CALIFORNIA COASTAL COMMISSION

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Revised Findings:	05/24/01
Hearing Date on Revised Findings:	06/13/01

REVISED FINDINGS

APPLICATION FILE NO.: **E-00-014**

APPLICANTS: **Southern California Edison Company, San Diego Gas and Electric Company, City of Anaheim, and City of Riverside**

PROJECT DESCRIPTION: Construction of San Onofre Nuclear Generating Station (SONGS) Units 2 and 3 temporary spent nuclear fuel storage facility.

PROJECT LOCATION: 5000 Pacific Coast Highway (unincorporated San Diego County). (Exhibit 1)

SUBSTANTIVE FILE DOCUMENTS: See Appendix B

COMMISSIONERS ON THE PREVAILING SIDE: Dettloff, Estolano, Hart, Kruer, McCoy, Orr, Weinstein, Rose, Woolley, Wan

STAFF NOTE

On November 14, 2000, the Coastal Commission held a public hearing on this application but continued consideration of it, requesting that staff analyze the geologic stability of the proposed project, including, but not limited to, potential hazards from earthquakes, tsunamis, and landslides, consistent with Section 30253 of the Coastal Act. At a public hearing on March 13, 2001, the Commission approved the proposed project, as conditioned, and added special conditions #3, 4, and 5.

SYNOPSIS

Southern California Edison Company, San Diego Gas and Electric Company, the City of Anaheim, and the City of Riverside (hereinafter, applicants) propose to construct a temporary spent nuclear fuel storage facility at the San Onofre Nuclear Generating Station (SONGS), located in an unincorporated portion of northern San Diego County. The facility will house spent fuel used to generate electricity at SONGS Units 2 and 3. It will be located on an existing, developed industrial site at Unit 1.

The applicants propose to construct three separate steel-reinforced concrete pads (covering an approximate area of 25,550 square feet) and approximately 104 steel-reinforced concrete fuel storage modules that will be placed on top of the pads. The facility will be designed and constructed in accordance with the SONGS 2 and 3 Nuclear Regulatory Commission (NRC) operating licenses and NRC regulations. The fuel storage facility will be constructed in three separate phases from approximately 2002 to 2015.

According to the applicants, additional storage capacity is necessary to store SONGS 2 and 3 spent fuel until their NRC operating licenses expire in 2022. The SONGS 2 and 3 spent fuel storage pools currently provide the capacity to store all fuel that will be used by both units through roughly 2007. The applicants are proposing dry storage, as opposed to a new pool storage facility, because the method is more economical and it places the fuel into containers that can be removed from the SONGS site by the Department of Energy when its permanent repository becomes available. Some fuel currently stored in water-filled pools will be transferred to the proposed storage facility until the U.S. Department of Energy (DOE), under obligation pursuant to the Nuclear Waste Policy Act of 1982, accepts the fuel for final disposal at a federal repository. The applicants will continue to use the existing SONGS 2 and 3 pool spent fuel storage facility. Spent fuel will be stored in these pools for a minimum of five years before it is transferred to dry storage.

The U.S. Nuclear Regulatory Commission has sole jurisdiction over the regulation of nuclear power plants, including radioactive hazards, safety issues, and spent fuel handing and storage. **The State of California is preempted from imposing upon nuclear power plant operators any regulatory requirements concerning radiation hazards and nuclear safety**. The possession, handling, storage, and transportation of spent nuclear fuel similarly are precluded from state regulation. The applicants' SONGS 2 and 3 operating licenses require them to comply with all NRC regulations that apply to the operations and activities conducted at those units, including the possession, use, and storage of nuclear fuel. The applicants will control and monitor radioactive releases from the proposed project using the same programs and procedures currently implemented for the commercial operation of the plant.

Coastal Act Issues

The San Onofre bluffs, site of the SONGS facility, are an area of high geologic, flood and fire hazard. The Commission has identified the following geologic issues that must be considered to find that the proposed development will minimize risk to life and property (including the proposed development), and to assure stability and structural integrity at the site: seismic safety (including ground shaking, fault rupture, liquefaction, and tsunami runup), bearing capacity of the foundation elements, safety from coastal bluff retreat and shoreline erosion, and stability of slopes adjacent to the proposed development. As proposed, the project will minimize risk to life and property and will not create nor contribute significantly to erosion, geologic instability, or destruction of the site or surrounding area.

Because the proposed project will take place on an existing, industrial site currently occupied by SONGS 1, no on-site biological resources exist. Potential lighting and noise impacts to nearby environmentally sensitive habitat areas will be avoided. Recreation on and public access to the adjacent San Onofre State Beach will not be restricted during project operations. All relevant air quality permits, if required, will be obtained through the San Diego County Air Pollution Control District.

Commission Action

On March 13, 2001, by a vote of 10-0, the Commission granted subject to conditions Coastal Development Permit (CDP) No. E-00-014 for the proposed project. In doing so the Commission adopted the following resolution:

The Commission hereby approves Coastal Development Permit E-00-014 on grounds that the development as conditioned will be in conformity with the policies of Chapter 3 of the Coastal Act and will not prejudice the ability of the local government having jurisdiction over the area to prepare a Local Coastal Program conforming to the provisions of Chapter 3. Approval of the permit complies with the California Environmental Quality Act because either 1) feasible mitigation measures and/or alternatives have been incorporated to substantially lessen any significant adverse effects of the development on the environment, or 2) there are no further feasible mitigation measures or alternatives that would substantially lessen any significant adverse impacts of the development on the environment.

1.0 STAFF RECOMMENDATION ON APPROVAL OF REVISED FINDINGS

Motion:

I move that the Commission adopt the revised findings set forth in this staff report dated May 24, 2001, in support of the Commission's conditional approval on March 13, 2001, of CDP No. E-00-014.

Staff recommends a **YES** vote on the foregoing motion. Pursuant to section 30315.1 of the Coastal Act, adoption of findings requires a majority vote of the members of the prevailing side present at the March 13, 2001 hearing, with at least three of the prevailing members voting. Only those Commissioners on the prevailing side of the Commission's action on the permit are eligible to vote. See the list on page 1. Approval of the motion will result in the adoption of revised findings as set forth in this staff report.

2.0 STANDARD CONDITIONS See Appendix A

3.0 SPECIAL CONDITIONS

The Commission grants this permit subject to the following special conditions:

1. **Construction Debris**. Construction debris generated as part of the proposed project shall at the earliest practicable opportunity be disposed of at an appropriate offsite facility. Any construction debris or material present on-site, including construction debris or material subject to removal in accordance with the preceding requirement, that could potentially contribute to increased sediment loading shall be covered and/or contained during precipitation events.

2. **Sump Monitoring and Maintenance**. Sediment and other material that collects in the on-site sump from the project site's yard (storm water) drains shall be monitored and removed before such sediment or material reach quantities sufficient to pose a risk to the proper functioning of the sump.

3. **Sump Maintenance Fund**. To assure that sufficient financial resources are available to monitor and maintain the sump and yard drains in working order, prior to commencement of project construction, the applicants shall enter into an agreement, in substantially the same form and content as the draft "SONGS ISFSI Yard Sump Maintenance Trust Account" attached hereto as Exhibit 19 and incorporated herein by reference, with a state or federally chartered financial institution of the applicant's choice for the purpose of establishing a sump maintenance fund. The applicant shall deposit into the fund $136,000, which represents the present value of the full costs of monitoring and maintaining the sump for the life of the project. The sump maintenance fund shall be reviewed and approved by the Executive Director, in coordination with the applicants. Prior to commencement of project construction, the applicant shall provide a copy of the fully executed agreement and evidence that the funds were deposited as described above to the Executive Director.

4. **Permit Expiration.** Unless extended by action of the Commission pursuant to an application submitted prior thereto, this permit shall terminate and be of no further force and effect on November 15, 2002.

5. **Future Development Restriction.** This permit is only for the development described in the project description set forth in this staff report dated May 24, 2001. Pursuant to Title 14 California Code of Regulations Section 13253(b)(6), the exemptions otherwise provided in Public Resources Code Section 30610(b) shall not apply to the project. Accordingly, any future improvements to the permitted structure, including but not limited to any structural or physical modifications to the Independent Spent Fuel Storage Installation, an increase in storage capacity of spent nuclear fuel, the storage of spent nuclear fuel from nuclear power plants other than the San Onofre Nuclear Generating Station Units 2 and 3, and the storage of anything other than spent nuclear fuel which are proposed within the restricted area shall require an amendment to coastal development permit E-00-014 from the Commission or shall require an additional coastal development permit from the Commission or from the applicable certified local government.

4.0 FINDINGS AND DECLARATIONS

The Commission finds and declares the following:

4.1 PROJECT DESCRIPTION

Project Location

The San Onofre Nuclear Generating Station (SONGS) is located in an unincorporated area of northern San Diego County on the United States Marine Corps Base, Camp Pendleton (Exhibit 1).

Background and Preemption of State Regulation

SONGS Units 2 and 3 have operated as 1127-megawatt commercial nuclear power plants since 1983 and 1984, respectively. Both units were constructed on land leased from the U.S. Department of the Navy, U.S. Marine Corp Base, Camp Pendleton. SONGS Unit 1, currently non-operational and in the process of being decommissioned, is located adjacent to and immediately north of Unit 2. The entire SONGS site covers 83.6 acres. SONGS 2 and 3 are collectively owned by Southern California Edison (75.05% interest), San Diego Gas and Electric Company (20%), the City of Anaheim (3.16%), and the City of Riverside (1.79%).

A power plant that uses radioisotopes in the production of energy is required to comply with the federal Atomic Energy Act (Act) (42 U.S.C. Sect. 2011). The Nuclear Regulatory Commission (NRC) was created to issue operating licenses under the Act and to enforce the requirements of the Act and a plant's operating license. Federal regulations (e.g., 10 CFR Parts 20, 50, 71 and 72) also govern the possession, handling, storage, and transportation of radioactive materials from a nuclear power plant. **The State of California is preempted from imposing upon the**

operators any regulatory requirements concerning radiation hazards and nuclear safety. In Pacific Gas and Electric Company v. State Energy Commission, 461 U.S. 190, 103 S.Ct. 1713 (1983), the U.S. Supreme Court held that the federal government has preempted the entire field of "...radiological safety aspects involved in the construction and operation of a nuclear plant, but that the states retain their traditional responsibility in the field of regulating electrical utilities for determining questions of need, reliability, costs and other related state concerns."

The possession, handling, storage, and transportation of spent nuclear fuel similarly are precluded from state regulation. The applicants' SONGS 2 and 3 operating licenses require them to comply with all NRC regulations that apply to the operation of both units, including the possession, use, and storage of spent nuclear fuel. The applicants will control and monitor radioactive releases from the proposed project using the same programs and procedures currently implemented for the commercial operation of the units.

On February 15, 2000, the Commission approved CDP E-00-001, authorizing the demolition of the structures comprising SONGS Unit 1 and the construction of the SONGS 1 spent fuel storage facility (19 fuel storage modules) that the applicants will undertake in connection with the decommissioning of Unit 1. The proposed project will be constructed adjacent to and integrated into the SONGS 1 storage facility, adding 104 fuel storage modules to house SONGS 2 and 3 spent fuel (Exhibit 3).

Project Purpose

According to the applicants, additional storage capacity is necessary to store SONGS 2 and 3 spent fuel until their NRC operating licenses expire in 2022. The SONGS 2 and 3 spent fuel storage pools currently provide the capacity to store all fuel that will be used by both units through roughly 2007. The applicants are proposing dry storage, as opposed to a new pool storage facility, because the method is more economical and it places the fuel into containers that can be removed from the SONGS site by the Department of Energy when its permanent repository becomes available. Some fuel currently stored in water-filled pools will be transferred to the proposed storage facility until the U.S. Department of Energy (DOE), under obligation pursuant to the Nuclear Waste Policy Act of 1982, accepts the fuel for final disposal at a federal repository. The applicants will continue to use the existing SONGS 2 and 3 pool spent fuel storage facility. Spent fuel will be stored in these pools for a minimum of five years before it is transferred to dry storage.

According to the applicants, the DOE does not expect to start accepting SONGS 2 and 3 spent fuel or spent fuel from any U.S commercial nuclear power plant until 2010, at the earliest. Until then, the applicants are required by NRC regulations to safely monitor and maintain the SONGS 2 and 3 fuel.

Temporary Spent Nuclear Fuel Storage Facility

As stated above, until the U.S. Department of Energy accepts SONGS spent fuel for final disposal at a federal repository, the applicants are required by NRC regulations and their operating licenses to safely store and maintain it. The proposed project, an "Independent Spent Fuel Storage Installation" (ISFSI) is comprised of an array of concrete fuel storage modules (FSMs) located on a reinforced concrete pad. A stainless steel canister containing the spent fuel assemblies is secured inside the FSMs. The proposed project will be located within the existing Unit 1 boundaries on a generally flat area at an approximate elevation of 20 feet above sea level. It will be a minimum of 180 feet away from the beach/seawall and a minimum of 150 feet from the slopes surrounding the plant.

Approximately 104 steel-reinforced FSMs that will be placed on top of three steel-reinforced concrete pads, covering an approximate area of 25,550 square feet (Exhibit 2). The concrete pads will be a minimum of three feet thick (with the top being at the existing grade elevation) and will be approximately 43 feet wide and long enough to accommodate the module array. It will contain 7/8" diameter reinforcing bar (rebar) spaced on 12" centers running the length of the pad (top and bottom) and 1-1/8" diameter rebar spaced on 12" centers across the width of the pad. The minimum compressive strength of concrete is 4000 lbs./inch^2. The pad will be designed in accordance with the requirements of American Concrete Institute (ACI-349), "Code Requirements for Nuclear Safety Related Concrete Structures".

A FSM is shaped like a rectangular box and will be no more than 22 feet in height above the existing grade by 9 feet wide and 23 feet long. The FSMs are constructed of reinforced concrete and weigh over 400,000 lbs. each. Generally, rebar within the FSM will range in size from ½" to 1" in diameter with spacing ranging from 6" to 18". The FSMs are tied together in arrays with a combination of 1.5" bolts and 1" rebar. The minimum compressive strength of concrete is 5000 lbs./inch^2. The design and construction of the FSMs will be in accordance with ACI-349 and ACI-318, "Building Code Requirements for Reinforced Concrete".

Each FSM will house a NRC-licensed steel cask or canister that may contain up to 24 fuel assemblies. A fuel assembly consists of 236 zircalloy metal tubes approximately 12.8 feet long and 3/8" in diameter, in which ceramic uranium dioxide fuel pellets are placed. Known as fuel pins, the tubes are completely sealed with welded end plugs. Each fuel assembly has an overall length of about 15 feet and weighs approximately 1,500 lbs.

As indicated above, the proposed project will consist of three separate reinforced concrete pads, to be constructed in three separate phases. The first pad will be constructed adjacent to and integrated into the construction schedule of the SONGS 1 spent fuel storage facility. This phase is proposed to commence in November 2002. The second pad is anticipated to be constructed in 2008 after the SONGS 1 decommissioning is complete and as additional capacity is needed. The third pad is to be constructed sometime between 2011 and 2015 as the need arises.

The proposed fuel storage facility will be constructed within the existing, developed SONGS 1 site (Exhibit 3). The construction process will involve: (1) minor grading without breaking new ground; (2) placing the flat, reinforced concrete pad at ground level; (3) installing a chain-link security fence, perimeter lighting, and cameras and; (4) lifting and setting the free-standing spent FSMs, to be fabricated offsite, on the pad. This work will involve customary grading equipment (such as a front-end loader and a compaction roller) and concrete construction equipment (such as forms, concrete tooling, and a mobile crane). Concrete will be delivered pre-mixed from local suppliers. Construction activities are scheduled to be performed during daylight hours. However, the applicants state that some tasks, completion of which cannot be delayed, such as a large concrete pour or finishing, could occasionally continue until after daylight hours.

The entire facility will be designed and constructed in accordance with NRC regulations (10 C.F.R. Part 72, Subpart K, "General License for Storage of Spent Fuel at Power Reactor Sites," as published in the Federal Register on July 18, 1990, 55 FR 29191) and the SONGS 2 and 3 operating licenses. The applicants maintain that the proposed project will be undertaken in accordance with the existing programs that implement and comply with NRC and Occupational Safety and Health Administration regulations. Existing lighting, telephone, and drainage infrastructure may be modified to accommodate the storage facility. However, the project will not change the existing drainage pattern from the site. All liquid discharges from the construction project will be regulated under the current SONGS 1 National Pollution Discharge Elimination System (NPDES) permit. There will be no liquid discharges or gaseous emissions from the storage facility.

4.2 PRIOR COMMISSION APPROVALS

In 1974, the Commission conditionally approved the construction of SONGS Units 2 and 3 (6-81-330). In 1991, the Commission further conditioned the same permit to require the applicants to implement a compensatory mitigation program. In 1997, the Commission, among other things, approved an amendment (6-81-330-A) to the SONGS 2 and 3 permit to amend the condition that required mitigation for adverse impacts to the marine environment caused by SONGS Units 2 and 3.

On February 15, 2000, the Commission approved coastal development permit E-00-001 authorizing Southern California Edison and San Diego Gas and Electric Company to decommission Unit 1 and construct a temporary spent fuel storage facility for Unit 1. The facility, slated for construction in November 2002, will consist of 19 fuel storage modules and cover an area approximately 4067 sq. ft. and reach 38 feet high.

4.3 OTHER AGENCY APPROVALS

U.S. Nuclear Regulatory Commission

The U.S. Nuclear Regulatory Commission (NRC) has three principal regulatory functions: (1) establish standards and regulations, (2) issue licenses for nuclear facilities and users of nuclear materials, and (3) inspect facilities and users of nuclear materials to ensure compliance with the requirements. The applicants are required to possess, use, and store radioactive waste streams in accordance with federal regulations (*e.g.*, 10 CFR Parts 20, 50, and 72) and their SONGS 2 and 3 NRC Operating License. NRC regulations allow licensees to store spent nuclear fuel either in a wet (pool storage) or dry (cask storage) method. However, they require an applicant to obtain

either a specific or seek coverage under a general license[1]. Under a specific licensing process, the NRC conducts site-specific review of the proposed storage site. A general license allows persons authorized to possess or operate nuclear power plants to contract with an NRC-approved supplier of spent fuel storage casks. The supplier has the obligation to obtain NRC approval (*i.e.*, a Certificate of Compliance) of its casks pursuant to 10 C.F.R. 72, Subpart L.
In a letter dated October 4, 2000 to the NRC, the applicants informed the NRC that they will pursue a general license and that they have contracted with Transnuclear West Inc. to furnish storage casks. Transnuclear West Inc. submitted an application for a Certificate of Compliance (COC) to the NRC on September 29, 2000. A COC expires 20 years after the date that the cask is first used by the general licensee to store spent fuel, unless the cask's COC is renewed.

In order to seek coverage under a general license, the applicants are required to comply with the general license conditions pursuant to 10 C.F.R. 72.212 and others as indicated in 10 C.F.R. 72.13(c). Among other requirements, the former section requires the applicants to:

1. Formally notify the NRC at least 90 days prior to the initial storage of spent fuel.

2. Register use of each cask with the NRC no later than 30 days after using that cask to store spent fuel.

3. Perform written evaluations, prior to use, that establish that conditions set forth in the COC have been met and cask storage pads and areas have been designed to adequately support the statis load of the stored casks.

4. Review the Safety Analysis Report (SAR) referenced in the Certificate of Compliance and the related NRC Safety Evaluation Report, prior to use of the general license, to determine whether or not the reactor site parameters, including analyses of earthquake intensity and tornado missiles, are enveloped by the cask design bases considered in these reports.

5. Protect the spent fuel against the design basis threat of radiological sabotage in accordance with the same provisions and requirements as are set forth in the licensee's physical security plan.

6. Review the reactor emergency plan, quality assurance program, training program, and radiation protection program to determine if their effectiveness is decreased and, if so, prepare the necessary changes and seek and obtain the necessary approvals.

Additionally, 10 C.F.R 72.122 specifies overall requirements the proposed project must meet. Major requirements include:

[1] In issuing 10 C.F.R. 72.210, a general license for the storage of spent fuel in an independent spent fuel storage installation was effectively granted to persons authorized to possess or operate nuclear power reactors. Applicants wishing to seek coverage under this license must comply with the general license conditions pursuant to 10 C.F.R. 72.212 and others as indicated in 10 C.F.R 72.13(c).

(a) *Quality Standards*. Structures, systems, and components important to safety must be designed, fabricated, erected, and tested to quality standards commensurate with the importance to safety of the function to be performed.

