UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

CHAIRMAN

April 8, 2011

The Honorable Barbara Boxer
Chairman, Committee on Environment
and Public Works
United States Senate
Washington, D.C. 20510

Dear Madam Chairman:

On behalf of the U.S. Nuclear Regulatory Commission (NRC), I am responding to your letter of March 16, 2011. In light of the recent events in Japan, you asked that we perform a thorough review of the Diablo Canyon and San Onofre nuclear power plants and posed a number of questions. Detailed responses to the questions contained in your letter are provided in the enclosure.

Regarding a review of the California facilities, the Commission directed the NRC staff to establish a senior level agency task force to conduct a methodical and systematic review of our processes and regulations to make recommendations to the Commission whether the agency should make additional improvements to our regulatory system. This review will include an assessment of any regulatory issues in the areas of earthquakes and emergency preparedness mentioned in your letter. This activity will have both near-term and longer-term objectives. We are also pursuing limited actions that appear to be prudent, including inspection activities to look at the readiness of plants to deal with both design basis and beyond design basis accidents. We will keep you and our other stakeholders informed as we proceed.

While the NRC continues to provide assistance to the Japanese government, I want to assure you that the NRC continues to make its domestic responsibilities for licensing and oversight of the U.S. licensees its top priority and that the U.S. nuclear power plants continue to operate safely. With the near-term evaluation of the relevance of recent events to the U.S. fleet underway, the NRC is continuing to gather the information needed for us to take a longer, more thorough look at the events in Japan and their lessons for the NRC. Based on these efforts, the agency will take all appropriate actions necessary to ensure the continuing safety of the American public.

Sincerely,

Gregory B. Jaczko

Gregory B. Jaczko

Enclosure: As stated

Identical letter sent to:

The Honorable Barbara Boxer
Chairman, Committee on Environment
and Public Works
United States Senate
Washington, D.C. 20510

The Honorable Dianne Feinstein
United States Senate
Washington, D.C. 20510

Responses to Questions from Senator Barbara Boxer and Senator Dianne Feinstein
Letter of March 16, 2011

<u>Plant Design and Operations</u>

1. **What changes to the design or operation of these facilities have improved safety at the plants since they began operating in the mid-1980s?**

We have taken advantage of the lessons learned from previous operating experience to implement a program of continuous improvement for the U.S. reactor fleet. We have learned from experience across a wide range of situations, including, most significantly, the Three Mile Island accident in 1979. As a result of those lessons learned, we significantly revised emergency planning requirements and emergency operating procedures for licensees, and made substantive improvements in NRC's incident response capabilities. We also addressed many human factors issues regarding control room indicators and layouts, added new requirements for hydrogen control to help prevent explosions inside of containment, and created requirements for enhanced control room displays of the status of pumps and valves.

Two significant changes after Three Mile Island (TMI) were the expansion of the Resident Inspector Program and the incident response program. Today, there are at least two Resident Inspectors at each nuclear power plant. The inspectors have unfettered access to all licensees' activities, and serve as NRC's eyes and ears at the power plant. The NRC Headquarters Operations Center and regional incident response centers are prepared to respond to all emergencies, including any resulting from operational events, security events, or natural phenomena. Multidisciplinary teams in these centers have access to detailed information regarding licensee facilities, and access to plant status information through telephonic links with the Resident Inspectors, an automated emergency response data system, and directly from the licensee through the emergency notification system. In the case of a significant event the NRC's response would include the dispatch of a site team to augment the Resident Inspectors on site, and integration with the licensee's emergency response organization at its Emergency Offsite Facility. The NRC's incident response program is designed to provide an independent assessment of events, to ensure that appropriate actions are taken to mitigate the events, and to ensure that State officials have the information they would need to make decisions regarding protective actions.

Further, a number of new regulatory requirements were imposed by the NRC following the TMI accident, which enhanced the domestic fleet's preparedness to cope with some of the problems have seen seeing in Japan. For example, the "station blackout" rule requires every plant in this country to analyze what the plant response would be if it were to lose all alternating current so that it could respond using batteries for a period of time, and then have procedures in place to restore alternating current to the site and provide cooling to the core.

