but it is stated that 100% of unplugged tubes were tested with the bobbin coil according to the 2003 NRC review ML031820241, pg 3 of PDF/unnumbered in report. Pg 4 of PDF/pg 2 of the April 2002 tube inspection ML031080421 states that 10,637 tubes were inspected for SG A and 10,636 were tubes were tested in SG B, which had one tube plugged by the manufacturer prior to installation, for a total of 21, 273 inspected, and 21,274 total when the pre-installation plugged tube is included.

Beaver Valley, Unit 1 in Pennsylvania: 3 replacement steam generators 2006.
1 tube plugged during first ISI after installation.

1 tube with 1 wear indication of 29%, believed to have been caused by a burr left from the manufacturing process. Source: 2007 ISI report ML080800448, see the table in pgs 4-6 of PDF, pgs 3-5 of the report, source for explanation is on pg 7 of PDF/pg 6 of attachment 1

The 3 replacement SGs are Westinghouse Model 54s, manufactured by ENSA in Spain, and containing 3,592 tubes each according to the preservice inspection report ML061990398, pg 21 of the PDF/pg 1 of Appendix 2.

Braidwood, Unit 1: 4 replacement steam generators 1998.
1 tube plugged during first ISI, 3 tubes plugged prior to service.

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One tube with one wear indication as stated in the 2000 tube inspection report ML010930262, pgs 8-10 of PDF/pg 7-9 of report. The single tube with one wear indication, that was subsequently plugged, had less than 10% through wall (TW) wear according to the 2000 steam generator inspection report ML010930262, pg 10 of PDF/pg 9 of report, this tube was preventively plugged (pgs 4-5 of PDF/pgs 3-4 of report).

The 4 replacement steam generators are Babcock and Wilcox models with 6,633 tubes per generator, see pg 4 of PDF/pg 3 of report

Callaway, Unit 1 in Missouri: 4 replacement steam generators 2005
0 tubes plugged during first ISI, 1 tube plugged prior to service.

214 wear indications on 36 tubes. The greatest through wall wear was 1 indication of 13%, the least was 1%. See Table 2, Summary of Wear Indications, pg 5-11 of PDF/pg 2-8 of attachment 1of the 2007 ISI, ML 073050323.

The steam generators have 5536 tubes each, SG A had one tube plugged prior to service for a total of 5,535 inspected and operational tubes. (pg 5 of PDF/pg 2 of report).

Calvert Cliffs, Unit 1 in Maryland: 2 replacement steam generators in 2002.
0 tubes plugged.

189 wear indications on 166 tubes. The great majority had wear under 10% and only two had wear equal or greater than 20%, at 20% and 22%, according to the 2004 tube inspection report ML050610714, attachment 1, pgs 4-8 of PDF/pgs 1-5 of attachment.

Both Babcock & Wicox replacement steam generators have 8,471 tubes each. See 2005 NRC review ML051440076, pg 3 of PDF/unnumbered in document.

Calvert Cliffs, Unit 2 in Maryland: 2 replacement steam generators in 2003.
29 tubes plugged in first ISI, 3 tubes plugged prior to service.

Of the 29 tubes plugged due to the 2005 inspection, 5 had wear indications and the other 24 were plugged as a precautionary measure due to a possible loose part in an area which cannot be visually inspected. See 2005 memo of NRC-licensee conference call, ML052410150, pgs 1-2 of PDF & memo.

All told, there were 200 wear indications on 170 tubes, with the majority having wear under 10%. 8 tubes had wear 20% or greater, with the highest indication being one tube with 25% wear. See 2005 tube inspection report ML060610081, pg 4-9 of PDF/1-6 of attachment.

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The replacement steam generators have 8471 tubes each, with 3 plugged prior to service, according to the cover letter to the tube inspection report ML060610081, pg 1 of PDF/pg 1of letter, and are described as Babcock & Wilcox design and manufacture in 2005 memo ML052410150, pg 1 of PDF & memo.

Comanche Peak, Unit 1 in Texas: 4 replacement steam generators in 2007.
0 tubes plugged during first ISI, 1 tube plugged during manufacture.

1 wear indication on 1 tube, depth ,10% TW. See ISI report 2008 pg 7 of PDF/pg 5 of ISI report ML090300118, pg 9 of PDF/pg 7 of report.

The steam generators are Westinghouse Model Delta 76s with 5,532 tubes per steam generator, reference steam generator tube inspection 2008 ML090300118, pg 3 of PDF/pg 1 of report.

Diablo Canyon, Unit 1 in California: 4 replacement steam generators in 2009
0 tubes plugged.

1 wear indication on 1 tube, at 5% TW. See 2010 steam generator inspection report ML111160101, pg 3,4, and 11 of PDF/pg 2,3, and 10 of enclosure. This one wear indication was the first report of AVB wear in Westinghouse model 54s, leading PG&E to inform the NRC on Oct 15,2010 (pg 4 of PDF/pg 3 of enclosure for ML111160101).

The replacement steam generators are Westinghouse Model Delta 54s and each one contains 4,444 tubes, according to the 2012 Nuclear Regulatory Commission review ML120740373, pg 2 of PDF & review and the 2010 steam generator inspection report ML111160101, pg 2 of PDF/pg 1 of report.

Diablo Canyon, Unit 2 in California: 4 replacement steam generators in 2008
0 tubes plugged during first ISI, 3 tubes plugged prior to service.

1 wear indication on 1 tube, see 2009 steam generator inspection ML101330269, pg 3 of PDF/pg 2 of enclosure.

The replacement steam generators are Westinghouse Model Delta 54s with 4,444 tubes each, according to pg 2 of PDF/pg 1 of enclosure above.

Farley, Unit 1 in Alabama: 3 replacement steam generators in 2000.
0 tubes plugged.

NO wear indications, see Fall 2001 ISI report ML020300072, pg 12 of PDF/unnumbered in report and 2002 supplemental information ML021960109, pg 4 of PDF/pg 2 of letter.

Westinghouse model 54F steam generators, 2001 inservice inspection ML020300072, pg 12 of PDF/unnumbered in report.

3,592 tubes in each of the 3 replacement steam generators, as stated in 2003 NRC review ML031110259.

Farley, Unit 2 in Alabama: 3 replacement steam generators in 2001.
0 tubes plugged.

NO wear indications. See Fall 2002 ISI report ML030300235 pg 12 of PDF/unnumbered in report, Sept/Oct 2002 inspection.

Westinghouse model 54F steam generators with 3,592 tubes per steam generator; see 2008 NRC Review ML083100232, pg 3 of PDF/unnumbered in enclosure.

Fort Calhoun in Nebraska: 2 replacement steam generators in 2006.
0 tubes plugged in first ISI, 1 tube plugged prior to service.

NO wear indications. See 2008 eddy current test ML083440629, pg 3 of PDF/pg 2 of attachment, pgs 9-11 of PDF/pgs 8-10.

Both Mitsubishi MHI-49TT-1 steam generators have 5,200 tubes each. See steam generator tube inspection review ML093000157, pg 2 of PDF/unnumbered in report.

Kewaunee in Wisconsin: 2 replacement steam generators in 2001.
0 tubes plugged.

NO wear indications. See 2003 annual report ML0460650370, pg 6 of PDF/pg 2 of report, and 2003 ISI ML032250165 pgs 156 &157 of PDF.

Westinghouse model 54Fs with 3,592 tubes in each steam generator, from April 2003 steam generator inspection ML032250165, pg 155 of PDF/pg 1 of attachment 8.

Palo Verde, Unit 1 in Arizona: 2 replacement steam generators 2005.
0 tubes plugged during first ISI, 116 tubes plugged prior to service.

4 wear indications on 4 tubes, <20% TW. See 2007 ISI report ML080090193, pg 9 of PDF/unnumbered in report, pgs 14-17 of PDF/unnumbered in report, Appendices B & C.

Palo Verde Units 1, 2, and 3 have essentially the same design for their replacement steam generators. They were all "designed by Asea Brown Boveri/Combustion Engineering (ABB/CE) (now Westinghouse) and manufactured by Ansaldo, and are considered a modified System 80 design (no specific model number)." There are 12,580 tubes for each steam generator; see ML082890538, pg 3 of PDF, pg 1 of enclosure.

Palo Verde, Unit 2 in Arizona: 2 replacement steam generators in 2003.
15 plugged during first ISI, 24 plugged prior to service.

81 wear indications on 48 tubes. See the data tables in 2005 tube ISI report ML053130156, pg 11 of PDF/unnumbered in report, Table 2 Indication Summary, pgs. 29-38 of PDF, Appendices C & D of report.

[Dents found were pre-existing before operation and not due to operational wear. According to the supplement to the steam generator report ML 060890657, pg 10 of PDF/pg 8 of enclosure, the dents were present in the preservice inspection, 100% of the dents > or equal to 0.5 volts were inspected in 2005 and none exhibited any change between the preservice inspection and the 2005 inspection. Regarding the dents that were plugged, these were plugged preventively though they hadn't changed any either, reference pg 3 of PDF/pg 1 of enclosure.]

There are 12,580 tubes per steam generator.

Palo Verde, Unit 3 in Arizona: 2 replacement steam generators in 2007.
4 tubes plugged during first ISI, 118 plugged prior to service.

140 wear indications on 68 tubes, according to Palo Verde 3 ISI report ML093310442, pg 10 of PDF/ pg 8 of report, Appendices B & C, pgs 15-22 of PDF/pgs 13-20.

Steam generators have 12,580 tubes in each. NRC review ML112060490, pg 2 of PDF/unnumbered in review.

Prairie Island, Unit 1 in Minnesota: 2 replacement steam generators in 2004.
6 tubes plugged during first ISI.

104 wear indications in 67 tubes, 2006 teleconference re: tube inspection ML061680005, pg 4 of PDF/pg 2 of report.

Framatome Model 56/19s with 4,868 tubes each, according to revision to the ISI ML101530111, pg 9 of PDF/pg 1 of enclosure 2.

Saint Lucie, Unit 1 in Florida: 2 replacement steam generators in 1997.
11 tubes plugged preventively during first ISI.

19 wear indications on 17 tubes, 1999 ISI, ML 003684169, pgs 4-6 of PDF/unnumbered in report.

Each Babcock and Wilcox advanced series pressurized water reactor steam generator has 8,523 tubes, according to 2008 NRC review ML100960626, p. 2 of PDF/unnumbered in review.

Saint Lucie, Unit 2 in Florida: 2 replacement steam generators in 2008.
14 tubes plugged during first ISI.

5,994 wear indications on 2,174 tubes. See 2009 tube inspection ML093230226, pg 13-115 of PDF/pgs 2-64 of attachment 1, pgs 2-40 of attachment 2.

Only 2 indications exceeded 30% wear, no indications over 35%; 2009 tube inspection ML093230226, pg 14 of PDF/pg 3 of Attachment 1, pg 78 of PDF/pg 3 of Attachment 2

Steam generators are Areva-NP Model 86/19TIs, 2009 tube inspection ML093230226, pg 2 of PDF/pg 1 of enclosure and have 8999 tubes each, according to the NRC review of 2009 tube inspection ML03340040, pg 2 of PDF/pg 1 of enclosure.

Salem, Unit 2 in New Jersey: 4 replacement steam generators in 2008.
10 tubes plugged during first ISI.

1,567 wear indications on 591 tubes, see 2009 steam generator tube inspection report ML101250176, pg 10 of PDF/pg 1 of attachment 3.

The steam generators are Areva Mod 61/19Ts with 5,048 tubes per steam generator, 2009 tube inspection ML101250176, pg 4 of PDF/pg 1 of attachment 1.

San Onofre 2 in California: 2 replacement steam generators in 2010.
510 tubes plugged during first ISI.

4721 wear indications on 1,595 tubes. See NRC tables in main body of report.

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Mitsubishi steam generators with 9,727 tubes per generator. See Southern California Edison, "San Onofre Nuclear Generating Station Confirmatory Action Letter Fact Sheet," last updated on 6/13/2012

San Onofre 3 in California; 2 replacement steam generators in 2011.
807 tubes plugged within one year of installation (tube failure during operation led to shutdown and inspection prior to normal ISI.)

10,284 wear indications on 1806 tubes.

Mitsubishi steam generators with 9,727 tubes per generator, same as Unit 2.

Sequoyah, Unit 1 in Tennessee: 4 replacement steam generators in 2003.
11 tubes plugged during first ISI, 20 plugged prior to service.

11 wear indications on 11 tubes; see 2004 ISI report ML050550413, pg 55 of PDF/unnumbered Appendix A.

All 11 tubes plugged as a result of this inspection were preventively plugged with TW% ranging from 8-17% according to Sequoyah 1 steam generator inspection ML053050386, pg 3 of PDF/unnumbered in report.

Model 57AG steam generators by Doosan, 4,983 tubes per SG. 2006 NRC review ML060950510, p. 4 of PDF/unnumbered in review.

Shearon Harris in North Carolina: 3 replacement steam generators in 2001
0 tubes plugged during first ISI, 2 tubes plugged during manufacture.

0 wear indications, 2003 ISI ML032680868, pg 7 of PDF/unnumbered report supplemental information ML041120371 pg 4 of PDF/pg 2 of attachment, pg 7 of PDF/pg 5 of attachment, 2003 tube test ML041320496 pg 5 of PDF/pg 2 of attachment 1.

Westinghouse Model Delta 75 replacement steam generators, 6,307 tubes in each steam generator, 2003 tube test ML041320496, pg 4 of PDF/pg 1 of attachment 1, and pg 3 of PDF, pg 1 of attachment,, ML042360545.

South Texas Project, Unit 1: 4 replacement steam generators in 2000.
0 tubes plugged during first ISI, 108 tubes pre-service.

0 wear indications, see 2001 ISI ML020390361, pg 12 of PDF/pg 7 of report.

Steam generators are Westinghouse Model Delta 94s with 7,885 tubes per steam generator, pg 6 of PDF/pg 1 of above report.

South Texas Project, Unit 2: 4 replacement steam generators in 2002.
0 tubes plugged during first ISI, 6 tubes plugged pre-service.

0 wear indications, 2004 ISI ML041730355, pg 13 of PDF/pg 8 of report, pg 14 of PDF/pg 9 of report.

Steam generators are Westinghouse Delta 94s with 7,585 tubes each, see South Texas Project 2 pre-service inspection ML030710429 pg 6 of PDF/pg 1 of report

Watts Bar, Unit 1 in Tennessee: 4 replacement steam generators in 2006.
7 tubes plugged during first ISI, 2 plugged prior to service.

9 wear indications on 6 tubes. All the tubes with any wear indications were plugged preventively. One tube with a tube sheet bulge detected prior to service was also preventively plugged which is why there were 7 tubes plugged and only 6 tubes with wear indications. The TW% detected ranged from 7% to 13%, well under the plugging limit of 40% TW. Source is 2008 tube inspection ML082600068, pg 5 of PDF/pg E-3 of report, pg 6 of PDF/pg E-4 of report.

Westinghouse designed the replacement steam generators, and Doosan Heavy Industry and Construction manufactured them. There are 5,128 tubes per steam generator, supplemental information ML090960558, pgs 4 and 9 of PDF/pgs 2 and 7 of enclosure.

APPENDIX B

NOTES ON SOURCES AND METHODS

NOTES ON SOURCES AND METHODS

Licensees are generally required to conduct, at the first shutdown for reactor refueling after installation of replacement steam generators, inspection of 100% of the steam generator tubes. That inspection is typically performed using eddy current testing (ECT). If signals from the ECT suggest a potential problem, frequently follow-on tests are performed to ascertain if indeed there is wear.

The licensee is required to submit to the NRC within a set period after completion a report on the results of the steam generator inspection conducted during the In-Service Inspection (ISI). NRC staff review the ISI report, and will occasionally submit requests for additional information to the licensee. Thus, the primary records related to the number of wear indications found during an ISI, the number of tubes experiencing wear, and the number of tubes plugged during the ISI, are: the ISI report itself, requests for additional information by NRC and responses thereto by the licensee, and correspondence by NRC concluding its review. When there is a significant problem identified, NRC may initiate a meeting or conference call with the licensee and a memorandum may result therefrom. Lastly, the pre-service inspection report—after installation but before operation with replacement steam generators—may also provide useful information about steam generator design and dings, dents, and manufacturing burnishing marks that pre-date operation and thus, if noted thereafter, are not due to operational wear.

Unfortunately, the ISI reports are not always entirely consistent in form and content from one licensee to another. Sometimes a summary is provided quantifying the total numbers of tubes and indications of wear that observed; other times one has to tabulate the figures by hand. Additionally, definitions are not always clear or consistent. For example, guidance from the Electric Power Research Institute (EPRI) defines wear as "the loss of tube material caused by excessive rubbing of the tube against its support structure, a loose part, or another tube," but also uses the term "degradation" as wear of greater than 20% or greater through wall (TW). ML ML080450582. NRC draft guidance on steam generator tube integrity, by contrast, defines a degraded tube as a tube showing any wear below the applicable plugging limit. ML003739223. To avoid any question, data for wear rather than degradation were relied upon for this report.

Furthermore, the raw data were reviewed to confirm, for example, that all measurable wear was in fact reported, not just wear below a threshold such as 20% TW. This was readily determinable for virtually all of the plants, as they reported wear down to a few % TW, and for those that reported zero wear, statements in the ISI or NRC communications generally made clear that this indeed meant no measurable wear.

In some cases, a few tubes were identified in the ISI reports as being involved with possible loose parts in the steam generators. Where damage to the tubes was indicated by %TW wear indications, they were generally included; where it appears that subsequent evaluation had determined no TW damage, they were not.

In some cases, tubes were plugged by the manufacturer or otherwise prior to operation. In Appendix A, tubes plugged prior to operation and tubes plugged thereafter at the time of the first ISI are both identified. Table 3 and Figures 3-5 of the main body of the report, however, are

worn tubes, i.e., those damaged by steam generator operation. The reports also generally identified dents, dings, manufacturing burnishing marks and the like that pre-dated operation. These also were not included here, as the analysis is on wear due to operations.

It is possible that ambiguities remain in the ISI reports that were not fully resolvable by reviewing associated documents such as correspondence with NRC, but it appears that they would not have any substantive effect on the fundamental conclusions of this report. One take-away suggestion from this analysis, however, is that greater uniformity and clarity in ISI reports would be helpful in analyzing national trends.

APPENDIX C

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APPENDIX D

ABOUT THE AUTHORS

DANIEL HIRSCH is President of the Committee to Bridge the Gap and has been associated with it since 1970. He is also a Lecturer at the University of California, Santa Cruz, where he teaches courses on Nuclear Policy and Environment Policy. He is the former Director of the Adlai E. Stevenson Program on Nuclear Policy at UCSC.

DORAH ROSEN is a Research Associate with the Committee to Bridge the Gap. She had primary responsibility for acquiring and compiling the steam generator tube data from licensee ISI reports and related documentation.

DALE BRIDENBAUGH is a retired Nuclear Engineer with forty years experience with the commercial nuclear industry. He was a nuclear engineer and manager for General Electric's Nuclear Division, spending twenty years with GE. In 1976, he and two colleagues resigned from GE and testified before Congress regarding their concerns that safety issues with the GE Mark I containment structures were being ignored. The subsequent Fukushima nuclear accident tragically proved them correct. After their resignation from GE, the three nuclear engineers formed MHB Associates, which for more than twenty years performed studies on the operation, safety and costs of nuclear plants for state agencies and foreign countries.

THE COMMITTEE TO BRIDGE THE GAP is a forty-two-year-old non-profit public policy organization focused on issues of nuclear safety, proliferation, waste disposal, and terrorism.

www.committeetobridgethegap.org

(831) 336-8003

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From: Torgen Johnson
Sent: Wednesday, September 19, 2012 12:18 PM
To: Mercedes Martin
Subject: Council Packet information for September 24th Del Mar City Council Meeting
Importance: High

Hello Mercedes,

Please include this email in the Council packet as well.

A knowledgeable Edison employee-whistleblower Dan Johnson from San Onofre has alerted us that the Flow Induced Vibration (FIV) responsible for the rapid degradation of the steam generator tubes in Reactors #2 and #3, has a corresponding impact on the nuclear reactor core that causes nuclear fuel cladding failure and breeches. It happened in the failure of the now decommissioned Reactor #1, and Dan Johnson claims it will happen again within months of a restart of Reactor #2.

Widespread industry reporting of this FIV/nuclear fuel failure problem is well documented. The whistleblower said that the steam generator failures in reactor #1 in the late 1980s, and the reactor's decommission in the early 1990s was a radiological mess that was under-reported by Edison to the NRC. He said the same FIV destruction of the steam generator tubes and resulting reactor core fuel failures are most likely taking place at the plant now.

Edison is again not revealing the seriousness of the problem but this time the NRC appears to be complicit in an attempt to delay investigation and cover up their lack of proper oversight of the recent $670million steam generator replacement project. Edison is positioning itself for restart of Reactor #2 at reduced power to avoid a mandatory CPUC Order Instituting Investigation, OII, and resulting refunds to ratepayers. By restarting a damaged nuclear reactor without identifying the root cause, Edison is placing profit before regional public safety.

Torgen Johnson
Solana Beach, CA
858 342-1664

Corrupt California PUC Chair Peevy And Utility Controlled Commission Delays Full Probe Of Southern California Edison San Onofre Nuke Plant Cover-up

Financial probe delayed at damaged Cal nuke plant

MICHAEL R. BLOOD, Associated Press

http://www.sfgate.com/default/article/Financial-probe-delayed-at-damaged-Cal-nuke-plant-3757714.php

Updated 05:13 p.m., Thursday, August 2, 2012

LOS ANGELES (AP) — The head of the California Public Utilities Commission recommended Thursday that the agency delay for several months an investigation into soaring costs tied to the damaged San Onofre nuclear power plant.
At issue is who is going to pay a bill that has reached $165 million so far for repairs, inspections and replacement electricity for a plant with crippled steam generators. San Onofre hasn't produced power since Jan. 31 and it's not clear when, or if, the twin reactors will return to service.

Meeting in San Francisco, the commission postponed for the second time voting on a proposed order requiring owners Southern California Edison and San Diego Gas & Electric to disclose the potential economic hit for ratepayers from the long-running shutdown.

According to a statement, commission President Michael R. Peevey recommended the panel wait until November to initiate an investigation, after Edison is required to notify the agency if a plant has been out of service for nine months.
He said the agency is working on options for power supplies for 2013, in the event the plant remains offline into next summer.

As costs and questions about the plant's future mount, consumer and environmental advocates have been pressuring the agency to move quickly. The commission determines how much utilities can charge homeowners and businesses for electricity.

The state Division of Ratepayer Advocates sent a letter to the agency Wednesday saying only the commission "can investigate whether SCE acted reasonably, how the cost responsibility should be resolved and whether future investments to repair or replace the steam generators are justified."
The letter was co-signed by executives from The Utility Reform Network, the Alliance for Nuclear Responsibility, Friends of the Earth and the Center for Energy Efficiency and Renewable Technologies.
"We think customers shouldn't be paying a dime for units that don't work because of mistakes by the utility," said Matthew Freedman, staff attorney for The Utility Reform Network. The delays are "a discouraging sign about their willingness to hold Edison accountable."
Freedman said the investigation being proposed by Peevey would be narrower in scope than the draft order, which could be revived at the commission's Aug. 23 meeting.

The trouble began to unfold in January, when the Unit 3 reactor was shut down as a precaution after a generator tube break. Traces of radiation escaped at the time, but officials said there was no danger to workers or neighbors. Unit 2 had been taken offline earlier that month for maintenance, but investigators later found unexpected wear on scores of tubes that carry radioactive water inside both units.

Gradual wear is common in such tubing, but the rate of erosion at San Onofre startled officials since the equipment is relatively new. The four generators — two in each plant — were replaced in a $670 million overhaul and began operating in April 2010 in Unit 2 and February 2011 in Unit 3.

Overall, investigators found wear from friction and vibration in 15,000 places, in varying degrees, in 3,401 tubes inside the four generators.

A three-month federal probe blamed a botched computer analysis for generator design flaws that ultimately resulted in heavy wear to the alloy tubing. Edison has been trying to determine how to correct the problem, while environmental activists have depicted the plant as a disaster in the making.

The generators, which resemble massive steel fire hydrants, are one of the central pieces of equipment in a nuclear plant. At San Onofre, each one stands 65 feet high, weighs 1.3 million pounds, with 9,727 U-shaped tubes inside, each three-quarters of an inch in diameter.

If a tube breaks there is the potential that radioactivity could escape into the atmosphere, and serious leaks also can drain cooling water from a reactor.

The steam generators were manufactured by Japan-based Mitsubishi Heavy Industries.

The plant is owned by SCE, San Diego Gas & Electric and the city of Riverside. The Unit 1 reactor operated from 1968 to 1992, when it was shut down and dismantled.

SCE is part of Edison International, and San Diego Gas & Electric is part of Sempra Energy.

CPUC Stuck In Culture of Corruption

OCT. 17, 2011

http://www.calwatchdog.com/2011/10/17/cpuc-stuck-in-culture-of-corruption/

It is shameful to punish the puppy when the pack leader is at fault. It is no different in the workplace and the corporate world – failure and corruption are usually the fault of the top dogs.

Two recent examples are Pacific Gas & Electric and the California Public Utility Commission. The utility company and the state regulator have talented employees, but problematic corporate big-dogs.

In fact, the entire utility regulatory system in California needs a new pack leader.

The first in line for the overhaul is Michael Peevey, the president of the CPUC since 2002. Politically well connected, Peevey is a former senior executive with Southern California Edison. His wife is State Sen. Carol Liu, D-La Canada-Flintridge.

It was on Peevey's watch that a succession of deadly events took place, including the horrific 2010 San Bruno gas pipeline explosion, which killed eight, injured more than 100 and destroyed 38 homes (pictured at right). Peevey was CPUC President when a gas line exploded in Rancho Cordova on Christmas Eve 2008, destroying a home and killing the occupant, as well as the very recent September pipeline explosion at a Cupertino condominium, which did not receive much press coverage.

After years of approving rate increases earmarked for the San Bruno pipeline upgrades, the CPUC never followed up to make sure that PG&E actually did the work. Instead, PG&E pocketed the rate increases, shined on the pipeline upgrades and kept going back to the CPUC trough for additional rate increase approvals.

'Culture of Complacency'

Post-explosion investigations by the National Transportation Safety Board, as well as by the CPUC, found irrefutable evidence of wanton negligence by PG&E – but also by the CPUC. Peevey's arrogance during the investigations was staggering. He even admitted a "culture of complacency," and a pattern of just "checking the boxes" by his own utility regulatory agency.

But Peevey still has his job. In fact, no one has paid for the gross negligence and lack of oversight by the CPUC and PG&E other than ratepayers and innocent San Bruno and Rancho Cordova residents.

PG&E received a $26 million fine for the Rancho Cordova explosion. For a utility company worth nearly $15 billion, that's like fining a guy who makes $50,000 a year, $5.00.

The next question on ratepayers' minds is: Who is going to pay for the fines, repairs and upgrades to PG&E's pipelines? Ratepayers have already been charged several times over. Perhaps if PG&E's shareholders had to reach into their own pockets to foot the bill, they would pay closer attention to the unholy relationship between PG&E and the CPUC.

Who Audits The CPUC?

The Senate Office of Oversight and Outcomes, a committee created in 2008 by Sen. Pres. Pro Tem Darrell Steinberg, D-Sacramento, has done great work. But thus far it has not reeled in the CPUC. The committee has done a good job exposing the CPUC and telecommunications industry issues, but needs to take a close look at the tainted relationship between the CPUC and PG&E. Then the Legislature needs to act.

The San Francisco Examiner did a recent analysis of utility rate-hike documents. It found, "PG&E customers had been charged multiple times for at least two dozen natural-gas improvement projects that had not been implemented. Customers were asked to pay more than $320 million for the projects in 2008, and then were asked to pay another $313 million for those same projects in 2011."