(b) *Protection against environmental conditions and natural phenomena.*

(1) Structures, systems, and components important to safety must be designed to accommodate the effects of, and to be compatible with, site characteristics and environmental conditions associated with normal operation, maintenance, and testing of the ISFSI [independent spent fuel storage installation] or MRS [monitored retrievable storage installation] and to withstand postulated accidents.

(2) Structures, systems, and components important to safety must be designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, lighting, hurricanes, floods, tsunami, and seiches, without impairing their capability to perform safety functions. The design bases for these structures, systems, and components must reflect:

(i) Appropriate consideration of the most severe of the natural phenomena reported for the site and surrounding area, with appropriate margins to take into account the limitations of the data and the period of time in which the data have accumulated, and

(ii) Appropriate combinations of the effects of normal and accident conditions and the effects of natural phenomena. The ISFSI or MRS should also be designed to prevent massive collapse of building structures or the dropping of heavy objects as a result of building structural failure on the spent fuel or high-level radioactive waste or on to structures, systems, and components important to safety.

(3) Capability must be provided for determining the intensity of natural phenomena that may occur for comparison with design bases of structures, systems, and components important to safety.

(c) *Protection against fires and explosions*. Structures, systems, and components important to safety must be designed and located so that they can continue to perform their safety functions effectively under credible fire and explosion exposure conditions. Noncombustible and heat-resistant materials must be used wherever practical throughout the ISFSI or MRS, particularly in locations vital to the control of radioactive materials and to the maintenance of safety control functions. Explosion and fire detection, alarm, and suppression systems shall be designed and provided with sufficient capacity and capability to minimize the adverse effects of fires and explosions on structures, systems, and components important to safety. The design of the ISFSI or MRS must include provisions to protect against adverse effects that might result from either the operation or the failure of the fire suppression system.

. . .

(e) *Proximity of sites.* An ISFSI or MRS located near other nuclear facilities must be designed and operated to ensure that the cumulative effects of their combined operations will not constitute an unreasonable risk to the health and safety of the public.

...

(g) *Emergency capability.* Structures, systems, and components important to safety must be designed for emergencies. The design must provide for accessibility to the equipment of onsite and available offsite emergency facilities and services such as hospitals, fire and police departments, ambulance service, and other emergency agencies.

(h) *Confinement barriers and systems.*

(1) The spent fuel cladding must be protected during storage against degradation that leads to gross ruptures or the fuel must be otherwise confined such that degradation of the fuel during storage will not pose operational safety problems with respect to its removal from storage. This may be accomplished by canning of consolidated fuel rods or unconsolidated assemblies or other means as appropriate.

...

(3) Ventilation systems and off-gas systems must be provided where necessary to ensure the confinement of airborne radioactive particulate materials during normal or off-normal conditions.

(4) Storage confinement systems must have the capability for continuous monitoring in a manner such that the licensee will be able to determine when corrective action needs to be taken to maintain safe storage conditions. For dry spent fuel storage, periodic monitoring is sufficient provided that periodic monitoring is consistent with the dry spent fuel storage cask design requirements. The monitoring period must be based upon the spent fuel storage cask design requirements.

(5) The high-level radioactive waste must be packaged in a manner that allows handling and retrievability without the release of radioactive materials to the environment or radiation exposures in excess of part 20 limits. The package must be designed to confine the high-level radioactive waste for the duration of the license.

Other requirements the proposed project must comply with specify criteria for nuclear criticality safety (10 C.F.R. 124), criteria for radiological protection (10 C.F.R. 126), quality assurance (10 C.F.R. 140-176), and operator requirements (10 C.F.R. 190, 194).

Construction of the SONGS 2 and 3 dry storage facility will not require further NRC approval. NRC staff may, however, inspect the construction of the fuel storage modules and the process of loading and moving the spent fuel to the storage facility.

San Diego Air Pollution Control District (APCD)

The San Diego Air Pollution Control District (APCD) has permit authority under the California Clean Air Act (CCAA) over direct emission sources in the project area. The APCD has not established California Environmental Quality Act emission thresholds for construction activity and instead relies on district rules to determine whether permit requirements are triggered by construction-related emissions.

Since the proposed project's emission sources will be construction equipment brought on the site temporarily, the APCD will require permits, if necessary, for these individual sources of emissions. The applicants will either obtain or contractually require vendors supplying the equipment to obtain necessary permits from the APCD. Mobile construction equipment (e.g., cranes) used in connection with the project may be permit exempt, as determined by the APCD.

4.4 COASTAL ACT ISSUES

4.4.1 Geologic Hazards

Section 30253 of the Coastal Act states, in part, that:

> *New development shall:*
>
> *(1) Minimize risks to life and property in areas of high geologic, flood, and fire hazard.*
>
> *(2) Assure stability and structural integrity, and neither create nor contribute significantly to erosion, geologic instability, or destruction of the site or surrounding area or in any way require the construction of protective devices that would substantially alter natural landforms along bluffs and cliffs.*
>
> ...

The San Onofre bluffs, site of the SONGS facility, are an area of high geologic, flood and fire hazard. Accordingly, the Commission's Senior Geologist has reviewed the documents submitted by both the applicants and the opponents to the project, and has conducted his own literature research. This section (4.4.1) contains his conclusions, which the Commission hereby incorporates as findings.

As described above, in section 4.1, the Commission is proscribed from applying section 30253—or any section of the California Coastal Act—to issues related to nuclear or radiation safety. Nevertheless, proposed development must assure geologic stability in order to conform to the Coastal Act. The analysis that follows relates to the safety of the proposed development from geologic hazard; it does not address the consequence of structural failure in terms of nuclear safety. Such consequences are under the jurisdiction of the Nuclear Regulatory Commission (NRC). The findings in this section relate only to issues of geologic stability pursuant to the California Coastal Act.

The Commission has identified the following geologic issues that must be considered to find that the proposed development will minimize risk to life and property (including the proposed development), and to assure stability and structural integrity at the site: seismic safety (including ground shaking, fault rupture, liquefaction, and tsunami runup), bearing capacity of the foundation elements, safety from coastal bluff retreat and shoreline erosion, and stability of slopes adjacent to the proposed development.

4.4.1.1. Geologic Setting

The SONGS site lies in the Peninsular Ranges geomorphic province of southern California. Bedrock at the site is the San Mateo Formation, a dense well lithified sandstone of Pliocene to Pleistocene age. Borings indicate that this formation extends to at least a depth of 900 feet below grade at the site. This bedrock unit is overlain by a series of marine and nonmarine terrace deposits approximately 50 feet thick, which have been dated by correlation with similar deposits containing mollusk fossils that are well dated at 80,000 to 180,000 years old (Fugro, 1975a; Fugro, 1975b). The bedrock at the SONGS site is nearly flat-lying, dipping 10-15 degrees to the northeast (Ehlig, 1977).

At the SONGS facility itself, the terrace deposits and the upper 10-20 feet of the San Mateo Formation have been removed by grading, and the finished grade of the facility is set well below the top of the coastal cliffs at an elevation of approximately 20 feet MLLW. The excavated material was placed on the beach as sand nourishment, greatly increasing the width of the beach in this area. Much of this material has now been removed by longshore drift, but a narrow beach still exists seaward of the facility.

The Cristianitos fault, an apparently inactive low-angle normal fault (Shlemon, 1987), lies south and east of the site, intersecting the seacliff approximately one mile south of the SONGS facility. South of the fault, bedrock consists of the Miocene Monterey Formation, which is underlain by the San Onofre breccia, well exposed in the San Onofre hills to the east. The marine and nonmarine terrace deposits overlie the Monterey Formation as well as the San Mateo Formation. In addition to the Cristianitos fault, which will be described in more detail below, four minor faults have been mapped on the northwest flank of the San Onofre hills to the east of the site. None show evidence of movement during the past two million years (U.S. Nuclear Regulatory Commission, 1981). Several sets of shears in the San Mateo Formation were uncovered during excavation for SONGS Units 2 and 3. These shears show displacements of 3 to 6 inches, but do not offset overlying terrace deposits (Fugro, 1974a; Fugro, 1974b) (Fugro, 1976), and the NRC concluded that they do not represent recent faulting at the site (U.S. Nuclear Regulatory Commission, 1975).

More distant geologic structures include the Newport-Inglewood-Rose Canyon fault zone (variously referred to during NRC review as the "Offshore Zone of Deformation," or the "Southern California Offshore Zone of Deformation"), which passes approximately 8 km offshore. Further offshore, in the region known as the California Borderland, lie several poorly understood northwest-southeast trending strike-slip and/or thrust faults including the Coronado Bank Fault Zone, San Diego Trough Fault Zone, Thirtymile Bank Fault Zone, and Oceanside

Thrust. Onshore, the northwest-southeast trending Elsinore, San Jacinto, and San Andreas Fault Zones pass 38, 73, and 93 km from the site, respectively. Despite the proximity to these active faults, the area is one of the most seismically quiet areas in coastal California, and historically has experienced severe ground shaking relatively rarely.

4.4.1.2. Earthquakes and seismic hazards

Like most of coastal California, the SONGS site lies in an area subject to earthquakes. The site lies approximately 8 km from the Newport-Inglewood-Rose Canyon fault system, 38 km from the Elsinore Fault, 73 km from the San Jacinto Fault, and 93 km from the San Andreas Fault, all of which have been designated "active" (evidence of movement in the past 11,000 years) by the California Division of Mines and Geology (Jennings, 1994). Several relatively nearby offshore faults, including the Coronado Bank Fault Zone, the San Diego Trough Fault Zone, the Thirty-Mile Bank Fault, and the Oceanside Thrust also may be active faults by this definition. Nevertheless, seismicity here has historically been relatively quiet compared to much of the rest of southern California (Exhibit 4), probably because of the relatively great distance of the San Andreas fault, which accommodates most of the plate motion in the area, and the relatively low slip rates of the closer faults (Peterson et al., 1996). A magnitude (M_L) 5.4 earthquake, associated with an unusually large swarm of aftershocks, occurred near the offshore San Diego Trough Fault Zone in 1986, but no other moderate or large (> M_w 5.0) earthquake has occurred within 50 km in historic time (Exhibit 4).

Seismic hazards at the site include ground shaking, surface rupture, liquefaction, slope instability, and tsunami runup. All of these issues are addressed in these findings, but ground shaking deserves special attention as it is the seismic hazard most likely to affect the proposed development. To fully discuss the ground shaking hazard, an understanding of the means geologists use to quantify ground shaking is necessary.

<u>Ground shaking</u>

Many different measures have been used over the years to assess earthquake magnitude. The familiar Richter, or local, magnitude (M_L) is based on the ground shaking observed on a particular type of seismograph that is most sensitive to short period (0.8 second) seismic waves. These waves die out with distance, and so this measure is inappropriate when applied over long distances (> ~500 km) to measure distant earthquakes. Moreover, for large earthquakes, the Richter magnitude "saturates," and fails to accurately reflect differences between large earthquakes of different magnitudes. The surface wave magnitude (M_S) was developed to measure shaking of long period (20 second) waves, and is more suited to larger earthquakes. This scale, like its counterpart the body wave magnitude (M_B) also saturates in large earthquakes and, like the Richter magnitude, is based solely on ground shaking, not the amount of energy released by an earthquake. Currently, most seismologists prefer the moment magnitude (M_W) for measuring large earthquakes. This measure is based on the strength of the rocks, the area of fault rupture, and the amount of slip during an earthquake, and is a better measure of the amount of energy released by an earthquake.

An earthquake of a given magnitude will produce different levels of ground shaking at different locations, depending on the distance of the location from the earthquake hypocenter, the nature of the soil or rock between the location and the earthquake, and soil and rock conditions at the site. The level of shaking is expressed by a term called "intensity," and is quantified by the Modified Mercalli Index, whereby intensities ranging from I (not felt) through XII (near total destruction) are assigned based on the level of damage sustained by structures. Better quantification of the level of shaking also is possible; and the standard measure is peak ground acceleration (PGA), usually expressed as a fraction of the acceleration due to gravity (9.81 m/s^2, or 1.0 g). Peak ground acceleration is typically measured in horizontal and vertical directions. It can be expressed deterministically ("a given earthquake can be expected to produce a peak horizontal ground accelerations at the site of *X* g"), or probabilistically ("given the seismic environment at the site, there is a 10% chance that a peak ground acceleration of *X* g will be exceeded in 50 years"). The current trend is to express seismic risk in probabilistic terms. The State of California has defined ground accelerations with a 10% chance of exceedance in 50 years as corresponding to the "maximum probable earthquake" for the site. Ground shaking with a 10% chance of exceedance in 100 years is defined as the "maximum credible earthquake." Peak ground accelerations depend not only on the intensity of the causative earthquake and the distance of the site from the hypocenter of the earthquake, but also on site characteristics. Most important is the depth and firmness of the soil and/or bedrock underlying the site. All of these parameters are evaluated in producing a seismic shaking hazard assessment of a site.

In evaluating the response of structures to ground shaking, the frequency (cycles per second) of that shaking is important—higher frequency shaking is more damaging to smaller, more rigid structures, whereas lower frequency shaking is more damaging to larger, or more flexible structures. The proposed ISFSI facility fits into the latter category. Different ground acceleration values apply to seismic waves with different frequencies. The inverse of the frequency of a seismic wave is its period. Thus, an earthquake with a peak ground acceleration of 0.7 g may have a peak "spectral acceleration" (SA) of 1.1 g for waves of 0.3 second period, but only 0.5 g for waves with periods of 1 second. A typical earthquake produces seismic waves with many different periods, and a plot of spectral accelerations for an earthquake shows the ground accelerations for waves of all periods. In addition, the duration of shaking appears to be important in determining the amount of damage caused by ground shaking. The duration of shaking correlates reasonably well with earthquake magnitude, but there are no currently accepted means of estimating the expected duration of ground shaking from a given earthquake.

<u>The SONGS Seismic Design Criteria</u>

The applicant maintains that the seismic safety of the site has been assured through review by the U.S. Nuclear Regulatory Commission, most recently the licensing review for Units 2 and 3. Accordingly, it is appropriate to evaluate the SONGS seismic design criteria when considering the safety of the proposed project, which would be located immediately adjacent to Units 2 and 3 on the site of the decommissioned Unit 1.

The recently-released seismic shaking hazard map of California (Peterson et al., 1999) portrays the San Onofre area as a region of "low" seismic shaking potential, with a 10% chance of exceeding approximately 0.3 g in 50 years. For comparison, the Big Sur coast is the only other part of coastal California having a comparably low ground shaking potential according to this assessment. The U.S. Geologic Survey's latitude-longitude earthquake ground motion hazard look-up page (http://geohazards.cr.usgs.gov/eqint/html/lookup.shtml) similarly reports an expected peak ground acceleration of 0.32 g (10% chance of exceedance in 50 years). The probabilistic peak ground accelerations and spectral accelerations for the San Onofre area, assuming firm bedrock conditions, are as follows (determined from the USGS lookup page):

	10% in 50 yr	5% in 50 yr	2% in 50 yr
PGA	0.32 g	0.47 g	0.67 g
0.2 sec SA	0.74	1.12	1.50
0.3 sec SA	0.64	1.06	1.36
1.0 sec SA	0.28	0.38	0.54

This assessment, however, is based only on current understanding of the likelihood of earthquakes of varying intensities on nearby faults. A deterministic study undertaken at the time of the licensing permit application for SONGS Units 2 and 3 (U.S. Nuclear Regulatory Commission, 1981) identified an earthquake on the Newport-Inglewood-Rose Canyon fault system, centered on the portion of the fault nearest to the SONGS site, to be the seismic event with the greatest potential ground shaking for the SONGS site. Other faults, such as the San Andreas Fault, although capable of producing larger earthquakes than the Newport-Inglewood-Rose Canyon fault system, are so far distant from the site that ground shaking would be less than an earthquake on the Newport-Inglewood-Rose Canyon fault system. Because the applicant refers to this assessment to assure the stability of the proposed project, analysis of how this assessment was performed follows.

The 1981 NRC document reviewed several methods put forth by the applicant to arrive at an estimate for the expected magnitude of a design basis earthquake (the "safe shutdown earthquake" of the NRC). One method is the evaluation of historical seismicity on the Newport-Inglewood-Rose Canyon fault system. Three historic earthquakes are known on this system, or its possible extension into Baja California. Only the most recent, which occurred on March 11, 1933, can be accurately assigned a magnitude. That earthquake, the damaging Long Beach earthquake, had a magnitude (M_W) of 6.4 (SCEC, 2001; the NRC (1981) reports both M_S and M_L of 6.3). The locations of the two other earthquakes are not accurately known, but may be related to this system. The first occurred near San Diego on November 22, 1800, and may have had a magnitude of about 6.5 (U.S. Nuclear Regulatory Commission, 1981). The other earthquake, the December 8, 1812 San Juan Capistrano earthquake, likely actually occurred on the San Andreas Fault (SCEC, 2001) and may have had a moment magnitude of about 7.5. The NRC assumed in 1981 that the earthquake was centered on San Juan Capistrano, placing it on the Newport-Inglewood-Rose Canyon fault, and estimated its magnitude as about 6.5 (Toppozada et al., 1979). An 1892 earthquake in Baja California (Laguna Salada earthquake), with an estimated magnitude of 6.9 (M_S; Toppozada et al., 1979; $M_W = 7.0$ according to SCEC, 2001) probably is not related to the Newport-Inglewood-Rose Canyon fault system (Gastil et al., 1979). From these data, the

NRC concluded that "the largest historical earthquakes which have an impact upon the assessment of the maximum earthquake on the OZD [the Newport-Inglewood-Rose Canyon fault system] are M_S = 6.3, 6.5, and 6.5 in southern coastal California and possibly M_S = 6.8 [sic] in Baja California." Earthquakes in southern California that have taken place since the NRC report was published in 1981, including the 1992 Landers (M_W = 7.3; SCEC, 2001), 1994 Northridge (M_W = 6.7; SCEC, 2001), and 1999 Hector Mine (M_W = 7.1; SCEC, 2001) earthquakes were not associated with the Newport-Inglewood-Rose Canyon fault system. Shaking from each of these events was minimal (< 0.1g) at the SONGS site (Collins, 1997).

A second approach to estimating the maximum earthquake likely to be produced by movement along a fault is based on estimates of fault parameters, especially the long-term rate of slip on the fault, estimates of the length of the fault that would rupture during an earthquake, and the amount of displacement that would occur during an earthquake. David Slemmons, consultant to the NRC, put forth over ten different estimates for the maximum magnitude of an earthquake on the Newport-Inglewood-Rose Canyon fault system using various estimates of these parameters. His analysis resulted in estimates of M_S ranging from 6.6 to 7.3 (U.S. Nuclear Regulatory Commission, 1981). These estimates used a long-term slip rate of 0.5 mm/year, and rupture lengths of up to 44 km (22 percent of the 200-km long system). Based on its own review, and a limited review by the U.S. Geological Survey, the NRC concluded "that M_S = 7.0 is a reasonable, yet conservative estimate of maximum earthquake potential based upon fault parameter evaluation" (U.S. Nuclear Regulatory Commission, 1981).

Estimating the amount of ground shaking expected at a particular location from a nearby earthquake is challenging. At the time of the licensing of SONGS 2 and 3, the applicant combined empirical data from recent earthquakes (especially the 1979 Imperial Valley earthquake) and theoretical models to estimate the ground shaking expected at the SONGS site as a result of the design basis earthquake (M_S = 7.0 at 8 km from the site). The theoretical estimate was arrived at by 1) characterizing the nature of the fault slip in terms of fault type, rupture velocity, dynamic stress release, and duration of slip; 2) propagating the energy released in (1) through the earth structure between the fault and the site; and 3) calculating actual ground motion by mathematically combining (1) and (2). The NRC and its consultants reviewed this procedure, and required some modifications to the model. The applicants responded with a model that assumes a rupture distance of 40 km, maximally focused at the site, with a fault offset of 130 cm and a rupture velocity equal to 90% of the shear wave velocity. The mean spectra has a peak acceleration of 0.31 g. After comparison with empirical models, and in order to build in conservatism for inaccuracies in the model, the NRC approved the calculated spectra multiplied by a factor of about 2. The NRC approved spectra thus is pegged at a high-frequency peak acceleration of 0.67 g (Exhibit 5) (U.S. Nuclear Regulatory Commission, 1981). Also shown in exhibit 5 are spectral accelerations expected at the site from the design-basis earthquake according to several newer models for the attenuation of seismic energy with distance.