Another post-TMI requirement, the hydrogen rule, required modifications to reduce the impacts of hydrogen generated for beyond-design basis events and core damage. In addition, there are equipment qualification rules that require equipment, including pumps and valves, to remain operable under the kinds of environmental temperature and radiation conditions that you would see in a beyond-design basis accident. With regard to the type of containment design used by the most heavily damaged plants in Japan, the NRC implemented a Boiling Water Reactor Mark I Containment Improvement Program. This program led to installation of hardened vent systems for containment pressure relief, as well as enhanced reliability of the automatic depressurization system.

Emergency planning and preparedness was also augmented substantially following the TMI accident, with the adoption of additional regulatory requirements and the conduct of mandatory emergency planning exercises on a biennial basis, including participation by state and local government officials. The NRC's emergency preparedness and planning requirements provide ongoing training, testing, and evaluations of licensees' emergency preparedness programs. In coordination with our federal partner, the Federal Emergency Management Administration (FEMA), these activities include extensive interaction with state and local governments, as those programs are coordinated with state and local officials and are evaluated and tested on a periodic basis.

As a result of the events of September 11, 2001, we identified important pieces of equipment that, regardless of the cause of a significant fire or explosion at a plant, licensees have available and staged in advance, as well as new procedures, training requirements, and policies that would help deal with a severe situation.

Since Diablo Canyon went into commercial service, many specific changes in design or operation have been implemented at the plant. These include the following:

- Added sixth on-site emergency diesel generator
- Increased volume of diesel generator fuel oil tanks to supply 7 days of fuel
- Added capacitor banks to the 230 kV offsite power source to improve reliability of offsite power source
- Replaced 500 kV offsite power source circuit breakers with new design that has increased earthquake resistance
- Replaced offsite power source transformers
- Replaced the reactor heads for the reactor vessels with a new design that has improved resistance to corrosion
- Replaced steam generators with new design that has improved resistance to corrosion
- Increased the capacity of the 4 kilovolt system circuit breakers
- Replaced plant process computer
- Replaced low pressure turbine rotors with a new design that is more resistant to turbine blade failure

- Replaced the water cooled positive displacement pumps for core injection with air cooled centrifugal charging pumps
- Replaced main feedwater pump control system to digital based control system
- Upgraded residual heat removal system piping to reduce potential flow induced erosion following an accident
- Replaced emergency core cooling system flow orifices to reduce potential potential flow blockage following an accident
- Replaced the containment sump strainer with a new design that is five times larger to minimize susceptibility to clogging
- Removed material from inside containment that could become a potential debris source following a loss of coolant accident
- Developed additional procedures to address potential natural and manmade disasters
- Implemented significant site changes to improve plant security
- Implemented procedures and training to improve human performance and reduce errors
- Implemented procedures and training to increase use of industry nuclear plant operating experience to improve plant safety

Changes in design or operation at San Onofre (SONGS) have included the following:

- Replaced steam generators with new design that has improved resistance to corrosion
- Developed additional procedures to address potential natural and manmade disasters
- Replaced the containment sump strainer with a new design that is five times larger to minimize susceptibility to clogging
- Removed material from inside containment that could become a potential debris source following a loss of coolant accident
- Implemented significant site changes to improve plant security
- Implemented procedures and training to improve human performance and reduce errors
- Implemented procedures and training to increase use of industry nuclear plant operating experience to improve plant safety
- Replaced all Emergency Planning Zone alert notification sirens in 2005 and 2006, and added paging capability.
- Replaced plant process computer
- Replaced low pressure turbine rotors with new design that is more resistant to turbine blade failure and stress corrosion cracking
- Replaced main feedwater pump control system to digital based control system
- Replaced service air compressors with modern model, and add cross-tie to instrument air
- Added vent to HPSI line to ensure ECCS system free of gas

- Increased safety related battery capacity (1200-1800 amp hours)
- Added degraded grid undervoltage relays to 1E 4KV buses
- Added a portable generator for steam generator water level indication in order to facilitate steam driven pump manual operation during beyond design basis blackout scenarios

2. What emergency notification systems have been installed at California nuclear power plants? Has there ever been a lapse of these systems during previous earthquakes or emergencies?