Investments

PG&E has an 11.35 percent rate of return. "Pacific Gas & Electric enjoys a near monopoly over 70,000 square miles of Northern and Central California, with 15 million customers," the New York Times recently reported. "The California Public Utilities Commission allows the company to charge rates 30 percent higher than the national average. As a regulated utility, the publicly traded company's shareholders benefit from a guaranteed 11.35 percent return on equity, which is also above the industry average of about 10.5 percent."

But when PG&E is derelict, sloppy or just lax, people die and ratepayers get handed the bill. Without competition, PG&E and the CPUC together appear to decide what policies to follow. The tail is wagging the dog.

Perhaps it is time for the Legislature to review PG&E's franchise, along with the CPUC's Rules of Practice and Procedure.

Passing Along the Accountability

The estimates PG&E has provided for the San Bruno pipeline repairs and updates are only for one phase of the improvement plan — approximately $2.2 billion. The cost increase to ratepayers is estimated to be about 4 percent, or about $1.93 each month to the average PG&E bill.

And, if PG&E's multi-year pipeline modernization plan, recently filed with the CPUC, receives approval, business customers will be facing outrageous rate hikes.

It is ironic that not only is the CPUC dishing out the fines to PG&E for the San Bruno explosion, but the regulator, which failed to prevent the San Bruno explosion, is responsible for approving PG&E's upgraded safety plan.

Who will fine and hold the CPUC accountable for failing so miserably at its job? Perhaps the place to start is with the top dog and his unruly pack. This culture of corruption, built around the top dogs, is the fox guarding the henhouse.

From: Torgen Johnson
Sent: Wednesday, September 19, 2012 1:18 PM
To: Mercedes Martin
Subject: Victor Gilinshky on U.S. Nuclear Reactors: An Expert's perspective

Hello Mercedes,

Please include this email in the council packet as well.

Thank you,

Torgen Johnson

Victor Gilinsky is an independent consultant--primarily on matters related to nuclear energy. He was a two-term commissioner of the US Nuclear Regulatory Commission from 1975-1984, and before that Head of the Rand Corporation Physical Sciences Department. He holds an Engineering Physics degree from Cornell University and a Ph.D. in Physics from the California Institute of Technology, which granted him its Distinguished Alumni Award.

http://energy.nationaljournal.com/2011/07/should-america-follow-europes.php#2025959

JULY 12, 2011 8:43 AM

Germany Is Not Acting Recklessly

By Victor Gilinsky

What can we learn? I write this from Berlin, where the Bundesrat, the representative body of the individual states, has just confirmed the government's policy—in response to the Fukushima accident—to phase out nuclear power over the next ten years. Time will tell whether this was the right thing to do, but contrary to some of the other comments, it is not the action of reckless people. We ought to treat the German decision as the start of an interesting experiment and take careful note.

The Fukushima accident caused widespread long-lasting contamination and forced evacuation, some of it likely permanent. Despite what you may have heard, there are important similarities with the effects of the 1986 Chernobyl accident. Western nuclear programs dismissed the significance of that accident on grounds that it was the product of Soviet incompetence and so "it couldn't happen here." This time however the reactors are of US design and the operating practices, with their faults, were likely similar, too.

When it comes to dealing with our own plants consider that none of them is designed to handle a severe accident, one in which the fuel melts. Nearly half of them—the GE BWRs and the Westinghouse ice condenser plants—have what the NRC calls "low containment free volume and low containment strength." Some of these should probably shut down, at least at the end of their original licenses. The situation is complicated by NRC's grant of 20 year license extensions to most of them after what can only be described as very superficial reviews.

In short, rather than throw stones at the Germans, we should concentrate on putting our own house in order. There is much to think about.

http://energy.nationaljournal.com/2012/02/is-america-poised-for-nuclear.php#2161672

February 13, 2012 6:13 AM

Fukushima Lessons Loom Large

By Victor Gilinsky

You ask whether NRC approval of the two Georgia reactors signals the long awaited nuclear renaissance. There is no renaissance on the horizon and there is no chance of one so long as natural gas is available at reasonable prices--ask John Rowe. There are other reasons for the nuclear industry to restrain its enthusiasm. What we have here is two heavily subsidized units with federal loan guarantees whose details are secret and whose generosity is unlikely to be duplicated; a captive state commission is pushing construction costs onto the ratepayers; and the plant passed an NRC hearing process that is heavily stacked against the public. This is not a model for gaining the public confidence needed for a real national nuclear take-off.

It is also extremely significant that in what must be a first, the NRC chairman voted against the license. He said that last year's Fukushima accident was such an extraordinary event that he thought it essential to insert a license condition that the necessary safety upgrades coming from the lessons of the accident would be incorporated into the...

You ask whether NRC approval of the two Georgia reactors signals the long awaited nuclear renaissance. There is no renaissance on the horizon and there is no chance of one so long as natural gas is available at reasonable prices--ask John Rowe. There are other reasons for the nuclear industry to restrain its enthusiasm. What we have here is two heavily subsidized units with federal loan guarantees whose details are secret and whose generosity is unlikely to be duplicated; a captive state commission is pushing construction costs onto the ratepayers; and the plant passed an NRC hearing process that is heavily stacked against the public. This is not a model for gaining the public confidence needed for a real national nuclear take-off.

It is also extremely significant that in what must be a first, the NRC chairman voted against the license. He said that last year's Fukushima accident was such an extraordinary event that he thought it essential to insert a license condition that the necessary safety upgrades coming from the lessons of the accident would be incorporated into the Georgia units before operation. The other four commissioners refused, opting to follow the existing NRC procedures and approve operation without any such condition. That the chairman took such a dramatic step, one that could be very costly to him politically, means that he does not have confidence that the agency will require the necessary safety measures without the license condition he supports. One cannot lightly dismiss the chairman's opinion on the need for a stronger nuclear safety commitment because in this his views are a lot closer to those of most people than are the views of the other four commissioners. That vote is not a plus for public confidence, either.

You ask what lessons we should draw from the Fukushima experience. Let me mention what to me is the key lesson coming out of the accident, one that has not gotten nearly enough attention either in the public or at the NRC: the extensive radioactive land contamination of the area around the Fukushima site. The nuclear community likes to focus on the comparative advantage of nuclear power over other energy sources in terms of fatalities. But there are other important costs. After the accident the Japanese evacuated an area of about 1000 square kilometers in which they estimated the public radiation dose would exceed 20 mSv per year (2 rems per year). nearly ten times background. About a 100,000 persons were affected. (Perhaps three times that many were affected around the Chernobyl site but we didn't pay attention.) Because the chief contaminant is cesium 137 with a 30 year half-life, many of those Japanese evacuees can never come back to their homes. Their lives have been upended. And it could have been much worse had the winds blown differently. This is the principal safety concern about nuclear power plants--that even with effective evacuation, the evacuees may have nowhere to go back to.

T AIR DATE: May 25, 2012

U.S. Nuclear Plants Ready for a Fukushima-Like Meltdown?

SUMMARY

Chairman Gregory Jaczko resigned from the Nuclear Regulatory Commission this week; reports suggested it was linked to battles within the commission over requirements. In the wake of the Fukushima nuclear disaster, Miles O'Brien reports on how government regulators in the U.S. set the safety bar for nuclear plants.

Transcript

JEFFREY BROWN: In **the wake of the Fukushima nuclear disaster**, how should government regulators here set the safety bar for nuclear power plants in the U.S.?

This week, the head of the Nuclear Regulatory Commission announced his resignation, and news reports suggest that battles within the commission over safety requirements may partially account for his departure.

NewsHour science correspondent Miles O'Brien has been looking into these bigger questions well before the latest news.

His report was produced in partnership with ProPublica.

MAN: We're staying on AOP-1 for reactor scrams and AOP-2 for turbine trips.

And the immediate actions for AOP-1 reactor scram are complete.

MILES O'BRIEN: This is a test, only a test. If it were a real nuclear accident in the making, you would know about it by now.

MAN: Also, right now, we have sustained a loss of RPS, plus Bravo.

MILES O'BRIEN: We're in the simulator at the River Bend nuclear power plant near St. Francisville, Louisiana, where these technicians are practicing how to respond to an accident.

Since the Three Mile Island meltdown in 1979, this has been part of the routine at all U.S. nuclear power plants, one of many changes in the way the industry does business in the wake of that accident.

But now, in the wake of the Fukushima meltdowns, U.S. regulators and the industry are grappling with how best to respond, or not, to what happened in Japan.

Gregory Jaczko is the ontgoing chairman of the Nuclear Regulatory Commission.

GREGORY JACZKO, chairman, U.S. Nuclear Regulatory Agency: Nuclear power plants generally work well when a lot of things aren't changing. So there is, I think, an inertia against change and against improvement. And I think it's something we have to he vigilant about and continue to push, as the regulator, to make sure that that change happens.

MILES O'BRIEN: An inertia against improvement, that doesn't sound like a very safe approach.

GREGORY JACZKO: Well, I think you look at the industry and where it is today vs. where it was 10, 15, 20 years ago, there have been a lot of enhancements to safety. Performance is much better than it used to be.

MILES O'BRIEN: I joined Jaczko as he toured the River Bend plant. Managers here showed us the layers of safety measures that stand between controlled nuclear fission and disaster.

In industry parlance, it is called defense in depth. These portahle generators at River Bend are the last line in that defense if a failure, a disaster, or terrorism knocks out the three larger hackup generators designed to keep the cooling water flowing and the nuclear fuel from melting.

But industry watchdogs warn there are holes in the defense at U.S. nuclear power plants.

DAVE LOCHBAUM, Union of Concerned Scientists: The biggest concern I have had with the NRC over the years I have been monitoring them is lack of consistency.

MILES O'BRIEN: Dave Lochbaum is a nuclear engineer who spent 17 years working for the industry before publicly blowing the whistle on safety concerns and joining the Union of Concerned Scientists, which just released an eye-opening report on the NRC and nuclear plant safety in the U. S. in 2011.

It documents 15 near-misses, many occurring hecause reactor owners either tolerated known safety problems or took inadequate measures to correct them; problems with safety-related equipment that increased the risk of damage to the nuclear core; recognized, but unresolved problems that often cause significant safety-related events at nuclear power plants or increase their severity.

And it says NRC inspeetors all too often foeus just on a specific problem, not its underlying cause.

DAVE LOCHBAUM: I think the challenge the NRC has is, when somethiug happens, it's easy to convince people they need to spend money, prevent the next one. But when something hasn't happened yet and it's just a postulated event or a hypothetical disaster, it's more difficult to get people to pony up millions of dollars to fix the hypothetical problem.

MILES O'BRIEN: The case in point may be the Indian Point nuclear plant that sits on the Hudson River, 35 miles from Times Square in Manhattan. The 40-year licenses to operate the reactors here are up for renewal.

Indian Point's owner, Entergy, is seeking a 20-year license renewal. But where to set the safety bar, especially after Fukushima, is at the heart of a raging dehate over whether Indian Point should get a new lease ou life.

Eric Schneiderman is the attorney general of the state of New York.

ERIC SCHNEIDERMAN, New York attorney general: It is clear to us that, at this point in time, they have not met their burden of proof of showing that they deserve to be relicensed.

MILES O'BRIEN: After Three Mile Island , a federal conrt ruling forced utilities to expand their list of what-if scenarios and consider the cost of protecting against more unlikely events than required by the NRC. They are ealled severe aecident mitigation alternative analyses, or SAMAs.

ERIC SCHNEIDERMAN: All that requires the utility to do is to examine, do a cost-benefit analysis of safety measures that are not prohibitively expensive, but could provide substantial additional safety for the plant.

MILES O'BRIEN: Indian Point's SAMA analysis revealed 20 cost- beneficial safety upgrades Entergy could perform. They include adding a diesel generator to charge batteries, a flood alarm, better flood protection, additional devices to monitor for leaks, and a valve to reduce the risk of hydrogen explosions.

In all, the upgrades carry a $77 million price tag. But, surprisingly, implementation of SAMA upgrades like these wasn't a prerequisite for an NRC license renewal.

Why not?

GREGORY JACZKO: We have a two-track approach to our review.

The first part is really the safety decision, and that's about the license. The second part is about the federal government needing to do a review to look at environmental consequences. So, it's as part of that -- that second review that we look at these severe accident issues, and they really are about looking at environmental impacts.

MILES O'BRIEN: So, that means you don't have to factor in a Fukushima scenario as you consider the possibility of relicensing a plant?

GREGORY JACZKO: We -- again, we do it as part of the environmental review, but not specifically in the safety context.

ERIC SCHNEIDERMAN: The NRC has taken a very narrow view of what's required for relicensing. It defies common sense. There is no one out there who thinks that that's the way a regulatory agency should behave.

MILES O'BRIEN: So Schneiderman took Entergy to court, and his unprecedented legal challenge paid off. In a landmark decision, the independent tribunal responsible for relicensing ruled that the company must now consider, and likely implement, the SAMA upgrades in order to get a new license.

ERIC SCHNEIDERMAN: We're not talking about wild, expensive stuff. These are only things that pass through this cost-benefit analysis. These are cheap remedies that yield a substantial safety, big bang for the buck, or little bang for the buck, I guess.

But it's something that they should absolutely be required to do. And now, in the context of Indian Point, because it will be a condition of their relicensing, they will be required to going forward. That should be our policy in every nuclear power plant in the country.

MILES O'BRIEN: Should be a given?

ERIC SCHNEIDERMAN: Yes, absolutely.

MILES O'BRIEN: Schneiderman hopes his victory will change the way the NRC does business, but as Gregory Jaczko points out, the agency is resistant to change.

In fact, the announcement of his resignation comes amid a battle with other commissioners over whether to embrace a menu of a dozen changes proposed by a task force that studied the Fukushima meltdowns.

Among the recommendations? A requirement that plants have vents designed to prevent buildup of explosive gas, that operators plan for outages at more than one reactor simultaneously, and, most important, the installation of extra generators like this one at River Bend that would allow a nuclear plant to endure a long blackout of at least eight hours without losing the ability to keep cooling water flowing over the hot nuclear fuel rods.

GREGORY JACZKO: That effort is going to take probably at least two years, and it will require focus and diligence on the part of the agency, as well as on the part of the industry, to make sure that we get that rule change done, and then we implement everything that it requires in a prompt and timely way.

MILES O'BRIEN: Two years, that's lightspeed for you guys.

GREGORY JACZKO: I think two years would be an aggressive schedule, but it's one that I think we can achieve.

MILES O'BRIEN: But other NRC commissioners and the nuclear industry are fighting the Fukushima task force safety upgrades, saying they need more time to implement them.

The meltdowns in Japan may have forced the industry to think about the unthinkable, but it is still unclear what actions may follow, and if the NRC will take the lead or be forced into taking action.

ALLIANCE FOR NUCLEAR RESPONSIBILITY
Economic Risk Strategist

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May 10, 2012

Contact: David Weisman david@a4nr.org
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FOR IMMEDIATE RELEASE:

CPUC APROVES RATEPAYER FUNDING FOR SEISMIC STUDIES AT SAN ONOFRE NUCLEAR PLANT WITHOUT INDEPENDENT OVERSIGHT, PLACING PUBLIC AT RISK

The California Public Utilities Commission (CPUC) today approved $64 million in ratepayer spending for updated seismic studies at Southern California Edison's (SCE) troubled San Onofre Nuclear Generating Station (SONGS).

Unlike similar studies for PG&E's Diablo Canyon reactors, the SONGS seismic update will not have the oversight of an indepedent peer review panel of state regulatory agencies conducted transparently and in accordance with the Bagley-Keene Open Meetings Act. Instead, all scrutiny of the studies will be conducted by internal staff of the CPUC Energy Division. "With the CPUC president a former SCE president, it's clear that Edison continues to get what it wants out of the CPUC, and ultimately, out of our wallets," commented Rochelle Becker, executive director of the ratepayer advocacy watchdog Alliance for Nuclear Responsibility (A4NR). A4NR had filed as intervenors in the case, insisting that the studies be held to the higher standards of the Diablo Canyon review work. She ads, "The open and public meetings of the Diablo review panel have been an incubator of productive and dilligent inquiry. Ratepayers regret that in the case of SONGS, the CPUC is turning over any outside scrutiny to the 'rubber-stampers' in its Energy Division."

In his proposed decision for the case, Administrative Law Judge Robert Barnett cited the "Bagley-Keene" open meeting process as being too "cumbersome" for the seismic review panel. However, as A4NR's Becker notes, "At no place in either the voluminous testimony nor the two days of evidentiary hearings in this case was the word "cumbersome" ever uttered or referenced with regard to the Diablo Canyon Independent Peer Review Panel." Furthermore, she adds, "Under cross examination, the CPUC's Division of Ratepayer Advocates admitted that there were no seismologists on the CPUC staff, that they had not consulted with a seismologist in recommending these studies, and that they had no intention of hiring or retaining a seismologist. How can ratepayers know that the scope of the study is adequate and SCE is spending our money properly absent that expertise?"

In the decision approved today, the CPUC Energy Division director will "will coordinate review of the seismic studies, including seeking comments on the study plan and completed study

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findings with the outside and interagency experts." There is no indication that the CPUC will adhere to the Bagley-Keene Open Meeting Act for this review, reinforcing criticism of the CPUC that it has failed to learn the lessons from its culpability in the tragic San Bruno gas pipeline explosion. "This is what early stage San Bruno disease looks like," commented A4NR attorney John Geesman.

######

Remarks of City Councilmember Larry Agran
Regarding the San Onofre Nuclear Generating Station
Irvine City Council Meeting
March 27, 2012

I.

Like billions of people around the world, beginning on March 11, 2011, I struggled to absorb the meaning of the horrific televised images coming from northern Japan. Like others watching from afar, I witnessed the shocking devastation caused by a massive 9.0 earthquake, followed by a 50-foot tsunami. And, like others, I witnessed the unfolding catastrophe at the Fukushima Daiichi nuclear power plant, where the earthquake and tsunami crippled its operations, leading to nuclear reactor meltdowns, major explosions, and the dreaded release of radioactive gases and particles that spread over vast areas of land and sea.

While we have all been witness to this enormous — and still unfolding — human tragedy, I've used much of this past year to think about these catastrophic events from my perspective as a long-time local elected official here in Irvine, right in the middle of Southern California and just 22 miles north of the San Onofre Nuclear Generating Station. Like Fukushima Daiichi, San Onofre is an aging nuclear power plant with a troubled history, located in a geologically uncertain and unstable place.

After a year of research, including meetings with engineers and scientists, numerous briefings and even a tour of the San Onofre facility, I've learned a great deal. I don't claim to be an all-knowing expert — in fact, I haven't met *anyone* who would claim expert knowledge *and* infallible judgment in all the complex matters of nuclear safety. But I do know enough to have reached this conclusion: *I believe that our shared community commitment to public safety requires that we bring about the safe, orderly decommissioning of the San Onofre Nuclear Generating Station as soon as possible — and certainly before 2022, when the current San Onofre nuclear reactor licenses expire. I believe the period immediately ahead should be used for planning the quickest possible transition to safer and more reliable energy sources. It should not be squandered engaging in a bitter, divisive fight with San Onofre's principal owner and operator, the Southern California Edison Company, regarding the possible re-licensing of the aging San Onofre facilities for 20 years, thereby extending its operations until the year 2042. Accordingly, I take this opportunity to call upon the corporate leadership of Southern California Edison to put public safety first by clearly and unequivocally renouncing any intention to pursue re-licensing San Onofre.*

II.

Here are the common sense lessons learned that inform my views about nuclear power generally and San Onofre in particular.

First, I've learned that measured in terms of public safety, the record of commercial nuclear power generation is at once alarming and depressing. There are reportedly 440 commercial nuclear power plants now operating worldwide, including 104 in the United States. Not included among these are three nuclear generating plants that experienced catastrophic failure well short of their expected 40-year useful life.

• In 1979, human error caused the destruction of the Three Mile Island nuclear facility in Pennsylvania, leading to the release of radioactive materials in the air and into the Susquehanna River, with billions of dollars in property damage and cleanup costs. The plant came within hours of a complete meltdown and explosion that would have devastated large parts of Pennsylvania. And, depending on wind conditions, the radioactive contamination field could have reached highly populated areas of New Jersey and the New York City area as well.

• The second failed plant — another case of failure attributed to human error — was Chernobyl, in the Ukraine. In 1986, the Chernobyl nuclear power plant experienced a meltdown and explosion, causing radioactive contamination and the permanent de-population of thousands of square miles.

• Last year, of course, the Fukushima Daiichi nuclear power plant failed in the aftermath of an earthquake and tsunami, although human errors apparently contributed to the disaster. Fukushima, like Chernobyl, caused mass evacuations and has rendered large areas of northern Japan uninhabitable.

Each of these catastrophes has been described by regulators and power plant owners and operators as a freak event, suggesting a kind of "one-in-a-million" likelihood of a nuclear accident occurring near you. Really? Looking back on the record of commercial nuclear power operations so far, I'd put the odds that a nuclear power plant would have a catastrophic failure during its 40-year lifecycle as closer to 1 in 100. I don't like those odds, especially when — in the case of San Onofre — most of Southern California is being put at risk.

Second, I've learned that, like Fukushima, San Onofre was built to withstand a 7.0 earthquake. In fact, the earthquake that struck northern Japan was 9.0 on the Richter scale. Remember, that's *exponentially* more powerful than a 7.0 quake; in other words, it's *100 times more powerful* than a 7.0 earthquake, with 100 times the violent shaking. Ever since the 1971 Sylmar earthquake, which was less than 7.0 but nevertheless devastated large portions of the San

Fernando Valley, we've been told that we're overdue for "The Big One" — an 8.0 or larger earthquake — in Southern California. Yet San Onofre, which sits on the coast next to the Newport-Inglewood Fault, is only built to withstand a 7.0 quake. Today, knowing what we know about seismic possibilities, that's clearly not good enough. This isn't simply my opinion. It's the opinion of senior scientists and engineers, including a senior engineer who was responsible for analysis and design of the San Onofre nuclear containment vessels.

The truth of the matter is that what we've learned about earthquakes since the 1970s is that we don't know very much at all. Time and again we are surprised. We simply cannot make confident predictions because we don't really know what's going on five miles below the earth's surface. With or without a tsunami — and I'm told by scientists that San Onofre's susceptibility to a tsunami is real — the chances that the nuclear reactors at San Onofre would escape catastrophic damage in the event of a very powerful earthquake appear to me to be poor.

Third, there are more than 4000 tons of radioactive waste stored on site at San Onofre, some stacked in reinforced casks in plain view and the balance in more vulnerable cooling ponds. The federal government's failure to provide a national nuclear waste repository — one that can secure nuclear waste for thousands of years — only compounds the risks we face at San Onofre.

Fourth, there is no way that public officials could possibly manage a full-blown nuclear emergency at San Onofre. Current evacuation plans appear to be totally inadequate, prescribing an evacuation zone of just 10 miles that includes about 150,000 people in San Clemente, Dana Point, San Juan Capistrano, and a number of smaller communities. Fukushima's evacuation zone ranged from 12 miles (imposed by Japanese officials) up to 50 miles (recommended by U.S. officials). A 50-mile evacuation zone around San Onofre would reach to San Diego in the south and to Long Beach in the north. It would also include all of Orange County, and big portions of Los Angeles County and the Inland Empire — potentially involving about 10 million people, depending on the extent of radioactive contamination. This contamination field, in turn, is literally dependent on which way the wind is blowing the radioactive materials. In the case of Chernobyl, areas as far as 100 miles away from the Chernobyl plant have been declared "zones of alienation" that are uninhabitable now and may remain uninhabitable for hundreds of years.

Think about that. Unlike a terrible brush fire or flood, evacuation in the face of a nuclear catastrophe could mean *permanent* evacuation — leaving just about everything behind, forever. It's difficult to do, but imagine large parts of Southern California — including the land itself and everything on it — could be rendered useless, dangerous and unlivable for decades, maybe for hundreds of years.

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If that doesn't humble you and make you think long and hard about our energy future, then nothing will. At some point, we must recognize that no matter how knowledgeable we think we are, we're still human beings with flaws and frailties. We are susceptible to "human error," sometimes compounded by overwhelming natural disasters. Mistakes and misjudgments are inevitably part of the human experience. But when they involve nuclear power generation, the consequences can be catastrophic.

III.

For these reasons, I repeat myself and implore Southern California Edison to set aside whatever plans it may have to seek the re-licensing of San Onofre nuclear reactors. By any standard, these facilities are old, in some respects decrepit — and their continuing operation poses an unacceptable risk to public health and safety. The San Onofre Nuclear Generating Station is nearing the end of its expected lifecycle. Instead of a fierce, costly, and exhausting license extension fight in which we endlessly argue about the probabilities of experiencing a nuclear nightmare scenario, I believe we should use the next few years to constructively engage the entire Southern California community — this includes Southern California Edison's top managers and scientists as well as a broad array of business and labor leaders, local elected officials, and hundreds of intelligent citizens who would step forward — to work together to achieve a safer, more reliable energy future for all of us.

That better future I'm talking about isn't pie in the sky. It is becoming available to us right now. On February 5th, the *Los Angeles Times* published a remarkable article, chronicling the progress of solar power installations throughout Southern California, most notably in the Mojave Desert and east of San Diego. These projects — more than 20 of them — at various stages of approval and construction, are not boutique pilot projects. In fact, taken together they are calculated to generate 8500 megawatts of electricity for Southern California — enough to meet the electricity needs of more than 5 million homes where more than 10 million Southern Californians live. This is nearly four times the 2200 megawatts produced at San Onofre. (Incidentally, San Onofre has been shut down since early February, following a steam-generator tube leak in one reactor and the discovery that similar steam tubes in the plant's other reactor were prematurely wearing out. Today, San Onofre is producing zero electricity.)

In chronicling the progress of the solar power installations soon to come on line, the *Times* didn't sugar-coat the difficulties that lie ahead — some technical, some environmental, some economic and political. But it's clear that these solar facilities will be part of our energy future in the next five to ten years. Moreover, natural gas production is soaring, providing even greater supplies of lower-cost energy. These developments, in turn, enable us to undertake the formidable task

of planning for the safe decommissioning of San Onofre, including deconstruction of the nuclear facility. Perhaps elements of the San Onofre plant can be re-purposed for electric power transmission that relies on relatively clean and safe technologies — such as major solar installations, wind turbines, and natural gas.

Mindful of the immense human tragedies that our limited lexicon now denotes simply as Three Mile Island, Chernobyl and Fukushima, I think these three catastrophic failures should humble us and cause us to work tirelessly for a safer, smarter, better energy future. I personally believe what I think most of us believe — that we should again put public safety and good planning first; that we should put people ahead of utility company profits; and that we should be good stewards for our community, for our civilization, and for this beautiful planet that we are so fortunate to call our home.

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Questions for Irvine City Staff
City Councilmember Larry Agran
March 27, 2012

1) In the event that the San Onofre nuclear power plant experiences a Chernobyl-like or Fukashima-like catastrophic failure — resulting in a major, widespread radioactive contamination field — what are our City's public safety responsibilities? Are we prepared to cope with such an emergency?

2) What is the emergency response chain of command within our City? What are the prescribed roles and responsibilities of the Mayor, the City Council, the City Manager, and the Director of Public Safety? What are the responsibilities of other public and private entities — Southern California Edison, the County of Orange, the State government, the federal Department of Homeland Security?

3) Are we prepared to respond to an evacuation order — to evacuate our entire City if ordered to do so, or to receive and provide for evacuees from elsewhere? Are our responsibilities clearly set forth in an evacuation plan available for public review?

4) Do we have equipment to measure radioactive contamination? Do we have access to sufficient masks, special suits and other protective equipment for our public safety workers and for the general public? Do we have iodine pills for widespread distribution to protect against thyroid cancer?