The approach outlined above is deterministic in nature: a design basis earthquake was established, and that earthquake was used to calculate expected ground acceleration. In 1995 a probabilistic study was undertaken. Three independent sets of consultants contributed to this product: Geomatrix (1994; 1995a; 1995b) determined the seismic source models; Woodward-

Clyde (1995a; 1995b) determined the seismic wave propagation (attenuation) models; and Risk Engineering (1995) integrated these results and performed hazard assessment. The results represent the annual frequency of exceedance of various ground motions at SONGS, shown as a family of seismic hazard curves and as seismic spectra corresponding to the "safe shutdown earthquake," (annual probability of occurrence of 0.00014, or recurrence interval of 7,143 years). This spectra peaks at somewhat higher accelerations than the deterministic spectra (Exhibit 6).

Recent studies and implications to seismic potential at the site

Some opponents to the proposed project indicate that, as a result of research undertaken since the licensing of SONGS 2 and 3, new information is available on the geologic environment offshore of the SONGS site that indicate that the design basis earthquake (M_S = 7.0 at 8 km; with high-frequency ground accelerations pegged at 0.67 g) may underestimate the seismic risk at the site. This is not the first time that the seismic safety of the SONGS facility has been formally challenged. On September 22, 1996, Stephen Dwyer, a geologist from southern California, petitioned the NRC to shut down the SONGS facility "as soon as possible" pending a complete review of the "new seismic risk." Mr. Dwyer asserted that the design criteria are "fatally flawed" on the basis of new information gathered at the Landers and Northridge earthquakes. In particular, he cited 1) ground accelerations as high as 1.8 g that were recorded during the M_W = 6.7 Northridge earthquake; 2) horizontal offsets of up to 20 feet in the Landers earthquake, and 3) the fact that the Northridge fault was a "blind thrust and not mapped or assessed." These issues were addressed by the NRC in "Director's Decision-97-23" (Collins, 1997). The high ground acceleration associated with the Northridge earthquake appears to be due to characteristics (still poorly understood) of one particular instrumented site (Rial, 1996). Nevertheless, as the record from strong motion instrumentation improves, geologists are obtaining more and more records showing high ground accelerations from even modest earthquakes (e.g., 0.48 g from the M_w 5.0 Napa earthquake of 3 September 2000; L. Jones, USGS, pers. comm., 2001). What is equally or more important than ground acceleration, however, is the spectral frequency at which the acceleration occurs and the duration of shaking. Most of these high acceleration values are of very short duration and occur at high spectral frequencies. The horizontal offset at the Landers earthquake is not germane to an earthquake on the Newport-Inglewood-Rose Canyon fault system as the fault dynamics are very different in the two cases. The NRC similarly dismissed the fact that the Northridge fault was a blind thrust as not being germane to the SONGS site in that the Newport-Inglewood-Rose Canyon system is known to be a strike-slip fault, not a blind thrust (Collins, 1997). There is, however, evidence (presented below) that a thrust component may contribute to this fault system. To summarize, the NRC found in 1997 that there was no basis for the Dwyer petition, that the design basis earthquake was adequate, and that the SONGS seismic design criteria exceed the expected seismic spectra from such an earthquake.

Dr. Mark Legg has expressed several concerns related to the proposed project (Exhibit 7). Like Mr. Dwyers, he is concerned with information gained by seismologists since the SONGS Units 2 and 3 licensing review:

- Newer attenuation relations based upon recent large earthquake activity including the 1989 Loma Prieta, California; 1992 Landers, California; 1999 Chi-Chi, Taiwan; 1999 Izmit, Turkey; and

> 1995 Kobe, Japan, and moderate earthquakes including the 1994 Northridge, California; 1987 Whittier Narrows, California; 1983 Coalinga, California; and 1984 Morgan Hill, California are more accurate in estimating ground motions than the relationships used for the Safety Evaluation conducted in the late 1970s (Abrahamson and Silva, 1997; Boore et al., 1997; Campbell, 1997; Sadigh et al., 1997).

This statement is true, and is in fact born out by similar data from even smaller earthquakes such as the 2000 Napa earthquake. However, as shown in Director's Decision 97-23 (Collins, 1997), the SONGS design spectra exceeds the spectral accelerations expected at the site from the design-basis earthquake according to the attenuation models cited by Dr. Legg (Exhibit 5). Even these attenuation models, as well as that by Spudich and others (1997), failed to predict the 0.48 g acceleration measured from the Napa earthquake of 2000—by a factor of four (Miranda and Aslani, 2001). Nevertheless, irrespective of the attenuation models adopted during the licensing review, the design spectra for the ISFSI facility is sufficiently conservative to allow for much larger ground accelerations than might be predicted by the newer attenuation models.

Dr. Legg also points out in his communication to Commission staff (Exhibit 7) that:

> it is now recognized that major detachment fault systems in the region are reactivated as thrust faults, some blind (not reaching the surface). The major Oceanside detachment/thrust system underlies the San Onofre Nuclear Generating Station (SONGS). Consequently, large thrust or oblique-reverse earthquakes on this system may generate shaking levels in excess of the design level of SONGS units 2 and 3 (Bohannon et al., 1990; Bohannon and Geist, 1998; Crouch and Suppe, 1993; Grant et al., 1999; Legg et al., 1992; Nicholson et al., 1993; Rivero et al., 2000).

He goes on to indicate that:

> ...the reverse fault character of microearthquakes recorded along the Cristianitos fault trend in the mid-1970s and reactivation of minor faulting uncovered during site excavations is consistent with overall reactivation of ancient normal fault structures by a new stress regime involving northeast-directed shortening or transpression. This assertion has now been confirmed by recent geologic studies in the neighboring offshore region...

and that, because of the dipping nature of these thrust faults, in an earthquake involving them

> ... the SONGS site would not be 5-7 km from the epicentral zone, but instead directly above the potential fault rupture plane. Estimation of strong motion should use an epicentral distance of zero (0).

The studies cited by Dr. Legg, as well as other studies, do suggest that a complex system of low-angle faults, which appear to be old normal faults (related to crustal extension) reactivated as thrust faults (related to crustal shortening) lie offshore of the SONGS site. The thrust character of these faults may be related to the bend in the Newport-Inglewood-Rose Canyon fault system offshore of Carlsbad. In this area Kuhn and others (Kuhn et al., 2000; Shlemon, 2000) have documented complex fault features that appear to be related to thrusting. It is probably significant that the 1986 Oceanside earthquake (M_L) 5.4, which was centered on one of these low-angle faults, showed a thrust fault mechanism.

Thus, there appears to be credible evidence that, in addition to the strike-slip faulting recognized at the time of the SONGS licensing review, thrust faults exist in the area offshore of the SONGS site which might interact with the Newport-Inglewood-Rose Canyon fault system in a complex way during an earthquake. If these faults are active or potentially active, the increase in potential fault rupture area has, at a minimum, the potential to increase the magnitude of an earthquake on the integrated fault system. Geologists' understanding of this area is rapidly evolving, and there are few constraints on the parameters needed to assess the increase in earthquake risk (such as slip rate on each of the potentially active faults, segmentation of the faults, and potential for cascading failure between fault segments). One of the few published estimates is that of Shaw and his students (Rivero et al., 2000), who hypothesize that the combined system may be capable of an earthquake ranging from M_W 7.1 to 7.6, depending on which sets of faults are involved in the earthquake (Exhibit 8). Shaw's tectonic model for the area is, however, quite controversial (Jones, USGS, pers. comm., 2001). Commission staff consulted with seismologists and geologists at the U.S. Geological Survey, California Division of Mines and Geology, California Seismic Safety Commission, within academia, and at private consulting firms. Although there was near unanimous recognition that there is an increased earthquake risk given our emerging understanding of the complexities of the region relative to a simple strike-slip model used in the SONGS seismic hazard assessments, no one could assess the potential ground shaking that might be expected at the SONGS site.

The Commission thus finds 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—a magnitude 7.0 earthquake on the Newport-Inglewood-Rose Canyon fault system 8 km from the site, resulting in ground shaking with a high frequency component peaking at 0.67 g—may underestimate the seismic risk at the site. This does not mean that the facility is unsafe—although the design basis earthquake may have been undersized, the plant was engineered with very large margins of safety, and would very likely be able to attain a safe shutdown even given the larger ground accelerations that might occur during a much larger earthquake. Assessing the safety of the SONGS facility is not under consideration with this application. As will be shown, the seismic design of the proposed project, which *is* under consideration, so far exceeds the ground accelerations anticipated from the design basis earthquake that it is reasonable to believe that it will be safe from even a much larger earthquake whose focus is even closer than the design basis earthquake.

<u>ISFSI seismic design</u>

Exhibit 9 shows the horizontal (X and Y) and vertical seismic spectra for which the proposed project is designed, together with spectra corresponding to SONGS seismic design, derived from the design basis earthquake described above. Superimposed on each is the Commission staff's calculation for the maximum spectra that would be required at the site according to the Uniform Building Code (Seismic Source A, epicentral distance <2 km, soil profile type S_C). The spectra labeled "SONGS" is derived from the NRC-approved "free-field" spectra and takes into account the interaction of the proposed structure with ground motions, which tends to amplify shaking. The design spectra corresponds to NRC Regulatory Guide 1.60, "Design response spectra for seismic design of nuclear power plants." Comparison of the design spectra with the calculated spectra corresponding to the design basis earthquake show a very large factor of safety. The design spectra greatly exceeds that of the design basis earthquake at all frequencies. It is accordingly reasonable to conclude that even a much larger earthquake, a much lower epicentral distance, or both, will not produce ground shaking exceeding the design of the proposed project.

Accordingly, the Commission finds that the proposed project has been designed to assure seismic stability, consistent with section 30253 of the Coastal Act.

<u>Surface Rupture and the Cristianitos Fault</u>

No active faults were found at the SONGS site despite concerted efforts during geologic studies related to construction and licensing permits before the NRC (Fugro, 1977; Shlemon, 1977; 1979). Several faults were encountered, but without exception they are truncated by the overlying marine terrace deposits, whose age has been established as approximately 120,000 years (1975a; Fugro, 1975b), thus indicating that there has been no movement on those faults since at least that time. Hence, the risk of surface rupture at the SONGS site is very low.

The largest fault near the SONGS site is the Cristianitos fault, which passes less than one mile south of the site (Exhibit 10). This fault, which appears to be a low-angle normal fault, is similarly overlain by undisturbed terrace deposits (Exhibit 11), indicating that there has been no movement on it for at least 120,000 years (Shlemon, 1987). Green and others (1979) did indicate that the fault may connect with the Newport-Inglewood-Rose Canyon system, based on limited seismic data. Despite this potential connection, and the occurrence of two small (magnitude 3.3 and 3.8) earthquakes that occurred near (but not on) the fault trace 30 km north of SONGS in January 1975, the NRC and its USGS consultants concluded that the Cristianitos fault is inactive (U.S. Nuclear Regulatory Commission, 1981). Without more compelling evidence to the contrary, the Commission concurs with this assessment.

Commission staff received a letter from Aladdin Masry, a geologist from Hemet, California, dated 26 June 2000 and originally addressed to "USGS" (Exhibit 12). In this letter, Mr. Masry states that a "recent visit to camp San Onofre indicated that the San Christianitos [sic] fault has moved and ruptures the ground." Mr. Masry goes on to express concern for the safety of the plant. Movement along a fault generally occurs through earthquakes. Movement sufficient to produce surface rupture should produce a substantial earthquake. Commission staff reviewed the earthquake database from the Southern California Earthquake Center for the period January 1998 through July 2000 and found no earthquake that could have been associated with movement of the Cristianitos fault. Commission staff visited the site on 10 January 2001, and found no evidence for surface rupture at the site. There has been recent landslide activity approximately ¼ mile south of the intersection of the Cristianitos fault and the sea cliff, and associated with the landslide are active ground fissures, some of them quite deep. It is possible that Mr. Masry mistook this activity for surface rupture of the Cristianitos fault. Fissures associated with landslides in the area have been previously mistaken for deep-seated faulting (Fugro, 1977).

Accordingly, the Commission finds that the stability of the site with respect to surface rupture can be assured consistent with section 30253 of the Coastal Act.

4.4.1.3. Liquefaction

As discussed below, under "bearing capacity," the SONGS site is underlain by dense sands of the San Mateo Formation. The upper terrace deposits which formerly overlaid the San Mateo formation were removed during construction of SONGS units 1, 2, and 3. Although the water table is very shallow at the site (+5 feet MSL; Southern California Edison Company, 1998), cyclic triaxial tests, field density tests, and very high blow counts during standard penetrometer tests show that liquefaction during the design basis earthquake should not occur. The minimum factor-of-safety against liquefaction in the plant area was calculated at 1.5 to 2.0 (Southern California Edison Company, 1998). The NRC concurred with the applicant's assessment that these calculated factors-of-safety against liquefaction of the San Mateo Formation at the site, for the design basis earthquake loading, are ample (U.S. Nuclear Regulatory Commission, 1981).

The applicant submitted a geotechnical investigation (Southern California Edison Company, 1995) in which liquefaction at the proposed project site itself was specifically addressed. They used the empirical approach of Seed and others (1985) relating Standard Penetration Test (SPT) blow count data from sites that have experienced liquefaction and at sites that have not experienced liquefaction for specific cyclic stress ratios. Using empirical data appropriate to the site characteristics (design basis earthquake, percent fines in the San Mateo Formation), the SPT blow count data indicate that the sands will not liquefy during the design basis earthquake (Exhibit 13).

Several geologists working in southern California have identified features in the San Onofre-Carlsbad area that they interpret to be the results of liquefaction that has occurred at various times in recent geologic history (Franklin and Kuhn, 2000; Kuhn et al., 1996; Kuhn et al., 2000; Shlemon, 2000). These features, including sand dikes, lenses, and disturbed bedding, were also mentioned by Dr. Mark Legg in his communication with Commission staff (Exhibit 7). Because these features appear to disturb Native American middens (Kuhn et al., 2000), it can be inferred that some of them, at least, are younger than about 10,000 years old, and perhaps as young as 2000-3000 years. Some such features occur in areas where the only likely source for the sand injected into higher layers of the soil is well-consolidated sandstones of Eocene age (Franklin and Kuhn, 2000). Kuhn (1996; Kuhn et al., 2000) cites these features as evidence for very large earthquakes in the area in the past.

Although these features are suggestive, the Commission does not consider them indicative of a serious liquefaction hazard at the site of the proposed project. Liquefaction in sands as dense as those encountered at the SONGS site have not previously been documented in even very large earthquakes; it is far more common for unconsolidated sands or artificial fills to fail by liquefaction. While it is possible that an earthquake much larger than the design basis earthquake might be capable of causing liquefaction of the San Mateo formation sands, no estimates have been provided by any of the cited studies as to the required ground shaking needed to induce such cyclic stresses. In light of the high factor of safety evident on Exhibit 13, and without credible data to the contrary, the Commission finds that the applicant has adequately addressed the liquefaction hazard at the site.

Accordingly, the Commission finds that the stability of the site with respect to liquefaction can be assured consistent with section 30253 of the Coastal Act.

4.4.1.4. Tsunamis

Several studies have been undertaken to address the potential for tsunami runup at the SONGS site. The most recent are summarized in the Safety Evaluation Report prepared by the NRC at the time of licensing hearings for SONGS 2 and 3 (Southern California Edison Company, 1998; U.S. Nuclear Regulatory Commission, 1981). Both local- and distant-sourced tsunamis were considered; the local-source tsunami (resulting from a magnitude 7.5 earthquake occurring 8 km offshore along the Newport-Inglewood-Rose Canyon fault system) was specifically modeled by Dr. Basil Wilson, consultant for Southern California Edison, at the time of original licensing review. By assuming that the vertical ground movement associated with this earthquake would be 7.1 feet, he calculated that a tsunami of 7.6 feet would result. By superimposing this tsunami on a 7-foot high tide (the 10% exceedance Spring high tide for the site) and a one-foot storm surge, the maximum "still" water level was found to be 15.6 feet MLLW. In its review, the NRC generally agreed with this model, arriving at a maximum still water level of 15.83 feet MLLW. In these calculations, the presence of the seawall was ignored.

The applicant submitted a geotechnical investigation (Southern California Edison Company, 1995) in which tsunami runup at the project site itself was specifically addressed. This evaluation made use of the tsunami calculations prepared for the SONGS 2 and 3 licensing application summarized above. Noting that the elevation of the proposed project's foundation pad is 20 feet MLLW, and the maximum still water level calculated by their consultant, the report notes that the foundation pad would be about 4.4 feet higher than proposed wave runup. To address the effects of breaking storm waves superimposed on this tsunami-generated still water runup, a wave uprush study used in the design of the seawall at the time of the SONGS Unit 1 design was applied. Again assuming that the seawall is not present, the wave would break at the riprap revetment protecting the walkway along the beach. The maximum breaking wave was found during the seawall study to be 8.8 feet high. If the seawall were not present, this wave would disperse as a wedge of water as it moved inland from the walkway. Volumetric calculations show that this wedge of water would fill the area between the riprap and the ISFSI site up to elevation 18.8 feet MLLW; 1.2 feet below the pad grade. The velocity of this wave would be low and the major impact to the site would be from flooding. Inundation of the pad itself would not harm either the pad or the casks (T. Yee, SCE, pers. comm., 2001).

For the initial examination of SONGS Units 2 &3, the only tsunamis considered were those generated by earthquakes. Several recent tsunamis have been generated by massive submarine landslides (e.g., Kulikov et al., 1996; Rabinovich et al., 1999, Tappin et al., 2001[in press]). These tsunamis are often localized, but very large events. There have been a number of studies in recent years which appear to demonstrate that massive underwater landslides have occurred off the southern California coast, particularly in Santa Monica Bay, in the recent geologic past. As described by Dr. Legg in his letter (Exhibit 7):

> It is likely that large underwater landslides would be triggered by severe earthquakes, and the possibility of both tectonic displacement and landslide inducement of tsunamis exists. Maximum expected run-up maps for locally generated tsunami are currently being prepared for coastal San Diego County (Bohannon and Gardner, 2001 (in press); Field and Edwards, 1993; Kuhn et al., 1994; Legg and Kamerling, 2001 (in press); Legg et al., 1995; Locat et al., 2001 (in press); Tappin et al., 2001 (in press); Watts and Raichlen, 1994).

These studies suggest that large local-source tsunamis could be generated by mechanisms other than those considered during licensing for SONGS 2 and 3, the basis for the 1995 SCE report. However, there have been no local runup studies based on this mechanism that are widely agreed upon, and certainly none for the SONGS site itself. As Dr. Legg indicates, tsunami runup maps are currently being prepared for San Diego County by individuals at the University of Southern California in conjunction with the Office of Emergency Services, but they are not currently available.

Commission staff accordingly concludes that although the proposed project may be threatened by tsunami, the major effect from an earthquake-generated tsunami would be site inundation. Possible inundation has been factored into the project design, and it would not adversely effect the stability of the site. There is also a potential for a submarine landslide to generate a tsunami that could threaten this site; however, current mapping and modeling do not provide any information of how the site would be effected by such an event. Even if the current models for locally-generated tsunami are insufficient, inundation of the pad by up to several feet of water should not damage the foundation pads or the storage casks.

Accordingly, the Commission finds that the stability of the site with respect to tsunami hazard can be assured consistent with section 30253 of the Coastal Act.

4.4.1.5. Bearing Capacity

The proposed ISFSI facility is a massive structure. The ISFSI facility for Unit 1, approved by the Commission in February 2000, will consist of a concrete pad 43 feet 6 inches wide by 188 feet long by 3 feet thick; the proposed pads for Units 2 and 3 will be of similar width, but may be longer as necessary to accommodate the module array. Assuming a unit weight of 145 pounds per cubic foot, the pad for Unit 1 will weigh approximately 3.5 million pounds. Each module consists of reinforced concrete shaped like a rectangular box 20 feet high, 9 feet wide and 23 feet long and weighs approximately 400,000 pounds. Into each module will be placed a stainless steel canister containing the spent fuel assemblies, weighing approximately 80,000 pounds. Thus, the 19 modules and pad approved for Unit 1 decommissioning will weigh approximately 12.6 million pounds. When completed, the complete project, which would consist of 104 modules, would weigh approximately 70 million pounds.

For perspective, this figure may be compared with the weight of the terrace deposits and the upper part of the San Mateo Formation formerly overlying the site. Since these deposits were approximately 70 feet thick, and had a unit weight of approximately 102-117 pounds per cubic foot, the volume formerly occupying the space above the Unit 1 pad weighed approximately 65 million pounds. Thus, even after the construction of the project, the weight applied to the San Mateo Formation at the site will be only about 20% of the pre-development weight.