An Early Warning System (EWS) is installed to provide prompt alerting of the public in the event of an emergency at both Diablo Canyon and SONGS. The EWS consists of 131 sirens positioned out to 22 miles from the plant at Diablo Canyon, and 50 sirens spanning 10 miles at SONGS. The EWS is used in conjunction with radio and TV broadcasts, and allows instructions, information, and necessary actions to be immediately communicated to the public. The sirens are equipped with battery or solar-powered back-up capability. This redundancy in power source was upgraded in the 2005-2006 timeframe. The sirens are tested daily, bi-weekly, quarterly, and annually. The sirens are monitored 24/7 with alarms for system failures.

For Diablo Canyon, prior to installing the power-back up capability, some sirens lost power during the December 2003 San Simeon earthquake. The sirens were not used during that earthquake but back-up route alerting was set up if the need for public alerting warranted. The SONGS EWS sirens have not been affected by past seismic activity.

3. What safety measures are in place to ensure continued power to California reactors in the event of an extended power failure?

U.S. plants are required to meet 10 CFR Part 50 Appendix A General Design Criterion 17, "Electric Power System." Reactor units must have two physically independent offsite power supplies capable of placing the units in a safe shutdown condition. Additionally, all plants are required to have onsite power supplies that are also independent and capable of placing the units in a safe shutdown condition assuming a worst case single failure. All U.S. plants (except Oconee which has an alternate system) have emergency diesel generators and battery backup systems. Most U.S. plants with diesels have two diesels per unit (Diablo Canyon has 3). The regulations do not specify the length of time that the diesels and batteries must be able to operate following a loss of offsite power. The required amount of time is dependent on the plant's site recovery strategy and is based on providing sufficient capacity to assure that the core is cooled and containment integrity and other vital functions are maintained in the event of postulated accidents.

If Diablo Canyon experiences a loss of power from the 500 kV and 230 kV offsite power switchyards, three emergency diesel generators (EDGs) are available to supply onsite power in each of the units. A unit can be safely shutdown utilizing any single

EDG. There are two-50,000 gallon diesel fuel oil tanks, sufficient to operate an EDG for seven days. The EDGs are located at an elevation of 85 feet, well above the maximum expected tsunami elevation.

In addition, Emergency Operating Procedures (EOPs) are in place that include procedures to cope with the loss of all vital AC power. For example, there are Casualty Procedures in place that have pre-planned actions in the event of earthquakes, tsunami warnings and fires. There are Severe Accident Management Guidelines in place that contain actions to take in extreme conditions that require coolant injection to the reactor core, mitigation of hydrogen flammability in containment, and coolant to flood-up containment and cover the reactor core. There are Extreme Damage Mitigation Guidelines (EDMGs) in place that postulate extensive plant damage due to a natural disaster or terrorist event. The EDMGs are invoked when the control of the plant cannot be established from the Main Control Room or there is no communication with the Main Control Room. The Extreme Damage event is assumed to disable all electric power. The EDMGs provide a procedure to perform multiple actions (if needed) to continue to cool the reactor core, cool the spent fuel pool, and minimize radiation release.

SONGS is similar to Diablo Canyon with 2 EDGs per unit and the EDGs are located 30 feet above sea level. SONGS also has a physical cross-tie ability such that the EDGs on one unit can be used to safely shutdown the other unit in the event that either unit loses both of its EDGs. The comments provided above concerning emergency procedure improvements at Diablo Canyon (i.e., EOPs, Severe Accident Mitigation Guidelines, and EDMGs) apply as well to SONGS.