5) Does our City of Irvine 20-Year Energy Plan address policy issues regarding the sources of electricity to meet future energy needs? Does the Energy Plan presume or propose policies that would provide for safer, more reliable energy sources such as major Southern California solar installations — and reduced dependence on nuclear power generation? Does the Energy Plan consider conservation measures that presume a short-term, long-term, or permanent shutdown of San Onofre?

6) Does the draft City of Irvine Budget for FY 2012-2013, soon to be submitted by the Mayor and City Manager, include stepped-up funding for emergency preparedness to cope with a catastrophic failure at San Onofre?

7) Have the Mayor and City Manager been in communication with the highest officials at Southern California Edison to inquire as to their intentions regarding San Onofre — to either permanently shut down and decommission the nuclear power plant in 2022, or to apply for license renewal that would extend operations to at least 2042?

8) In the event that Southern California Edison pursues license renewal, what is the process and what options are available for City participation before state and federal agencies?

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San Clemente Green
Citizens for a Sustainable Future

Request to add agenda item re: Public Safety Issues at San Onofre Nuclear Generating Station

Honorable Mayor and Council Members:

As a concerned citizens group we respectfully request that you consider allowing us to make a ten minute special presentation regarding public safety issues at the San Onofre Nuclear Generating Station. We ask to be put on your agenda as soon as possible. This matter of public safety has taken on even greater urgency especially for those of us within the reach of a radiation plume extending 50 miles and beyond. With the on-going disaster in Fukushima, which took place a little more than a year ago, we have grown in numbers and regional reach, including people within your own community. We are all in this together, regardless of city boundaries.

As you may already know, there was a recent event where radiation was released into the environment from a ruptured tube in one of the recently installed critical steam generators. All four steam generators are showing signs of unprecedented wear. This has resulted in the current unplanned closure of both nuclear reactors (Units 2 and 3) since January 2012.

Edison is losing about a million dollars a day while the plant is down, so they are highly motivated to restart the plant as soon as possible. We have reason to believe that the plant may be restarted prematurely and would like to share information we have that explains why we are concerned. Edison has implied there may be rolling blackouts if San Onofre is shut down through the summer. However, we have reports from the California Independent Systems Operator (CAISO) that confirms there is a safe margin of surplus electricity for the summer. If the steam generators fail again, huge amounts of radiation could be released into the atmosphere, permanently impacting our communities and our families. We, the public, simply can't allow this critical decision to be made without ample opportunity to review this approval process.

So far, all of the other cities with whom we have shared our "Awareness Campaign" have supported our call for tighter enforcement by the Nuclear Regulatory Commission to prevent the public from being exposed to hazardous levels of radiation. San Clemente, Laguna Beach, Solana Beach and Irvine, have each written strongly worded letters to those who may help make a difference in this dangerous situation. A copy of one such letter from the City of Irvine is included as part of this package. Several other cities are currently taking this matter into consideration. It is our hope, that after hearing our well documented concerns, you will join the other cities and compose a similar letter on behalf of the many people you represent.

There is a justifiable sense of urgency to allow concerned communities to be heard. I have attached a few additional documents which are particularly significant. These and many other referenced resources can be found on our website, SanOnofreSafety.org. A reply to our request to be on your agenda as soon as possible would be much appreciated.

Thank you,

Gary B. Headrick
gary@sanclementegreen.org

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2837 Penasco - San Clemente - California - 92673 (949) 218-4051

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IMPORTANT: Safety information for anyone within 50 miles of San Onofre Nuclear Plant

At the Fukushima Dai-ichi nuclear disaster, U.S. officials recommended Americans in Japan evacuate 50 miles. If you live or work in one of these five counties, you may be within the San Onofre 50 mile evacuation zone:

Orange, San Diego, Los Angeles, Riverside, San Bernardino

There is no safe emergency plan. Over 8.4 million people living in a 50 mile radius need to evacuate if there is an emergency at San Onofre. The Nuclear Regulatory Commission (NRC) does not require a current safe emergency plan for San Onofre (NRC Reg. 50.47).

Radiation from San Onofre will blow inland due to prevailing on-shore wind, so the safest evacuation location is upwind in the Pacific Ocean.

The NRC is under investigation for reducing safety standards in order to keep older nuclear plants running. The NRC has stricter rules for new plants than it does for existing nuclear plants.

San Onofre is not required to add safety systems that the NRC deems too expensive for the value of the lives they could save. The NRC value of a human life is roughly 1/3 to 1/2 the value used by other federal agencies ($3 million vs. $5-9 million).

San Onofre was redesigned for a 7.0 earthquake, but sits next to a fault capable of an 8.0 earthquake -- 10 times more powerful and long overdue.

San Onofre unsafely stores tons of toxic radioactive waste and continues to produce over 600 pounds every day. The waste is toxic for thousands of years.

San Onofre's "30 foot tsunami wall" is only 14 feet above high tide.

The NRC does not require seismic or tsunami studies for license renewal. San Onofre was originally licensed to shut down in 2013, but was extended to 2022. Next year they plan to ask for an extension to 2042. The plant was designed in 1973 for a 40-year lifespan.

San Onofre has 10 times more safety violations than the industry average making it the most dangerous nuclear plant of all 64 plants (and 104 reactors) in the nation.

The NRC says San Onofre continues to have serious Safety Culture problems, including poor decision making and employees reluctant to report safety problems for fear of retaliation from their management.

Human error contributed to all major nuclear disasters in the world. One human error contributed to Southern California's 9/8/2011 massive power blackout. It can happen at San Onofre.

In the event of a severe accident at San Onofre, radiation leaks could create a permanent "dead zone" beyond Los Angeles, San Diego, Catalina, and Riverside.

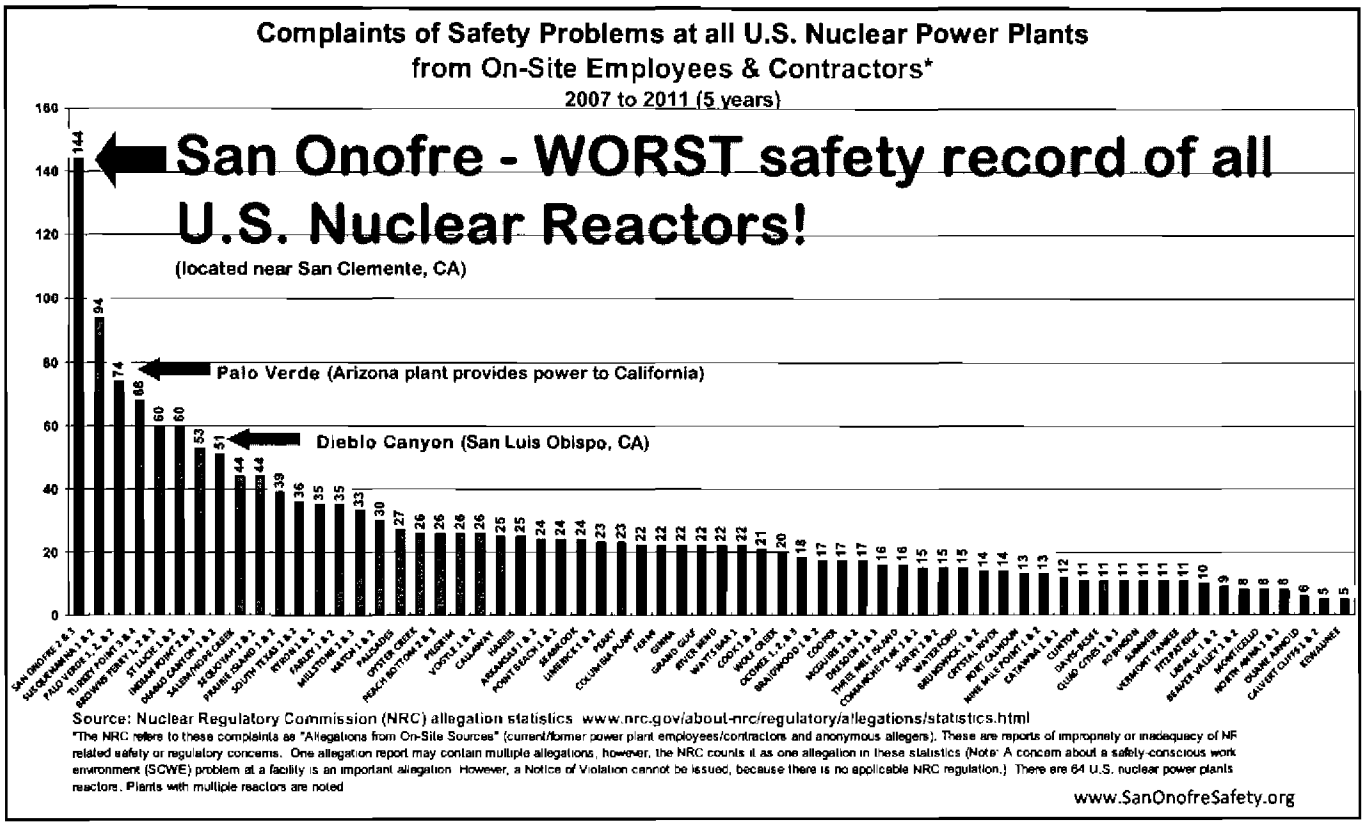
Children and pregnant women are most vulnerable to radiation. Cancer and genetic damage go undetected for years.

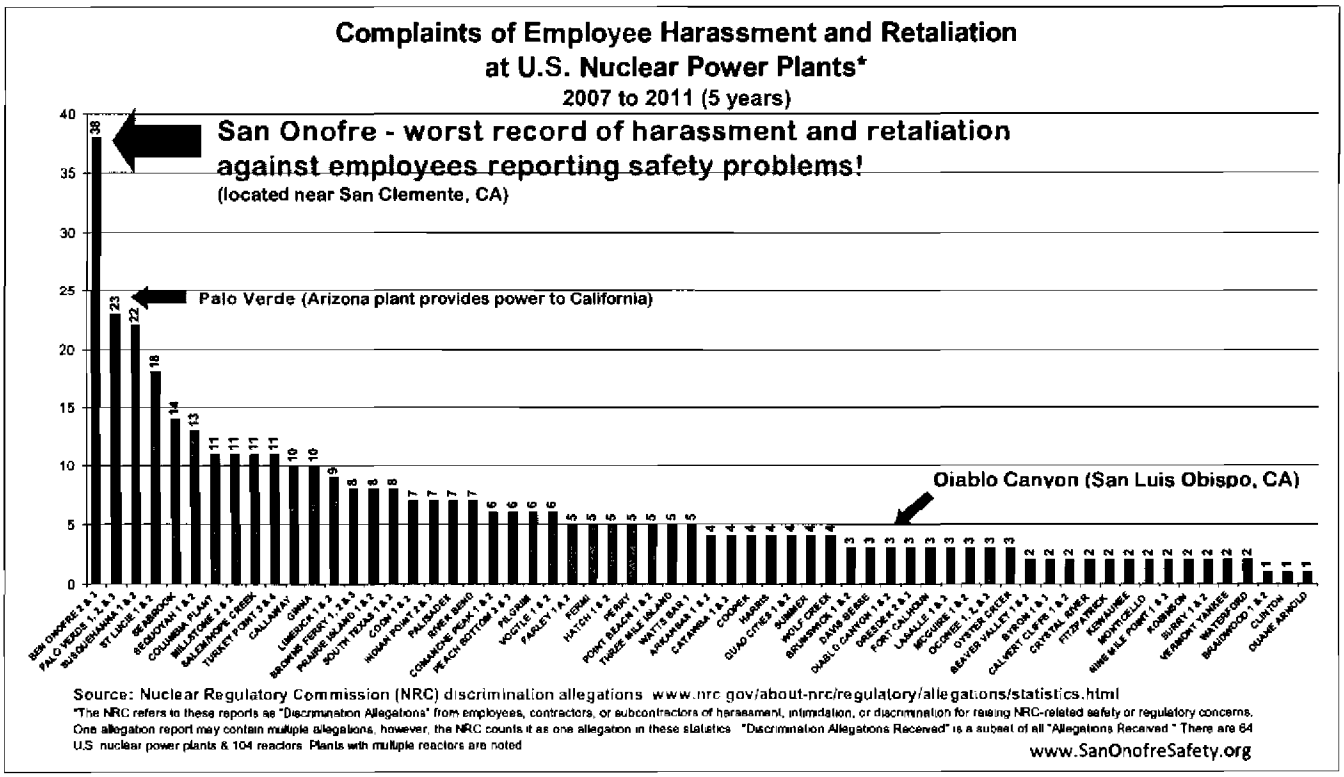
Your home and property cannot be insured against a nuclear disaster and reactor owners have limited liability.

Sources: CA Energy Commission www.energy.ca.gov/nuclear/california.html, Nuclear Information & Resource Service www.nirs.org, US Geological Survey www.usgs.gov, Nuclear Regulatory Commission www.nrc.gov, CA Public Utilities Commission www.cpuc.ca.gov

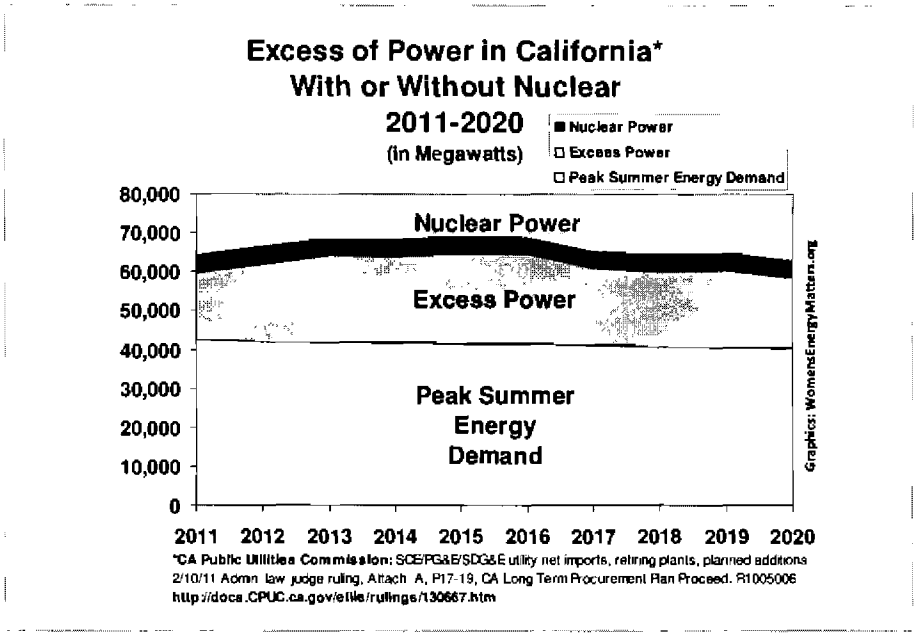
www.SanClementeGreen.com, www.SanOnofre.com, **www.SanOnofreSafety.org**
CREED - Coalition for Responsible Ethical Environmental Decisions
ROSE - www.ResidentsOrganizedforaSafeEnvironment.wordpress.com, www.AceHoffman.org

SAN ONOFRE NUCLEAR POWER PLANT HAS THE WORST SAFETY RECORD





No Rolling Blackouts with San Onofre Shut Down



CALIFORNIA HAS EXCESS POWER without nuclear power plants.[1]

Includes power needed for peak summer demand, voltage and grid stability.[2]

NUMEROUS OPTIONS AVAILABLE to avoid rolling blackouts.

California Independent System Operator (ISO) recommendations to avoid rolling blackouts:[3]

- **Restart Huntington Beach (HB) gas-fired units 3 and 4.** The Los Angeles area reserve is short by only **240 MW** under heavy load conditions (with San Onofre off-line). This is mitigated by restarting HB units, increasing import capability to San Diego by **450 MW**.

Reserves (MW) without San Onofre	Without Huntington Beach 3 & 4		With Huntington Beach 3 & 4	
	Mild Conditions	Heavy Load	Mild Conditions	Heavy Load
Reserve available	710	266	1060	616
Reserve required	603	603	603	603
Reserve margin [excess]	107	-337	457	13

[Estimates for additional megawatts (MW) available through load management, renewable energy, conservation and energy efficiency were **NOT** provided in the ISO presentation, but can increase reserve margin significantly.][4]

- **Conservation and demand response will provide additional margin.**
  - Fully fund Flex Alerts and restart CPUC 20/20 program. [SCE is planning a 10/10 program.]
  - Fully utilize available demand response (e.g., SCE air conditioner cycling). [SDG&E excludes San Clemente, Laguna Beach, Laguna Woods and Laguna Hills from air conditioner cycling]
  - Seek additional military and public agency demand response.
  - Take longer-term steps to increase available demand response system-wide.
- **Accelerate Barre-Ellis transmission upgrade, accelerate completion of Sunrise and related outage planning.**

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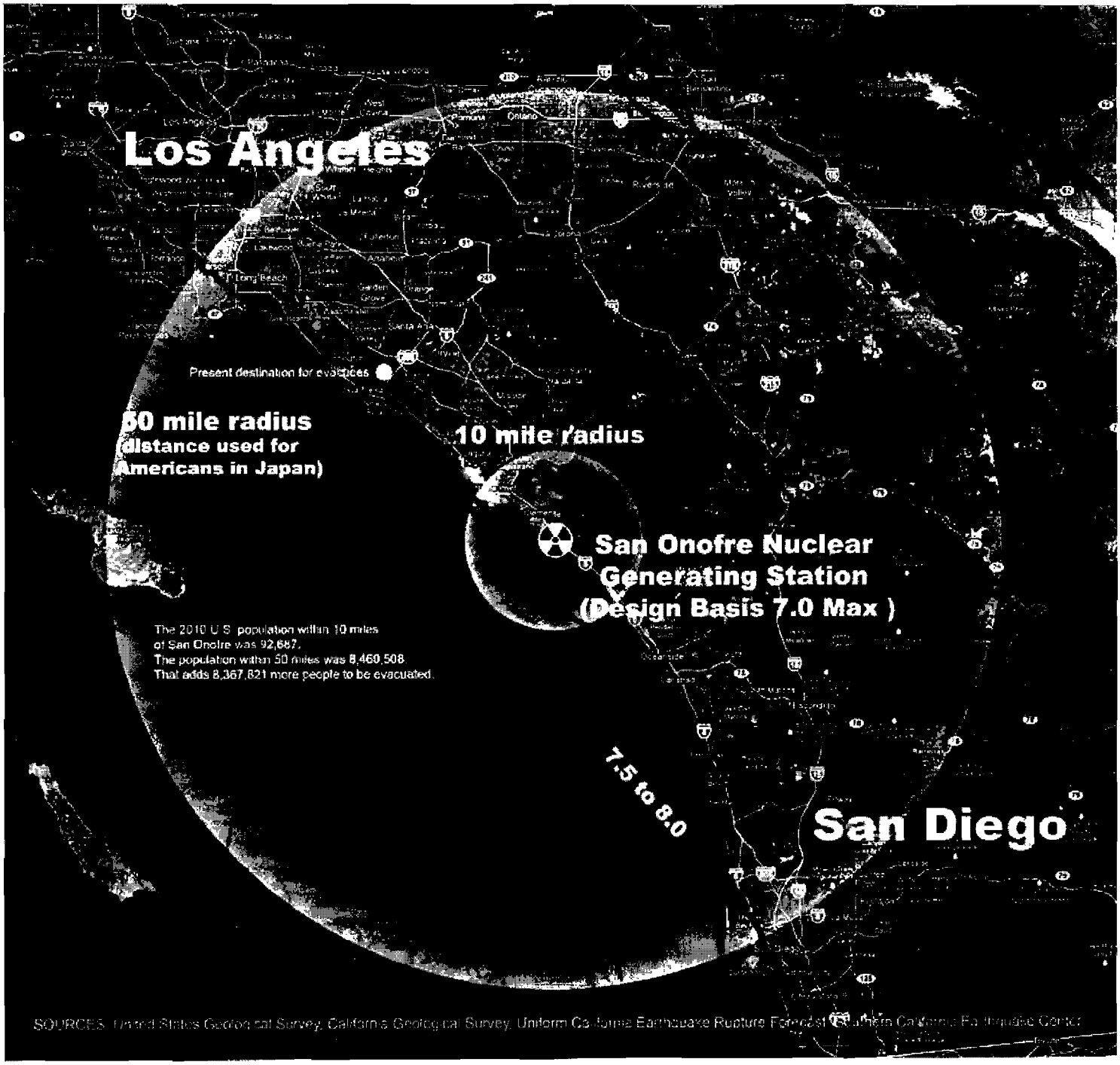
[1] 2/10/2011 CA Public Utilities Commission: Administrative Law Judge Ruling Attachment A, Pages 17-19, CA Long Term Procurement Plan Proceedings R005006 http://docs.CPUC.ca.gov/efile/rulings/130667.htm

[2] 2011-2012 ISO Transmission Plan http://www.caiso.com/Documents/Board-approvedISO2011-2012-TransmissionPlan.pdf

[3] 3/22/2012 ISO Summer 2012 Operations Preparedness presentation, Neil Millar, Executive Director, Infrastructure Development http://www.caiso.com/Documents/BriefingSummer2012OperationsPreparedness-Presentation-Mar2012.pdf

[4] SanOnofreSafety.org Energy Options http://sanonofresafety.org/energy-options

50 Mile Evacuation Area as Ordered for Americans in Japan and Present 10 Mile Evacuation Area



Known Faults Exceed Design Basis for 7.0 Earthquake
8.4 Million People live in a 50 Mile Radiaus

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San Onofre Steam Generator Problems

"When your nuclear reoctor is springing leaks and radioactive pipes are deteriorating twenty times faster than they should, it's a big deal, and no amount of nuclear spin by Edison or the NRC can hide that fact."

--- Friends of the Earth

Why is San Onofre shut down?

San Onofre has been shut down since January 31, 2012 due to defective replacement steam generators.

- Generators are critical for cooling the reactors. Failure can cause uncontrolled releases of radiation.
- A generator tube in reactor Unit 3 leaked radiation into the air after being installed less than a year.
- All four replacement steam generators show unprecedented premature wear.
- They cost ratepayers $680 million (in 2004 dollars). Before they failed, Edison said with this newer technology the generators should last 40+ years.

Can the steam generators be safely repaired?

Nuclear Engineer Arnie Gundersen said that the safest option is to replace the steam generators.

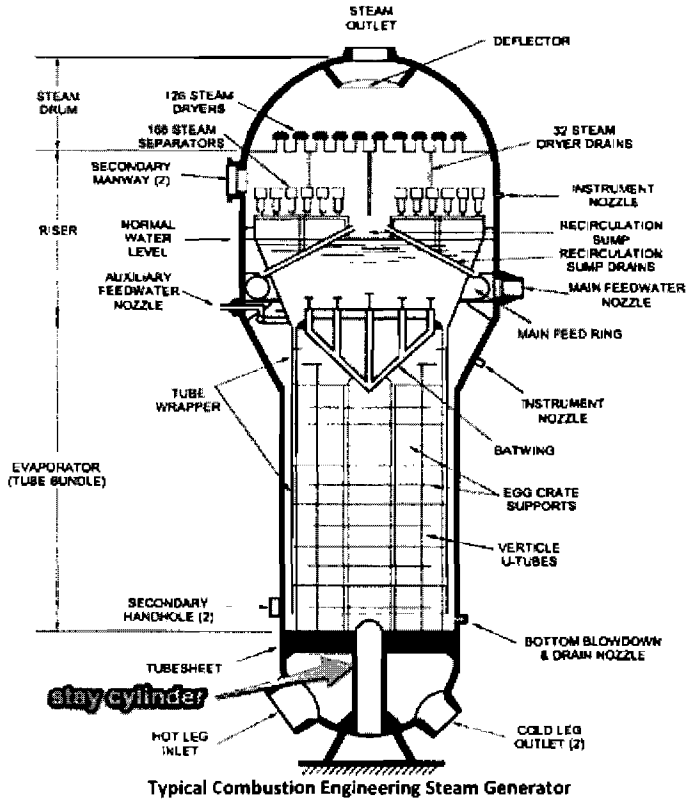
Southern California Edison made design changes to the replacement steam generators resulting in tube vibrations. This caused unprecedented extensive damage to some of the 9727 tubes within each generator.

What is the impact of the design changes?

- The tubes are now "at risk of bursting in a main steam accident and spewing radioactivity into the air".
- The top of the new steam generator is now "starved of water, therefore making tube vibration inevitable".

What are the significant design changes?

- The original design had a unique tube support to prevent vibration – these supports were changed in the new design and 377 tubes added to each generator.
- The main structural **stay cylinder** was removed (see diagram). This support cylinder was designed to secure the generator and prevent vibration – exactly the kind of vibration that seems to be causing tube degradation.
- All of these changes necessitated pressure and flow changes in the generator's operation.



Typical Combustion Engineering Steam Generator

Will plugging tubes and reducing power help?

- Vibration is the result not the root cause of the steam generator problems at San Onofre.
- Plugging tubes cannot repair design changes that cause the tubes to collide with each other.
- Reducing power does not provide a remedy for the underlying structural problems that are creating the vibration that has damaged and will continue to damage the tubes.
- Reducing power will not change the pressure inside or outside the tubes. Previously damaged tubes will continue to vibrate, damaging surrounding tubes and tube supports and worsen the existing damage.
- Lower power might create a resonate frequency at which vibration might increase without notice.
- Historical evidence at other reactors has shown that operating at lower power has not been an effective solution.

Arnie Gundersen, Chief Engineer at Fairewinds Associates, is a 40-year veteran of the nuclear power industry. A former nuclear industry senior vice president, he earned his Bachelor and Master Degrees in nuclear engineering, holds a nuclear safety patent, and was a licensed reactor operator. During his nuclear industry career, he managed and coordinated projects at 70 nuclear power plants around the country.

http://fairewinds.com/content/san-onofre-bad-vibrations

Sukhee Kang, Mayor

www.cityofirvine.org

City of Irvine, One Civic Center Plaza, P.O. Box 19575, Irvine, California 92623-9575 (949) 724-6233

April 30, 2012

The Honorable Gregory Jaczko
Chairman
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Dear Chairman Jaczko:

The disaster at the Fukushima Daiichi Nuclear Power Plant in Japan has renewed world-wide concern regarding the safety of commercial nuclear power. The City of Irvine is located 22 miles north of the San Onofre Nuclear Generating Station (SONGS) and is home to 220,000 people. Irvine has a workday population of nearly 350,000. A 50-mile radius around the San Onofre Plant extends into five California counties. This area includes the three most populous California counties – Los Angeles, San Diego and Orange Counties – as well as San Bernardino and Riverside Counties.

The City is fortunate to have Federal elected officials who are well informed and active in the Nation's ongoing discussion about nuclear power.

After careful deliberation, on behalf of the citizens of the City of Irvine and my City Council colleagues, the Irvine City Council requests the following:

- Support for Senator Feinstein's April 20, 2011 letter to you requesting that the Nuclear Regulatory Commission (NRC) examine "seismic and tsunami hazards, operational issues, plant security, emergency preparedness, spent fuel storage options and other elements of a nuclear power plant's 'design basis' within the scope of the relicensing process." While we are aware that the NRC used best possible science of that era during the SONGS Unit 2 and 3 licensing process in 1982 and 1983, respectively, much has been learned and modern technologies have been developed since SONGS was licensed. In addition to the effects of age-related degradation of the facility. We agree with Senator Feinstein that: "These new threats logically should be considered in a relicensing process, just as they would be in the licensing of a new nuclear power plant in the United States."

  All pertinent information should be taken into account before relicensing is considered. This includes the need for permanent off-site storage solution for spent nuclear fuel to be identified as a condition for relicensing. The continued accumulation of spent fuel on site presents a significant hazard that must be solved at the federal level and a solution implemented before continuing to generate more spent fuel. In California, researchers have recently found new faults close to nuclear power plants, and tsunami experts have learned that submarine landslides can

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generate local tsunamis far larger than previously believed.