More germane to the question of the ability of the site materials to support the ISFSI is a calculation of the bearing capacity of the San Mateo Formation relative to general or local shear failure. The applicant has supplied a calculation of static ultimate bearing capacity (Exhibit 14) indicating that, assuming a 67-foot square footing, the bearing capacity for the San Mateo Formation is 449,000 pounds per square foot. Commission staff has checked these calculations, and finds that the applicant may overestimate bearing capacity because (1), the project design specifications are for a rectangular (not square) pad only 43 feet six inches wide and (2), the effects of ground water, typically located at about elevation 5 MLLW (15 feet below grade), were not considered. Nonetheless, because the foundation will only be loaded to approximately 1750 pounds per square foot (Exhibit 15), a sufficient factor of safety exists to conclude that the static bearing capacity of the San Mateo Formation sands will not be exceeded.

The applicant also has submitted a dynamic analysis, SCE Calculation No. C-296-01.04, Rev. A (Exhibit 16), which demonstrates the capacity of the pad design under seismic loading, and an analysis of soil response to ground shaking using two bounding cases for estimates of soil properties (Exhibit 17). These calculations, which make use of 1.5 g horizontal and 1.0 g vertical ground accelerations (considerably higher than the NRC-approved SONGS criteria), demonstrates not only the adequacy of the foundation, but also shows that with the recommended steel reinforcement, the concrete pads will not fail during an earthquake with the specified ground accelerations.

Accordingly, the Commission finds that the materials at the site have sufficient bearing capacity to assure stability of the proposed development, consistent with section 30253 of the Coastal Act.

4.4.1.6. Coastal Erosion and Bluff Retreat

The proposed development lies within an industrial site, protected by a seawall, and has been protected from coastal erosion and bluff retreat for more than 25 years. To the south of the site, in the footwall of the Cristianitos fault, bedrock is the Monterey formation. This rock unit is known to be susceptible to landsliding throughout the state, and the seacliff in this area is collapsing through a series of large, ongoing landslides. This process appears to be the primary mechanism of bluff retreat in this region. To the north of the Cristianitos fault, bedrock consists of the relatively dense San Mateo Formation, a sandstone that is not highly susceptible to landsliding. Although no large landslides comparable to those to the south occur, the overall rate of seacliff retreat, measurable over geologic time (hundreds of thousands of years) would appear to be comparable, as no "point" or "embayment" in the coastline occurs where the bedrock types change. The mechanism for seacliff retreat in the San Mateo Formation are unclear, but the shape of the seacliff suggests dominantly marine process, such as undercutting, block collapse, and slumping of poorly consolidated upper bluff (terrace) materials.

The rate of bluff retreat in the San Onofre area is somewhat difficult to assess, due both to its episodic nature and to the varying mechanisms of retreat along the coast. There is no doubt that active bluff retreat is occurring south of the site, at San Onofre State Beach where bedrock is the Monterey Formation and where runoff has been concentrated through the creation of new drainage systems associated with the construction of Interstate 5 (Kuhn, 2000). In the vicinity of the proposed project, however, there has been little appreciable bluff retreat or headward erosion of the terrace deposits for at least the last 120 years. The U.S. Army Corps of Engineers reviewed U.S. Coast and Geodetic Surveys (USCGS) along the San Diego Coast and, based on their ability to locate all of the triangulation monuments installed by the USCGS, concluded that "the bluff line had, between 1889 and 1934, remained unchanged" (U.S. Army Corps of Engineers, 1960). The monuments also were located in 1954, indicating no measurable retreat of the bluff line at that time as well. Although no data are available since that time, comparison of aerial photographs and maps indicate that there has been little measurable bluff retreat through 1998 (Kuhn, 2000).

There is, however, substantial subaerial erosion of the terrace deposits and the Monterey Formation south of the SONGS site (Kuhn, 2000). This erosion takes the form of headward erosion of gullies, slumping of the face of bluffs, and deep-seated landslides. These landslides are seated in the Monterey Formation south of the Cristianitos Fault, and do not affect the SONGS site, which is underlain by the dense sandstones of the San Mateo Formation.

In any case, any bluff erosion has been severely retarded over natural rates at the SONGS site because: 1) armoring of exposed natural and artificial cliff exposures in gunite, and 2) the installation of a seawall protecting the entire site. The former tends to protect the affected cliffs from subaerial erosion, and the latter effectively prevents marine erosion. The seawall consists of a sheet pile wall driven 18 feet below finish grade of the SONGS facility (to a depth of approximately 2 feet MLLW), a 2.5 inch layer of gunite secured by wire mesh, and a rock revetment extending seaward 12 feet from the seawall. Documents furnished by the applicant indicate that the sheet pile wall is subject to corrosion, including through-going holes. This, together with the shallow depth of emplacement, lack of foundation elements, and the lack of an engineered key to the rip-rock revetment, suggest that continued maintenance of the seawall may be necessary for its continued function. Nonetheless, the low bluff retreat rates indicate that it is not needed to guard against bluff retreat at the SONGS site.

The applicants indicate further that the seawall is not necessary for the protection of the proposed project; in particular the evaluation of tsunami hazard described above assumes that the seawall is not present. Given that section 30253 of the Coastal Act requires that new development not depend on shoreline protection devices, it is necessary to evaluate whether the proposed project would be safe from coastal erosion and bluff retreat without the seawall. No expected economic life of the development is available, but the site is intended as a temporary facility awaiting licensing of a Federal high-level nuclear waste depository, which will probably not be available for at least ten years. The SONGS Units 2 and 3 operating licenses expire in 2022.

Given the setback of the proposed pad, at least 180 feet from the seawall, and its elevation at approximately 20 feet MLLW, and the low rate of coastal bluff retreat where bedrock is the San Mateo Formation, the Commission finds that facility should be safe from coastal erosion for its anticipated useful life. Sea level rise that might occur over the expected life of the facility likewise is not expected to effect the site, given its elevation of 20 feet MLLW and its setback from the seawall.

Accordingly, the Commission finds that the proposed development will be safe from coastal erosion and bluff retreat and will not require the construction of protective devices that would substantially alter natural landforms along bluffs and cliffs, as required by section 30253 of the Coastal Act.

4.4.1.7. Slope Stability

The proposed project is located approximately 200 feet south of a cut slope approximately 70 feet high, and approximately 170 feet west of a somewhat lower cut slope. Both slopes are covered in gunite, although a small portion (approximately 1/3) of the slope to the north is not. During studies for the SONGS Unit 1 ISFSI facility (Southern California Edison Company, 1995), the applicant produced slope stability analyses to determine the minimum factor of safety of these slopes during seismic shaking corresponding to the design basis earthquake (described above). These analyses, performed using the method of Makdisi and Seed (1977), are for four cross sections through the cut slopes (Exhibit 18), and demonstrate minimum factors of safety ranging from 1.77 to over 3. The study concluded that:

> The small displacements estimated using the Makdisi-Seed procedure suggest that only minor sloughing of the near slope surface material is likely to occur during design basis earthquake ground shaking. Minor sloughing will not adversely affect the ISFSI which is located at distances greater than about 60 feet [sic] from the toe of the slopes. Therefore, slope stability will not be a concern for the ISFSI facility since the 60 feet offset provides a sufficient standoff distance.

Despite this conclusion, the applicant performed an additional evaluation to determine, if a slope failure were to occur, what distance the soil could be expected to travel (Hadidiafamjed, 2000). The concern was whether landslide material could bury the dry storage casks, blocking their cooling vents (a nuclear safety issue). This calculation indicated that the maximum distance the soil would travel would be 120 feet, and the site for the ISFSI was moved accordingly to isolate the site from the potential runout zone.

The Commission finds that these analyses adequately address the stability of the cut slopes adjacent to the proposed project. Concern has been raised that ground shaking during the maximum possible earthquake at the site may, in light of recent discoveries, exceed the design basis earthquake (see discussion above, under "ground shaking"). Nevertheless, the high factors of safety demonstrated by the calculations cited above suggest that it is reasonable to believe that the cut slopes will remain stable even during a much larger earthquake whose focus is even closer than the design basis earthquake.

South of the site, at San Onofre State Beach, several coalescing large active landslides affect the coastal bluff (Kuhn, 2000; Kuhn and McArthur, 2000). These slides are each seated within the Monterey Formation, which is known to contain weak layers and to be prone to landsliding throughout California. The Monterey Formation is not known to occur near the surface north of the Cristianitos fault, and landslides of the character occurring south of the fault have not been observed to the north of it. The SONGS site, lying north of the Cristianitos fault, is underlain by the San Mateo Formation to depths of at least 900 feet as confirmed through boreholes undertaken prior to development of SONGS Unit 1. Accordingly, there is very little risk that a landslide similar to those in San Onofre State Beach south of the SONGS site could involve the SONGS site itself. If the site is, nevertheless, subject to a slow-moving, deep seated landslide similar to those south of the site, this should be manifested by differential vertical movement across the site. Commission staff asked for, and received, settlement records from throughout the SONGS site. These records show the elevation of over 100 survey monuments as determined by repeated surveys extending from 1975 to 1999. Very little settlement occurred at the site, probably due primarily to the overconsolidation of the finish grade due to removal of the overlying terrace deposits. The maximum settlement observed is less than 0.1 inch, and there is no indication of differential settlement across the site, as might be expected during a rotational landslide.

Accordingly, the Commission finds that the stability of the slopes adjacent to and underlying the proposed project is assured consistent with section 30253 of the Coastal Act.

4.4.1.8. Conclusions

For all of the reasons described above, the Commission finds that the proposed project will minimize risk to life and property pursuant to section 30253(1) and, pursuant to section 30253(2), will not create nor contribute significantly to erosion, geologic instability, or destruction of the site or surrounding area. Further, the proposed project will not require the construction of protective devices, and does not depend on the existing seawall installed at the site.

4.4.2 Public Access and Recreation

Coastal Act Section 30211 states:

> *Development shall not interfere with the public's right of access to the sea where acquired through use or legislative authorization, including, but not limited to, the use of dry sand and rocky coastal beaches to the first line of terrestrial vegetation.*

Coastal Act Section 30220 states:

> *Coastal areas suited for water-oriented recreational activities that cannot be readily provided at inland water areas shall be protected for such uses.*

The nearest public access to coastal waters or recreation areas is at San Onofre State Beach, directly to the north and south of SONGS. A pathway directly in front of the SONGS site connects these two beach areas. There is no public access to the beach through the SONGS site.

Public access to and recreation on San Onofre State Beach will not be restricted in any way by the proposed project. Additionally, the pathway in front of the SONGS site will remain accessible for pedestrian passage. The project will take place entirely within the SONGS 1, 2, and 3 boundaries. No development will extend onto or adjoin San Onofre State Beach.

4.4.2.1 Conclusion

Because the proposed project will not affect public access or recreation areas, the Commission finds that the proposed project is consistent with Coastal Act Sections 30211 and 30220.

4.4.3 Marine Resources, Water Quality, and Environmentally Sensitive Habitat Areas

Coastal Act Section 30230 states:

> *Marine resources shall be maintained, enhanced, and where feasible, restored. Special protection shall be given to areas and species of special biological or economic significance. Uses of the marine environment shall be carried out in a manner that will sustain the biological productivity of coastal waters and that will maintain healthy populations of all species of marine organisms adequate for long-term commercial, recreational, scientific, and educational purposes.*

Coastal Act Section 30231 states in part:

> *The biological productivity and the quality of coastal waters... appropriate to maintain optimum populations of marine organisms and for the protection of human health shall be maintained and, where feasible, restored....*

Coastal Act Section 30240 states in part:

> *Environmentally sensitive habitat areas shall be protected against any significant disruption of habitat values, and only uses dependent on those resources shall be allowed within those areas.*

4.4.3.1 Marine Resources and Water Quality

According to the applicants, there will be no liquid discharges from the spent fuel storage facility. Existing drainage infrastructure may be modified to accommodate the new facility but the project will not change the existing drainage pattern from the site. The existing storm or yard drains, water treatment facilities, and sump will not be altered. However, during construction of the proposed project, stormwater may be generated and could contribute to sediment loading of receiving waters.

Currently, stormwater and other non-radioactive liquid waste streams generated by SONGS 1 are discharged under an existing industrial National Pollutant Discharge Elimination System (NPDES) permit (#CA0001228), renewed by the San Diego Regional Water Quality Control Board on February 11, 2000. The proposed project will be covered under this NPDES permit. The permit contains specific numeric effluent limits for all suspected pollutants associated with industrial activities at SONGS 1 and runoff from the site. Stormwater flows are co-mingled with other industrial discharges and monitored for effluent limit exceedances at several stages prior to final discharge through the SONGS 1 outfall. The applicants are required to report any exceedances to the RWQCB within 24 hours and propose remedies for immediate compliance with the effluent limits. During the construction of the proposed project, the applicants will continue to perform routine sampling of liquid effluents consistent with the SONGS 1 NPDES permit and NRC effluent control procedures.

Best Management Practices contained in the applicants' Storm Water Pollution Prevention Plan (prepared as a condition to the NPDES permit) specifically assess the potential for discharges of hazardous waste and material to the ocean through plant site runoff, sludge and waste disposal, spillage or leaks, and drainage from material storage areas. In addition, training for good housekeeping practices and emergency response is provided to personnel, and regular site inspections are performed. Water used for dust suppression will be collected and either filtered or treated at the wastewater treatment plant prior to discharge. Stormwater runoff will be collected, co-mingled with other discharges, monitored, and treated when necessary, prior to discharge through the SONGS 1 outfall.

However, during precipitation events, exposed debris or soil materials can runoff into the SONGS 1 yard drains and potentially contribute to increased sediment loading to receiving waters. This increased sediment loading can potentially increase turbidity of coastal waters, resulting in decreased water clarity, and over the long-term, can impact epifaunal organisms. **Special Condition 1** requires the applicants dispose of construction debris, at the earliest practicable opportunity, generated as part of the proposed project at an appropriate offsite facility. The condition also requires the applicants to cover or contain any debris or material left on-site that could potentially contribute to increased sediment loading to receiving waters during precipitation events.

Special Condition 2 requires the applicants to monitor and remove sediment and other material collected in an on-site sump before such sediment or material reach quantities sufficient to pose a risk to the proper functioning of the sump. This sump has a nominal capacity of 10,000 gallons and collects stormwater flowing into yard drains from the SONGS 1 site. The sump has a weir configuration designed to trap and settle sediment. As mentioned above, these waste discharges are sampled and treated, if necessary, prior to discharge to receiving waters. However, if the sump is not properly monitored and maintained, its ability to effectively remove sediment can be compromised, resulting in additional sediment loading and turbidity to receiving waters, as discussed above.

In addition to regulating runoff from SONGS 1 essentially as a point source pollutant under the existing NPDES permit, SONGS 1 is currently covered under a general stormwater NPDES permit for industrial activities. However, because the effluents limits contained in the individual NPDES permit, as described above, are more specific and stringent than the general stormwater NPDES permit, compliance with the former provides a higher level of protection to receiving waters.

To assure that the applicants have sufficient financial resources to implement Special Condition 2 for the life of the project, **Special Condition 3** requires that, prior to project construction, the applicant shall establish a sump maintenance fund similar in form and content as the draft "SONGS ISFSI Yard Sump Maintenance Trust Account" (Exhibit 19). The fund shall provide for the full costs of monitoring and maintaining the sump for the life of the project (through November 15, 2022) and shall represent the present value of the full cost of all monitoring and maintenance costs that the applicants will incur over the life of the permit. The maintenance fund shall be reviewed and approved by the Executive Director, in coordination with the applicants.

Based on at least 15 years of operating history, the applicants estimate total annual sump maintenance and monitoring costs of $7,364.00, including labor costs. These costs are itemized in the table below. In addition to chemical analyses of sump discharges, as required by the NPDES permit, it is visually inspected periodically for the presence of significant amounts of oils or sediments. When visual inspection indicates a significant accumulation of sediment or oil in the sump, a vacuum truck is contracted to pump out the sump contents, clean the sump if necessary, and dispose of the contents at a permitted offsite disposal facility.

Table 1. SONGS Units 2 and 3 Sump Maintenance and Monitoring Costs

Task	Cost
Required inspections	$1535.00
Sampling and chemical analysis	$1044.00
Removal of sand and debris from yard sump	$3991.00
Sub-total	$6570.00
Contingency	$794.00
Total	**$7364.00**

The attached draft "SONGS ISFSI Yard Sump Maintenance Trust Account" Agreement (Trust Account), prepared by the applicant in coordination with Commission staff, provides that all funds deposited in the Trust Account are to be held in trust and shall be disbursed only for expenditures for storm water sump monitoring and maintenance, consistent with Special Condition 2. A deposit of $136,000 will be made by the applicants to the Trust Account at its inception, which is the estimated present value of the sump monitoring and maintenance costs plus the estimated present value of the expenses of the trustee for the life of the project through December 31, 2022. Over its life, the account balance is assumed to grow at an average annual percentage rate of 6.0% (in a federally insured certificate of deposit or U.S. Treasury Bill), while the cost of sump maintenance, estimated at $7,500/year, is assumed to inflate at an average annual rate of 3.0%. Using a more conservative growth rate of 5.5% and inflation rate of 3.5%, the principal amount would be sufficient to cover sump monitoring and maintenance costs for the life of the project. The account will be debited $2,000 each year for bank administrative fees.

The assumptions for sump maintenance cost inflation and trust fund growth are derived from the applicants' Economic Assumptions Manual, dated July 1, 1999, which is part of the applicants' standard accounting practices that are independently audited periodically pursuant to federal regulations.

The Commission recognizes that Special Conditions 2 and 3 will substantially minimize any impacts to water quality and coastal resources caused during project construction or operation. However, there is still a possibility that residual or other impacts due to, for example, untimely sump maintenance or stormwater flows that overwhelm the capacity of the sump could adversely affect water quality and coastal resources. Additionally, according to the applicants and the NRC, a federal repository for permanent spent fuel storage may be established by the U.S. Department of Energy and begin accepting transfers of spent nuclear fuel generated by the nation's commercial nuclear facilities, including the SONGS, as early as 2010. Thus, the proposed project may become unnecessary after this date. The Commission finds that under a circumstance in which it is foreseeable that the underlying rationale for a project may change or even disappear, it is reasonable place a finite limit on the term of the permit that authorizes that project. In this connection the Commission notes that the SONGS Units 2 and 3 NRC operating licenses expire on February 16, 2022 and November 22, 2022, respectively. Accordingly, **Special Condition 4** limits the term of this coastal development permit to November 15, 2022, the later of the two above-identified expiration dates, thus eliminating any potential residual or other impacts to coastal resources or water quality that may occur after this date.

However, according to the applicants, decommissioning Units 2 and 3 may take upwards of 20 years after they cease operating, which may require onsite storage of spent fuel during this time. Additionally, the transfer of spent fuel from Units 2 and 3 to the federal repository may not take place immediately after it begins accepting transfers of spent fuel as fuel from other nuclear power plants may have priority given their older age. Thus, the Commission acknowledges that the applicants may need to amend CDP No. E-00-014 to extend its term beyond November 15, 2022. To do so the applicants must prior to this expiration date submit to the Commission an application for an extension of the term of the permit supported by: 1) evidence that additional storage time beyond November 15, 2022 is needed during the decommissioning of Units 2 and 3; 2) evidence that a federal repository will not become operational or available to accept Units 2 and 3 spent fuel during the term of this permit or; 3) other newly discovered material information, which they could not, with reasonable diligence, have discovered and produced before the permit was granted and which justifies an extension of the term of the permit.

Finally, **Special Condition 5** states that this coastal development permit is only for the development described in the project description. Pursuant to Title 14 California Code of Regulations Section 13253(b)(6), the exemptions otherwise provided in Public Resources Code Section 30610(b) shall not apply to the project. Accordingly, any future improvements to the permitted structure, including but not limited to any structural or physical modifications to the Independent Spent Fuel Storage Installation, an increase in storage capacity of spent nuclear fuel, the storage of spent nuclear fuel from nuclear power plants other than the San Onofre Nuclear Generating Station Units 2 and 3, and the storage of anything other than spent nuclear fuel which are proposed within the restricted area shall require an amendment to coastal development permit

E-00-014 from the Commission or shall require an additional coastal development permit from the Commission or from the applicable certified local government. This condition ensures that the Commission will have an opportunity to review changes to the project and identify any potential impacts to marine resources or water quality not considered or mitigated in this staff report.