<u>Type of Reactor</u>

1. **What are the differences and similarities between the reactors being used in California (pressurized water reactors) and those in Japan (boiling water reactors), as well as the facilities used to house the reactors, including the standards to which they were built and their ability to withstand natural and manmade disasters?**

The two types of light-water reactors in operation in the United States are pressurized (PWR) and boiling (BWR) water reactors. The PWRs use a two-stage system where the water in the reactor is maintained at a high pressure, and an additional coolant loop is used to transfer heat from that system to produce steam to drive the turbines, while BWRs use a single-stage system that allows water in the reactor to boil to produce steam to drive the turbines directly. The NRC is not yet fully aware of all of the attributes of the specific BWR reactors in question in Japan and how they are different from or similar to BWRs or other reactors in operation in the U.S. Many changes have been made over the years in the design and operation of U.S. nuclear power plants through our program of safety improvement (as described in our response to Question #1 above), which may or may not have been made to reactors operating in Japan.

We have, since the beginning of the regulatory program in the United States, used a philosophy of Defense-in-Depth, which recognizes that nuclear reactors require the highest standards of design, construction, operation, and oversight, and does not rely on any single layer to protect public health and safety. We begin with designs for every individual reactor that take into account site-specific factors and include a detailed evaluation for any credible natural event, such as earthquakes, tornadoes, hurricanes, floods, and tsunamis, as they relate to that site. There are multiple physical barriers to the release of radiation in every reactor design. Additionally, there are both diverse and redundant safety systems that are required to be maintained in operable condition and are frequently tested to ensure that the plant is in a high condition of readiness to respond to any scenario.

Looking at basic design differences between the Japanese BWRs and the California plants, the following can be noted:

- The Japanese reactors have containments that are part of the reactor design and the buildings in which they are placed are not containment structures. By contrast, the California reactors have significantly larger volume containment buildings that house the reactors. This reduces the chance of exceeding the containment design pressure or having a hydrogen explosion inside containment following a natural or manmade disaster that can result in a release of radioactive material to the environment.
- In the event of the loss of power at a U.S. PWR, the reactor core can be cooled using natural circulation of water (without pumps) in the primary coolant loop to transfer heat from the reactor core to the secondary loop. The secondary loop in a PWR can be used to remove the primary loop heat (without power) by pumping non-radioactive water in the secondary loop into heat exchangers (steam generators) with a steam driven pump and releasing non-radioactive steam to the atmosphere via manually operated valves or spring operated safety relief valves. By contrast, venting steam from the Japanese BWRs resulted in a release of radiation to the reactor building from which it escaped to the environment. In addition, there are multiple other pre-planned methods available to provide on-site stored water to the reactor core and to the steam generators to ensure continued core cooling after a disaster.
- The spent fuel pool at a U.S. PWR is contained in a separate building, instead of being contained above the primary containment structure as in a Japanese BWR.
- There are multiple on-site stored water sources and pre-planned measures in place to provide water to the spent fuel pools.

Earthquakes and Tsunamis

1. **We have been told that both Diablo Canyon and San Onofre Nuclear Generating Station are designed to withstand the maximum credible threat at both plants, which we understand to be much less than the 9.0 earthquake that hit Japan. What assumptions have you made about the ability of both plants to withstand an**

earthquake or tsunami? Given the disaster in Japan, what are our options to provide these plants with a greater margin for safety?

All U.S. nuclear power plants are built to withstand external hazards, including earthquakes, flooding, and tsunamis, as appropriate. Regarding earthquakes, nuclear plants, are designed based on ground motion levels, not earthquake magnitudes. Ground motion is a function of both the magnitude of an earthquake and the distance from the fault to the site. The existing nuclear plants in the U.S. were designed based on a "deterministic" or "scenario earthquake" basis that accounted for the largest earthquakes that could reasonably be expected in the area around the plant. A margin is further added to the predicted ground motions to provide added robustness. The NRC's Generic Issue 199 (GI-199) project is using the latest probabilistic techniques used for new nuclear plants to review the safety of existing plants.