Accordingly, we ask that the NRC adopt the following positions:

- Mindful that Senators Feinstein and Boxer have called upon the NRC to swiftly adopt the "Near-term Task Force Recommendations for Enhancing Reactor Safety in the 21st Century," *we urge the NRC implement the recommendations without delay. For SONGS, special care should be given to reevaluating seismic and flooding hazards.*

- *Expand the Emergency Planning Zone to 50 miles.* The current 10-mile radius is inadequate. We acknowledge the focused effort of the current Inter-jurisdictional Emergency Planning Committee, as we have remained involved as a nearby agency. We also acknowledge that there may be different emergency planning needs at differing distances from SONGS. However, increased strategic emergency planning efforts to include vicinity communities that are clearly part of evacuation plans and potentially within plume zones should be incorporated into an expanded Emergency Planning Zone. The "Recommendations for Enhancing Reactor Safety in the 21st Century" provides only a cursory discussion of Fukushima which required additional protections up to *and beyond* a 16-mile (20 kilometer) area.

- *Revise the risk/benefit analysis that the NRC uses to ensure that it adequately assesses public risk levels.* There have been important lessons learned regarding human performance, and unforeseen human error. We acknowledge that there is a *Human Reliability Analysis* component in the NRC's high-level Probabilistic Risk Assessment. We also acknowledge that the NRC emphasizes employee training, certification and management, and believe that SONGS employees are earnest in their desire to safely conduct their daily duties. Management, by SCE in this case, is a critical component here.

  We have learned that human error contributed to catastrophic nuclear plant failures and exacerbated conditions following failure. Recent years-long human performance and safety culture issues at SONGS bring urgency to our concerns. Human performance and safety culture issues at SONGS took at least four years to address – and included willful violations. These issues were placed on the Regulatory Response Action Matrix. There were multiple letters from NRC and SCE, multiple NRC staff reviews, and at least two independent assessments before changes were made showing sustained improved performance to NRC's satisfaction as of the September 6, 2011 closure of the "chilling effect" letter. In its March 4, 2009 Annual Assessment letter, the NRC made a number of specific disturbing findings:

  - "Known performance problems have persisted and new performance problems have emerged"
  - "Ineffective use of human error prevention techniques"
  - "The effectiveness of your initiatives has not been evident and this annual assessment is the third cycle where substantive cross-cutting issues were identified in human performance and problem identification and resolution."

We acknowledge that regular assessment, monitoring and correction to maintain an effective feedback loop is important to safely operate a nuclear power facility. We also recognize the transparency within which NRC conducts this monitoring. However, this does not reduce our concerns related to human performance – especially management and safety culture issues. There are 440 commercial nuclear power plants worldwide, with 104 in the United States. Not included among those are three nuclear generating stations that experienced catastrophic failure well short of their expected 40-year life – related in part to human performance.

- We urge you to require utilities to move spent fuel rods to dry cask storage as soon as those rods can be safely moved. The storage of spent fuel rods on site at SONGS continues to be of concern to the Irvine City Council and is an area we believe that the NRC can take more immediate action. Our understanding is that the spent fuel rods stored in dry cask storage at Fukushima Dalichi were unaffected by the tsunami. Although movement of spent fuel away from the community will require many federal agencies to reach agreement, we believe the movement to dry cask storage is an area of regulation within the authority of the NRC.

- We request that the NRC withhold permission to restart San Onofre Nuclear Generating Station Units 2 and 3 (both shut down since January 31, 2012 because of excessive and inexplicable wear of steam generators) until the NRC provides full assurance that Units 2 and 3 will not exhibit any of the current vibration, corrosion, and degradation problems during the remaining 10 years of licensed operations.

On behalf of the citizens of Irvine and my elected colleagues, I respectfully request that your agency respond to the above requests. As representatives of the people we serve, it is our City Council's duty to be informed and to act upon our knowledge. Where we cannot exercise authority, we will advocate for the public's best interest. We appreciate the role of the NRC as the government agency that ensures that commercial nuclear power plants operate safely.

Sincerely,

Sukhee Kang
Mayor

cc: Irvine City Council
Sean Joyce, City Manager
Senator Barbara Boxer
Senator Dianne Feinstein
Congressman John Campbell

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Testimony Submitted by
James D. Boyd
Vice Chairman, California Energy Commission
California Liaison Officer to the
U.S. Nuclear Regulatory Commission
Before the Environment and Public Works Committee
Subcommittee on Air and Nuclear Safety
U.S. Senate
April 12, 2011

Review of the Nuclear Emergency in Japan and Implications for the U.S.

Thank you, Chairman Boxer, Chairman Carper, Ranking Members Inhofe and Barrasso, and Members of the Committee. I am Jim Boyd, Commissioner and Vice Chair, appearing on behalf of the California Energy Commission. I serve as the California Liaison Officer to the U.S. Nuclear Regulatory Commission (NRC). I appreciate the opportunity to appear before you today to discuss California's nuclear power plants in the wake of unfolding events at Japan's Fukushima Daiichi Nuclear Power Plant.

California's Nuclear Power Plants

The 9.0 earthquake, devastating tsunami, and their impacts on the Fukushima Daiichi Nuclear Plant in Japan underscore the importance of addressing seismic uncertainties at nuclear power plants. California has two large operating nuclear power plants located in earthquake prone areas on California's coastline and they are susceptible to tsunamis. Diablo Canyon Nuclear Power Plant, owned by Pacific Gas & Electric (PG&E), is a 2,160 MW two-unit plant located near San Luis Obispo. The San Onofre Nuclear Generating Station (SONGS) owned by Southern California Edison (SCE) and San Diego Gas & Electric (SDG&E), is a 2,200 MW power plant located north of San Diego. These plants provide approximately 13 percent of California's overall electricity supply and are licensed to operate through the mid-2020s. Their construction permits were issued in the 1960-1970 timeframe and they began commercial operation in the mid-1980s. California also has three permanently shut down commercial power reactors: Rancho Seco, near Sacramento (closed in 1989), SONGS Unit 1 (closed in 1992) and Humboldt Bay 3 in northern California, which was closed in 1976 due to seismic concerns.

Seismic Safety Concerns at Diablo Canyon and San Onofre

Over the last few decades, earthquake and tsunami concerns have been raised at both Diablo Canyon and San Onofre. The Hosgri Fault, located only three miles offshore, was discovered during the construction of the Diablo Canyon plant. In January 1976, the USGS concluded that the Hosgri Fault should be considered capable of producing an earthquake with a magnitude 7.0 to 7.5. As a result, Diablo Canyon was redesigned

and upgraded for a 7.5 magnitude earthquake. Construction costs exceeded the initial $320 million estimate (1968 dollars) by more than $5 billion primarily due to required seismic upgrades. In 1978 the NRC required PG&E to implement a Long Term Seismic Program as a condition of Diablo Canyon's operating license. San Onofre, licensed and built before Diablo Canyon, was not under the same requirements.

In November 2008, the Energy Commission completed a two-year comprehensive study of the Diablo Canyon and San Onofre plants, as required by California legislation (Assembly Bill 1632, Blakeslee).[1] This assessment examined the vulnerability of these plants to a major disruption from an earthquake or plant aging, the impacts from such a disruption, and the costs and impacts of the accumulating nuclear waste at these plants.[2] Concurrent with the Energy Commission's adoption of this study and report in 2008, PG&E announced that the USGS had discovered a previously unknown major offshore fault—the Shoreline Fault—less than a mile from Diablo Canyon. This is the second major fault discovered near the plant. PG&E and NRC subsequently concluded that Diablo Canyon's design would withstand the potential ground motions from this fault. However, this fault's major characteristics are largely unknown including its length, whether it might extend beneath the plant, its relationship to the Hosgri Fault, and if these two faults may interact causing a larger earthquake than if either fault broke separately. The Energy Commission's 2008 study concluded that important data on Diablo Canyon's seismic hazard and plant vulnerabilities are incomplete and that advanced three-dimensional geophysical seismic reflection mapping and other advanced technologies could help resolve questions about the nature of the Hosgri Fault and change estimates of the seismic hazard at the plant.

The Energy Commission's study also found that data, which has become available since the San Onofre plant was built, indicate that this coastal power plant could experience larger and more frequent earthquakes than was anticipated when the plant was originally designed for a maximum 7.0 earthquake. A review in 2001 by the California Coastal Commission stated that, "there is credible reason to believe that the design basis earthquake approved by the NRC at the time of the licensing of SONGS 2 and 3... may underestimate the seismic risk at the time."[3] The Coastal Commission also recently concluded that, "more recent examinations indicate that a larger earthquake or a large submarine landslide could generate a tsunami larger than that considered by SCE or the NRC."[4] Although this new information does not necessarily imply that the facility is unsafe, since the plant was engineered with a large safety margin, the possibility that the safety margin is shrinking suggests that further study is essential to characterize the seismic and tsunami hazard for the site, especially since so much less is known about the seismic setting of SONGS than the seismic setting at Diablo Canyon.

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[1] California Energy Commission, *An Assessment of California's Nuclear Power Plants: AB 1632 Report,* November 2008, CEC-100-2008-009-CMF.
[2] The Energy Commission in 2008 adopted the study and report entitled "*An Assessment of California's Nuclear Plants: AB 1632 Report (AB 1632 Report)* and the *Integrated Energy Policy Report (IEPR 2008).*
[3] California Coastal Commission, http://www.coastal.ca.gov/energy/E-00-014-3mmi.pdf, page 19.
[4] Mark Johnsson, Coastal Commission. "The Tohoku Earthquake of March 11, 2011: A Preliminary Report on Implications for Coastal California, March 24, 2011.

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California Agencies' Recommendations

The California Energy Commission and the California Public Utilities Commission (CPUC) in 2009 directed PG&E and SCE to undertake the studies recommended in the AB 1632 Report as part of their license renewal evaluations. These studies include using three-dimensional geophysical seismic reflection mapping and other advanced techniques, such as those used in oil and gas exploration, to supplement ongoing seismic research programs at Diablo Canyon and San Onofre. These studies also include reviewing the tsunami hazards at their plants in light of recent research and improved scientific understanding of tsunamis. The Energy Commission also recommended in 2008 that PG&E and SCE should return their spent fuel pools to more open racking configurations as soon as feasible.

PG&E has begun some of the recommended advanced seismic studies and plans to complete them in 2013. SCE has applied to the CPUC for funds for these studies and plans to complete them in 2016. The Energy Commission also recommended that the NRC should consider the findings from these studies in its relicensing review. The NRC, PG&E and SCE disagree with this recommendation.

Plant License Renewal Review Process

Recent events in Japan reinforce California officials' position that the advanced seismic studies for Diablo Canyon and San Onofre should be completed, independently reviewed, and that the study findings should be included in the CPUC's and the NRC's relicensing evaluations for these plants. NRC's plant license renewal evaluations for these plants should include the advanced studies recommended in the Energy Commission's AB 1632 Report. They also should include any major additional equipment or follow-up actions required in response to the lessons learned from Japan. The 9.0 magnitude earthquake and resulting tsunami at the Fukushima Daiichi plant far exceeded the original design basis (7.9 magnitude earthquake) for this plant and underscores the importance of addressing seismic risk uncertainties for Diablo Canyon and San Onofre during license renewal evaluations.

In November 2009, PG&E filed an application with the NRC to renew Diablo Canyon's operating licenses (15 years before the licenses expire) before PG&E had completed the AB 1632 Report studies. By filing before completing these studies, the company ignored the Energy Commission's and the CPUC's directives to them that they first complete these studies before filing for license renewal. The California Energy Commission in formal comments to the NRC in 2010 requested that the NRC include in their license renewal evaluation for Diablo Canyon site-specific and updated analyses of seismic/tsunami risks, spent nuclear fuel management, safeguards and security, emergency response planning, plant safety culture, energy alternatives, and once-through plant cooling. These analyses are imperative to evaluate the true cost and benefits of an additional 20 years of Diablo Canyon's operation. However, the NRC has indicated that their license renewal review process does not evaluate seismic vulnerabilities and does not require that advanced seismic studies be included within

the scope of their review of a license extension application. As a result, the NRC's license renewal review for Diablo Canyon is proceeding without the benefit of the updated advanced seismic/tsunami studies that the California officials directed PG&E to perform. NRC plans to issue a Final Supplemental Environmental Statement for Diablo Canyon's license renewal review in early 2012.

The NRC's license renewal process focuses on plant aging and plant hardware issues, such as metal fatigue, and evaluates the environmental impacts from an additional 20 years of plant operation. NRC does not evaluate site-specific seismic issues during license renewal reviews and excludes from its license renewal proceedings issues that states and public interest groups have raised that are not directly related to plant aging or deficiencies in the environmental assessment. For example, during license renewal reviews for the Indian Point Power Plant in New York, the NRC dismissed from the proceeding the State of New York's contentions regarding seismic vulnerability, plant vulnerability to a terrorist attack, risk of spent fuel pool fires, and the inadequacy of emergency plant evacuation plans.

While PG&E has undertaken some recent seismic evaluations and has received funding for the advanced seismic/tsunami studies at Diablo Canyon, PG&E has regularly indicated that these studies will not be completed during the NRC's license renewal proceeding. SCE has also indicated that seismic issues will not be part of their license renewal activities for SONGS.

Lessons Learned from Japan's Nuclear Plant Crisis

Several national and international organizations, including the International Atomic Energy Agency (IAEA), NRC, Nuclear Energy Institute (NEI), and the Institute for Nuclear Power Operations (INPO) will examine the events and lessons learned from the Fukushima Daiichi Nuclear Plant. Although it is too soon to identify any lessons learned from Japan, follow-up actions most certainly will be required from these studies. As was the case after the Three-Mile Island accident and 9/11, the costs associated with operating nuclear power plants likely will increase as additional measures and equipment are required to provide additional assurances that U.S. reactors will not be susceptible to events similar to those occurring at the Fukushima plant.

NRC should include the lessons learned from these studies in NRC's plant license renewal reviews and should more closely scrutinize significant plant or site-specific issues, including seismic and tsunami issues, in these proceedings. NRC has initiated a 30-day and a 90-day review related to the nuclear plant crisis in Japan to identify potential near-term actions that affect U.S. power reactors. These include actions related to spent fuel pools, station blackout (loss of all A/C power for a reactor), external events that could lead to a prolonged loss of cooling, plant capabilities for preventing or dealing with such circumstances and emergency preparedness. We strongly support these efforts. If normal or backup power had been restored at Fukushima before the back-up batteries were depleted, the devastating events at this plant likely could have been avoided.

In addition to the lessons learned studies already underway, we recommend that the following issues be reexamined:

1. **Waste Confidence Decision:** NRC's Waste Confidence Decision, which concluded that spent nuclear fuel can be stored safely onsite at reactor sites for at least 100 years, should be reexamined particularly spent fuel stored in seismically active coastal areas. The safety of long-term storage of spent fuel in seismically active or tsunami prone areas needs to be reevaluated in light of events at the Fukushima Daiichi plant.

2. **Spent Fuel Management:** The nation's spent fuel management system and practices should be reevaluated, including the current practice of storing spent fuel in pools in tighter storage configuration than original plant designs. Storing more spent fuel in pools in closer configuration creates greater heat loads thereby increasing the risks of potential fires. As more and more spent fuel accumulates at reactors sites, plant owners have had to rerack their spent fuel pools multiple times to increase their onsite spent fuel storage capacity. The National Research Council of the National Academies' in 2006 recommended that the NRC should analyze the vulnerabilities and consequences of loss-of-pool-coolant events that could lead to propagating fires and the release of large quantities of radioactive materials to the environment. They recommended that the NRC take actions to address any significant vulnerabilities identified. These recommendations are even more vital today, given events in Japan.

3. **Spent Fuel Pool Overheating:** The risks of loss-of-coolant events in spent fuel pools should be reexamined. Actions needed to reduce the consequences of such events should be recommended and implemented as soon as feasible. The severe spent fuel pool overheating problems at Fukushima highlight the importance of ensuring that plant operators take prompt and effective measures to reduce the consequences of loss-of-pool-coolant events in spent fuel pools that could lead to fires. The Energy Commission in 2008 recommended that PG&E and SCE should return their spent fuel pools to more open racking configurations as soon as feasible.

Conclusions

The 9.0 magnitude earthquake in Japan and resulting tsunami greatly exceeded the plant's earthquake design (7.9 magnitude) and tsunami predictions. These events and the resulting devastation at the Fukushima Daiichi plant underscore the importance of completing the advanced seismic and tsunami studies at Diablo Canyon and San Onofre and having these studies included in NRC's license renewal evaluations for these plants. Like the Fukushima Daiichi plant, California's nuclear power plants are older plants with significant inventories of spent nuclear fuel located near major earthquake faults on the coast.

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Analyses of the lessons learned from Japan will be important to determine what measures and equipment might be necessary to ensure that US plants are not susceptible to conditions and events similar to those that occurred in Japan. The NRC has announced a short-term and long-term review of events at Fukushima. If their response to the Three Mile Island accident is any indication, we can expect a thorough investigation of the lessons learned with comprehensive recommendations for addressing the problems revealed in Japan. It is essential that Congress support the NRC in these efforts and help ensure that the necessary follow-up actions are implemented at U.S. reactors as soon as feasible. These studies should be completed as soon as feasible and any significant measures or major additional equipment needed to reduce potential vulnerabilities at U.S. plants should be identified and the costs included as part of license renewal evaluations.

That completes my prepared remarks. I would be happy to answer any questions.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION IV
612 EAST LAMAR BLVD, SUITE 400
ARLINGTON, TEXAS 76011-4125

March 2, 2010

EA-10-024

Mr. Ross T. Ridenoure
Senior Vice President and
Chief Nuclear Officer
Southern California Edison Company
San Onofre Nuclear Generating Station
P.O. Box 128
San Clemente, CA 92674-0128

SUBJECT: WORK ENVIRONMENT ISSUES AT SAN ONOFRE NUCLEAR GENERATING STATION – CHILLING EFFECT

Dear Mr. Ridenoure:

The purpose of this letter is to verify Southern California Edison (SCE) is taking appropriate actions to ensure San Onofre Nuclear Generating Station (SONGS), Units 2 and 3, is a workplace that fosters an environment where employees feel free, and are encouraged, to raise safety concerns.

The Nuclear Regulatory Commission (NRC) has concluded that some employees in multiple workgroups at SONGS have the perception that they are not free to raise safety concerns using all available avenues, and that management has not been effective in encouraging employees to use all available avenues without fear of retaliation. This conclusion resulted from numerous observations, including; (1) employees expressing difficulty or inability to use the corrective action program; (2) a lack of knowledge or mistrust of the Nuclear Safety Concerns Program (NSCP); (3) a substantiated case of a supervisor creating a chilled work environment in his/her work group; and (4) a perceived fear of retaliation for raising safety concerns.

The NRC has identified that safety concerns are being raised by SONGS personnel through some communication avenues, and has not identified any safety issues that were not reported by some available avenue. The NRC has determined that some employees do not consider certain avenues available, such as discussing a concern with their immediate supervisor, but would find an alternate avenue to communicate their safety concern.

The NRC has received a significant increase of allegations from onsite sources at SONGS to nearly ten times the industry median in 2009. During this time, there was a significant increase in chilling effect, discrimination, and anonymous concerns raised to the NRC as compared to prior years. These allegations were received from multiple onsite organizations.

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The NRC observed that not all SCE managers have completed Safety Conscious Work Environment training, and that SCE communications and policy statements do not clearly reflect the availability of multiple avenues for raising safety concerns. Also, the NRC's 2009 Mid-Cycle Assessment noted that this was the fourth consecutive assessment period with substantive cross-cutting issues in the areas of human performance and problem identification and resolution. SCE's corrective actions have not demonstrated adequate improvement in these areas, and the NRC continues to identify additional problems in these areas. These internal communication issues, long-term failure to correct substantive cross-cutting issues, and a potential inconsistent understanding of expectations and standards are contributors to some employees' reluctance to raise safety concerns.

Supporting details from NRC inspections, allegations, and NRC conducted focus group interviews are provided in the attachment to this letter.

Action:

Within 30 days of the date of this letter, the NRC requests that SCE provide:

(1) Results of your Safety Conscious Work Environment root cause evaluation and focus group interviews, conducted on or about January and February 2010. As part of the results, provide the basis for determining the number of interviews and scope of work groups selected, as well as the questions used for the interviews. Also provide what immediate actions were taken to address these results, and what longer-term actions are planned, including descriptions, milestones, and due dates;

(2) Your action plans to address existing Safety Conscious Work Environment issues to improve the environment at SONGS. The action plans, at a minimum, should specifically address how each avenue for raising concerns will be improved, including ease of use of the corrective action program, knowledge and use of the NSCP, availability of the NRC, and SCE's open door policy. Also include the measures that will be used to determine your action plan effectiveness;

(3) Your plan to communicate expectations and policies concerning Safety Conscious Work Environment at SONGS, and methods used to verify that all SCE and contract personnel have received the message and clearly understand it;

(4) Your plan to ensure that individuals who are not satisfied with the resolution of a problem can pursue the concern further through additional avenues (such as SCE management, the corrective action program, the NSCP, or the NRC) without fear of retaliation;

(5) Through focus group interviews, the NRC has identified Safety Conscious Work Environment issues in multiple work groups, as indicated in the enclosure to this letter. For those groups, provide your actions taken and planned to address the chilled environment. This discussion should include the specific actions taken to repair the willingness of individuals in those groups to raise safety concerns, and what longer term actions you are taking or plan on taking to ensure the effectiveness of these actions;

(6) Your plan to identify any other specific workgroup that may have Safety Conscious Work Environment issues that have not been previously identified;

(7) What actions you have taken or plan to take to ensure that actions taken against individuals are not perceived as retaliatory to avoid a further chilling of the environment at SONGS; and

(8) Your plans to inform the SONGS workforce, including contractors, of: (i) the issuance and content of this chilling effect letter; (ii) the current status of Safety Conscious Work Environment at SONGS; and (iii) your action plans to address the Safety Conscious Work Environment issues.

Furthermore, the NRC requests that SCE provide at a public meeting, within six months of the date of this letter:

(9) The results of your evaluations of progress in addressing the Safety Conscious Work Environment concerns at SONGS, and;

(10) Any additional actions or changes in actions planned and taken to address Safety Conscious Work Environment issues at SONGS.

The NRC also requests that SCE provide in writing, within six months of the date of this letter:

(11) The effectiveness of actions taken to address the Safety Conscious Work Environment concerns in the specific groups identified in Action (5) above;

(12) The effectiveness of actions taken to address Safety Conscious Work Environment issues in any additional SCE identified groups with Safety Conscious Work Environment concerns; and

(13) Any additional actions or changes in actions planned and taken to address Safety Conscious Work Environment issues at SONGS.

Following receipt and review of SCE's response, we will determine if a meeting is needed to discuss SCE's approach and schedule, and the NRC's planned oversight.

In accordance with 10 CFR 2.390 of the NRC's "Rules of Practice," a copy of this letter will be made available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's document system (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html (the Public Electronic Reading Room). In addition, on May 14, 1996, the Commission issued a policy statement regarding the freedom of employees in the nuclear industry to raise concerns without fear of retaliation. This policy statement is accessible from the NRC Web site at http://www.nrc.gov/about-nrc/regulatory/allegations/scwe-frn-5-14-96.pdf.

Because your response will be placed and made available electronically for public inspection in the NRC Public Document Room or from the PARS component of ADAMS, to the extent possible it should not include any personal privacy, proprietary, or safeguards information so that it can be made available to the public without redaction. If personal privacy or proprietary information is necessary to provide an acceptable response, then please provide a bracketed copy of your response that identifies the information that should be protected and a redacted copy of your response that deletes such information. If you request withholding of such material, you must specifically identify the portions of your response that you seek to have withheld and provide in detail the bases for your withholding claim (e.g., explain why the

disclosure of information will create an unwarranted invasion of personal privacy or provide the information required by 10 CFR 2.390(b) to support a request for withholding confidential commercial or financial information). If safeguards information is necessary to provide an acceptable response, please provide the level of protection described in 10 CFR 73.21.

If you have any additional questions regarding these matters, please contact Mr. Ryan Lantz, Chief, Project Branch D, at (817) 860-8173.

Sincerely,

/RA/

Elmo Collins
Regional Administrator

Dockets: 50-361, 50-362
Licenses: NPF-10, NPF-15
w/ Enclosure: Background Information

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Publicly Avail	☒Yes ☐ No	Sensitive	☐ Yes ☒ No	Sens. Type Initials	RL

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Background:

In 2008 – 2009, the NRC received 57 allegations for SONGS, including 37 allegations with 53 separate concerns related to the safety conscious work environment (SCWE) at SONGS. This included 25 allegations of fear of retaliation for raising safety concerns and 17 allegations of retaliation for raising safety concerns. An additional three concerns were related to lack of confidence in the Nuclear Safety Concerns Program. In contrast to the 2008 trend where 11 allegations were received with 19 concerns related to the SCWE at SONGS, the NRC received a significantly higher number of allegations in 2009, including 26 allegations with 34 concerns related to the SCWE at SONGS. The above include the following breakdown:

(1) In 2008, four allegations were received alleging retaliation for raising safety issues, while in 2009, 11 allegations were received alleging retaliation for raising safety issues.

(2) In 2008, seven allegations were received alleging fear of retaliation for raising safety issues, while in 2009, 18 allegations were received alleging fear of retaliation for raising safety issues.

(3) In 2008, one allegation was received with a concern of lack of confidence in the Nuclear Safety Concerns Program, while in 2009, two allegations were received with a concern of lack of confidence in the Nuclear Safety Concerns Program.

(4) From 2008 – 2009, 21% of NRC allegations were anonymous.

(5) In 2008, 18 allegations were raised from on-site sources, which was more than six times the industry median. In 2009, 34 allegations were raised from on-site sources, which was nearly ten times the industry median.

These concerns were received from multiple on-site organizations including operations, engineering, maintenance, emergency preparedness, work control, procedure writers, procurement, painters, security, regulatory affairs, and contractor organizations. Through 2008 and 2009, the NRC's allegation staff and SCE periodically discussed and compared allegation trends, which encompassed similar work groups. In November 2009, the NRC acknowledged that SCE did substantiate a claim that a manager created a chilled work environment in his/her work group.

On December 3, 2008, the NRC issued "San Onofre Nuclear Generating Station Units 2 and 3 – NRC Problem Identification and Resolution Inspection Report 05000361/2008012 AND 05000362/2008012, and Confirmatory Order (EA-07-232) Follow-Up Inspection" (ML083390399). The inspectors determined all of the individuals interviewed during the inspection expressed a willingness to raise safety concerns and were able to provide multiple examples of avenues available, such as their supervisor, writing a notification, other supervisors/managers, the Nuclear Safety Concerns Program, and the NRC. However, all the interviewees also provided negative feedback and shared concerns about their working knowledge of SAP, which included the site's new corrective action program system. The interviewees indicated that they either did not know how to write a notification or found the process to be very difficult. Regarding effectiveness of problem resolution, some interviewees in all of the focus groups indicated that the difficulties of using SAP have started affecting their confidence in the corrective action program. Regarding management response to issues

raised, half of the focus groups explained that sometimes management does not have the proper understanding of problems due to limited presence in the field.

Regarding the nuclear safety concerns program, participants in four of the six groups did not have an opinion because they have not had any experience with the program or a need to use it. Two of the focus groups expressed some concerns regarding the effectiveness of the program in resolving problems, believing it to be of limited effectiveness. However, they indicated they would use the nuclear safety concerns program if necessary. None of the interviewees expressed any concerns or awareness of retaliation for raising safety concerns. Two of the individual interviewees explained that due to perceptions around a recent management change, they had some concerns about potential negative reactions for raising safety issues in general.