4.4.3.2 Environmentally Sensitive Habitat Areas ("ESHA")

The proposed project will take place on land that is currently occupied by SONGS Unit 1, an existing, disturbed industrial site with no on-site biological resources. The entire SONGS site is situated upcoast and downcoast from the San Onofre State Beach and is bordered on the west by the Pacific Ocean and beach area. According to the resource ecologist overseeing the San Onofre State Beach, high-quality gnatcatcher coastal sage habitat exists in the state beach approximately 1.5 miles north of SONGS 1 and 0.5 mile south of the SONGS Units 2 and 3 (Pryor, 2000). Gnatcatchers have been observed in this habitat. The U.S. Fish and Wildlife Service listed the gnatcatcher in 1993 as a federal threatened species.

The proposed project will involve the installation of lighting as required by NRC federal regulations. The U.S. Fish and Wildlife Service has previously required that artificial lighting from development be shielded or angled away from gnatcatcher habitat to minimize potential threats such as predation, collision, and decreased breeding success (Miller, 2000). Current lighting requirements for the SONGS 1, 2, and 3 site are specified by NRC federal regulations. After SONGS 1 is fully decommissioned, the existing perimeter lighting will be removed. New lighting will be installed, consistent with NRC federal regulations, for the SONGS 1, 2, and 3 fuel storage facility. However, the new lighting will not be more intense than the existing SONGS 1 perimeter lighting. Thus, there is no potential for project-related lighting to adversely impact nearby environmental sensitive habitat areas or the gnatcatcher.

The U.S. Fish and Wildlife Service has established a 60 dbA (decibel) threshold or criterion for analyzing noise impacts to the gnatcatcher or when assessing the level of a take of this species (Hays, 2000). Noise levels at or above this threshold are assumed to indirectly affect the reproductive success of songs birds, including the gnatcatcher, increase stress levels, and interfere with predator avoidance, among other impacts (Miller, 2000). Thus, if project-related noise reached beyond the SONGS site and into the gnatcatcher habitat, which includes Units 1, 2, and 3, the gnatcatcher may be impacted, especially during nesting season (February 1 to July 15). However, according to the applicants, any noise generated from project-related activities will be short-term and is not expected to result in any noticeable change in noise levels beyond the entire SONGS site.[2] Furthermore, the entire SONGS site is physically sited 50-70 feet below the surrounding geography, providing a noise buffer. Any project-related noise extending beyond the SONGS site is expected to attenuate to undetectable levels before reaching nearby gnatcatcher habitat. Thus, the proposed project will not disrupt the resources of the adjacent ESHA.

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[2] It should be noted that a railroad line and Interstate Highway 5 lies directly to the east of SONGS and the San Onofre State Beach.

4.4.3.3 Conclusion

The Commission finds that with the imposition of **Special Conditions 1, 2, 3, 4,** and **5** the proposed project will be carried out in a manner that will sustain the biological productivity of coastal waters, maintain healthy populations of all potentially affected species of marine organisms, and protect environmentally sensitive habitat areas in conformity with the requirements of Coastal Act Sections 30230, 30231, and 30240.

4.4.4 Visual Quality

Coastal Act Section 30251 states in part:

> *The scenic and visual qualities of coastal areas shall be considered and protected as a resource of public importance. Permitted development shall be sited and designed to protect views to and along the ocean and scenic coastal areas, to minimize the alteration of natural land forms, to be visually compatible with the character of surrounding areas, and, where feasible, to restore and enhance visual quality in visually degraded areas.*

The SONGS site is situated directly on the Pacific Ocean and bordered on the east by Interstate 5. With the exception of the SONGS 1 sphere enclosure building (scheduled for demolition in 2006), which is partially visible from Old Highway 101 and Interstate 5, current views of the SONGS 1 site are generally obscured or blocked. Looking south from the bluff north of SONGS, the bluff blocks any view of the project area. From south of the SONGS site, Units 2 and 3 block views of the project area. From the beach looking landward, an existing SONGS seawall blocks most views into the project area.

The proposed fuel storage facility is estimated to reach 42 feet or 22 feet above the existing grade, but will not be visible from areas accessible to the public. Similarly, construction equipment, including a mobile crane, will not be visible from outside the SONGS site.

4.4.4.1 Conclusion

Since the proposed project will not be visible from areas accessible to the public, the Commission finds that the proposed project is consistent with the requirements of Coastal Act section 30251.

4.4.5 Air Quality

Coastal Act Section 30253(3) requires that:

> *New development shall:*
>
> ...
>
> *(3) Be consistent with requirements imposed by an air pollution control district or the State Air Resources Control Board as to each particular development.*

Since the proposed project's emission sources will be construction or other equipment brought on the project site temporarily, the San Diego County APCD will require permits, if necessary, for these individual sources of emissions. Internal combustion (IC) engines powering, for example, generators and pumps, portable diesel generators, cranes and other construction equipment brought on the SONGS 1 site will either have individual APCD permits, California registration[3], or be permit exempt (drive engines that power construction equipment are exempted by the APCD).

4.4.5.1 Conclusion

The Commission finds that the project will be carried out consistent with the requirements of the San Diego APCD and thus is consistent with Coastal Act Section 30253(3).

4.5 THE CALIFORNIA ENVIRONMENTAL QUALITY ACT (CEQA)

Section 13096 of the Commission's administrative regulations requires Commission approval of CDP applications to be supported by a finding showing the application, as modified by any conditions of approval, to be consistent with any applicable requirements of the California Environmental Quality Act (CEQA). Section 21080.5(d)(2)(A) of the CEQA prohibits approval of a proposed development if there are feasible alternatives or feasible mitigation measures available that would substantially lessen any significant impacts that the activity may have on the environment.

The project as conditioned herein incorporates measures necessary to avoid any significant environmental effects under the Coastal Act, and there are no less environmentally damaging feasible alternatives. Therefore, the Commission finds that the proposed project is consistent with the resource protection policies of the Coastal Act and with the CEQA.

[3] Portable equipment can be registered with a local air district or the state Air Resources Board. The registration process imposes emission limits on certain portable equipment (e.g., internal combustion engines, abrasive blast booths) but is considered a more expeditious permitting process.

APPENDIX A
STANDARD CONDITIONS

1. Notice of Receipt and Acknowledgment. The permit is not valid and development shall not commence until a copy of the permit, signed by the permittee or authorized agent, acknowledging receipt of the permit and acceptance of the terms and conditions, is returned to the Commission office.

2. Expiration. If development has not commenced, the permit will expire two years from the date on which the Commission voted on the application. Development shall be pursued in a diligent manner and completed in a reasonable period of time. Application for extension of the permit must be made prior to the expiration date.

3. Interpretation. Any questions of intent of interpretation of any condition will be resolved by the executive director or the Commission..

4. Assignment. The permit may be assigned to any qualified person, provided assignee files with the Commission an affidavit accepting all terms and conditions of the permit.

5. Terms and Conditions Run with the Land. These terms and conditions shall be perpetual, and it is the intention of the Commission and the permittee to bind all future owners and possessors of the subject property to the terms and conditions.

APPENDIX B
SUBSTANTIVE FILE DOCUMENTS

Coastal Development Permit Application Materials
Application for Coastal Development Permit E-00-014, as amended.

Agency Permits and Orders
Order No. 2000-04, NPDES Permit No. CA0001228, Waste Discharge Requirements for the Southern California Edison Company San Onofre Nuclear Generating Station, Unit 1, San Diego County.

Environmental Documents and Reports
"Final Environmental Statement Related to the Operation of the San Onofre Nuclear Generating Station Unit 1", Southern California Edison Company and San Diego Gas and Electric Company, Docket No. 50-206, approved by the U.S. Atomic Energy Commission, October 1973.

"Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities- NUREG-0586", prepared by the U.S. Nuclear Regulatory Commission, August 1988.

"Environmental Assessment by the Office of Nuclear Reactor Regulation Relating to the Conversion of the Provisional Operating License to a Full-Term Operating License", Southern California Edison Company and San Diego Gas and Electric Company, San Onofre Nuclear Generating Station Unit 1, Docket Number 50-206, approved by the U.S. Nuclear Regulatory Commission September 16, 1991.

Post Shutdown Decommissioning Activities Report for San Onofre Nuclear Generating Station Unit 1, submitted to the U.S. Nuclear Regulatory Commission, December 1998.

Storm Water Pollution Prevention Plan, as amended, submitted to the California Regional Water Quality Control Board, San Diego Region, September 27, 2000.

Lease Documents
Grant of Easement to Southern California Edison Company and San Diego Gas and Electric Company by United States Department of the Navy, May 12, 1964.

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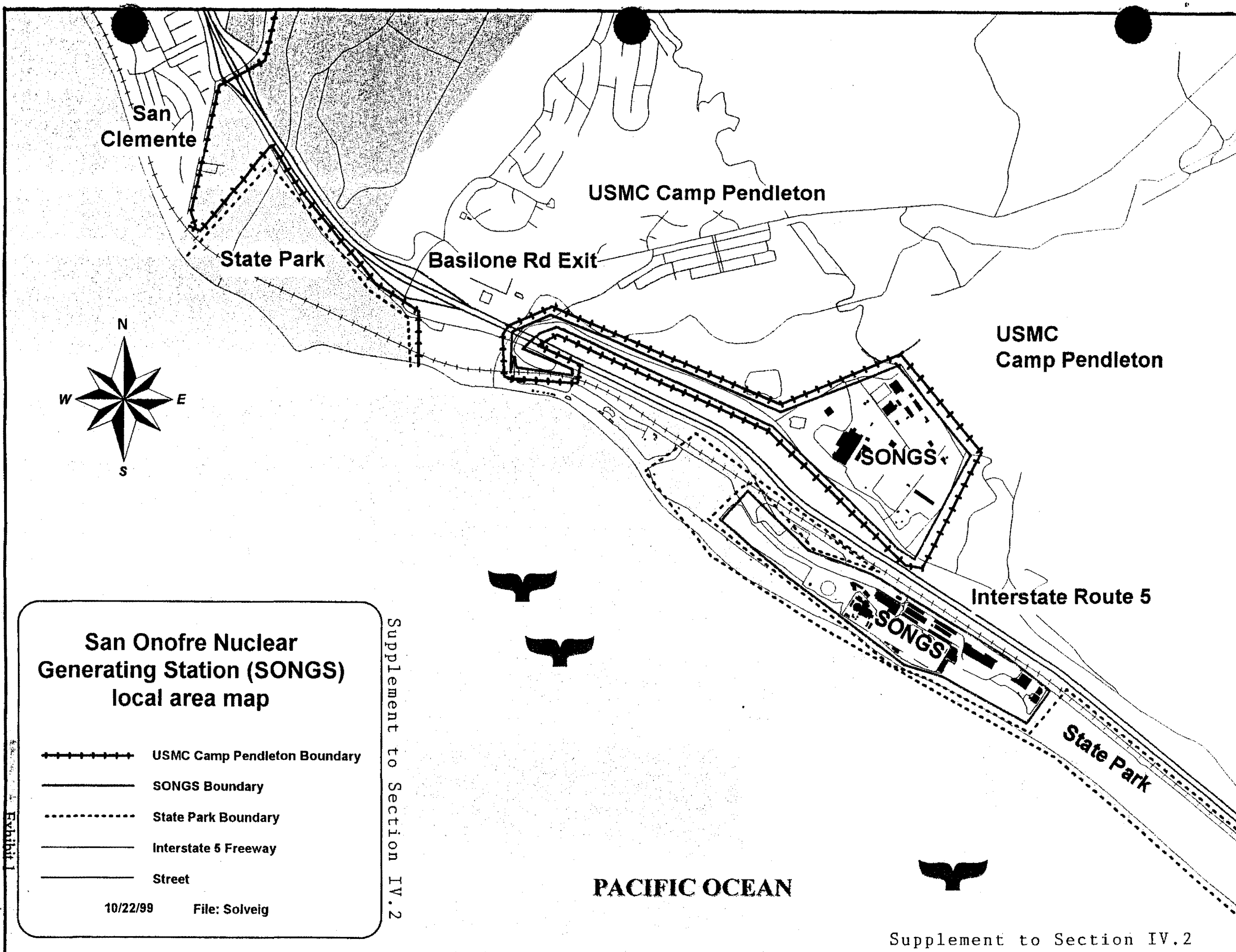
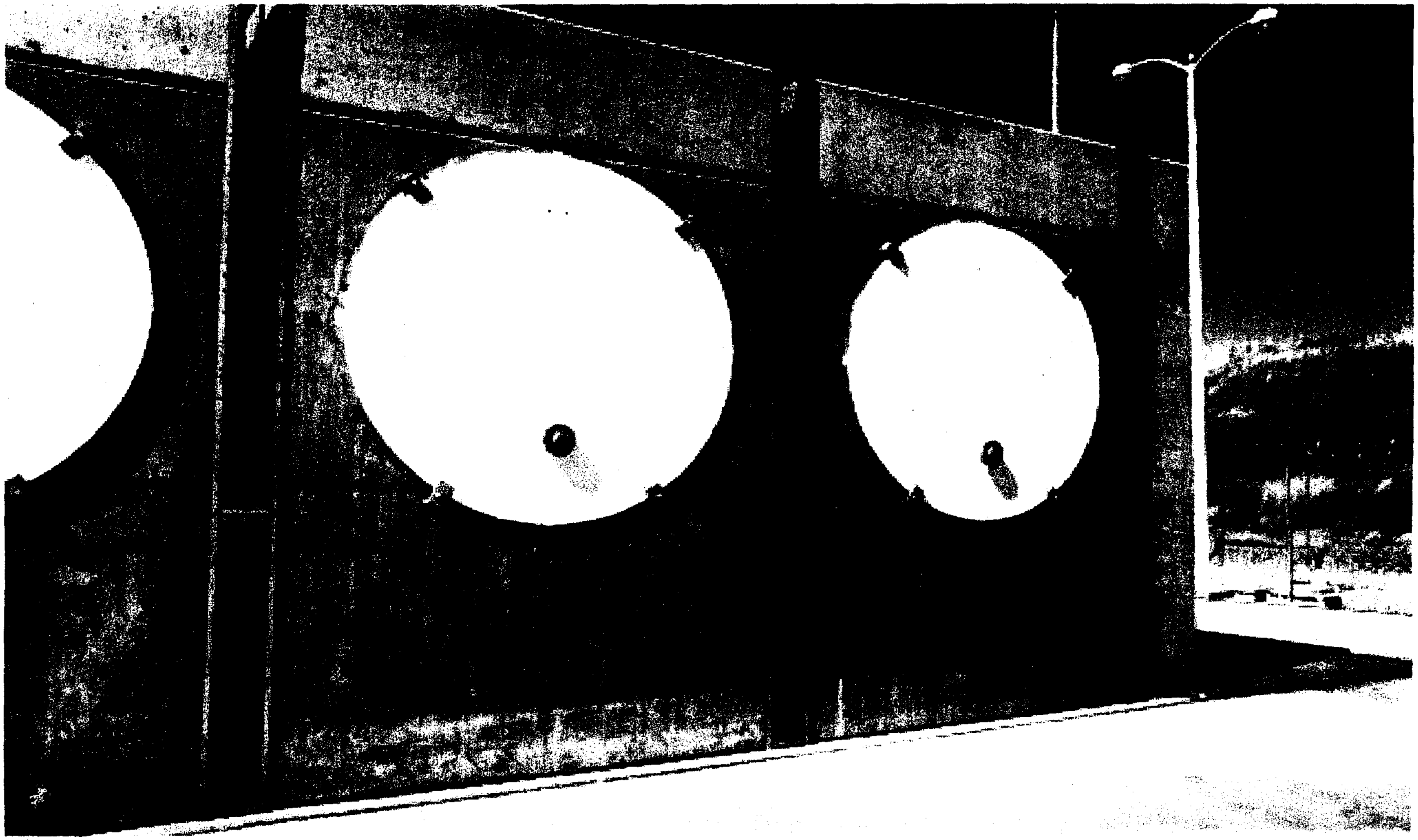

San Clemente
State Park
USMC Camp Pendleton
Basilone Rd Exit
USMC Camp Pendleton
SONGS
SONGS
Interstate Route 5
State Park
PACIFIC OCEAN
N
S
W
E
San Onofre Nuclear Generating Station (SONGS) local area map
USMC Camp Pendleton Boundary
SONGS Boundary
State Park Boundary
Interstate 5 Freeway
Street
10/22/99
File: Solveig
Supplement to Section IV.2

Exhibit 1

Temporary Fuel Storage Modules



Supplement to Section II.2
Attachment B-4
(See Sections II.4-6 and
IV.7 for dimensions.)