Both Diablo Canyon and SONGS are known to have a tsunami hazard. As such, they are designed to withstand the maximum predicted tsunami with coincident wave action.

It is too early to tell what the lessons from this earthquake are. The NRC will look closely at all aspects of the plants' response to the earthquake and tsunami to determine if any actions need to be taken in U.S. nuclear plants and if any changes are necessary to NRC regulations.

2. **Have new faults been discovered near Diablo Canyon or San Onofre Nuclear Generating Station since those plants began operations? If so, how have the plants been modified to account for the increased risk of an earthquake? How will the NRC consider information on ways to address risks posed by faults near these plants that is produced pursuant to state law or recommendations by state agencies during the NRC relicensing process?**

A new Shoreline fault zone near Diablo Canyon was discovered in late 2008. In 2009 and 2010 Pacific Gas and Electric (PG&E) acquired, analyzed, and interpreted new data to better assess the seismic hazard from the Shoreline fault zone. PG&E submitted the final Shoreline fault zone report to the NRC on January 7, 2011. PG&E has concluded that maximum ground motions at the site from local faults are bounded by ground motions for which the plant had been previously evaluated. PG&E has also stated that the tsunami hazard threat from the Shoreline fault zone is relatively small since it is a strike-slip fault rather than a reverse fault and, therefore, the tsunami hazard is not expected to exceed the plant's design-basis tsunami characteristics.

The NRC staff is evaluating the tsunami hazard and is conducting an independent deterministic seismic hazard analysis of the Shoreline fault based on the information provided by the licensee to confirm the licensee's conclusions regarding the safe operation of the plant. In this regard, the staff has reviewed interim seismic studies related to the Shoreline fault zone. The staff is also in the process of reviewing PG&E's final Shoreline fault zone report to determine whether any licensee or regulatory action may be needed. In addition to these specific efforts, the staff plans to continue discussions with PG&E on a possible license amendment to codify a Long Term Seismic Program methodology for the management of new geotechnical seismic information.

For SONGS, no new active faults have been discovered.

With regard to studies performed by other entities, such as the State of California, the NRC reviews each study's results for any new information and design challenges. The State of California is funding a new seismic study that is currently in the planning and draft phase. Licensees are required through their Technical Specifications to notify the NRC at any time during a review or study should evidence of a design challenge be identified.

The NRC considers seismic hazards to be an ongoing regulatory concern; therefore, we address seismic hazards as part of our reactor oversight process for operating reactors whenever a significant change is recognized. As a result, the NRC does not separately re-analyze seismic hazards for the license renewal process. The license renewal review is focused on managing the effects of aging and not a re-review of the current licensing basis.

3. What are the evacuation plans for both plants in the event of an emergency? We understand that Highway 1 is the main route out of San Luis Obispo, what is the plan for evacuation of the nearby population if an earthquake takes out portions of the highway and a nuclear emergency occurs simultaneously?

Each U.S. nuclear power plant has an emergency plan for ensuring the health and safety of members of the public who live within the emergency planning zone. Emergency plans contain contingencies for alternate evacuation routes, alternate means of notification, and other backup plans in the event of a natural disaster that damages the surrounding infrastructure.

FEMA reviews off-site emergency plans formally every 2 years during a biennial emergency preparedness exercise. The NRC evaluates on-site emergency plans during the same exercise, as well as on an annual basis. Population studies are conducted every 10 years, and evacuation time estimates are re-evaluated at that time. FEMA reviews the offsite emergency plans and evacuation time estimates, and determines whether there is a reasonable assurance that adequate protective measures can and will be taken in the event of an emergency at a nuclear power plant.

Evacuation of members of the general public is the responsibility of San Luis Obispo County for Diablo Canyon and San Diego County for SONGS, working in conjunction with the State of California, and would be carried out in accordance with their prearranged plans. The areas to be evacuated and specific evacuation routes would depend on the meteorological conditions and route viability at the time of the accident. PG&E and Southern California Edison (SCE) would act in an advisory capacity, giving technical assessments of the conditions at the plants and the probabilities for a potential off-site release as well as other pertinent information. This information, along with the licensee's recommended protective actions, would be assessed by responsible county and state officials in determining appropriate actions to be taken.