Safety Culture Assessments:

On March 4, 2009, in "Annual Assessment Letter – San Onofre Nuclear Generating Station (NRC Inspection Reports 05000361/2009001 and 05000362/2009001)," (ML090640307) the NRC requested SCE perform an independent assessment of the safety culture at SONGS as described in NRC Manual Chapter 0305 "Operating Reactor Assessment Program," (ML082770835) on the basis of having two substantive cross-cutting issues open for three consecutive assessment periods. On September 1, 2009, in the letter titled "Midcycle Performance Review and Inspection Plan – San Onofre Nuclear Generating Station," (ML092450392) the NRC requested SCE provide a letter discussing the results of this assessment and any associated planned actions and projected completion dates.

On October 29, 2009, SCE sent letter titled "Independent Safety Culture Assessment Results and Action Plans (Response to NRC Mid-Cycle Performance Review Letter for the San Onofre Nuclear Generating Station)," (ML100151707) to the NRC, describing the results of the independent safety culture assessment and associated planned actions and projected completion dates to address those actions. Overall, SCE's independent safety culture assessment determined that the safety culture at SONGS is sufficient to support safe plant operations. The independent safety culture assessment identified five areas of performance (Action Areas) in which action is necessary for SONGS to preserve and improve its safety culture, and eleven specific site groups in which there are particular safety culture issues warranting attention. The Actions Areas included accountability and disciplined follow-through, change management and site engagement, utilization of oversight and external input, functions and roles of key programs, and consistent strategic vision and approach. In response to the survey results, SONGS developed action plans and corrective actions to address the issues.

From November 16 – 20, 2009, the NRC performed a focused problem identification and resolution team inspection to assess SCE's independent safety culture evaluation results and the inspection team conducted eleven focus group interview sessions involving 102 personnel as documented in NRC Inspection Report 05000361; 362/2009009. The interviewees represented various functional organizations and included both contractors and SCE staff. From the interviews, the NRC identified degradation in aspects of safety culture of the facility. The weaknesses were apparent across several functional groups at the site. This is of concern because it indicates that, as an overriding priority, nuclear plant safety issues may not always receive the timely, focused attention warranted by their significance. The inspection team determined that the safety culture at SONGS was adequate; however, several areas were identified that needed improvement.

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(1) All of the individuals interviewed expressed a willingness to raise safety concerns and were able to provide multiple examples of avenues available, such as their supervisor, writing a notification, other supervisors/managers, or the Nuclear Safety Concerns Program; however, approximately 25% of those interviewed indicated that they perceived that individuals would be retaliated against if they went to the NRC with a safety concern if they were not satisfied with their management's response.

(2) Most of the interviewees provided negative feedback and shared concerns about their working knowledge of SAP, which included the site's corrective action program. Many interviewees indicated that they either did not know how to write a notification or found the process to be very difficult. Regarding training on the system, most of the interviewees explained that they either did not receive any, or the training they received was of limited effectiveness. The interviewees provided examples of current workaround practices such as going directly to their supervisors or other individuals with safety issues instead of entering them into SAP. There was general concern expressed by all the interviewees about not feeling comfortable using SAP for all the tasks needed for their specific job functions.

(3) Regarding the Nuclear Safety Concerns Program, approximately half of the participants interviewed (mostly contract personnel) were unaware it existed or how to use it. The remaining personnel interviewed had little or no experience dealing with Nuclear Safety Concerns Program, but indicated they would use the program if necessary.

(4) Regarding effectiveness of problem resolution, multiple interviewees in most of the focus groups indicated that obtaining feedback on notifications was difficult, and that in some cases notifications on the same issue had to be generated multiple times in order for the problem to be addressed and corrected.

(5) When asked about the 2009 nuclear safety culture assessment, all of the individuals interviewed remembered having attended a briefing session on the results. However, only the general result of "safety culture was adequate" was recalled by those interviewed.

(6) Also, about half of those personnel interviewed indicated that procedures in place had confusing or inadequate steps, but that the enhancement rate was improving.

In December 2009, due to the NRC's observations during the November 2009 focused problem identification and resolution team inspection, and following NRC management discussions with SCE on allegations relating to Safety Conscious Work Environment (SCWE), SCE initiated a root cause evaluation to analyze the potential SCWE issues. The root cause and the corrective actions are currently being developed by SCE.

In January 2010, the NRC reviewed SCE's programs and processes for establishing, maintaining, and assessing SCWE, including:

(1) SCWE policy statements: SCE documented expectations for management behavior to encourage employees to raise concerns, unrestricted access to multiple avenues for raising concerns, and prohibitions on retaliation in Directive D-008, "SONGS Safety Conscious Work Environment and Resolution of Nuclear Safety Concerns" Revision 11; Directive D-003, "Nuclear Safety Culture," Revision 2; and Brochures

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"What is a Safety Conscious Work Environment," "What is a Nuclear Safety Concern," and "Our Commitment to a Safety Conscious Work Environment." The inspectors noted that Directive D-008 and Brochure "Our Commitment to a Safety Conscious Work Environment" directed SCE employees to report safety concerns by writing a Nuclear Notification in the Corrective Action Program, contacting supervision, contacting the Nuclear Safety Concerns Program, or going to the NRC. However, for contract workers, SCE documents direct them to raise safety concerns to their employer or to SCE management, but did not direct them to contact the NRC or the Nuclear Safety Concerns Program if needed.

(2) SCWE communications: SCWE communications, including management SCWE expectations, were sent out January 2009, November 2009, December 2009, and January 2010. The inspectors determined these communications described the SCWE policies accurately; however, there were inconsistencies in the information provided. Again for contract workers, the communications directed them to raise safety concerns to their employer or to SCE management, and did not direct them to contact the NRC or the Nuclear Safety Concerns Program if needed. Also, the Weekly Standup Package stated to go to the NRC if you have not had your nuclear safety issue resolved. The inspectors determined this direction could be read by some individuals to mean they should not raise their concern to the NRC as an available first option.

(3) SCWE training: The NRC inspection in November 2009 identified that not all managers received the SCWE management training. Only managers enrolled in the Management and Supervisory Development Program received the training. However, it is the office Director's discretion whether a manager enters this program. Since then, SCE has performed no interim actions to ensure all managers received this training. Southern California Edison plans on incorporating this training into the Leadership Academy that starts at the end of February 2010, but due to the small size of the classes, all managers will not be trained until February 2013. Further, SCE has no action or plan to make SCWE management training continuing training.

(4) Corrective Action Program: Procedure SO123-XV-50.CAP-1, "Writing Nuclear Notifications for Problem Identification and Resolution," Revision 2, stated, "All SONGS employees and supplemental personnel are responsible for promptly identifying, reporting and documenting problems by writing a Nuclear Notification;" however, not all SCE and contract personnel have access to write a Nuclear Notification.

On February 1-10, 2010, the NRC conducted additional focus group interviews to perform a more extensive assessment of the safety culture at the plant, as the first part of an inspection of SCE's problem identification and resolution program. This effort involved interviews with approximately 400 workers through 40 focus group interview sessions and some individual interviews as documented in NRC Inspection Report 05000361; 362/2009009. In summary, the results of the focus group interviews indicated a continued degradation in the safety conscious work environment at the plant. The February 2010 NRC-led focus groups indicated:

1) A majority of individuals felt comfortable raising concerns to their supervisors or managers, the Nuclear Safety Concerns Program, and the NRC, however, some individuals from multiple work groups were not comfortable raising concerns without fear of retaliation.

2) A majority of individuals expressed confidence in raising an issue to the Nuclear Safety Concerns Program, however, several individuals in multiple work groups indicated a lack of confidence in the Nuclear Safety Concerns Program, and a few individuals stated that people who used the Nuclear Safety Concerns Program had been punished or retaliated against.

3) Supervisors had not been trained on how to address potential SCWE issues involving a worker or supervisor in another organization, nor on investigation of non-nuclear safety incidents (such as occupational safety).

4) Several individuals indicated a lack of confidence in SCE's corrective action program (SAP). Examples cited included prioritization issues, schedule pressures due to large workload delaying more significant issues, and low priority for procedure modifications..

5) Many of the craft expressed the sentiment that if a person gets hurt on the job, the evaluation of the incident is cursory at best and the worker will end up fired.

6) Managers and Supervisors were not engaging workers in the field or their workstations. Many focus group members had never personally met their direct management above front-line supervisors.

Summary:

Paleoseismic features as indicators of earthquake hazards in North Coastal, San Diego County, California, USA
Engineering Geology - 80 (2005) /Gerald G. Kuhn

Paleoseismology is the study of the timing, location, and size of prehistoric earthquakes.

The Newport-Inglewood/Rose Canyon fault system is a major component of the San Andreas Fault System. p. 120 /2

Although Emery (1960, p.124) indicated that Southern California was not immune to tsunamis, many considered that San Diego was relatively safe owing to the bordering, wide continental shelf that inhibits seismically-induced wave attack generated outside the region (Van Dorn, 1965). Recently, however, geophysical research shows that the Southern California Continental Borderland is crossed by many active faults with characteristics capable of producing large-scale, co-seismic sea floor deformation during submarine earthquakes (Legg, 1991; Legg and Kennedy, 1991; Rivero et al., 2000; Grant and Rockwell, 2002).

Additionally, local strong seismicity generated by any potential local earthquake sources, both onshore and offshore, could trigger large-scale slope failures and thereby generate local tsunamis (McCarthy et al., 1993; Borrero et al., 2001; Legg et al., 2003).

Additionally, many large slope failures have been mapped in the Southern California Continental Borderland (Field and Richmond, 1980; Clarke et al., 1985, 1987; Legg and Kamerling, 2003), even off Carlsbad and Encinitas (Greene and Kennedy, 1987; Clarke et al., 1987; Fig. 37).

Paleoseismic investigations also show large coastal earthquakes occurred within the Holocene, and historically at least four measurable local tsunamis impacted the Southern California region in 1812, 1862, 1927, and 1930 (McCulloch, 1985; Lander et al., 1993). Accordingly, evidence for paleotsunamis is abundant, and the potential for future impact is high (McCarthy et al., 1993; Legg et al., 2003, 2004).

Based on the extent (730 km), character, and distribution of paleoseismic features and the residual evidence afforded by mima-mound topography and tsunamigenic deposits, it seems likely that the causative earthquakes were of at least M~7.0 (Kuhn et al., 2000, 2004). The specific fault(s) that triggered the liquefaction and likely secondary surface faulting is not well constrained. However, the likely seismic sources are the Newport–Inglewood/Rose Canyon Fault Zone (NIRC), ~ 4–6 km offshore and possibly under the study area (Kuhn et al., 2000, 2004), other Continental Borderland faults (Legg, 1991), and possible site-specific faults (Figs. 1 and 2).

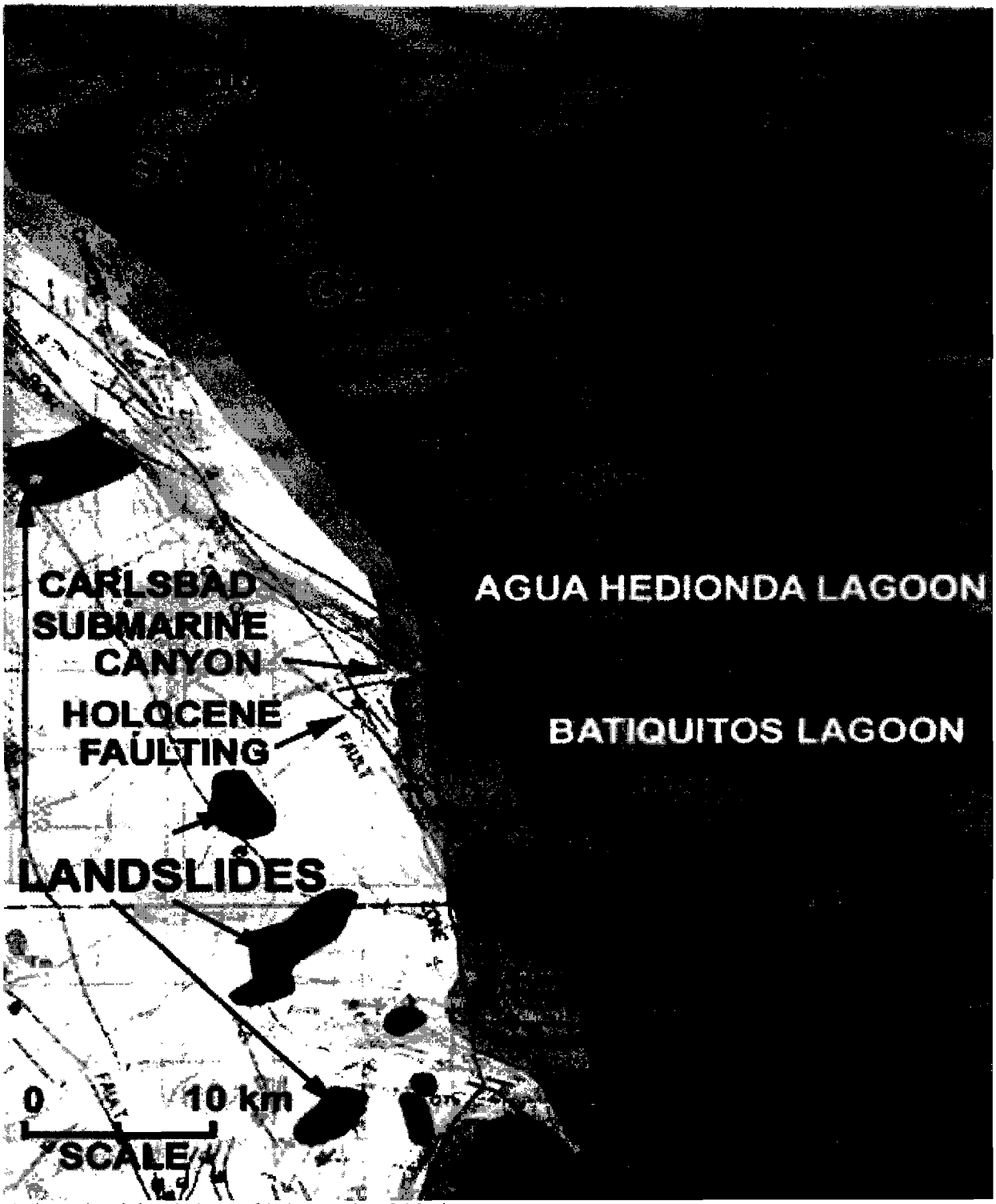

Fig. 37. Portion of a bGeologic map of the inner-southern California Continental MarginQ. Note: The red square (located at the Carlsbad Submarine Canyon) indicates sea floor faulting that cut strata of Holocene age. Also note the adjacent large submarine landslide (adapted from: Clarke et al., 1987).

Mima mound topography also characterizes much of the North San Diego County study area. Although these features alone do not provide incontrovertible evidence for local area paleoseismicity, their presence compliments and otherwise supports major seismic events in the late Quaternary. Extensive mound fields were once in evidence (Orcutt, 1887) and visible on aerial photography taken along the North San Diego County coastal surfaces, prior to urbanization (USGS,1947; USDA, 1953). Scattered mounds still occur in Carlsbad and Encinitas **and on the Camp Pendleton Marine Base.**

The Newport–Inglewood/Rose Canyon fault zone (NIRC) is the longest and most active in the north coastal San Diego County area (Figs. 2 and 37). It is therefore the most likely seismogenic source for the observed paleoseismic features (Lindvall and Rockwell, 1995; Grant et al., 1999; Rivero et al., 2000;

The NIRC Newport–Inglewood/Rose Canyon fault zone, other nearby offshore faults, plus possible local onshore faults, are all capable of generating relatively high-magnitude earthquakes. These collectively can produce the myriad of paleoseismic features now exposed in the north San Diego County area.

Many paleoseismic events probably originated on the nearby Newport–Inglewood/Rose Canyon fault system. Eastern dipping segments of the NIRC project under the north coast of San Diego County. Accordingly, the seismic hazard of this area may be substantially higher than heretofore assumed.

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Paleoseismic features as indicators of earthquake hazards in North Coastal, San Diego County, California, USA

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Abstract

New road cut and mass-grading excavations in the north coastal area of San Diego County, California expose heretofore generally unrecognized, probable late Holocene tsunami deposits and paleoseismically deformed sediments. Remnant tsunami deposits occur up to 100 + m in elevation around the margins of modern coastal lagoons and estuaries and, combined with local mima mounds of possible sand blow origin, provide indirect but compelling evidence for the late Quaternary activity of onshore and offshore faults in the immediate study area. Probable paleoliquefaction features are regionally widespread and range from fissures filled with sediments derived from overlying marine terrace sand and soil, to the more traditional sand-filled injection dikes and sills, lateral spreads, and filled craterlets. The source of most liquefied sediment is underlying Tertiary "bedrock sand" and local, Quaternary marine-terrace deposits. A paleoseismic liquefaction origin rather than soft-sediment loading is deduced for these features based on morphology, internal stratigraphy, field setting, and near proximity to known seismogenic sources.

Some paleoseismic events impacted late Holocene Indian middens and burial sites. The last seismic event probably occurred within the past 1 to 3 ka, and possibly even records the historic earthquakes of either November 22, 1800 or May 27, 1862. The liquefaction features also affect marine terrace sediments tens of meters above modern regional water levels, inferentially "recording" paleoseismic events in this Mediterranean-type climatic region during winter rains when high-level, perched water saturates the several meter thick source sediments.

Based on their regional extent, the paleoseismic features were likely caused by M ~ 7+ tectonic events inferentially generated by the nearby offshore Newport–Inglewood/Rose Canyon fault system, or possibly by smaller, recently exposed, related and localized faults. Accordingly, the seismic hazard of the north coastal area of San Diego County may be substantially higher than previously assumed, and hence of concern owing to the rapid ongoing and projected population increase.

Keywords: Earthquake indicators; Tsunami deposits; Holocene; California; Paleoseismic events

1. Introduction

The population of southern California is now approximately 20 million and increasing. Much

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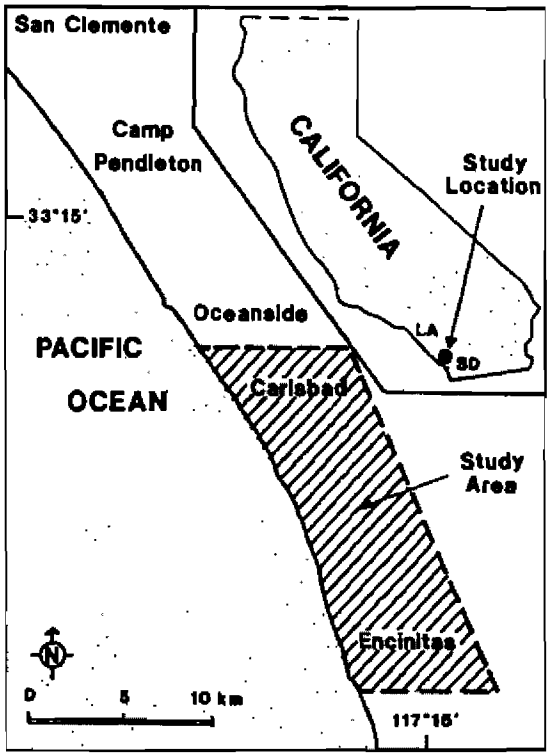

Fig. 1. Map showing location of paleoseismic features along the north San Diego County coast. Los Angeles (LA), San Diego (SD) and the study area (hatchured) are shown for reference.

new growth is taking place along the coastal area of northern San Diego County (Fig. 1). Here, from the shoreline to about 18 km inland, thousands of new houses and commercial centers have been, and are being, constructed. Combined with related road and infrastructure excavation, the new exposures now reveal hundreds of heretofore unrecognized paleotsunami and seismically-induced liquefaction features. Detailed mapping, both in vertical cuts and in continuous, grading-excavations, shows that these features are regionally widespread and recurrent. Accordingly, they provide stratigraphic evidence of late Quaternary, prehistoric earthquakes and possible harbingers of future earthquakes and risk in this part of California. The north coastal area of San Diego County has a typical Mediterranean climate: average annual precipitation is approximately 250 mm; mostly occurring during the winter months of November through March. Much natural vegetation has long been removed, and is now supplanted by exotic introduced species such as eucalyptus, palms, and a host of other decorative plants associated with rapid, post-WW II urban spread.

The presence of people and active faults often form a deadly combination, well demonstrated in California by recent, high-magnitude earthquakes and related damage in the 1971 San Fernando earthquake (Oakshott, 1975), and the 1994 Northridge earthquake (Woods and Seiple, 1995). Neotectonic investigations in California traditionally focus on onshore surface rupture associated with geomorphically well defined fault systems as documented by many workers for the San Andreas and its various splays (Table 1). New investigations now show that many seismic sources are "so-called" blind faults, which can generate high-magnitude earthquakes and yet have only subtle or broadly distributed surface geomorphic expression (Namson and Davis, 1988; Davis et al., 1989; Shaw and Shearer, 2000). Similar blind thrusts and other seismic sources occur immediately offshore the southern California coast as deduced from interpretation of geophysical data (Bohannon and Geist, 1998; Rivero et al., 2000; Figs. 1 and 2; Table 2). Because of their offshore location, the earthquake history of these faults is poorly known; however, it now appears that at least some are recorded by onshore tsunami deposits and related paleoliquefaction features.

Table 1
Local and regional onshore geology

Blake, 1856a,b; Goodyear, 1888; Fairbanks, 1893; Ellis and Lee, 1919; Hertlein and Grant, 1944, 1954; Larson, 1948; Emery, 1950a; Wilson, 1972; Hannan, 1973; Moyle, 1973; Barrows, 1974; Crowell, 1974; Kennedy, 1975; Kennedy et al., 1975; Shepard and Kuhn, 1977; Sieh, 1978; Guptill and Heath, 1981; Emery and Kuhn, 1982; Weber, 1982; Hall, 1984; Kuhn and Shepard, 1984; Eisenberg, 1985; Weldon and Sieh, 1985; Tan, 1986; Harden and Matti, 1989; U.S. Geological Survey [USGS], 1990a; Lajoie et al., 1991; Prentice and Schwartz, 1991; Aydin et al., 1992; Kern and Rockwell, 1992; USGS, 1992, 1998; USGS and Southern California Earthquake Center [SCEC], 1994; Lindvall and Rockwell, 1995; Sims and Garvin, 1995; Tan and Kennedy, 1996; Grant et al., 1999, 2002; Vaughan et al., 1999; Baldwin et al., 2000; Franklin and Kuhn, 2000; Kuhn, 2000; Kuhn et al., 2000, 2004; Lienkaemper, 2001; Grant and Rockwell, 2002; Stone et al., 2002.

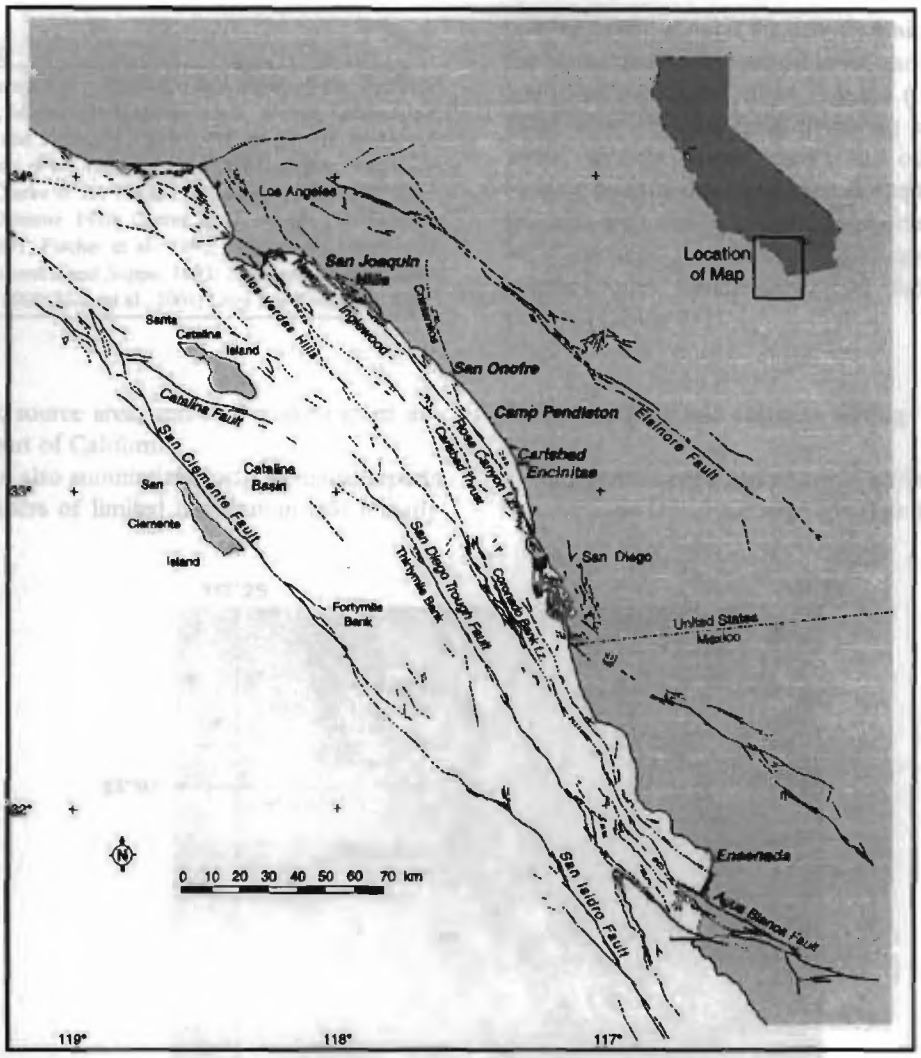

Fig. 2. Major fault zones in the immediate offshore and onshore area of the southern California coast from Los Angeles on the north to near Ensenada in Baja, California on the south. Modified from Legg (1985).

The north coastal paleoliquefaction features are particularly well preserved on flights of marine terraces and within their underlying regressive sands (Figs. 3 and 4). These have been mapped, albeit discontinuously, from approximately San Diego on the south to north of Los Angeles (Fig. 2). Locally, the wave-cut platforms and overlying marine deposits are capped by beach ridges, former dune fields now somewhat lithified. Recent mass-grading (excavations for new houses and commercial development) now exposes hundreds of "anomalous" sedimentary features, which are reasonably judged to be of paleoseismic origin. Accordingly, this paper initially sets forth the geomorphic and neotectonic setting of the study area. This is followed by description of the inferred paleoliquefaction features and the reasons why they are not a result of local loading and soft-sediment deformation. Also discussed is indirect evidence supporting the paleoseismic hypothesis; namely, the inferred seismic origin of local mima mounds, and the character and presence of tsunami deposits. This is followed by interpretation of data concerning paleoseismic recurrence and magni-

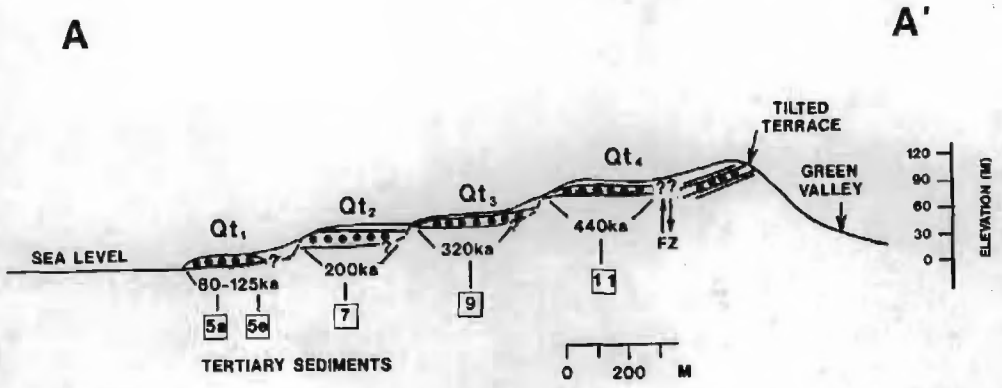

Fig. 4. Schematic cross-section near Encinitas, California (Fig. 3) showing major marine terraces and wave-cut platforms (Qt_1 through Qt_4). Approximate age of terrace sediments deduced from association with the marine-isotope stage chronology (Shackleton and Opdike, 1976), substage 5a through stage 11. Basal regressive marine sand and cobbles deposited denoted by "dots"; fault zone (FZ); terrace thickness exaggerated.

and refined over the past 100 years (Table 1). In addition to published papers and informal guidebook articles, there is a plethora of pertinent unpublished reports and data compilations, many pertaining to neotectonism and earthquake hazards in the area (Table 6). Some data were originally proprietary, obtained for the mid-1970s geologic investigations at and near the San Onofre Nuclear Generating Station in the northwest corner of the Camp Pendleton Marine Corps Base (Fig. 1). Many associated reports dealt with the origin, relative age and deformation history of coastal marine terraces (Table 6), the same as those in the San Diego County north-coastal area that harbor the postulated paleoseismic features described herein (Table 1).