Exhibit 2
E-00-014
Supplement to Section II.2
Attachment B-4

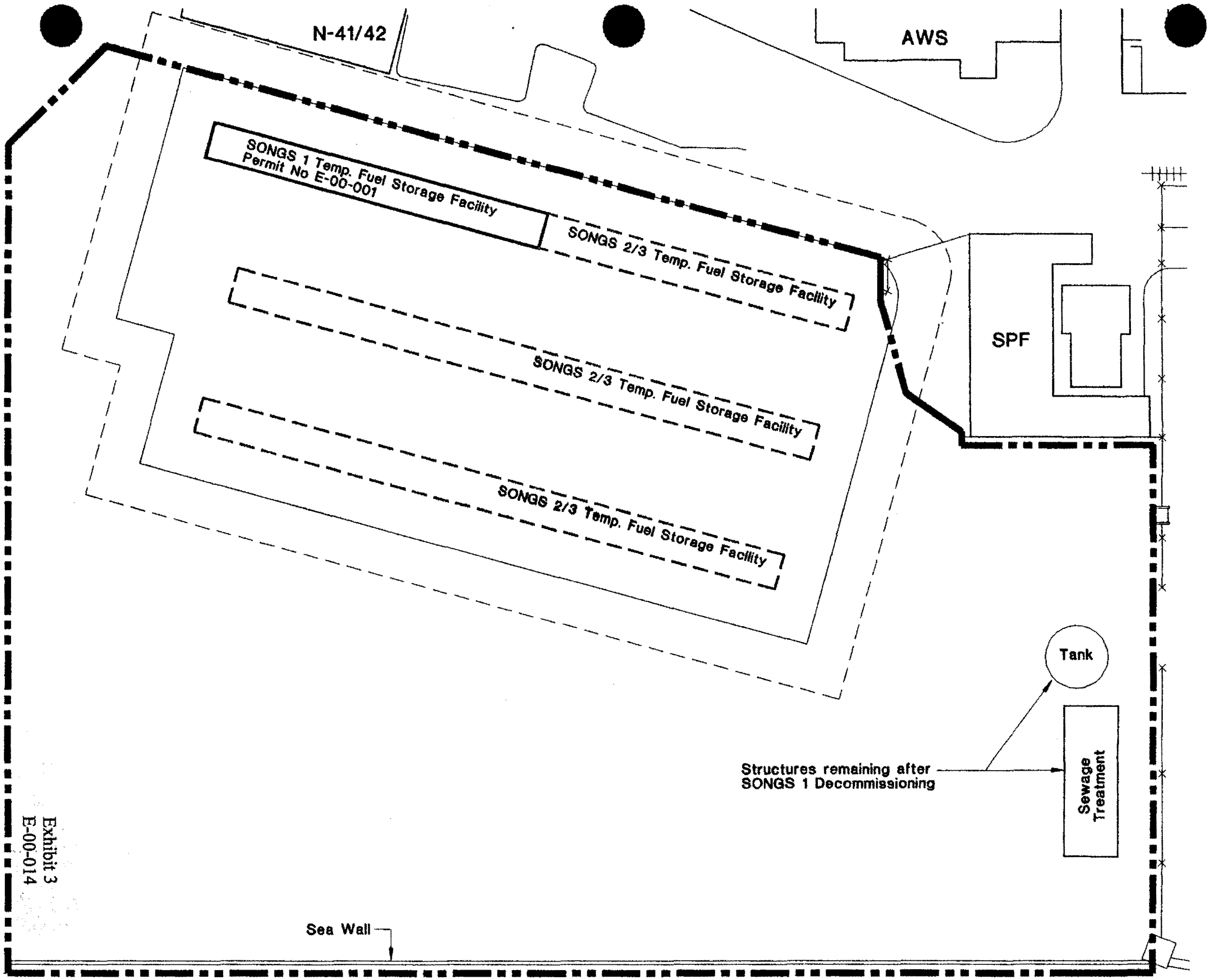


Exhibit 3
E-00-014

Supplement to Section II.2
Attachment B

Not to Scale

Temporary Fuel Storage Facility
SONGS 1 Project Area

Supplement to Section II.2
Attachment B

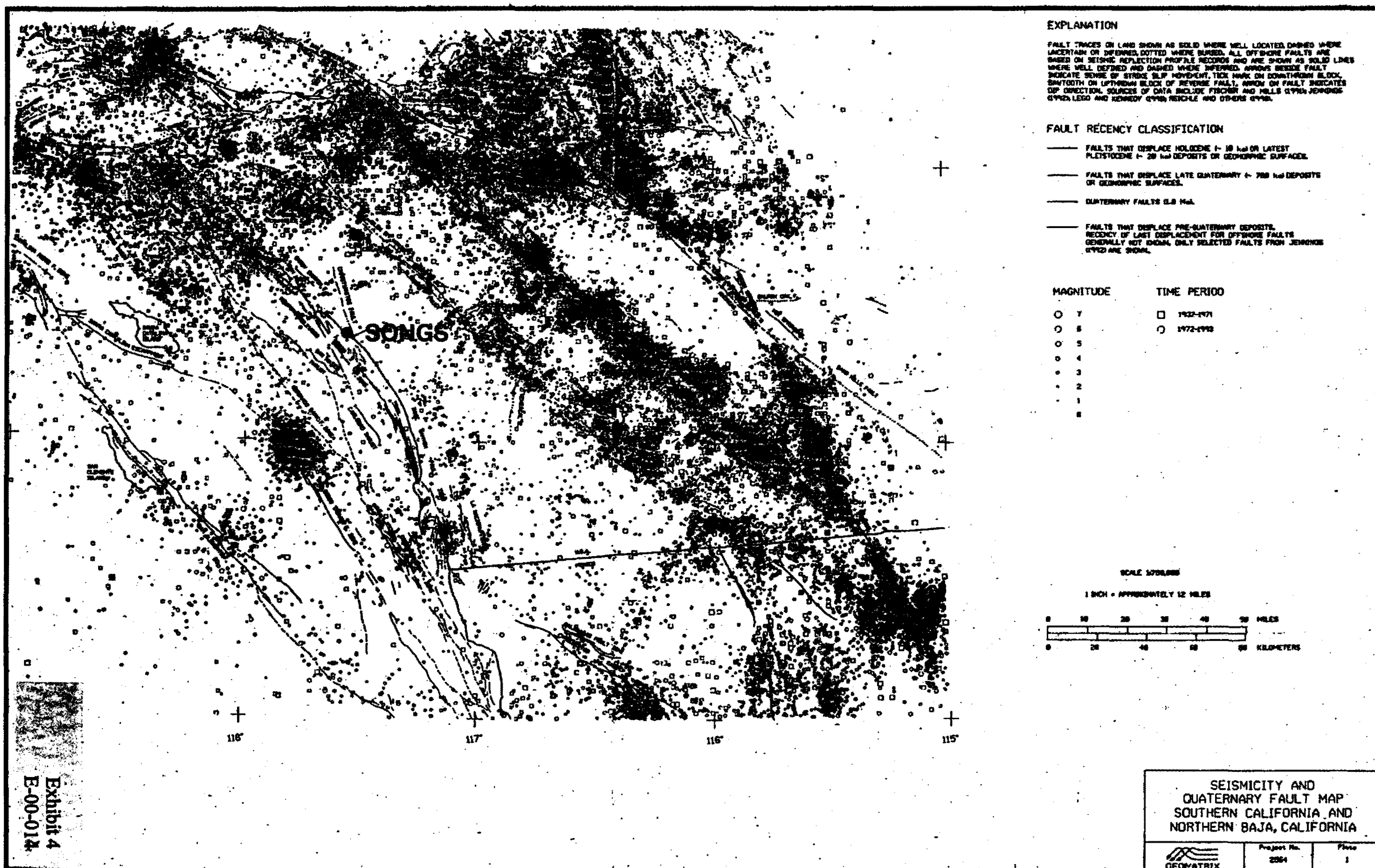


Exhibit 4
E-00-014

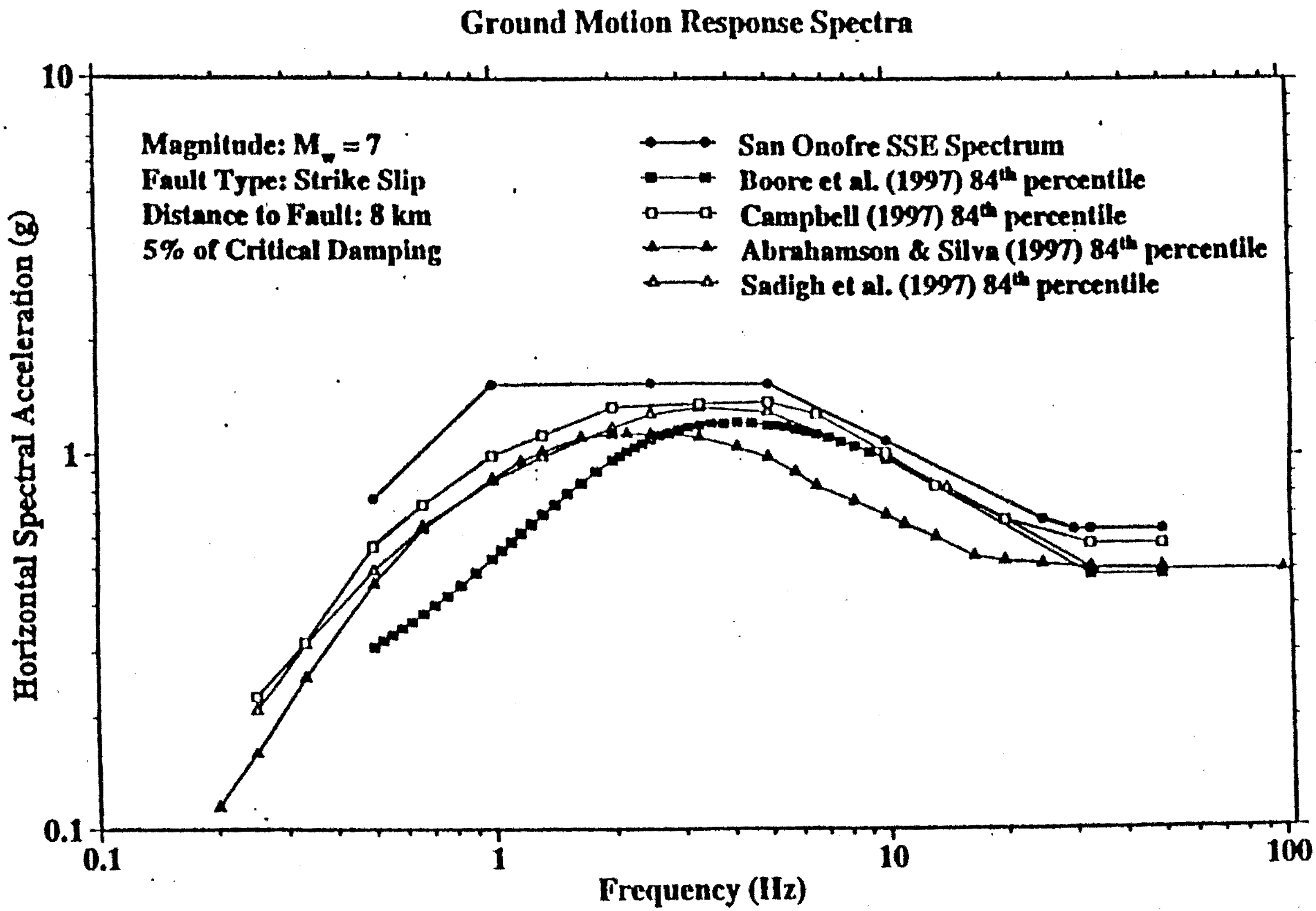


Exhibit 5
E-00-014

Figure 3

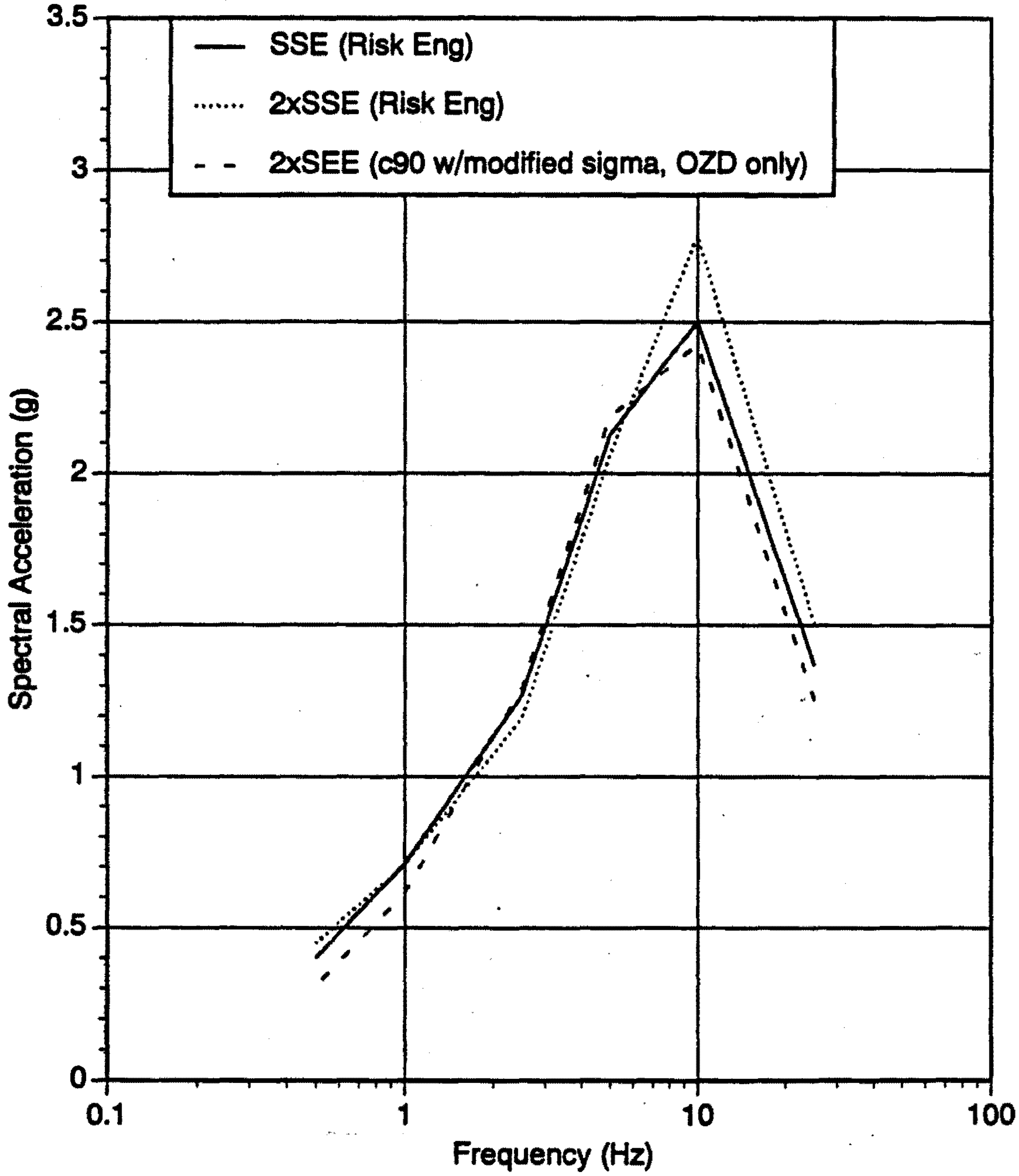


Exhibit 6
E-00-014

Figure 6-34. Comparison of vertical spectral shapes at the SSE and 2xSSE levels.

Comments on the Faulting and Seismic Hazard at San Onofre, San Diego County, California
Submitted by Mark R. Legg, PhD, California Reg. Geologist #6463, Reg. Geophysicist #948.
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1. It is now well established that the Rose Canyon and Newport-Inglewood fault zones are continuous, via the South Coast Offshore Zone of Deformation. Consequently, the combined fault system is capable of large earthquakes (M>7). [Fischer and Mills, 1991]

2. It is now recognized that major detachment fault systems in the region are reactivated as thrust faults, some blind (not reaching the surface). The major Oceanside detachment/thrust system underlies the San Onofre Nuclear Generating Station (SONGS). Consequently, large thrust or oblique-reverse earthquakes on this system may generate shaking levels in excess of the design level of SONGS units 2 and 3. [Bohannon and others, 1990; Legg and others, 1992; Nicholson and others, 1993; Crouch and Suppe, 1993; Bohannon and Geist, 1998; Mueller and others, 1998; Grant and others, 1999; Rivero and others, 2000]

   a. The SONGS site would not be 5-7 km from the epicentral zone, but instead directly above the potential fault rupture plane. Estimation of strong motion should use an epicentral distance of zero (0).

   b. Newer attenuation relations based upon recent large earthquake activity including the 1989 Loma Prieta, California; 1992 Landers, California; 1999 Chi-Chi, Taiwan; 1999 Izmit, Turkey; and 1995 Kobe, Japan, and moderate earthquakes including the 1994 Northridge, California; 1987 Whittier Narrows, California; 1983 Coalinga, California; and 1984 Morgan Hill, California are more accurate in estimating ground motions than the relationships used for the Safety Evaluation conducted in the late 1970s. [Abrahamson and Silva, 1997; Boore and others, 1997; Campbell, 1997; Sadigh and others, 1997]

   c. The recent earthquake experience has shown that near source effects are substantial, resulting in strong amplification of ground motions. The SONGS site lies directly above the detachment/thrust system, and therefore is subject to such effects. These effects include focusing of energy due to the rupture propagation and hanging wall effects wherein the seismic energy is trapped and amplified in the wedge of crust above the fault plane.

   d. As stated during my testimony during the NRC hearings in 1981, the reverse fault character of microearthquakes recorded along the Cristianitos fault trend in the mid-1970s and reactivation of minor faulting uncovered during site excavations is consistent with overall reactivation of ancient normal fault structures by a new stress regime involving northeast-directed shortening or transpression. This assertion has now been confirmed by recent geologic studies in the neighboring offshore region, and in fact, may have been deduced from the proprietary exploration industry data available to the Safety Evaluators in the late 1970s.

3. Geologic investigations along the coast in the Carlsbad and Camp Pendleton areas to the south of the SONGS site have identified numerous paleoseismic features indicative of prehistoric large earthquakes along the north San Diego County coastline. [Kuhn and others, 1996; Franklin and Kuhn, 2000; Kuhn and others, 2000]

   a. Abundant evidence of paleoliquefaction has been identified at numerous sites in the Carlsbad and Camp Pendleton area. This liquefaction involved Pleistocene terrace deposits, and in some cases, older Eocene siltstone bedrock. It is rare that such older and densified, but not lithified, materials liquefy. Consequently, the recognition of such liquefaction in Holocene time, as evident by involvement of Native American midden deposits, implies that the strong motion (shaking) was very severe. Reasons to expect such severe shaking were outlined above.

b. Some of the ground deformation features identified with the paleoliquefaction include sand blow deposits and craters, low-angle slip surfaces associated with lateral spreading, and numerous shallow sand filled fissures, sand injection dikes, and polygonal structures. Some of these features look remarkably similar to features uncovered during the excavation of the building pads for SONGS units 2 and 3; the nature of these features was unrecognized or unknown at the time of the Safety Evaluations.

4. Large active landslides along the coast immediately south of the SONGS site, at San Onofre State Beach, may have been considered ancient for the Safety Evaluation during the 1970s. The reactivation, and continued movement for more than two (2) years demonstrates that the coastal bluffs are highly unstable along the north San Diego County coastline. Although the surficial lithology and structure are somewhat different at San Onofre, being in the hanging wall of the Cristianitos fault, the relative straight or smoothly curving character of the shoreline and coastal bluff suggests that some active coastal erosion mechanisms, possibly landsliding or block falls, have acted in the past in the San Onofre area to keep pace with the active landslide headward erosion of the coast to the south. This process needs to be investigated to determine what threat exists to the San Onofre site, and whether seawall installed provide adequate protection for such processes. [Ehlig, 1977; Kuhn, 2000]

5. Locally generated tsunami, from large nearby offshore earthquake or submarine landslide, is now recognized as a serious threat to coastal southern California. With the recognition of major oblique components to offshore faulting, including blind thrusts, restraining bend uplifts and transtensional sags along strike-slip faults, major seafloor displacement during large (Mag>6.5) submarine earthquakes are likely to generate tsunami that attack the southern California coast with destructive force. Indeed, long term uplift of coastal marine terraces may attest to infrequent, but large tectonic displacements of the southern California coast. Furthermore, the steep slopes in unstable geologic materials on offshore ridges, banks, and basins, may generate large amplitude tsunami that can be locally destructive to the nearby coast, as occurred in Papua New Guinea. It is likely that large underwater landslides would be triggered by severe earthquakes, and the possibility of both tectonic displacement and landslide inducement of tsunamis exists. Maximum expected run-up maps for locally generated tsunami are currently being prepared for coastal San Diego County. The presence of steep coastal bluffs, like those near SONGS, also tend to amplify the wave so that narrow coastal valleys or lowlands may expect even higher wave run-up than broader low-lying coastal areas. [Field and Edwards, 1993; Lander and others, 1993; McCarthy and others, 1993; Kuhn and others, 1994, 1995; Legg, 1994; Watts and Raichlen, 1994; Bohannon and Gardner, 2001; Legg and Kamerling, 2001; Locat and others, 2001; Tappin and others, 2001]

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Oceanside and Thirtymile Bank blind thrusts: Implications for earthquake hazards in coastal southern California

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ABSTRACT

We define an active blind thrust system in offshore southern California that extends from Los Angeles south to the United States–Mexico international border. These blind thrusts formed by tectonic inversion of Miocene extensional detachments. We attribute the 1986 Oceanside (M_L 5.3) earthquake, local uplift of marine terraces, seafloor fold scarps, and observed geodetic convergence to motion on these faults. Single and multisegment fault rupture scenarios suggest the potential for large (M 7.1–7.6) but infrequent earthquakes that would affect the Los Angeles and San Diego metropolitan areas.

Keywords: blind thrusts, strike-slip faults, tectonic reactivation, earthquakes, Inner California Borderland, Oceanside.

INTRODUCTION

The importance of blind thrust faults as sources of destructive earthquakes in southern California was demonstrated by the 1994 Northridge (M 6.7) event, which caused more than $35 billion in damage to metropolitan Los Angeles (U.S. Geological Survey and Southern California Earthquake Center Scientists, 1994). Similar blind thrusts have been proposed to underlie much of the Los Angeles basin (Davis et al., 1989; Schneider et al., 1996; Shaw and Suppe, 1996; Shaw and Shearer, 1999). In this paper we show that active thrusting extends to the offshore California Borderlands, on the basis of analysis of more than 10 000 km of seismic reflection data. These thrusts reactivate Miocene extensional detachments (Crouch and Suppe, 1993), and may pose significant hazards to coastal California.

OCEANSIDE AND THIRTYMILE THRUSTS

Recent studies invoke low-angle normal faults in the Neogene formation of the Inner California Borderlands and rotation of the Transverse Ranges (Luyendyk and Hornafius, 1987; Crouch and Suppe, 1993; Nicholson et al., 1994; Bohannon and Geist, 1998; Ingersoll and Rumelhart, 1999). Through detailed mapping and structural modeling, we demonstrate that two of these faults, the Oceanside and Thirtymile Bank detachments, extend south from Laguna Beach and Catalina Island, respectively, to at least the United States–Mexico international border (Fig. 1). The extensional nature of these faults is reflected in the normal separation of basement (Figs. 1 and 2), and in the presence of extensional folds (rollovers) and Miocene growth structures (Crouch and Suppe, 1993; Bohannon and Geist, 1998).

Here we document that large portions of these detachments have been reactivated to form the Oceanside and Thirtymile Bank blind thrusts, which compose the Inner California Borderlands blind thrust system. Tectonic inversion of the Oceanside detachment is reflected by a submarine fold-and-thrust belt located offshore between Dana Point and Oceanside (Fisher and Mills, 1991) (Fig. 2A). In contrast to the extensional features, these contractional structures deform Pliocene and younger strata, and are commonly associated with pronounced seafloor fold scarps. These structures do not cut or fold the detachment. Thus, we interpret that they sole into the Oceanside thrust.

The Oceanside thrust is mapped over an area of more than 1800 km^2. In migrated seismic reflection profiles, the thrust is imaged as a coherent set of strong reflections that dip to the northeast between 14° and 25° (Fig. 2). The thrust extends south along the Coronado Banks to the international border near San Diego Bay (Fig. 1). At Coronado Banks, thrusting is reflected by tectonic inversion of the Coronado Bank detachment (Fig. 2B and 2C) (Nicholson et al., 1993; Sorlien et al., 1993).