For Incidents of National Significance where the critical infrastructure is severely damaged, DHS has a lead role as a coordinating agency to orchestrate Federal, State, and local assets. The Nuclear/Radiological Incident Annex to the National Response Framework provides for the NRC to be a coordinating agency for incidents involving NRC-licensed materials.

The main route out of San Luis Obispo is Highway 101. The main route for SONGS is Highway 5. For both sites, evacuation studies are conducted by demography specialists and provide information on various evacuation scenarios that could take place. The studies' results consider normal road conditions, time of day, degraded weather/visibility, and road condition.

4. What is the NRC's role in monitoring radiation in the event of a nuclear accident both here and abroad? What is the role of EPA and other federal agencies?

A number of U.S. agencies are involved in domestic monitoring and radiation assessment, including the EPA, Department of Energy, and NRC. NRC regulations require nuclear power plants to report any radiation levels detected at the plant that could be harmful to the public. This would include radiation levels generated by the plant or by an external source. EPA and DOE are responsible for more comprehensive domestic radiation monitoring.

The EPA utilizes its existing nationwide radiation monitoring system, RadNet, to continuously monitor the nation's air, and it regularly monitors drinking water, milk, and precipitation for environmental radiation.

5. What monitoring systems currently are in place to track potential impacts on the U.S., including California, associated with the events in Japan?

See response to Question #4 above. All U.S. plants are required to have a Radiological Environmental Monitoring Program (REMP) in the surrounding communities that are monitored at specific intervals and analyzed in a laboratory as part of a normal offsite monitoring and sampling program.

In addition, Diablo Canyon and SONGS have near-site radiation monitoring systems in place utilizing pressurized ion chambers (radiation detectors). The facilities' pressurized ion chambers are owned and operated by the EPA and are a part of the RadNet system. The EPA monitors the real-time data from these monitors on a continuous basis. The EPA is able to share their data with other agencies during emergency situations. Questions regarding the details of specific monitoring systems of EPA and other federal agencies should be directed to those agencies.

6. **Which federal agency is leading the monitoring effort and which agencies have responsibility for assessing human health impacts? What impacts have occurred to date on the health or environment of the U.S. or are currently projected or modeled in connection with the events in Japan?**

   See response to Question #4 above. The EPA, working with the NRC, DOE and others, has the lead for radiation monitoring activities and regularly samples air, water, and milk. An interagency advisory team that includes the NRC, the Departments of Energy, Health and Human Services, Agriculture, and others, has been established under EPA's leadership and is regularly evaluating potential health and environmental impacts from events in Japan.

   Only trace amounts of radioactive material have been identified through U.S. monitoring; those trace amounts are far below levels of natural background radiation and are not of public health concern. The NRC does not expect any U.S. states or territories to experience harmful levels of radioactivity as a result of the events in Japan.

7. **What contingency plans are in place to ensure that the American public is notified in the event that hazardous materials associated with the events in Japan pose an imminent threat to the U.S.?**

   Under the Nuclear/Radiological Incident Annex to the National Response Framework, the U.S. EPA is the federal lead for plumes that come across our borders. In such situations, EPA would proceed in accordance with its established processes and procedures to work with state and local governments to protect public health and safety.

   If an event requiring protective measures were to occur, U.S. residents would be advised to listen to their state and county authorities who are responsible for making protective action decisions for public health and safety. If necessary and, as appropriate, protective action decisions could include: preventing contaminated food from reaching the marketplace, recommending that all local produce be thoroughly rinsed prior to consumption, or sheltering or evacuating affected citizens. The NRC will continue to work with its local, state, and federal partners to ensure that appropriate emergency response procedures are prepared, reviewed, and exercised in accordance with NRC regulations.