In 1991, LaJoie et al. summarized marine terrace evolution for this part of California, and dated several erosion platforms using amino-acid and uranium-series techniques. Tan and Kennedy (1996) compiled prior geological mapping for the study area and applied local names for the lower four marine terraces that range in elevation from about 3 to 130 m. Based on association with the marine, oxygen-isotope stage chronology, on local radiocarbon and uranium-series dating, and on relative soil (pedogenic) profile development, the terraces are designated and inferentially dated as: Qt_1 (lowest), ~80–125 ka (marine, oxygen-isotope substages 5a through 5e, respectively); Qt_2, ~200 ka (stage 7); Qt_3, ~320 ka (stage 9), and Qt_4, ~440 ka (stage 11; Figs. 3 and 4).

Table 3
Liquefaction issues

Atwater et al., 2001; Obermeier and Dickenson, 2000. *[Regarding U. S. Northwest Cascadian Earthquake of 1700 A.D.]*
Fuller, 1912; Morse, 1941; Saucier, 1987; 1991a,b; Obermeier, 1987, 1989, 1996a,b; USGS, 1990b; Obermeier et al., 1991, 1993, 2004; Marple and Schweig, 1992; Su and Follmer, 1992; Munson et al., 1995; Li et al., 1996; Tuttle et al., 1996; Obermeier and Pond, 1999; Cox et al., 2001; Hough, 2001. *[Regarding Midwestern U. S. Earthquakes.]*
Dutton, 1889; Obermeier et al., 1985, 1990, 2002; Talwani and Cox, 1985; Peters and Hermann, 1986; Amick and Gelinas, 1991; Marple and Talwani, 2000. *[Regarding Charleston, South Carolina Earthquakes.]*
Lawson, 1908; Holzer et al., 1989; 2004; Holzer and Clark, 1993; Meisling, 1979; Jachens et al., 2002; Michael et al., 2002; Rymer et al., 2002a,b; Sylvester et al., 2002. *[Regarding California Earthquakes.]*
Harp et al., 2003. *[Regarding Denali, Alaska Earthquake of 2002.]*
Rajendran and Rajendran, 2003. *[Regarding Kachchh Region, India Earthquakes.]*

Table 4
Paleoseismites

Lamont, 1936; Galli and Ferreli, 1995; Landuzzi et al., 1995; Lucci, 1995; Michetti et al., 1995; Reiter, 1995; Bartholomew et al., 2002; Ettensohn et al., 2002; Greb and Dever, 2002; Mariotti et al., 2002; Merriam and Forster, 2002; Moretti et al., 2002; Obermeier et al., 2002; Stewart et al., 2002; Wheeler, 2002.

Table 5
Tsunamis

Emery, 1950b; Shepard et al., 1950; Natland and Kuenen, 1951; Reimnitz and Marshall, 1965; Coleman, 1968; Eiby, 1982; Foster et al., 1991; Shi et al., 1993; Daag et al., 1995; Dawson, 1994, 1995, 1999; Minoura et al., 1994; Bondevik et al., 1995; Bourgeois, 1995; Carver and Gilpin, 1995; Kelsey et al., 1995; Moore and Lewis, 1995; Nishimura and Miyaji, 1995; Peterson and Priest, 1995; Tuttle et al., 1995; Dawson et al., 1996; Morner, 1996; Borrero et al., 1997; Imamura et al., 1997; Synolakis et al., 1997; Ortiz et al., 1998; Clague et al., 1999; Hindson and Andrade, 1999; Kawata et al., 1999; Takashimizu and Masuda, 2000; Atwater et al., 2001; Carey et al., 2001; Zitellini et al., 2001; Okal et al., 2002a,b; Pratt, 2002; Legg et al., 2003, 2004; Scheffers and Kelletat, 2003; Brookfield, 2004; Costa, 2004.

The marine abrasion platforms are typically sequentially overlain by ~1-m-thick veneer of cobbles (former beach gravel), several meters of regressive marine sand, and locally by prograding continental deposits. Locally, the terrace surfaces are covered by "beach ridges," former coastal dunes now topographically rounded and often relatively lithified. These beach ridge dune sands and the underlying marine sands are prone to seismically-induced liquefaction when saturated, this typically occurring during winter rains when local perched water levels are common (Kuhn et al., 2000, 2004).

From a tectonic standpoint, several prominent aerial-photographic lineaments trend across the study area (Kuhn et al., 2004). These lineaments form a general rhombohedral pattern, with prominent axes oriented northwest and northeast, respectively (Fig. 5). Some lineaments coincide with NW-trending valleys that define the back edge of the terraces; these are now demonstrably fault related as exposed in road and grading cuts and locally in the sea cliffs (Seitz, 1983; Shepard and Kuhn, 1977; Kuhn and Shepard, 1984). The lineaments and related fault patterns are now identified as possible major ancient tectonic shear zones (Slosson et al., 2000), that are probably re-activated. Additionally, new offshore,

Table 6
Unpublished reports

Euge et al., 1972; Western Geophysical, 1972; Fugro, 1975a,b, 1977a,b; Anderson et al., 1977; Ehlig, 1977; Shlemon, 1977, 1978a,b, 1979a,b,c,d.

Table 7
Engineering-geology publications

Housner, 1958; Seed and Lee, 1966; Lee and Seed, 1967; Seed, 1968; Scott and Zuckerman, 1973; Youd, 1973, 1984, 1985; Lowe, 1975, 1976; Youd et al., 1978; Seed and Idress, 1983; National Research Council, 1985; Owen, 1987; Holzer et al., 1989; Meier, 1993; Nichols, 1995.

seismic reflection profiles document the nearby presence and transtensional and transpressional character of the Newport–Inglewood/Rose Canyon fault (NIRC), a major component of the San Andreas fault system (Fig. 2). The new urban exposures also show that many onshore lineaments are aligned with concentrations of sand dikes and boils, filled fissures and lateral spreads, features herein interpreted to be of paleoliquefaction origin.

3. Description of interpreted paleoliquefaction features

In this section, North San Diego County's liquefaction-induced features are discussed according to their morphology and genesis. The most widespread and common are dikes, sills, and laccoliths. These intrusions occur on marine terraces Qt_1 through Qt_4. Craterlets are common, but principally occur only on two terraces. Likewise abundant are lateral spreads and filled fissures. One terrace has a very irregular and undulating surface topography caused by liquefaction at depth (Fig. 5).

3.1. Sand dikes, sills, and laccoliths

3.1.1. Field observations

Railroad and urban-excavation cuts now expose many dikes filled with fine sand that pierce terrace sediments (Figs. 6 and 7), and such terrace sediments range in age from 100 to over 300 ka. The dikes vary from about a few mm to ~10-cm wide, and often taper upward and locally form cross-cutting patterns (Fig. 8). A trench across prominent aerial lineaments on the lowest coastal terrace (Fig. 5) exposed unmatched soil and stratigraphic units, suggesting that this particular lineament is fault controlled (Franklin and Kuhn, 2000; Fig. 9). The trench also exposed paleoliquefaction features such

Fig. 5. 1953 vertical aerial view of the coastal lagoons and terraces at Carlsbad, California. The circular features located in the center of the photograph are "mima mounds;" many are now confirmed to be "sand blow" deposits. Thus several lineaments include lateral spread surfaces or fissure fills (photograph from U.S. Department of Agriculture Photograph #AXN-8M-100, taken on 11 April, 1953).

as sand dikes, lateral spreads, and a sand laccolith. Locally, the source sands, as exposed in the trench, are traced to the underlying Tertiary marine sand (Fig. 10).

Of particular relevance to origin is the relationship of the sand laccolith and the overlying topography (Fig. 11). Here the sand laccolith is demonstrably fed by several sand dikes, which in turn had locally pierced and or otherwise given rise to an irregular, micro-topography. The overlying surface bears a soil likely no more than about 2 to 3 ka old profile and perhaps much younger (Shlemon, 1999, pers. com.) based on the relative degree of development. The liquefied sediments exposed in this trench vary in age from late Holocene to probably late Pleistocene, and demonstrate that two and perhaps several seismic events occurred in this area. The Tertiary source sands here are still relatively cemented and therefore prone to liquefy under seismic loading (Fig. 10). Terrace sediments containing the dikes vary widely in origin, ranging from Pleistocene (?) regressive marine and clay-rich marsh and lagoon deposits to prograding continental and eolian deposits.

Other trenches on the same marine terrace exposed more sand sills, dikes, laccoliths, and warped argillic soil horizons (Fig. 12), as well as highly contorted lateral spreads that flowed over deformed, tilted sandflat and marsh sediments (Fig. 13). Also observed were liquefied and offset channel-lag deposits in

Fig. 6. View (1994) of a railroad cut exposure showing fine grain, tan and white sand dikes cutting into and through continental deposits and into an overlying Bt argillic soil horizon at Carlsbad, California (15.24 m el. MSL).

which the adjacent horizontal bedding had been uplifted and eroded (Fig. 14).

Likewise evident are irregularly shaped clay beds with entrained sand, showing that the sand had moved laterally and upward. Implicitly the contorted clay and sand probably moved plastically to nearby swales, ultimately giving rise to the undulating, modern ground topography.

On adjacent terraces, urban grading cuts exposed polygonal, reticulated, and sand-filled features (Fig.

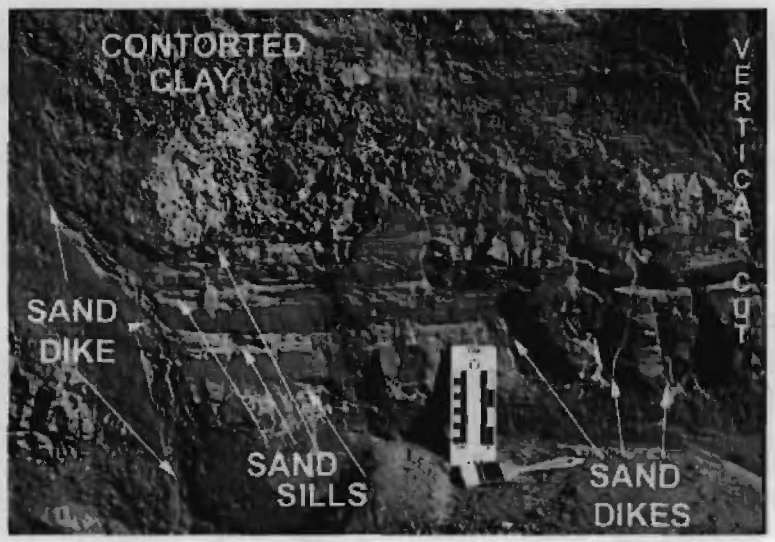

Fig. 7. View (1994) of sand dikes cutting vertically through clay-rich estuarine deposits at Carlsbad, California (13.41 m el. MSL). Note: Numerous multi-colored "source sand sills" are confined by clay layers, forming sand dikes that fine upward.

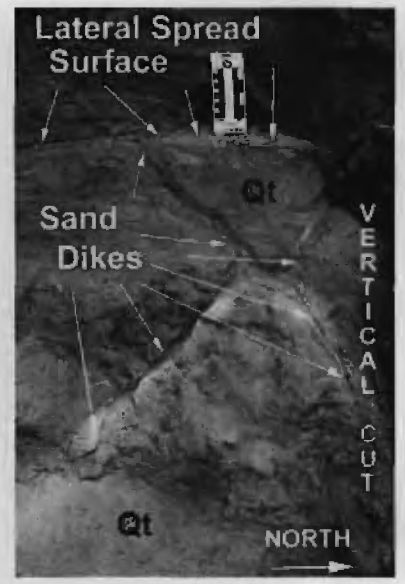

Fig. 8. A vertical cut exposing sand-dikes cutting coastal terrace sands at Carlsbad, California (46.63 m el. MSL). Note: The scale is resting on a lateral spread surface which has cutoff the underlying sand dikes, which are injected from below.

15). Where exposed vertically the sand fillings proved to be tabular dikes, which often trended along pre-existing tectonically-related stress fractures. The dikes are filled with upward-fining, loosely-packed, clean and cohesionless sands. And here, too, some sands are traced to their source in their underlying Tertiary marine beds. Also, as exposed in the various cuts, the dikes are horizontally sheared by lateral spreads (Fig. 8); and where coalescing, the sand dikes are injected into overlying coastal terrace sediments and often form sand laccoliths (Fig. 12).

Terrace Qt_2 exposures show the local presence of gravel-bearing sands at, and near, the tops of vents (Fig. 16). These gravels are similarly traceable into the underlying source sediments, where they have been dragged upward and truncated by lateral spreads. The gravel at the top of the dike may well stem from gravel entrainment during eruption of the liquefied sediment, a phenomenon resulting from strong seismic shaking (Prentice et al., 1992; Meier, 1993; Yegian et al., 1994).

3.1.2. Source mechanism

The geometry and character of the sand-filled dikes observed in the study area is very similar to those reported to have originated as a result of seismic liquefaction as documented by Obermeier (1996b) Also, north San Diego County dikes are associated with sand-filled laccoliths, similar to the seismic-induced features of Obermeier (1996a). Accordingly, the sand dikes, sills, and laccoliths are most likely, heretofore, unrecognized paleoseismic features.

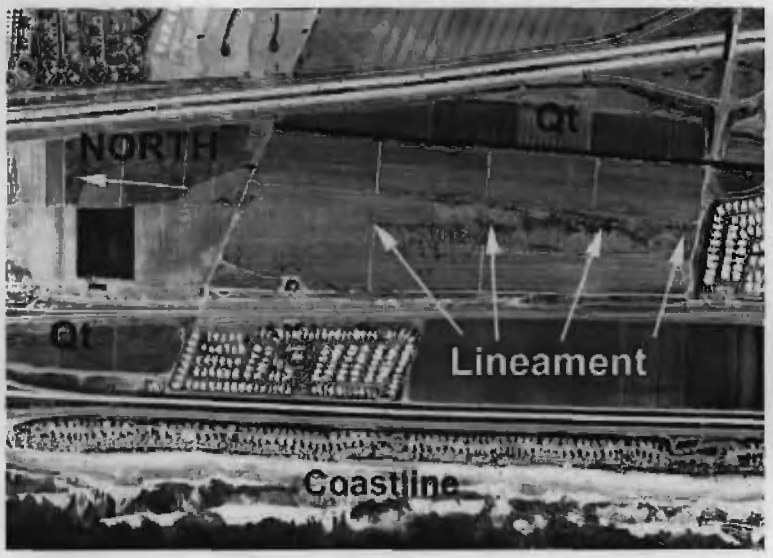

Fig. 9. 1994 color aerial photograph taken along the lowest coastal terrace at Carlsbad, California. Note: The strong, dark lineament coincides with depressions.

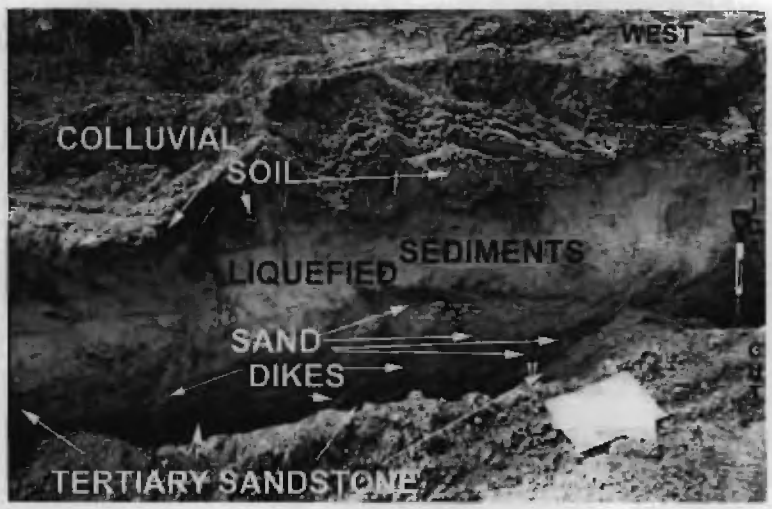

Fig. 10. Trench cut into a coastal terrace at Carlsbad, California exposing liquefied sediments (light layer) overlying the Eocene-age Santiago Formation (B member) with numerous sand dikes emanating from below.

3.2. Craterlets

Obermeier (1996a) pointed out that liquefaction-induced craterlets were extensively produced during the 1886 Charleston, South Carolina earthquake. Similar swarms of craterlets occur in the study area, particularly in terrace Qt_4 (Figs. 3 and 17) likewise supporting a probable seismic origin.

In plan view, the filled craterlets are nearly circular throughout their height and vary in diameter from about 0.3 to 2.0 m (Fig. 18). Their heights vary from about 2 to 10 m. At depth, their internal stratigraphy is characterized by vertical zones of upward-fining, clean, fine- to medium-grained sands, locally varying in color and texture (Fig. 19). These sands, as recorded during field observations, are injected through each other and locally into and through a central core. The upper part of most craterlets appears to be a collapse feature, creating depressions 0.5 to 1.3 m deep (Fig. 20). These craterlets are confined to an

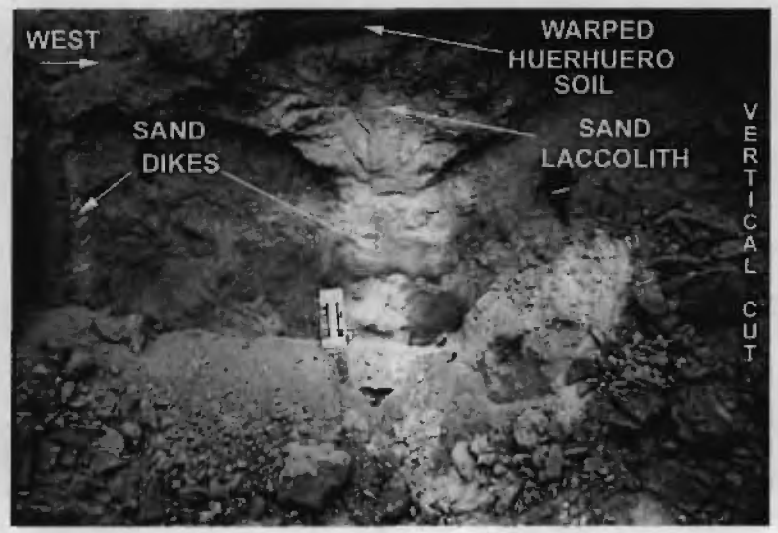

Fig. 11. Closeup view of warped Holocene colluvial sediments and sand dikes exposed in a trench cut into a coastal terrace at Carlsbad, California. Note: Location is the same as Fig. 9.

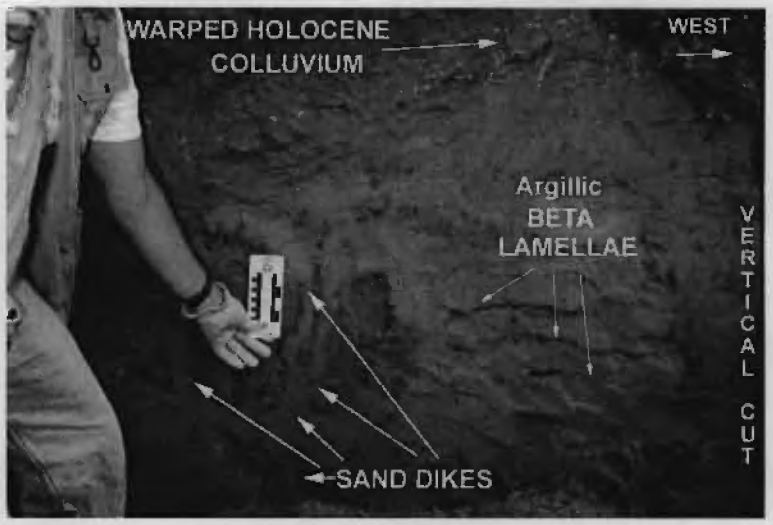

Fig. 12. Exposure of a storm-drain cut into the lowest coastal terrace (15.54 m el. MSL) at Carlsbad, California. Note: Multi-colored sand dikes are traceable from marsh source sands (located at base of brush), are upward-fining, and cut through, offset, and warped "beta" (argillic) lamellae.

ancient beach ridge, where the dike sand demonstrably originated as fluidized sediment transported upward from underlying Tertiary marine sands. Locally, the internal stratigraphy of the craterlets shows that they were likely produced during two or more discrete episodes (Fig. 18).

The craterlets also occur in sediments filling linear swales along the back edge of terrace escarpments and local beach ridges (Figs. 3, 4, and 17). Here the craterlets are filled by fluidized sediment, which later was replaced almost entirely by silica. These features occur near the base of the wave-cut platform and grade into a strongly cemented, 1- to 2-m-thick silcrete duripan. Based on local geomorphic and stratigraphic relations, it is deduced that the craterlets similarly formed by seismic liquefaction,

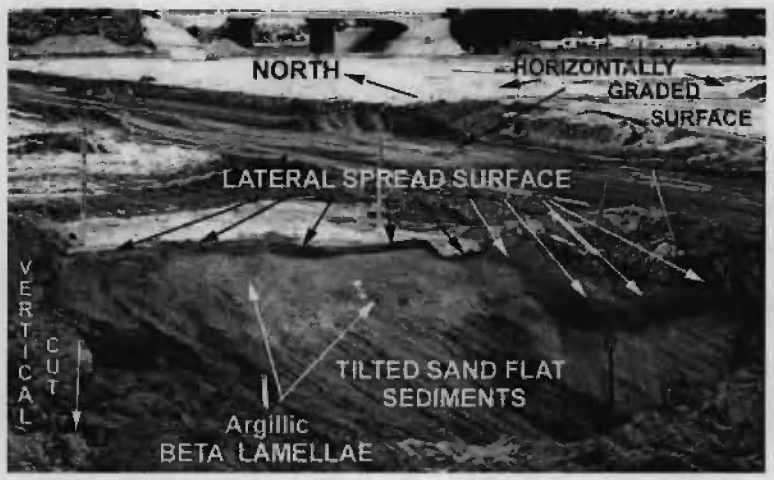

Fig. 13. A construction trench in the lowest coastal terrace (15.84 m el. MSL) at Carlsbad, California exposing tilted paleosand flat sands and marsh sediments, overlain by remnant v-shaped wedges of "beta" (argillic) lamellae, and capped by a clay-rich lateral spread, which flowed easterly, forming a depression. Note: These same sediments, as exposed in sea bluff exposures located 100 m to the west, dip to the west or are near-horizontal.

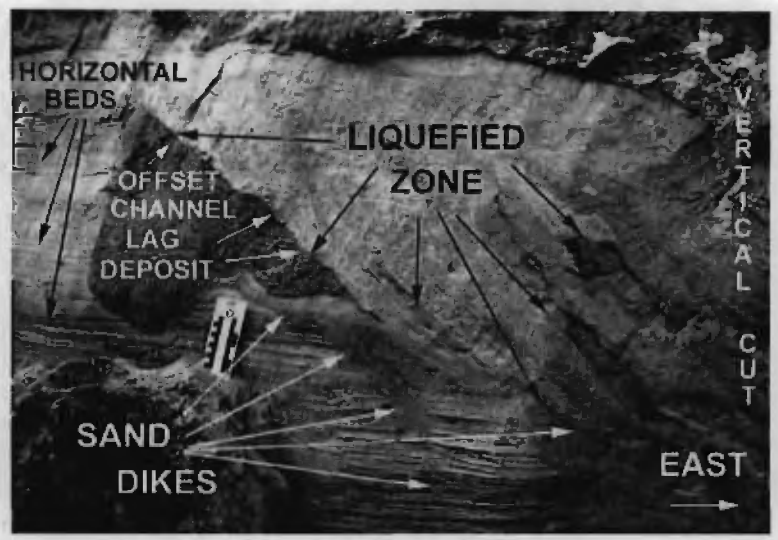

Fig. 14. A construction trench exposing marsh and sand flat sediments vertically cut by sand dikes at Carlsbad, California (19.50 m el. MSL). The liquefied, dragged, and offset channel-lag deposit and that the adjacent bedding has been eroded.

comparable to that reported by Twidale (1976), in Australia.

Elsewhere many craterlets in late Quaternary sediments are characterized by N30W to N70W filled fissures. These craterlets were later offset by the filled fissure deposits which, themselves, trend from N–S to approximately E–W. These particular craterlets vary in diameter from about 1.2 to 1.5 m, have a central

Fig. 15. A horizontally-graded terrace surface at Carlsbad, California (46.32 m el. MSL) exposing polygonal-shaped, "reticulated" multi-colored sand-filled features. Note: Vertical cuts of these same polygonal features expose numerous, adjacent, coalescing, upward-fining sand dikes demonstrably injected from below and not the result of surface infill.

Fig. 16. Near-vertical exposure in a coastal terrace made for a major highway cut at Carlsbad, California (33.52–35.05 m el. MSL). Note: The gravel to boulder-bearing sands, deposited in a very fine, well-sorted dark mineral-rich matrix, are observed at the top of vents, and traceable to sand sills and dikes emanating from underlying marine source sands.

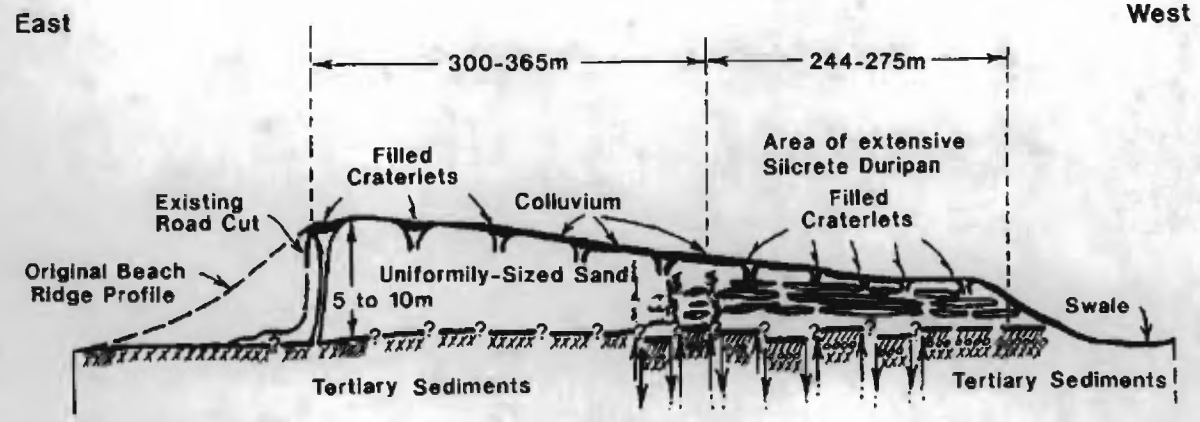

Fig. 17. Schematic vertical section of ancient barrier bar (beach ridge) showing sediment types, filled craterlets, and approximate abrasion platform contacts (former shorelines) at Encinitas, California (see Figs. 3 and 4). Adapted from Obermeier (1996b), his Fig. 13, p. 20.

core, and are formed during at least two intrusive episodes (Fig. 18).