The Thirtymile Bank thrust is west of the Oceanside fault, and also originated as an extensional detachment (Legg et al., 1992). The fault defines an almost linear, continuous scarp extending from southwest of Catalina Island to Thirtymile Bank (Fig. 1). The hanging wall of the thrust contains Neogene synrift strata that are gently folded in a manner consistent with thrust inversion of the underlying fault.

Growth strata in contractional folds above the Oceanside and Thirtymile Bank thrusts suggest that thrusting began in the Pliocene. The shallow, east-vergent fold-and-thrust belt above the Oceanside thrust between Dana Point and Oceanside is the most direct evidence for this tectonic inversion. Folds in this belt generate pronounced seafloor scarps that persist for ~30 km. Although these scarps may reflect recent activity of the underlying Oceanside thrust (Fig. 2), they are not definitive; we lack precise age control on seafloor sediments. However, young contractional folds also occur along the coast and involve dated marine terraces. These structures record recent fault activity that may be attributed to the Oceanside thrust.

The San Joaquin Hills are at the southern margin of the Los Angeles basin, where the mapped part of the Oceanside thrust extends onshore. The hills are formed by a northeast-vergent anticline that uplifts and deforms marine terraces. Grant

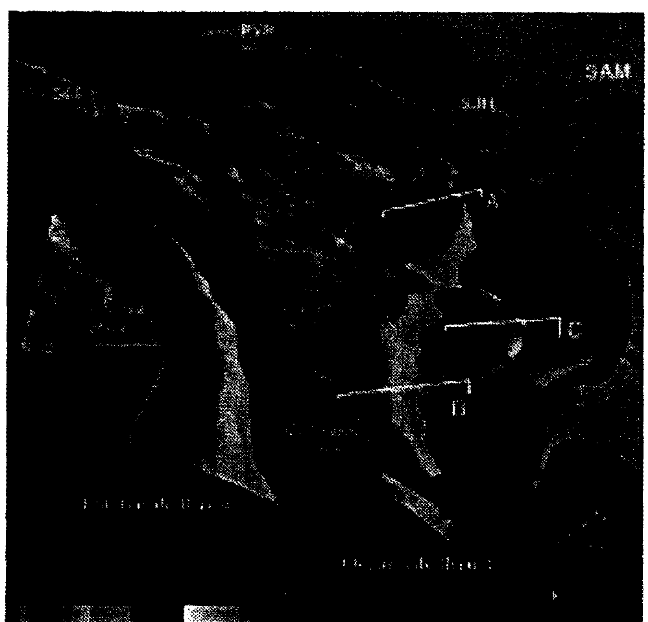

Figure 1. Perspective view of three-dimensional model of Oceanside and Thirtymile Bank blind thrusts. Gray surface is top of basement (Catalina Schist). Small triangles indicate areas of recent uplift (Lajoie et al., 1979, 1992; Barrie and Gath, 1992; Kern and Rockwell, 1992; Grant et al., 1999; Kier and Mueller, 1999). Digital shaded relief map of southern California topography was derived from digital elevation data provided by U.S. Geological Survey. SAM—Santa Ana Mountains; SJH—San Joaquin Hills; PVP—Palos Verdes Peninsula; SCI—Santa Catalina Island.

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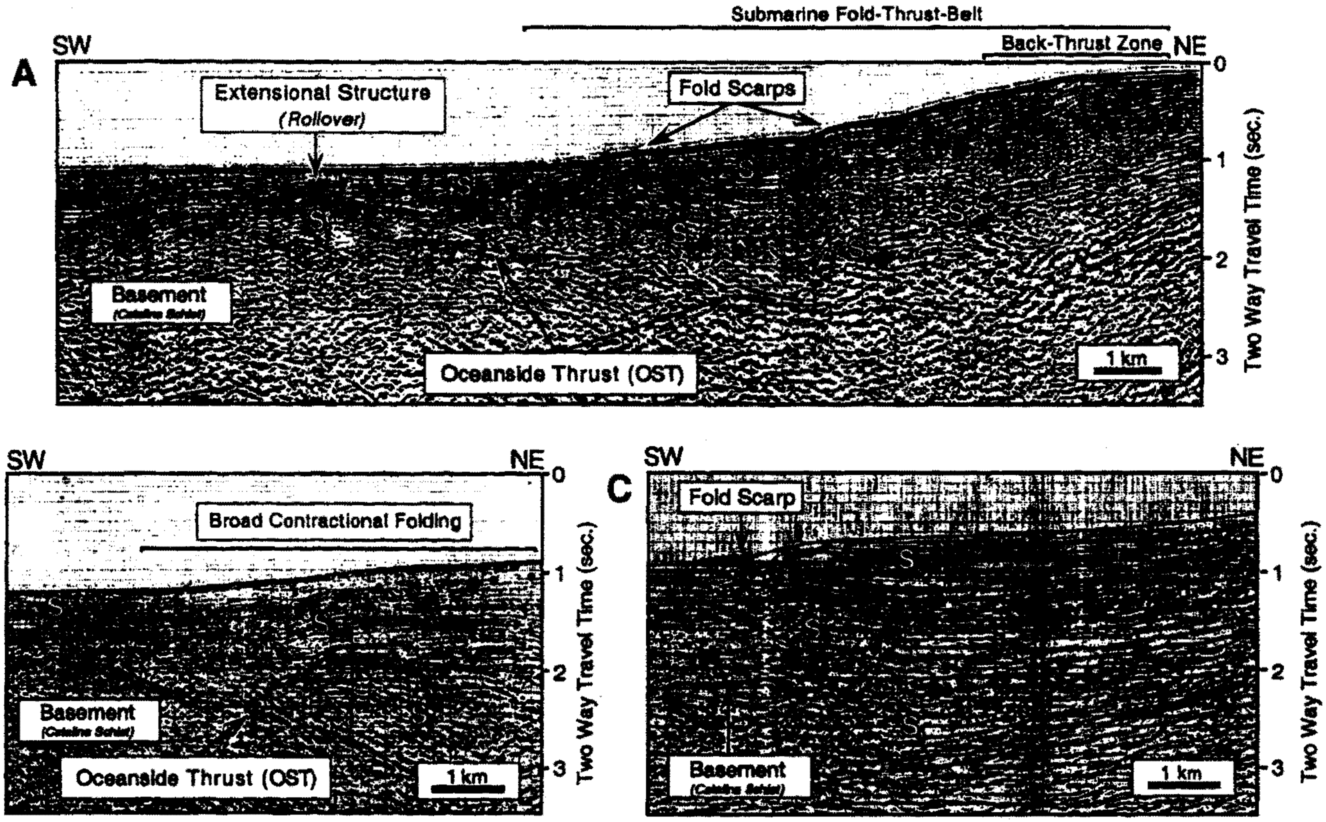

Figure 2. Geometry of Oceanside thrust as imaged in seismic reflection profiles. A: Migrated seismic reflection profile imaging segment of thrust south of Lasuen Knoll. Sharp and continuous reflections dipping to east define location of thrust. Note shallow fold-and-thrust belt above Oceanside thrust that produces seafloor fold scarps. This contractional deformation does not affect thrust; thus, we interpret Oceanside as basal thrust of sequence. Note older (Neogene) extensional rollover structure buried by Pliocene and younger strata preserved on west end of section. B: Migrated seismic image of Oceanside thrust northeast of Coronado Banks. Oceanside thrust motion is reflected by broad, contractional fold involving shallow sedimentary units and forming broad seafloor slope. C: Migrated seismic reflection profile across Carlsbad thrust, which resides in hanging wall of Oceanside thrust east of Crespi Knoll. Fault is defined by offset of top basement reflection, and produces contractional fold with pronounced seafloor scarp. Unit S_1 is Miocene and Oligocene(?) synextensional strata; S_2 is late Miocene–early Pliocene postextensional drape; S_3 is late Pliocene(?)–Holocene syncontractional strata. S_1 and S_2 are grouped where undifferentiated. Vertical scale is ~1:1; datum is sea level; s—seconds. Section traces are shown in Figure 1.

et al. (1999) proposed that the fold is developed above an active, southwest-dipping blind thrust that slips at a rate of ~0.42–0.79 mm/yr, based on uplift rates of 0.21–0.27 mm/yr. Our seismic data image the offshore extension of this structure (Fig. 3), and confirm that it formed above a shallow blind thrust with an average southwest dip value of 23°. However, this shallow fault is restricted to the hanging wall of the Oceanside thrust; at depth, we interpret that this shallow fault soles into the thrust, forming a structural wedge (Medwedeff, 1992; Mueller et al., 1998). We combined the observed dip values for the backthrust system (23°) and the Oceanside thrust (14°–25°) with the uplift rate at the San Joaquin Hills into a structural wedge model and calculated a slip rate on the thrust of 0.27–0.41 mm/yr. This slip rate yields an uplift rate above the Oceanside thrust, in the absence of the backthrust, of 0.07–0.17 mm/yr. This result is compatible with the observed 0.13–0.17 mm/yr uplift rate of marine terraces south of the San Joaquin Hills, which extend to San Diego and into northern Mexico (Lajoie et al., 1979, 1992; Barrie and Gath, 1992; Kern and Rockwell, 1992) (Fig. 1). If the Oceanside blind thrust is responsible for all or part of this coastal uplift, it implies that the thrust is active far to the south of the San Joaquin Hills.

We consider the calculated slip rates for the Oceanside thrust to be minimum values because they are derived from uplift rates, which may be affected by isostatic compensation and/or flexural subsidence that may occur due to crustal thickening (Shaw et al., 1994). To govern maximum slip rates, we use geodetic observations that indicate as much as 2 mm/yr of northeast-southwest (N43°E) convergence between Catalina Island and the coast (Kier and Mueller, 1999). Given that shortening produced by the Oceanside thrust should not exceed this value, we calculate a maximum slip rate for the thrust of 2.2 mm/yr. Similarly, the slip rate of the Thirtymile Bank thrust should be no more than 0.96 mm/yr, such that the resultant shortening does not exceed the geodetic convergence rate of 0.86 mm/yr calculated between Catalina Island and San Clemente Island

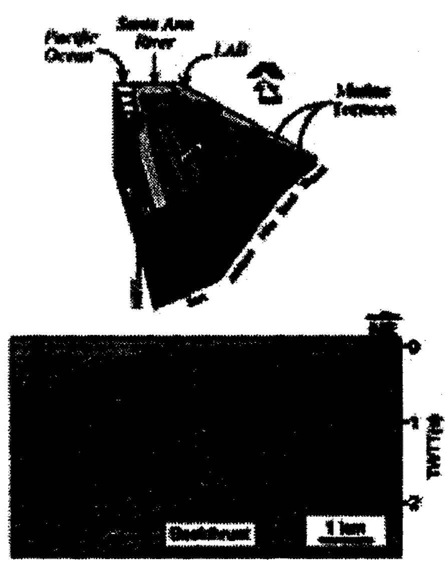

Figure 3. Top: Kinematic model of blind thrust faulting and terrace uplift beneath San Joaquin Hills (Grant et al., 1999). LAB—Los Angeles basin; NIFZ—Newport-Inglewood fault zone. Bottom: Migrated seismic reflection profile imaging offshore extension of this fold system, which has developed above west-dipping backthrust. TWTT—two-way traveltime; s—seconds.

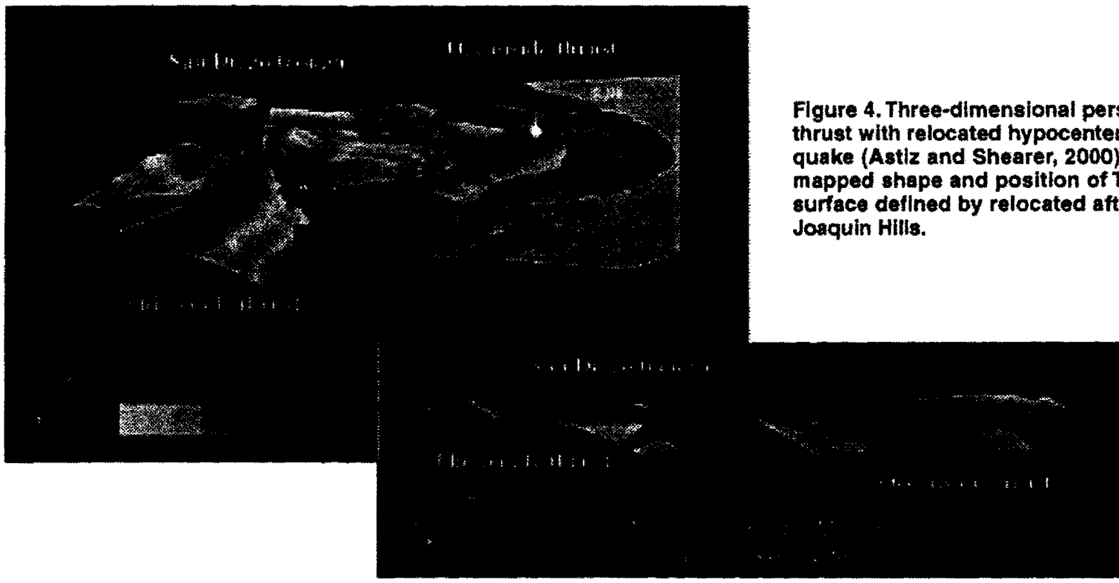

Figure 4. Three-dimensional perspective of Thirtymile Bank thrust with relocated hypocenters of 1986 Oceanside earthquake (Astiz and Shearer, 2000). Note correlation between mapped shape and position of Thirtymile Bank thrust with surface defined by relocated aftershock cluster. SJH—San Joaquin Hills.

(Kier and Mueller, 1999), which is west of the Thirtymile Bank thrust.

To further define activity on the Inner Borderlands thrust system, and to determine if these faults are seismogenic, we sought to establish the origin of the 1986 Oceanside (M_L 5.3) earthquake. The mainshock had a dominant component of thrust movement, whereas many of the aftershocks were strike slip (Hauksson and Jones, 1988). Astiz and Shearer (2000) relocated the mainshock and aftershocks of the Oceanside earthquake by using the L_1-norm waveform cross-correlation method and quarry blast information from Catalina Island. The relocated earthquake sequence is clustered at ~8 km depth, and defines a 25°–30° east-dipping surface (Fig. 4). The orientation and position of the fault plane are consistent with the downdip projection of the Thirtymile Bank thrust. Thus, we suggest that the earthquake ruptured a small part of the thrust, revealing the activity and seismogenic potential of thrust faults in the Inner California Borderlands.

SEISMIC HAZARDS

We assess the seismic hazard posed by these blind thrusts using fault areas to predict earthquake magnitudes and recurrence intervals based on empirical relations among rupture area, slip rate, and moment magnitude (Wells and Coppersmith, 1994). Lacking direct evidence of fault segmentation, we consider complete ruptures of the faults and thus maximum earthquake magnitudes, although ruptures may occur in smaller and more frequent events.

We defined the seismogenic fault area as the interval between 5 km depth and the base of the seismogenic crust at 20 km depth. If the Oceanside thrust ruptures only along the extent of the San Joaquin Hills (1390 km^2), this would produce an earthquake of M_w 7.1. This magnitude is similar to that proposed for a south-dipping blind thrust (Grant et al., 1999), but invokes an opposed northeast-dipping seismic source. We contend, however, that the Oceanside and Thirtymile Bank thrusts are active over a region much larger than the extent of the San Joaquin Hills, on the basis of the Oceanside earthquake, coastal uplift, seafloor scarps, and observed geodetic shortening. To define these larger potential rupture areas, we must first address the interaction of these thrusts with active strike-slip faults in the region (Fig. 5). The Newport–Inglewood–Rose Canyon fault system is above or adjacent to the Oceanside thrust. Similarly, the San Diego trough strike-slip fault is above the Thirtymile Bank thrust.

We propose four possible interactions between these two classes of faults, each solution invoking a different fault geometry at depth that influences hazard estimates. One solution would have younger strike-slip faults cutting and precluding further activity on older thrusts (Fig. 5A). We contend that this solution is incompatible with the seismologic, geodetic, and geologic evidence supporting present activity on the thrust system. A second solution would have the thrusts terminate in the strike-slip faults (Fig. 5B). This scenario would dictate that the strike-slip faults cut down through the entire seismogenic crust, as is considered in most current hazard assessments. This solution is plausible for the Oceanside thrust. In this scenario, only the area of the Oceanside thrust west of this Newport–Inglewood–Rose Canyon strike-slip fault system should be considered as a possible earthquake source. In contrast, the location of the Oceanside earthquake indicates that the Thirtymile Bank thrust extends east of the San Diego trough fault (Fig. 4), precluding the type of fault linkage shown in Figure 5B.

Alternatively, the thrusts may cut the strike-slip fault zones (Fig. 5C). This solution would permit coeval activity on both types of faults and would yield two independent sources for each of the paired thrust and strike-slip systems. In the final scenario, the thrust and strike-slip faults may merge into a single structure at depth (Fig. 5D). In this case, oblique slip on a deep fault would partition into pure thrust and strike-slip motion on the shallow faults. This linkage would imply that the combined areas of the strike-slip and thrust faults should be considered to determine maximum potential rupture areas.

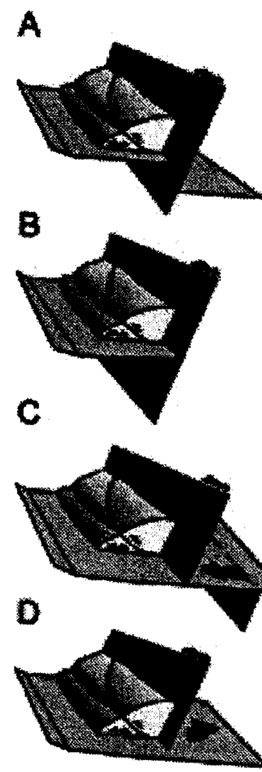

Figure 5. Potential configurations for thrust and strike-slip fault interaction (see text for discussion).

If the Oceanside thrust terminates in the Newport–Inglewood–Rose Canyon fault zone, as dictated in solution two, the thrust would have an area of 1890 km^2. A rupture of this entire fault would generate an earthquake of M_w 7.3. In contrast, if the Oceanside thrust extends through the Newport–Inglewood–Rose Canyon system, then it would have an area of 3180 km^2, which could produce an event of M_w 7.5. An estimated seismogenic area of 2516 km^2 for the Thirtymile Bank thrust would generate similar (M_w 7.4) earthquakes. If the Oceanside thrust and Newport–Inglewood–Rose Canyon system are linked, as described in the last solution (Fig. 5D), then the combined fault area (4393 km^2) could produce M_w 7.6 earthquakes. This fault linkage scenario would not affect the magnitude estimate for the Thirtymile Bank thrust, because the San Diego trough fault is confined to sediments in the upper 2 km of the crust.

To estimate average recurrence intervals for these earthquake scenarios, we use minimum slip rates derived from terrace uplift (0.27 mm/yr for the Oceanside thrust), and maximum slip rates governed by the observed geodetic shortening (2.2 mm/yr for the Oceanside thrust; 0.96 mm/yr for Thirtymile Bank thrust). On the basis of these rates, M_w 7.1 events on the Oceanside thrust limited to the extent of the San Joaquin Hills would occur every 600–4600 yr. M_w 7.3 and 7.5 earthquakes on the greater Oceanside thrust would occur every 790–6400 and 1100–8800 yr, respectively. M_w 7.4 events on the Thirtymile Bank thrust would have minimum repeat times of 2100 yr. For the M_w 7.6 rupture scenario linking the Oceanside thrust and Newport–Inglewood–Rose Canyon faults, we must consider the oblique-slip rate that is resolved on the thrust and strike-slip faults. Onshore studies at San Diego Bay provide a slip rate of 1.07 ± 0.03 mm/yr for the Newport–Inglewood–Rose Canyon system (Rockwell et al., 1992). This strike slip combined with the range of dip-slip rates on the Oceanside thrust (0.27–2.2 mm/yr) yields an oblique slip range of 1.19–2.91 mm/yr. On the basis of these ranges of oblique slip rates, M_w 7.6 earthquakes would occur on average every 960–2300 yr. These rupture scenarios predict very large, but infrequent, earthquakes similar to those documented on other thrust faults in southern California (Rubin et al., 1998). Alternatively, stress on the Oceanside and Thirtymile Bank blind thrusts could be released in smaller but more frequent events.