3.2.1. Source mechanism

The craterlets in the study area are likewise interpreted as of paleoseismic liquefaction in origin, based mainly on the similarity of their internal stratigraphy, their morphology, and their occurrence in tectonic regimes where such craterlets have been previously described. For example, Dutton (1889), noted swarms of similar appearing craterlets, and deduced them to be liquefaction features associated with the 1886 Charleston, South Carolina earthquake of M~7.2. More recently, similar liquefaction-induced craterlets were regenerated in the Kachchh Region of India following the M~7.7 earthquake in 2001 (Rajendran and Rajendran, 2003). A likely earthquake origin for the study area craterlets is also indicated by the sand-filled tabular fissures whose overall dimensions and shapes suggest that they are "incipient craterlets" (features described by Obermeier, 1996b).

Although yet uncertain, the source of the strong seismic shaking may well be "hidden" or "blind" faults directly beneath the site, locally enhanced by topo-

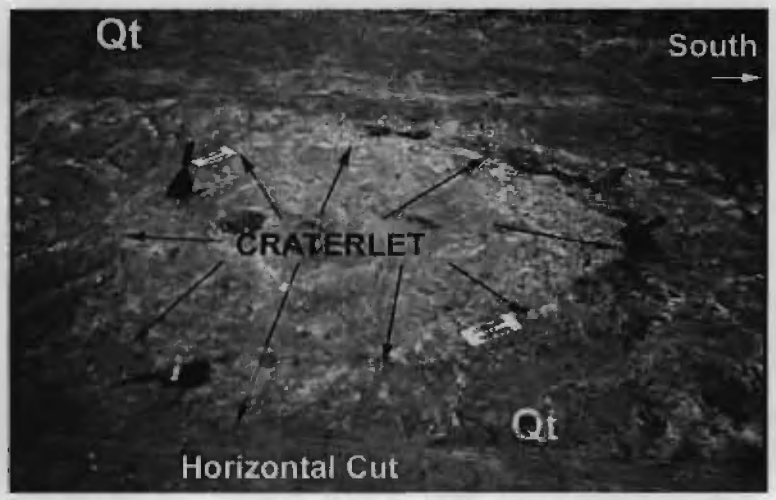

Fig. 18. Near-circular paleoliquefaction features (craterlets) exposed on the surface during construction grading on a coastal terrace at Encinitas, California (110.94 m el. MSL). Note: The boundary is outlined by scraping tools and scales.

graphic amplification, a phenomenon observed during the 1971 M~6.6 San Fernando, California earthquake (Saul, 1975, p. 68–69), and during the 1886 M~7.2 earthquake at Charleston, South Carolina (Obermeier, 1996a, p. 345).

Also suggestive of local faulting is the apparent displacement of terrace Qt_4 (Fig. 17), which, to the east, dramatically increases in dip (Fig. 4). Exposures here show that Qt_4 is apparently offset by a fault zone 3–4 m wide. Local faulting and regional tilting in this area has been postulated by others, although few urban and related grading cut exposures were then available (Wilson, 1972; Hannan, 1973; Eisenberg, 1985; Lajoie et al., 1991; Tan and Kennedy, 1996).

Conceivably, although unlikely, the craterlets may owe their origin to some unique, local artesian condition. This postulate, however, is rejected as a source mechanism because the study area craterlets are regionally extensive, and it occurs up-slope from dune field swales where local perched water would most likely occur. Additionally, the craterlets lack a regional hydrogeologic recharge/source area to supply the necessary head for their sole occurrence.

Fig. 19. Paleoliquefaction feature exposed in a vertical cut during construction grading on a coastal terrace at Encinitas, California (102.41 m el. MSL). Note: The multi-colored "flowering upward" feature, cuts through marine terrace sands and underlies the "craterlet" seen in Fig. 18. The blue hue on the right was made by the scraper blade on the terrace wall.

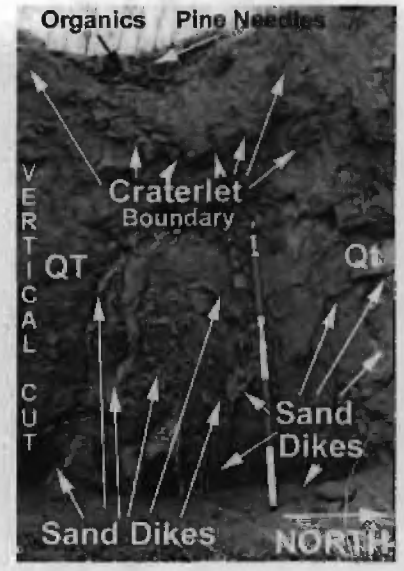

Fig. 20. Paleoliquefaction features exposed in a vertical escarpment along a coastal terrace at Encinitas, California (118.87 m el. MSL). Several episodes of upward-fining, multi-colored, tonal and textured sands are postulated to have been injected through each other, into and through a central core, and exhibit a "collapsed" infilled cone at the top.

3.3. Lateral spreads

3.3.1. Field observations

The myriad of new road cuts and grading pads on terraces Qt_1 through Qt_4 expose many dikes and other ground failure features typically associated with seismically-induced lateral spreads, features well described by Seed (1968) and Youd (1984), and depicted graphically by Obermeier (1996a, Fig. 7, part 3).

The new cuts now provide cross-section plan views, thereby permitting above-average field documentation of lateral spread extent and morphology.

The lateral spreads are exemplified by large blocks that are bordered by dikes, which are nearly linear in plan view. The dike sidewalls and widths range from about ~5 to about 45 cm; many have a left or right-step, en-echelon plan-view pattern. In vertical cuts, horizontal ground shifting is apparent by the truncation and general displacement of sand dikes and filled fissures (Fig. 15).

The lateral spreads occur on 1°–8° slopes, although locally slopes may exceed 10° forming minor "landslide" topography (Fig. 13).

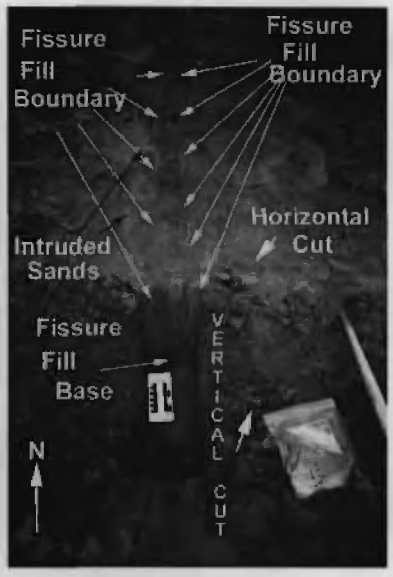

Fig. 21. Paleoliquefaction features (fissure fill and intruded sands) exposed by construction grading on coastal terrace at Carlsbad, California (16.45 m el. MSL). Note: The fissure fill, measuring 3.81–5.08 cm wide, consists of down-dropped colluvium in terrace sands, is near-vertical to vertical below the surface, and becomes wedge-shaped with depth.

3.3.2. Source mechanism

According to Youd (1984), lateral spreads can take place on slopes as low as 0.1° in the form of laterally moving landslides of non-liquefied sediments moving atop a liquefied layer. Such lateral spreads may also form grabens at their headwall and thrusting shear zones at the toe (Seed, 1968; Obermeier, 1987). The study area features are morphologically similar to those described by Seed, Youd, and Obermeier and, because they are in direct association with tabular sand dikes, sand laccoliths, and filled fissures, they are therefore interpreted as similarly being of seismic liquefaction origin (Fig. 13).

3.4. Filled fissures

3.4.1. Field observations

Hundreds of filled fissures are exposed in new excavations on marine terraces. These fissures are vertical to near-vertical fractures that widen near the ground surface. Most pinch out at depth. They range in height and width from about 5 to 35 cm and from 4 to 8 cm, respectively. Sediments filling the fissures have two sources; some demonstrably emanated from the ground surface and apparently moved downward through gravitational flow (Fig. 21); but other fissures are clearly filled with sand emplaced by fluidization of underlying Tertiary sediments. In sectional view many fissures are tabular and have laminations that parallel fissure walls. Also, many filled fissures cross-cut one another and thus may be highly contorted (Fig. 22).

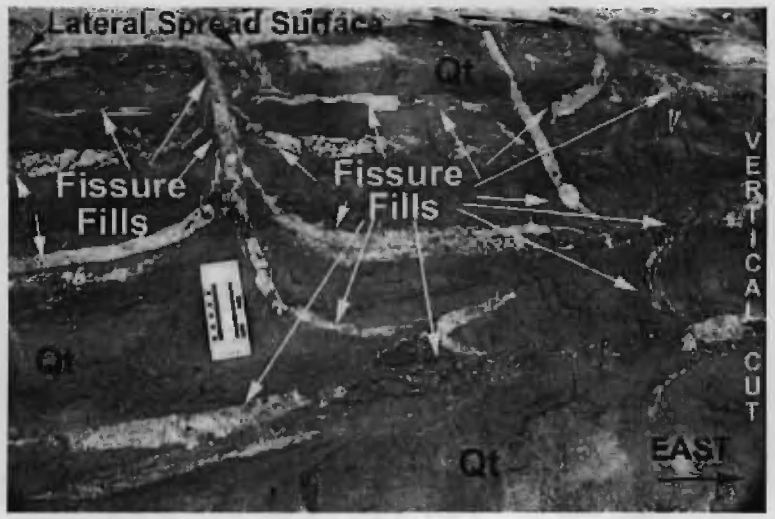

Fig. 22. Paleoliquefied features (fissure fills and lateral spreads exposed on a steeply dipping cut slope on a coastal terrace at Encinitas, California (71.32 m el. MSL). Note: Northwest, northeast, and east–west fissure fill sediments offset, drag, and even reverse themselves in a strike-slip mode. Also note that a laterally-spread liquefied layer at the top has cut off fissure fills.

Fig. 23. Exposure displaying 3 epochs of Quaternary terrace fissure fills (from 3.81 to 5.08 cm wide), down-dropped into the underlying "parent" Tertiary sandstone at Carlsbad, California (6.09–7.62 m el. MSL).

The filled fissures occur on a wide age range of sediments; and locally some appear to penetrate into the underlying Tertiary parent sandstone (Fig. 23), and even form wedge-shaped down-dropped blocks (Fig. 24).

3.4.2. Source mechanism

Based on their widespread occurrence, on the multiple sources of fill, and on their association with lateral spreads, the study-area, filled fissures probably formed recurrently.

Locally some fissures may be associated with landslides, themselves possibly induced by seismic events. Indeed, it is also plausible that some filled fissures reflect faulting at depth, for the surface fissure pattern mimics bedrock fractures. Regional faulting is largely strike-slip (Sylvester, 1988; Weldon et al., 1996), and this style of deformation typically gives rise to reversal of throw, transtensional and transpressional fractures and thus to widespread complex ground fissuring (Obermeier et al., 2004).

4. Basis for a liquefaction origin

A proposed seismic liquefaction origin for the filled fissures is similarly based on comparing the morphology of these features with those described elsewhere that are associated with documented seismicity (Tables 1–3). Specifically, the filled fissures in the study area are very similar to those described by Sims and Garvin (1995) who analyzed and described liquefaction features associated with the M~7.1, 1989 Loma Prieta, California earthquake.

Alternative mechanisms for origin of the filled fissures range from local artesian flow to wave-cutting along paleo-shorelines. But these hypotheses are untenable in the study area for artesian flow is not, and has not occurred given the local geomorphic, hydrogeologic, and stratigraphic setting, and wave-cutting is similarly ruled out owing to relative "recency" of liquefaction in marine terrace sediments now tens of meters above present sea level. Of particular interest, however, is the nearby presence of the active Newport–Inglewood/Rose Canyon fault zone, and a related blind thrust immediately offshore (Fig. 2). According to Rivero et al. (2000) and Legg (personal communication, 2004) the blind thrust extends directly under the study area, and may be capable of generating seismic events of M~7.0 or greater (Kuhn et al., 2000, 2004).

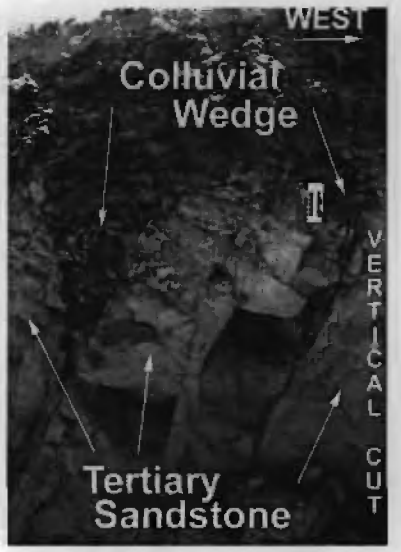

Fig. 24. Colluvial wedges; inferred to be large fissure fills exposed in Tertiary sandstone (fractured grey-white unit) at Carlsbad, California (6.09–7.62 m el. MSL).

5. Indirect paleoseismic evidence

Mima mound topography also characterizes much of the North San Diego County study area. Although these features alone do not provide incontrovertible evidence for local-area paleoseismicity, their presence compliments and otherwise supports major seismic events in the late Quaternary. Extensive mound fields were once in evidence (Orcutt, 1887) and visible on aerial photography taken along the North San Diego County coastal surfaces, prior to urbanization (USGS, 1947; USDA, 1953). Scattered mounds still occur in Carlsbad and Encinitas and on the Camp Pendleton Marine Base. As shown on aerial photographs and originally noted in soil surveys (USDA, 1918, 1973), continental and estuarine deposits located on coastal terraces Qt_1 at Carlsbad are mantled by a local microrelief or hummocky landscape of "mima mounds," each of which is usually less than ~1 m high and 2 to 3 m in diameter (Fig. 5).

5.1. Field observations

Site-specific excavation of Carlsbad and Encinitas coastal mound sites show that some mound fields are aligned along fissure fills and laterally spread depressions called "vernal pools". The mound topography and adjacent vernal pools are irregular. They appear concentrated along some lineaments, possibly fault or fracture zones, a phenomena reported elsewhere in California (Shlemon et al., 1973). The mounds are typically subrounded, are frequently confined by an expansive clay cap, and are often filled by clean white to tan sand, giving rise to a dramatic contrast in color and grain-size, when compared with the generally dark-colored clayey sediments characteristic of surrounding continental or estuarine deposits. As exposed in grading cuts, some mounds directly coincide with sand dikes and sand laccoliths. These sand dikes, which are tabular and tubular in plan view, are traceable to underlying sand source beds derived from Tertiary bedrock. Most terraces are burrowed, and the sand dikes, sills and source sands are often occupied by ground squirrels and gophers that indicate an ongoing biogenic maintenance by rodents. Similar-appearing mound complexes in the San Clemente area, about 48 km to the north, have been interpreted to be mainly constructional (bioturbation), in origin (Shlemon et al., 1997), however a paleoseismic origin was not precluded.

5.2. Multiple origin of mounds

There are many hypotheses for the origin of mounds: eolian deposits (Barnes, 1879); water-deposited features (Dietz, 1945); water and glacial combined (Newcomb, 1952; Washburn, 1997); physical or chemical segregation (Ritchie, 1952); features created by human agency (Aten, 1981); ants, ground squirrels or pocket gophers (Dahlquist and Scheffer, 1942; Arkley and Brown, 1954; Cox, 1990, 1991); seismogenic (Berg, 1990; Riefner and Pryor, 1996), and "multiple origins" (Krinitzsky, 1949).

5.2.1. Source mechanism

Some of the Carlsbad and Encinitas mounds evidently originated as sand blows, and were then later colonized by fossorial rodents. Also some the mounds apparently formed during genesis of sand laccoliths, which hydraulically deformed the overlying clay expansive cap where fluidized sand could not escape to the ground surface. Many of the associated vernal pools were in part created by lateral spreads which are linear in plan view (Kuhn et al., 2000).

The Carlsbad and Encinitas mima-mound topography, is therefore a probable important indicator of paleoseismicity because morphologically similar features are associated with tabular sand dikes, sand laccoliths, sand blow deposits, lateral spreads, filled fissures and plausible tsunami features (Kuhn et al., 1995a,b,c, 2000, 2004). This is contrary to observations from the extensively studied New Madrid Seismic Zone where seismicity apparently did not produce mima mounds (Saucier, 1991a). It should be noted that from aerial photos, the New Madrid sand blows are similar in form to mounds; however, agricultural leveling for almost 200 years has destroyed much of their relief.

6. Age of liquefaction features

6.1. Evidence for quaternary paleoseismic events

6.1.1. Field observations

Features interpreted to be of seismic liquefaction origin in the Carlsbad to Encinitas area include

extensive swarms of craterlets, principally found on the ~440 ka terrace Qt_4 (Fig. 4). Moreover, fissure fills, sand dikes, lateral spreads and mounds occur on all terraces, which vary in age from ~ 80 ka to 440 ka. A "classic" exposure at one location in Carlsbad shows that 11 epochs of paleoliquefied sand dikes, fissure fills, and lateral spreads probably occurred during the past 120 ka (Figs. 25 and 26).

6.2. Evidence for Holocene paleoseismic events

6.2.1. Field observations

The north coastal area of San Diego County contains widespread Paleo-Indian sites, some of which are radiocarbon-dated at more than 8 ka (Breschini et al., 1992). These archaeological sites consist of burials, "kitchen middens," and transitory camps that contain diverse artifacts dated mainly by shells and charcoal (Carter, 1957; Gallegos, 1987, 2002). Several early-to-late Holocene archaeological sites have been affected by paleoseismic features. For example, liquefied sand dikes and sills extend upward, intrude and deform midden deposits located on the Qt_1–Qt_4 terraces in the Carlsbad area (Fig. 3). Further, based on radiocarbon-dating, at least one major event took place about 6 to 8 ka bp (Smith, 1996). Some of these liquefaction-deformed archaeological sites occur on uplifted 60-m high, marine terrace deposits, well above Holocene regional water levels (Shlemon and Kuhn, 1997; Fig. 27). It is thus inferred that liquefaction likely took place during the winter rainy season when the high-level terrace sands contained perched water (Kuhn et al., 2000).

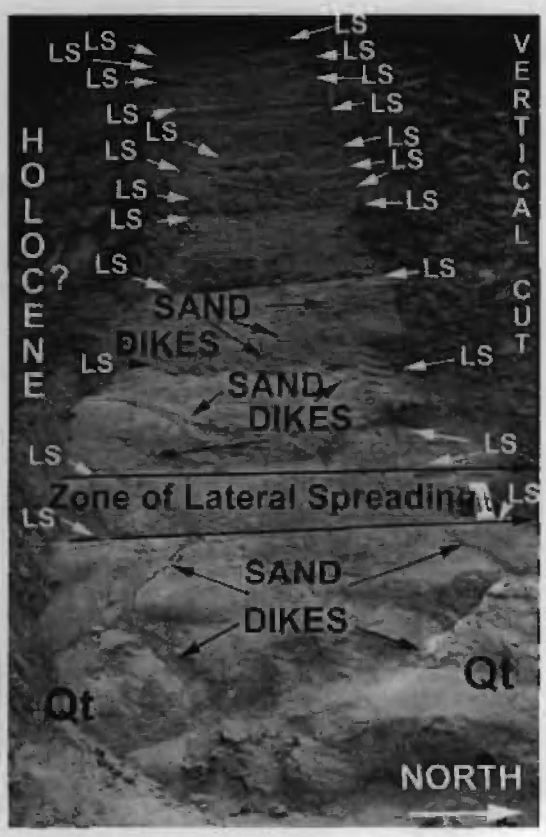

Fig. 25. Photograph of a vertical cut exposing sand dikes cutting coastal terrace sands at Carlsbad, California (47.24–51.81 m el. MSL) Note: The scale is resting on a lateral spread surface that has cut-off the underlying sand dikes, which were injected from below. At least 10 episodes of lateral spreads cut-off sand dikes. Measured sections of multiple lateral spread surfaces in vertical cuts are shown in Fig. 26.

Other archaeological evidence suggests that seismically-induced liquefaction may have taken place as recently as 2 to 3 ka ago (Franklin and Kuhn, 2000). Indeed, an archaeological site at Batiquitos lagoon in Carlsbad (Gallegos and Associates, 1997) exposed an intact prehistoric hearth. One test pit in the center of the site (feature 97-1) exposed artifacts and shells that were apparently offset and locally dragged upward by fissure fill sediments (Fig. 28). The deformed artifact horizons yield radiocarbon dates of 0.9 to 1.3 ka, documenting incontrovertible evidence for paleoseismic liquefaction and ground deformations in late Holocene time (Fig. 29).

7. Tsunamigenic features

The possible tsunamigenic features identified in this investigation are based on comparison with stratigraphic relations and internal characteristics of tsunami deposits recorded elsewhere (Table 5).

7.1. Field observations

Many abrupt, chaotic, convulsive sedimentary features now exposed in the north coastal area of San Diego County cannot be simply explained by non-seismic soft-sediment deformation, nor by variations

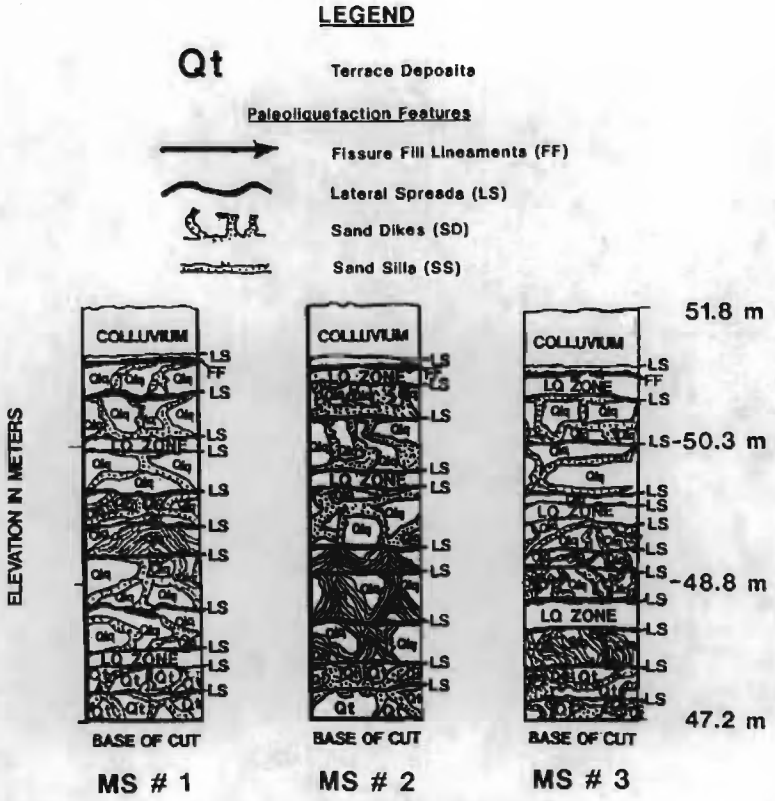

Fig. 26. Measured sections of vertical cuts made 15 m apart showing multiple lateral spread surfaces. Same location as seen in Fig. 25.

and cyclicity of storm deposits ("tempestites," of Aigner, 1985). Rather, the features are similar to those formed by (1) ancient earthquakes ["seismites" (Seilacker, 1969, 1984)]; 2), turbidity current deposits ["turbidites" (SEPM, 1951; Kuenen, 1947, 1957, p. 231)], and; 3) modern tsunami deposits ["tsunamites" (Pratt, 2002)]. Many coastal features also show unusual chaotic variations here likewise inferred to be caused by paleoliquefaction. Typically, a locally generated tsunami deposit can also be deformed by large aftershocks.

The convulsive features in the north coastal Carlsbad–Encinitas region have characteristics that are in common with other tsunamis described elsewhere (Table 5). Specifically:

(1) The presence of chaotic, turbid, sedimentary debris (Fig. 30), commonly mixed with wood fragments, shells, clay balls and pods of sharp, angular pieces of terrace deposits and bedrock, and locally capped by peat (Fig. 31).
(2) The initial event deposits grade from coarse to landward-fining, rather than landward-coarsening, typical of "tempestites" (storm deposits).
(3) The pebbles are imbricated (Fig. 32).
(4) The landward movement of sediment is "lobe form" (Fig. 33), similar to those in the Philippines Islands produced by the 1994 Mindoro earthquake (Daag et al., 1995).
(5) The "v-shaped" chaotic features were inferentially caused by an abrupt "hydraulic jump" when tsunami waves reach a "bedrock high" or very resistant surface feature (Fig. 34), a phenomenon often associated with fluid-like features exposed in the overlying sediments (Morner, 1996; Fig. 35), and;

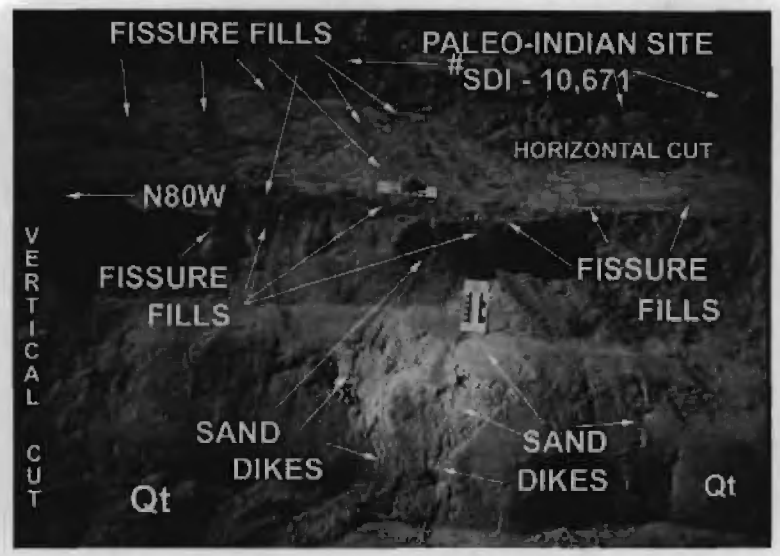

Fig. 27. Paleoliquefaction features exposed by grading deform, cut, and offset a shell (*Argopecton* sp., *Chione* sp.), charcoal, and artifact-rich, Indian midden site located on a 60 m high, now well-drained terrace at Carlsbad, California. Note: Arrows point to sand dikes, fissure fills (trending N20W and N80W), and lateral spreads that crosscut the terrace sands and offset each other.

(6) The abrupt landward termination of sand wedges has an angle similar to, but steeper than dunes (Daag et al., 1995; Fig. 36).

Because of their similar internal stratigraphy and occurrence on former abrasion platforms on modern "bedrock highs," the anomalous, chaotic, con-

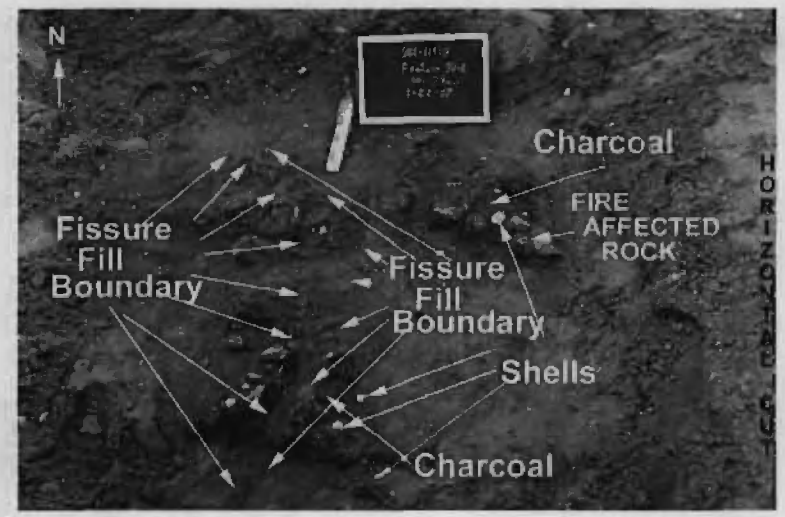

Fig. 28. An archaeological site located along the north side of Batiquitos Lagoon at Carlsbad, California (5.18–5.48 m el. MSL). Note: Paleoliquefaction features (fissure fill and liquefied sediments) appear to offset, dragged, and disrupted fire-affected rocks and 0.9 to 1.3 ka year old, calibrated radiocarbon-dated shells (i.e. *Argopecton* sp., *Chione* sp.) and charcoal (photograph: Courtesy of Dennis Gallegos).

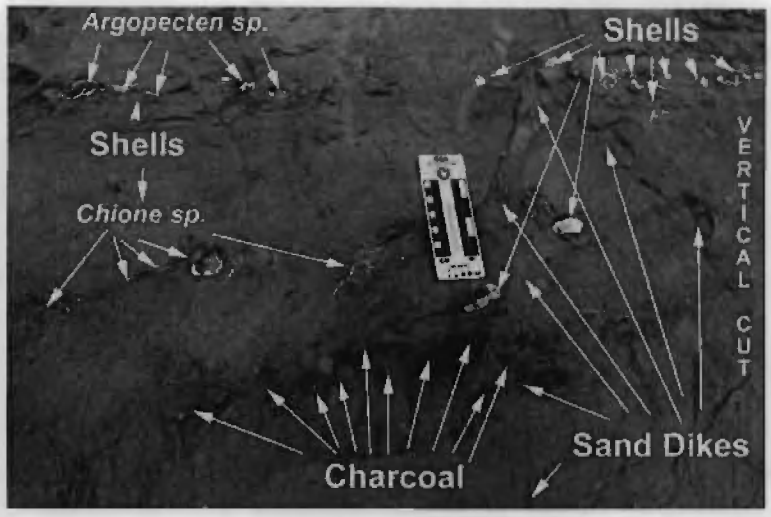

Fig. 29. Paleoliquefaction features exposed in a cut slope on the north side of Batiquitos Lagoon at Carlsbad, California (6.09–7.62 m el. MSL), located near the site seen in Fig. 26. Note: Shell horizons (*Argopecton* sp., *Chione* sp., and *Ostrea lurida*), charcoal, fire-affected rock fragments, and cobbles are offset, dragged, and liquefied upward into pre-existing fractures and into sand dikes.

vulsive, deposits in the Carlsbad to Encinitas area were likely produced by paleoseismic events, and hence are here deduced to be tsunamigenic in origin.

7.2. Local tsunami mechanism

Although Emery (1960, p.124) indicated that southern California was not immune to tsunamis,

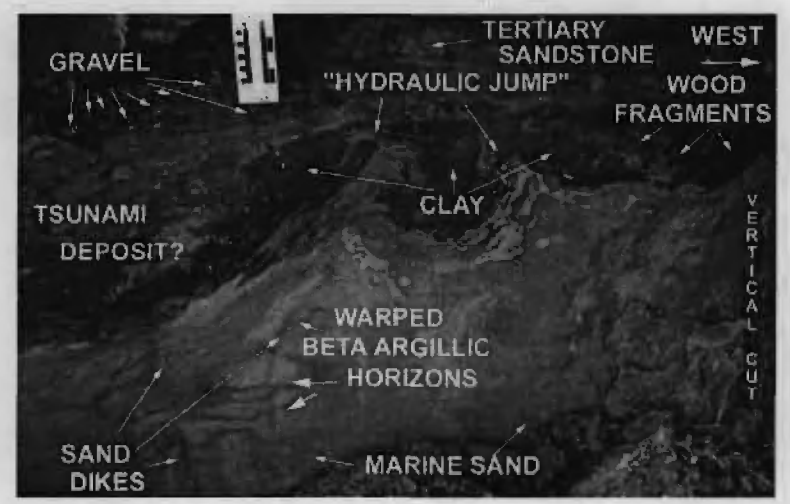

Fig. 30. View looking south of a storm drain trench wall cut into a coastal terrace exposing possible tsunami deposits at Carlsbad, California (15.54 m el. MSL). Note: Exposed are highly disturbed, contorted, chaotic, turbid sediments and debris overlying liquefied and dragged Bt horizons resting on a Tertiary sandstone abrasion platform. The upper half of this exposure interpreted as tsunamigenic in origin, for it also displays a distinct "hydraulic jump", markedly different from documented paleoliquefaction features documented elsewhere.

Fig. 31. "Anomalous sediments" inferred to be tsunami deposits exposed in a vertical cut adjacent to a coastal lagoon at Carlsbad, California (6.70–9.14 m el. MSL). Note: The Jacob staff (scaled in 1′ increments), rests in highly disturbed, mudflat sediments containing shells (*Chione* sp.), rock and clay fragments, overlain by chaotic, convulsive, turbid, sedimentary debris, including wood fragments, sharp angular pods of terrace deposits and Tertiary sandstone "bedrock". These sediments are capped by lagoonal tidal flat organic-rich sands, "peat", pieces of terrace sands and other chaotic sediments.

many considered that San Diego was relatively safe owing to the bordering, wide continental shelf that inhibits seismically-induced wave attack generated outside the region (Van Dorn, 1965). Recently, however, geophysical research shows that the southern California Continental Borderland is crossed by many active faults with characteristics capable of producing large-scale, coseismic sea floor deformation during submarine earthquakes (Legg, 1991; Legg and Kennedy, 1991; Rivero et al., 2000; Grant and Rockwell, 2002). Additionally, local strong seismicity generated by any potential local earthquake sources,

Fig. 32. An abrupt, highly localized, disrupted, "chaotic" imbrication of marine gravels exposed in a vertical excavation in the lowest coastal terrace showing possible tsunamigenic and/or paleoliquefaction features at Carlsbad, California (3.04–3.35 m el. MSL). Note: Tape measure (in in.) for scale (1 in. = 2.54 cm).

Fig. 33. View of landward-fining sand layers forming lobes on on-lapping coastal terrace sands at Carlsbad, California (20.72–21.33 m el. MSL). Note: Putty knife rests against terrace sands for scale; also see irregular sharp contact with white sands at top of photo. These features are morphologically similar to tsunami deposits photographically documented during the 1994 Mindoro event in the Philippine Islands (Daag et al., 1995).

both onshore and offshore, could trigger large-scale slope failures and thereby generate local tsunamis (McCarthy et al., 1993; Borrero et al., 2001; Legg et al., 2003). Additionally, many large slope failures have been mapped in the southern California Continental Borderland (Field and Richmond, 1980; Clarke et al., 1985, 1987; Legg and Kamerling, 2003), even off Carlsbad and Encinitas (Greene and Kennedy, 1987; Clarke et al., 1987; Fig. 37). Paleoseismic investigations also show large coastal earthquakes occurred within the Holocene, and historically at least four measurable local tsunamis impacted the southern California region in 1812, 1862, 1927, and 1930 (McCulloch, 1985; Lander et al., 1993). Accordingly, evidence for paleotsunamis is abundant, and the potential for future impact is high (McCarthy et al., 1993; Legg et al., 2003, 2004).

8. Potential seismic sources

Based on the extent (730 km), character, and distribution of paleoseismic features and the residual evidence afforded by mima-mound topography and tsunamigenic deposits, it seems likely that the causative earthquakes were of at least M~7.0 (Kuhn et al.,

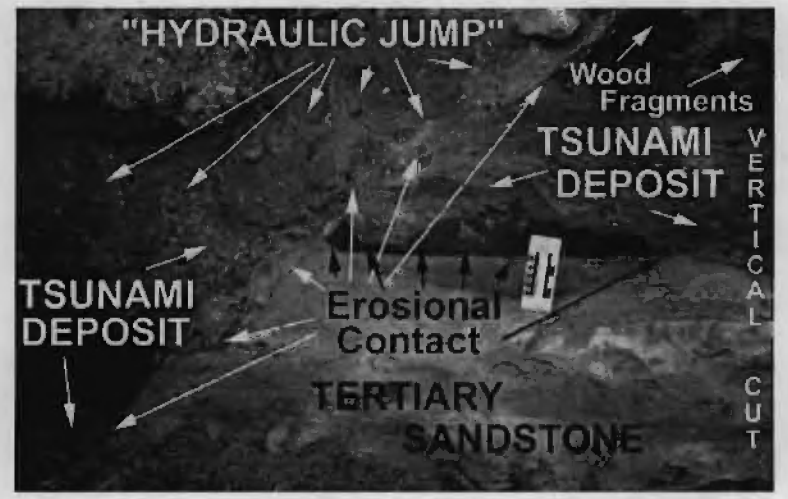

Fig. 34. North wall of a sewer-line trench cut into a terrace and exposing a possible paleotsunami deposit at Encinitas, California (93.26 m el. MSL). Note: The scale is located on a Tertiary-age sandstone abrasion platform, which is unconformably capped by a chaotic, turbid deposit containing small angular pieces of terrace and "parent" Tertiary sandstone and small rocks. Also note the "v-shaped upward climbing" chaotic features interpreted to result from an abrupt "hydraulic jump" created when tsunami waves reached a bedrock high.

Fig. 35. North wall of a cut slope exposing possible tsunamigenic and/or paleoliquefaction features at Encinitas, California (95.09 m el. MSL). Note: These features are the same as seen in Fig. 34 but are 3 m higher in the section.

2000, 2004). The specific fault(s) that triggered the liquefaction and likely secondary surface faulting is not well constrained. However, the likely seismic sources are the Newport–Inglewood/Rose Canyon Fault Zone (NIRC), ~4–6 km offshore and possibly under the study area (Kuhn et al., 2000, 2004), other Continental Borderland faults (Legg, 1991), and possible site-specific faults (Figs. 1 and 2).

8.1. Newport–Inglewood/Rose Canyon fault zone

The Newport–Inglewood/Rose Canyon fault zone (NIRC) is the longest and most active in the north-coastal San Diego County area (Figs. 2 and 37). It is therefore the most likely seismogenic source for the observed paleoseismic features (Lindvall and Rockwell, 1995; Grant et al., 1999; Rivero et al., 2000;

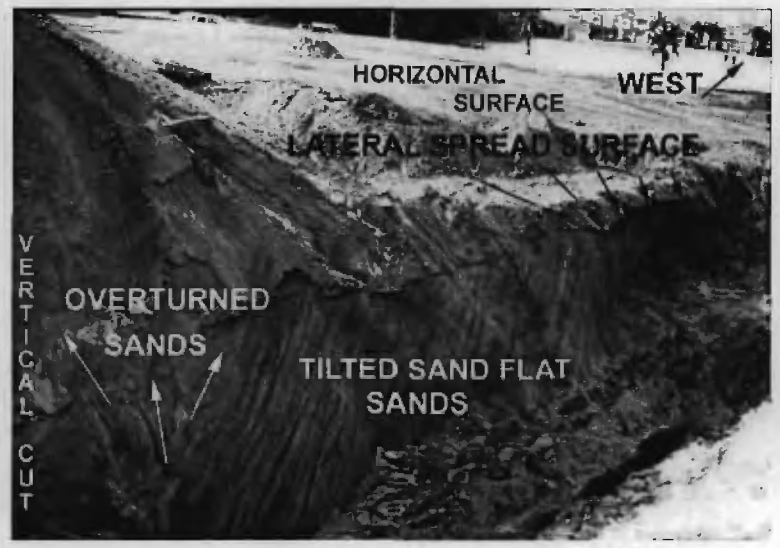

Fig. 36. View looking southwest at abnormally tilted "sand flat" sediments exposed in a storm-drain trench cut into a coastal terrace at Carlsbad, California (28.65–29.26 m el. MSL). Note: The bedding dip varies from near-vertical (left) to 75 to 80 degrees (middle) to 46 degrees (right), to locally completely deformed. This exposure is morphologically a "twin" of deposits photographically documented during the tsunami that followed the 1994 Mindoro earthquake in the Philippine Islands (Daag et al., 1995).

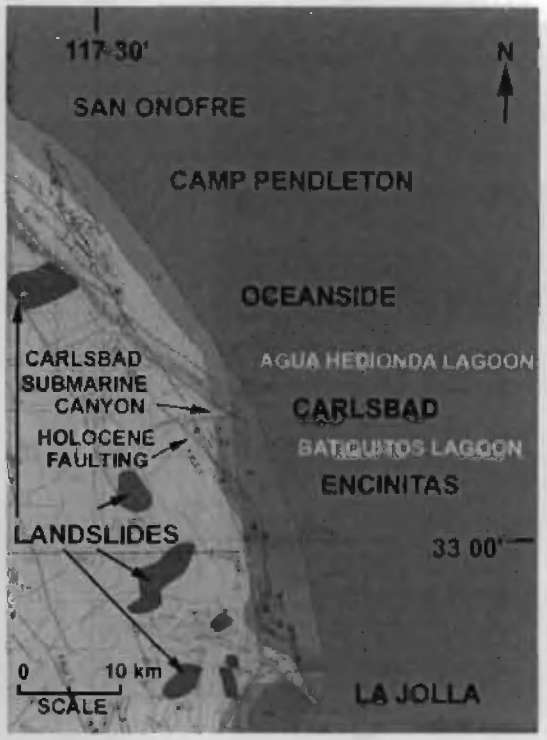

Fig. 37. Portion of a "Geologic map of the inner-southern California Continental Margin". Note: The red square (located at the Carlsbad Submarine Canyon) indicates sea floor faulting that cut strata of Holocene age. Also note the adjacent large submarine landslide (adapted from: Clarke et al., 1987).

Grant and Rockwell, 2002). It has also been suggested that the NIRC dips eastward beneath the coast (Kuhn et al., 1994), possibly merging with a deep northeast-dipping Neogene detachment fault system (Legg, 1991; Crouch and Suppe, 1993). Though presently somewhat speculative, an east-dipping seismogenic zone under Carlsbad to Encinitas may trap seismic wave energy in the hanging wall (Legg et al., 1994; Kuhn et al., 2000, 2004).

Approximately 1.5 km offshore lies the Carlsbad Submarine Canyon (Shepard and Emery, 1941), characterized by Holocene sea floor offset, and large subsurface landslides (Kennedy et al., 1985, 1987; Fig. 37). Similarly, Fischer et al. (1992) indicated that a coastal "tectonic dam" had beheaded the former drainage in the Carlsbad area. These tectonic features are directly offshore the Holocene liquefaction and tsunamigenic, chaotic features described in this paper (Kuhn et al., 2000).

North to northeast-trending branching and secondary fault zones also extend onshore from the NIRC (Hannan, 1973; Adams and Frost, 1981). These are exemplified by the Cristianitos fault zone near San Onofre (Western Geophysical, 1972; Moyle, 1973), and by an unnamed fault zone about 10 km north of Carlsbad (Euge et al., 1972). The Carlsbad to Encinitas area is located at a major transition in the NIRC, the "Carlsbad–Encinitas Overstep" of Fischer and Mills (1991), where the offshore Rose Canyon fault zone changes from a more northerly, transtensional trend to a more westerly, transpressional trend along the South Coast Offshore Zone (Kuhn et al., 2000). In sum, the NIRC, other nearby offshore faults, plus possible local onshore faults are all capable of generating relatively high-magnitude earthquakes. These collectively can produce the myriad of paleoseismic features now exposed in the north San Diego County area.

8.2. Urbanization-caused increase in the hazards of seismically-induced liquefaction

The population of coastal North San Diego County is expected to triple over the next decade (SANDAG, 1991). Excavations of new residential tracts have provided excellent exposures of the neotectonic features described herein, and likely will continue largely on the marine and non-marine terraces. Terrace sediments are typically fine to medium sands, which are inherently susceptible to liquefaction when saturated. Although permanent ground water levels are presently low along the undeveloped coast, shallow perched water tables occur locally. Also, surface water also recharges perched and regional water levels via pre-existing fractures and sand dikes (Fig. 38). Almost all water for urban landscaping and recreational use is imported, so that soil moisture and infiltration will likely increase from the present 250 mm/year to an anticipated 2000 mm/year in the coming decade (Shlemon and Kuhn, 1997). Groundwater is typically perched within the Quaternary sediments (terrace deposits) on the underlying, relatively impermeable bedrock surface or "hardpan." These "high-elevation" perched water levels will rise an expected ten-fold owing to urban-water infiltration (Shlemon, 2000). The active NIRC is within 4 to 6 km of the coast, and if an east-dipping fault plane exists at depth, coastal development will lie within the 5-km, near-

Fig. 38. Horizontal exposure made by grading on a coastal terrace at Carlsbad, California (29.26 m el. MSL). Note: Rainfall-induced surface runoff water flows into the subsurface along pre-existing fractures and sand dikes, thus recharging groundwater levels.

source zone for this active fault. Consequently, enhanced shaking may be expected from moderate to large earthquakes along this portion of the NIRC. Such strong shaking increases potential liquefaction of late Pleistocene sands and in the overlying engineered fills. Accordingly, the potential for coastal area, liquefaction-induced ground failures will likely increase during the coming decades. Structures may then be subject to permanent ground displacements associated with lateral spreading, as well as widespread sand blows and fissuring. Such hazards have heretofore been largely ignored.

9. Conclusions

Recent man-made exposures at Carlsbad and Encinitas reveal late Pleistocene to probable Holocene faults, tsunamigenic deposits, and ground-failure hazards. Features interpreted to be of seismic liquefaction origin are widespread and common in the study area. Paleoliquefaction features include sand-filled dikes and sills, lateral spreads, filled craterlets, fissures fills, and other unconsolidated sand deformations derived from underlying Tertiary and Pleistocene marine and dune sediments. A paleoseismic liquefaction origin, rather than soft-sediment loading is deduced for these features based on internal stratigraphy, morphology, field setting, and proximity to active faults. The paleoliquefied sands are upward-fining, penetrate and locally deform regressive marine and prograding continental deposits and soils that mantle marine-terrace platforms at elevations from about 3 m to 130 m, and such marine-terrace platforms range in age from about 80 ka (lowest) to 400 ka. Some injection dikes and fissure fills are young, for they displace Holocene, Native-American Indian middens, burial grounds, and transitory camps, located on 60-m high terraces, far above modern regional ground levels. The paleoearthquakes were likely at least M~7, and may have occurred during unusually wet times, when perched groundwater saturated underlying sediments. Many paleoseismic events probably originated on the nearby Newport–Inglewood/Rose Canyon fault system. Eastern dipping segments of the NIRC project under the north coast of San Diego County. Accordingly, the seismic hazard of this area may be substantially higher than heretofore assumed.

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RESOLUTION 2012- ___

A RESOLUTION OF THE CITY COUNCIL OF THE CITY OF DEL MAR, CALIFORNIA REGARDING THE SAN ONOFRE NUCLEAR GENERATING STATION (SONGS).

WHEREAS Southern California Edison's (Edison) four replacement steam generators manufactured by Mitsubishi for the two nuclear reactors at their San Onofre site were shut down after one of their tubes failed and released radiation in January 2012, after less than two years of operation, while the original equipment operated for 28 years; and

WHEREAS Edison informed the Nuclear Regulatory Commission (NRC) that the replacement steam generators would be "like for like" or "in kind," that is, fabricated to the same design specifications as the original San Onofre Combustion Engineering steam generators, but in fact, the replacement generators have significant design changes from the original steam generators; and

WHEREAS the NRC has reported that design flaws and erroneous model calculations have led to the malfunction of the new steam generators; and

WHEREAS the replacement steam generators in San Onofre Unit 2 and Unit 3 are identical and are both showing excessive, early tube wear that the NRC confirms poses a serious safety problem; and

WHEREAS a thorough NRC licensing amendment process would have provided greater opportunity to bring attention to the replacement steam generator design problems, thus increasing the likelihood of preventing use of the faulty designs and the ultimate shutdown of the San Onofre nuclear facility; and

WHEREAS failing again now to subject the replacement steam generators at San Onofre to the rigorous and transparent review of the NRC licensing amendment process risks repeating dangerous errors; and

WHEREAS the consequences of regulators inadequately ensuring nuclear reactor safety are potentially severe; and

WHEREAS there is no agreed, safe long-term solution to storing nuclear waste; and

WHEREAS in a decision filed on December 15, 2005, the CPUC allocated $680 million dollars to be paid by ratepayers for four replacement steam generators manufactured by Mitsubishi at Southern California Edison's (Edison)

San Onofre Nuclear Generating Station ($569 million for replacement steam generator installation, and $111 million for removal and disposal of the original steam generators), with a reasonableness review required for expenses beyond this amount and a maximum ratepayer collection cap of $782 million; and

WHEREAS ratepayers are at risk of paying not only for the crippled replacement steam generators, but also potentially for costs associated with the outage and with the equipment repair or replacement; and

WHEREAS the California Public Utilities Commission Division of Ratepayer Advocates reports that SCE customers are paying about $54 million a month for operating and maintenance costs of the San Onofre Nuclear Generating Station while the facility is not producing any power, and recommends removing the San Onofre facility from rate to prevent this from continuing; and

WHEREAS an Order of Investigation (OII) by the California Public Utility Commission is needed to determine, in a transparent, public process, which parties are responsible for paying for the costs associated with the faulty replacement generators, including the costs incurred during the shutdown (for example, replacement power, inspections, monitoring) and the cost of any repairs; and

WHEREAS expenses for the San Onofre reactors will potentially increase further with seismic upgrades in the wake of advancing earthquake science, lessons learned from the nuclear disaster at Fukushima Daiichi, and seismic studies underway that California's nuclear power plant operators have been mandated to undertake by the State of California; and

WHEREAS the State of California has further mandated that coastal power plants end once-through cooling (OTC) technology due to the damaging impacts on sea life, and both San Onofre and Diablo Canyon nuclear power plants are currently undergoing feasibility studies for upgrades to their OTC systems, which would be extremely costly when implemented; and

WHEREAS it is therefore critical to create and implement strong contingency plans for alternative power sources to San Onofre, especially those deriving from conservation, energy efficiency and renewable resources, per the State of California's Loading Order, state mandated targets, and Governor Brown's Clean Energy Plan; and

WHEREAS the State of California has set aggressive goals for efficiency and renewable electricity installation, but has struggled to meet its targets on time; and

NOW, THEREFORE, BE IT RESOLVED, that the City of Del Mar urges the U.S. Nuclear Regulatory Commission to require that Edison undergo a public, transparent license amendment hearing regarding the replacement steam generators, before the San Onofre Nuclear Generating Station is allowed to restart; and

BE IT FURTHER RESOLVED, that the City of Del Mar strongly encourages the California Public Utilities Commission to: 1) expeditiously initiate and complete an Order Instituting Investigation regarding the costs and reliability of the San Onofre Nuclear Generating Station and to compare the San Onofre facility to other energy sources used today and throughout the current licensing duration; and 2) protect ratepayers from being held responsible for errors and/or malfeasance by San Onofre Nuclear Generating Stations's operator, which led to faulty replacement steam generators being installed, ongoing outage expenses, and continuing repair costs; and 3) immediately take the San Onofre power plant out of the rate base; and

BE IT FURTHER RESOLVED, that additional incentives and programs are urgently needed to support the rapid installation of new power generation, power savings, and grid stabilizing technologies, which together can serve as an alternative to San Onofre; and that these new electricity solutions should prioritize efficiency and renewable energy resources, per the State of California's load order and mandated targets, and should also prioritize local, distributed generation, per Governor Brown's Clean Energy Plan.

PASSED, APPROVED AND ADOPTED by the City Council of the City of Del Mar, California, at a Regular Meeting held the 24th day of September 2012.

_____
Carl Hilliard, Mayor
City of Del Mar

APPROVED AS TO FORM:

_____
Leslie E. Devaney, City Attorney
City of Del Mar

SEP 24 2012 ITEM 04

ATTEST AND CERTIFICATION:

STATE OF CALIFORNIA
COUNTY OF SAN DIEGO
CITY OF DEL MAR

I, MERCEDES MARTIN, City Clerk of the City of Del Mar, California, DO HEREBY CERTIFY that the foregoing is a true and correct copy of Resolution No. 2012-__ adopted by the City Council of the City of Del Mar, California, at a Regular Meeting held the 24th of September 2012, by the following vote:

AYES:

NOES:

ABSTAIN:

ABSENT:

Mercedes Martin, City Clerk
City of Del Mar

SEP 24 2012 ITEM 04

Subject: ITEM 4: Recommended simplification of draft San Onofre resolution

RED DOT

From: Diane Moss
Sent: Thursday, September 20, 2012 3:03 PM
To: Carl Hilliard; Terry Sinnott; Donald Mosier; Lee Haydu; Mark Filanc
Cc: Mercedes Martin; Scott Huth
Subject: recommended simplification of draft San Onofre resolution

Dear All:

As I mentioned to most of you, I submitted a sample resolution on San Onofre to the City Clerk last night. I was informed today by the City Clerk that a draft had already been submitted prior to my doing so.

I appreciate this proactive effort, and I also recommend that the existing "Be It Resolved" section be simplified slightly.
Specifically I suggest the first paragraph referring to the license amendment remain the same, while the second two paragraphs be condensed into one paragraph and streamlined to read as follows:

BE IT FURTHER RESOLVED, that the City of Del Mar strongly supports the California Public Utilities Commission in 1) expeditiously initiating and completing an Order Instituting Investigation regarding the costs and reliability of the San Onofre Nuclear Generating Station and 2) comparing the reliability and costs of San Onofre facility to a future based on alternatives, including efficiency, load management, demand response, renewable energy, and energy storage.

My suggestion is based on:

- recent reassurances we've received from the CPUC on their commitment to move forward with an Order Instituting Investigation by early November, whereas before they seemed to be postponing (ergo it is appropriate to "support" them)

- the fact we were assured by CPUC staff lately that long term costs and reliability of San Onofre are going to likely be part of more than one upcoming CPUC proceeding. The above resolution language corresponds more concisely and precisely to these movements on the state level than does the existing language.

- our earlier resolution sample from which the existing resolution draft on the agenda draws was bluntly more wordy than is necessary. :-)

As I expressed to most of you, I encourage you all to simplify/edit the Whereas section, as you deem appropriate for your community.

Original text of the resolution edited to show recommended changes:

NOW, THEREFORE, BE IT RESOLVED, that the City of Del Mar urges
the U.S. Nuclear Regulatory Commission to require that Edison undergo a public,

transparent license amendment hearing regarding the replacement steam generators, before the San Onofre Nuclear Generating Station is allowed to restart; and

BE IT FURTHER RESOLVED, that the City of Del Mar strongly ~~encourages~~ supports the California Public Utilities Commission ~~to~~ in: 1) expeditiously ~~initiate~~ initiating and ~~complete~~ completing an Order Instituting Investigation regarding the costs and reliability of the San Onofre Nuclear Generating Station and 2) ~~to compare~~ comparing the costs and reliability of the San Onofre facility to a future based on efficiency, load management, renewable energy, and energy storage. ~~other energy sources used today and throughout the current licensing duration; and 2) protect ratepayers from being held responsible for errors and/or malfeasance by San Onofre Nuclear Generating Stations's operator, which led to faulty replacement steam generators being installed, ongoing outage expenses, and continuing repair costs; and 3) immediately take the San Onofre power plant out of the rate base; and~~

~~BE IT FURTHER RESOLVED, that additional incentives and programs are urgently needed to support the rapid installation of new power generation, power savings, and grid stabilizing technologies, which together can serve as an alternative to San Onofre; and that these new electricity solutions should prioritize efficiency and renewable energy resources, per the State of California's load order and mandated targets, and should also prioritize local, distributed generation, per Governor Brown's Clean Energy Plan.~~

Please feel free to ask any questions. Many thanks again for your consideration.

Kind regards,

Diane

Diane Moss
Nuclear Campaign Consultant
Friends of the Earth
310-457-6141
310-463-1355 (cell)