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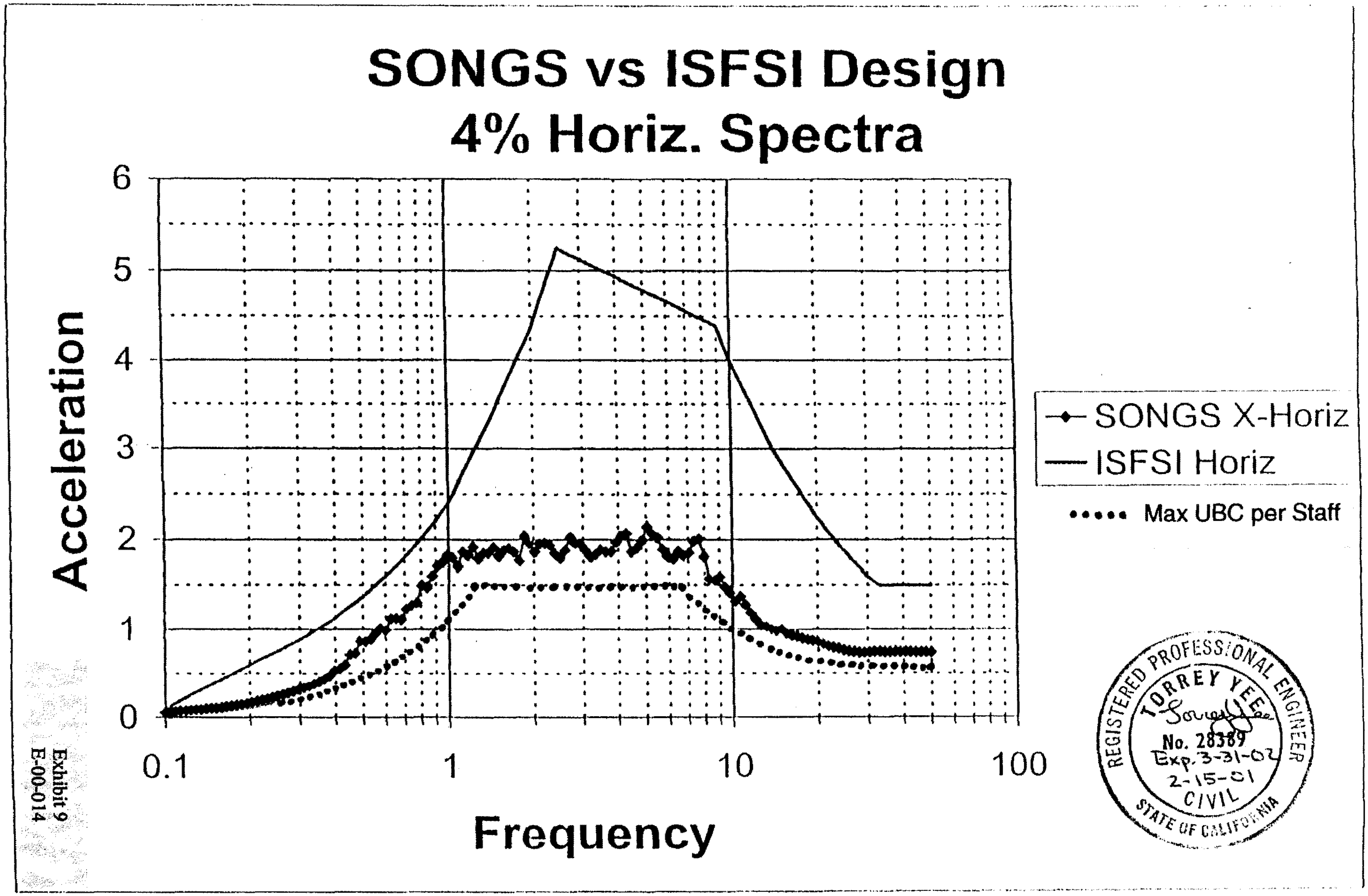
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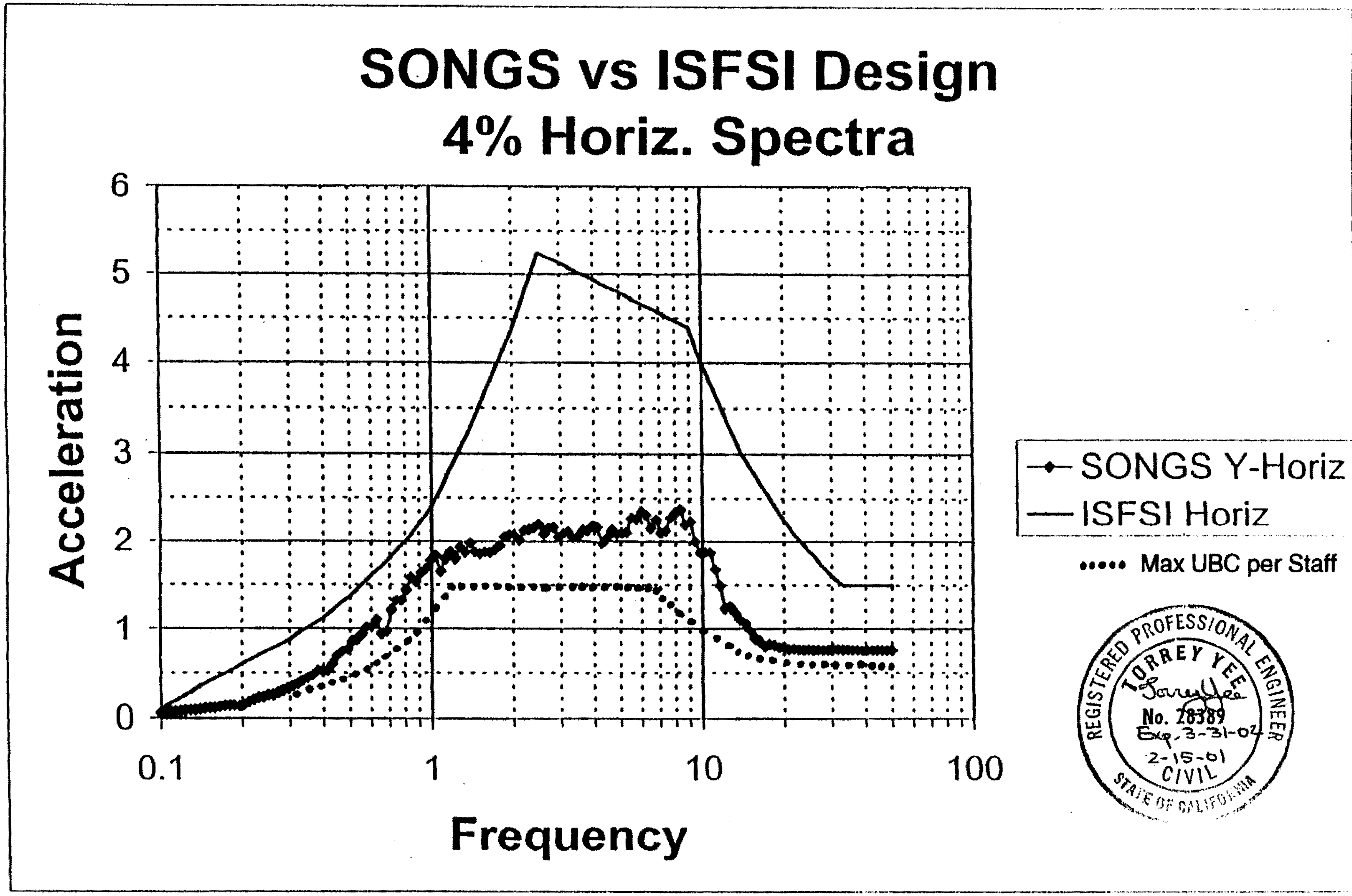
Figure 1


SONGS vs ISFSI Design
4% Horiz. Spectra
Acceleration
6
5
4
3
2
1
0
0.1
1
10
100
Frequency
SONGS Y-Horiz
ISFSI Horiz
Max UBC per Staff
REGISTERED PROFESSIONAL ENGINEER
TORREY YEE
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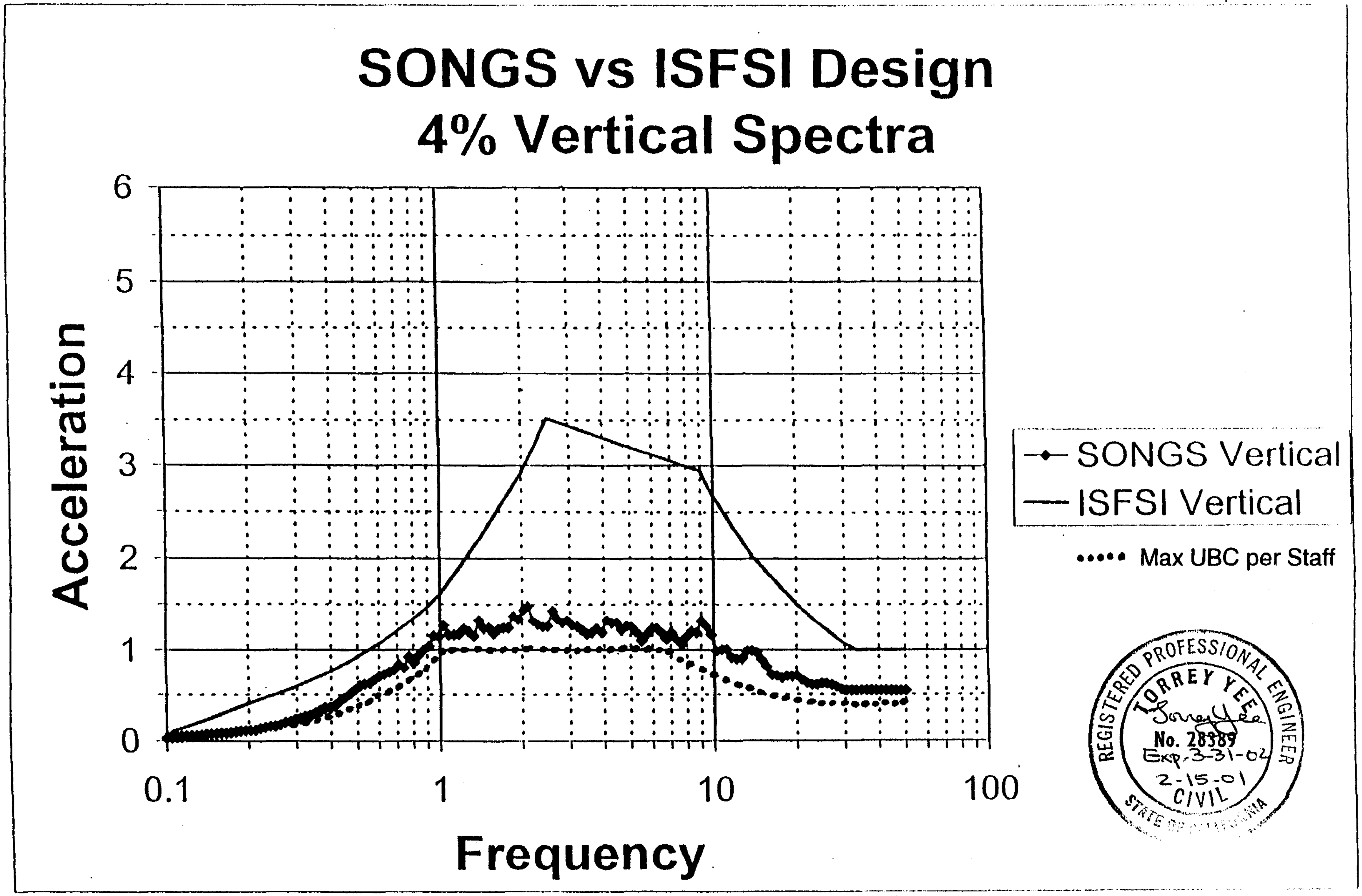
Exp. 3-31-02
2-15-01
CIVIL
STATE OF CALIFORNIA

Figure 2



SONGS vs ISFSI Design
4% Vertical Spectra
Acceleration
0
1
2
3
4
5
6
0.1
1
10
100
Frequency
SONGS Vertical
ISFSI Vertical
Max UBC per Staff
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No. 28389
Exp. 3-31-02
2-15-01
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Figure 3

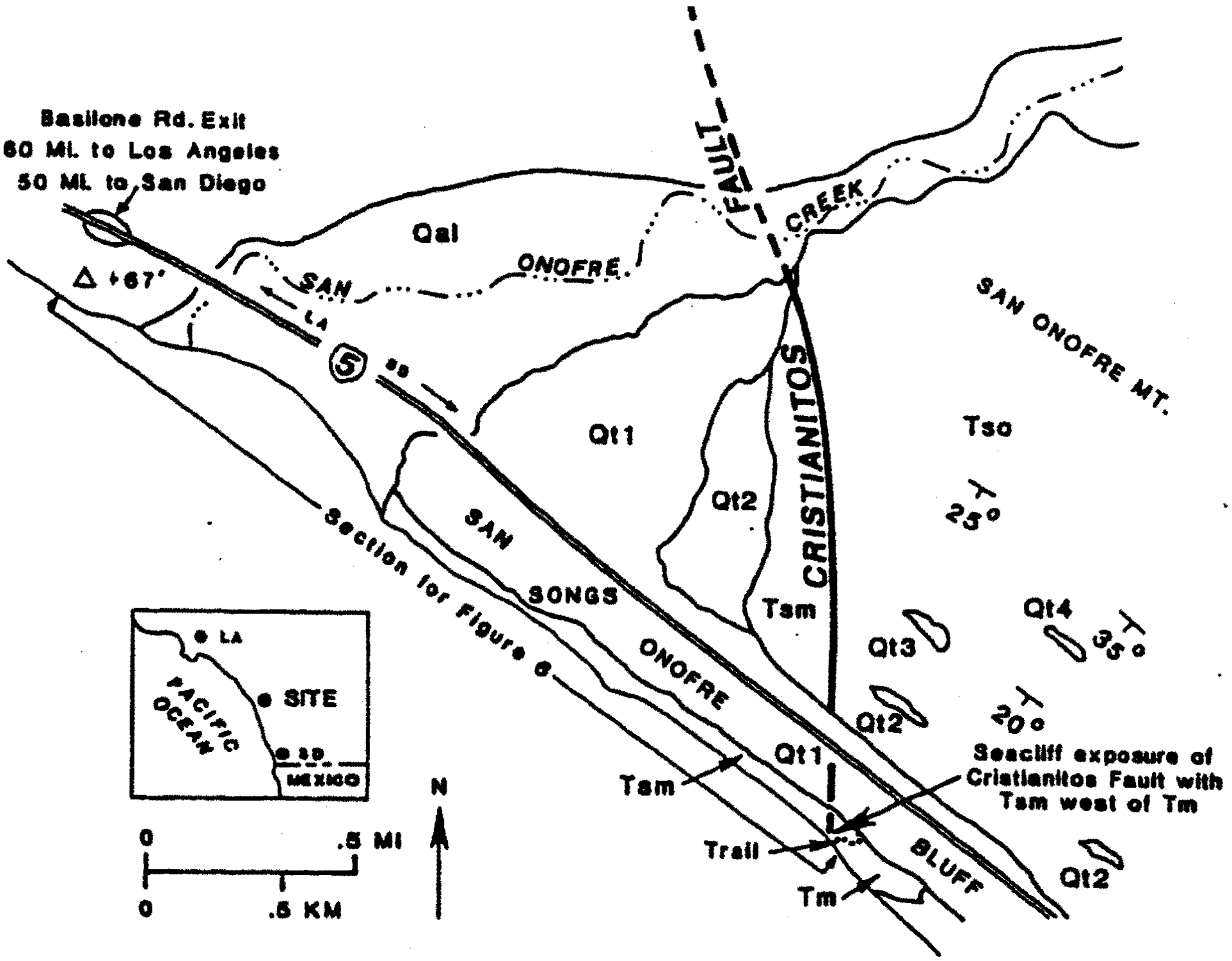

Figure 1. Generalized location and geologic map of the San Onofre State Beach and adjacent area. Geographic symbols: LA = Los Angeles; SD = San Diego; SONGS = San Onofre Nuclear Generating Stations. Geologic symbols: Qal = alluvium; Qt1 (younger), Qt2, etc. = marine terraces and fluvial terraces of San Onofre Creek; Tm = Tertiary Monterey Formation; Tsm = Tertiary San Mateo Formation; Tso = Tertiary San Onofre Breccia; + 67′ = Medio triangulation station (modified from Moyle, 1973; Hunt and Hawkins, 1975).

Exhibit 10
E-00-014

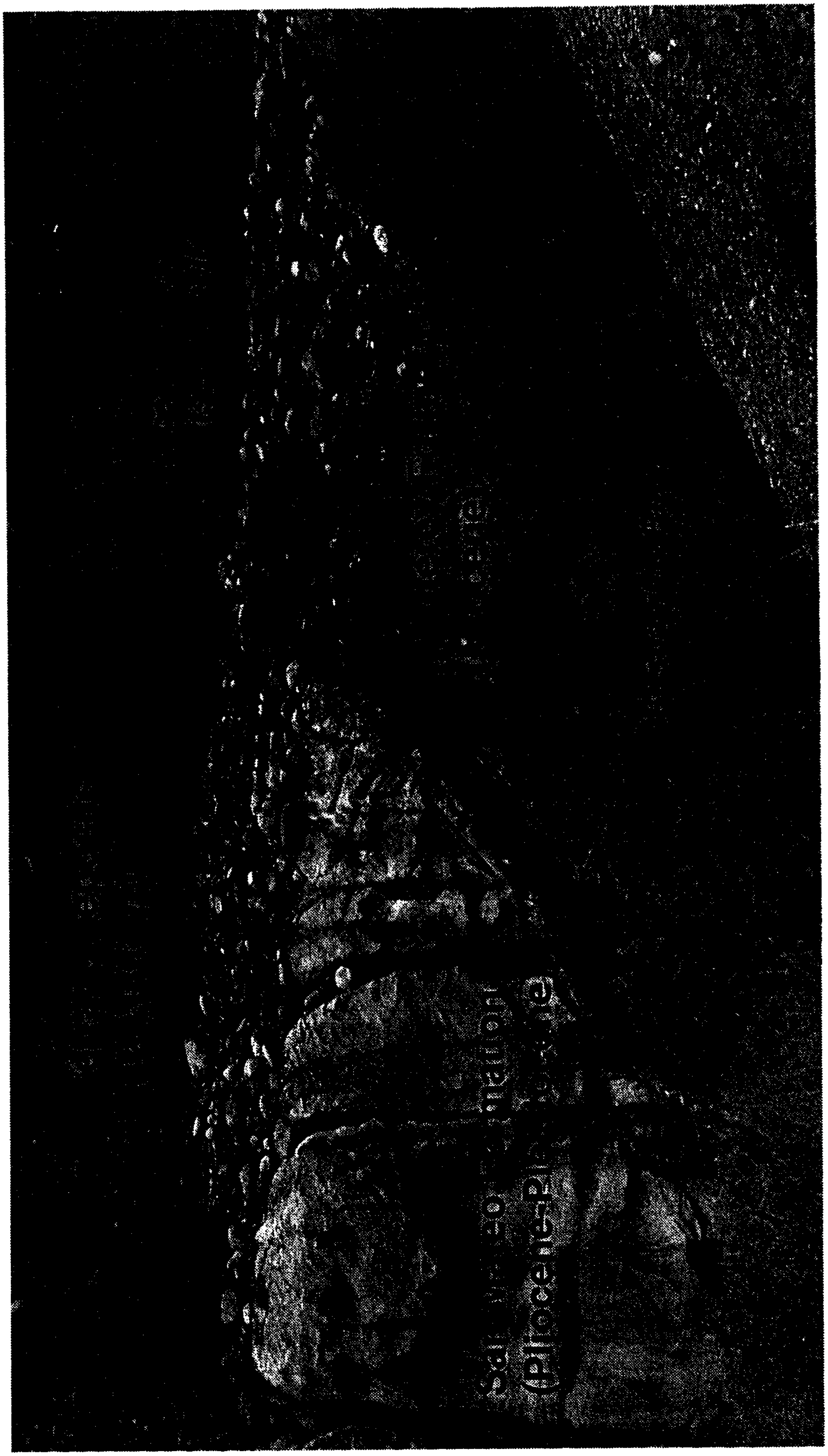

Exhibit 11
E-00-014

June 26, 2000

USGS:

Dear Gentlemen:

URGENT MESSAGE REGARDING PUBLIC SAFETY FRO GEOLOGIC HAZARD

Recent visit to camp San Onefre indicated that the San Christianitos Fault has moved and ruptures the ground. The fault runs in juxtaposition to San Onefre nuclear power plant and its movement endangers the plant structural integrity and possibly results in a nuclear disaster in the Southland of California, San Diego County.

The public has the right to know and the government has the obligations to initiate immediate technical investigation to determine the size and nature of the fault's displacement for risk assessment. This is a serious situation that requires immediate response.

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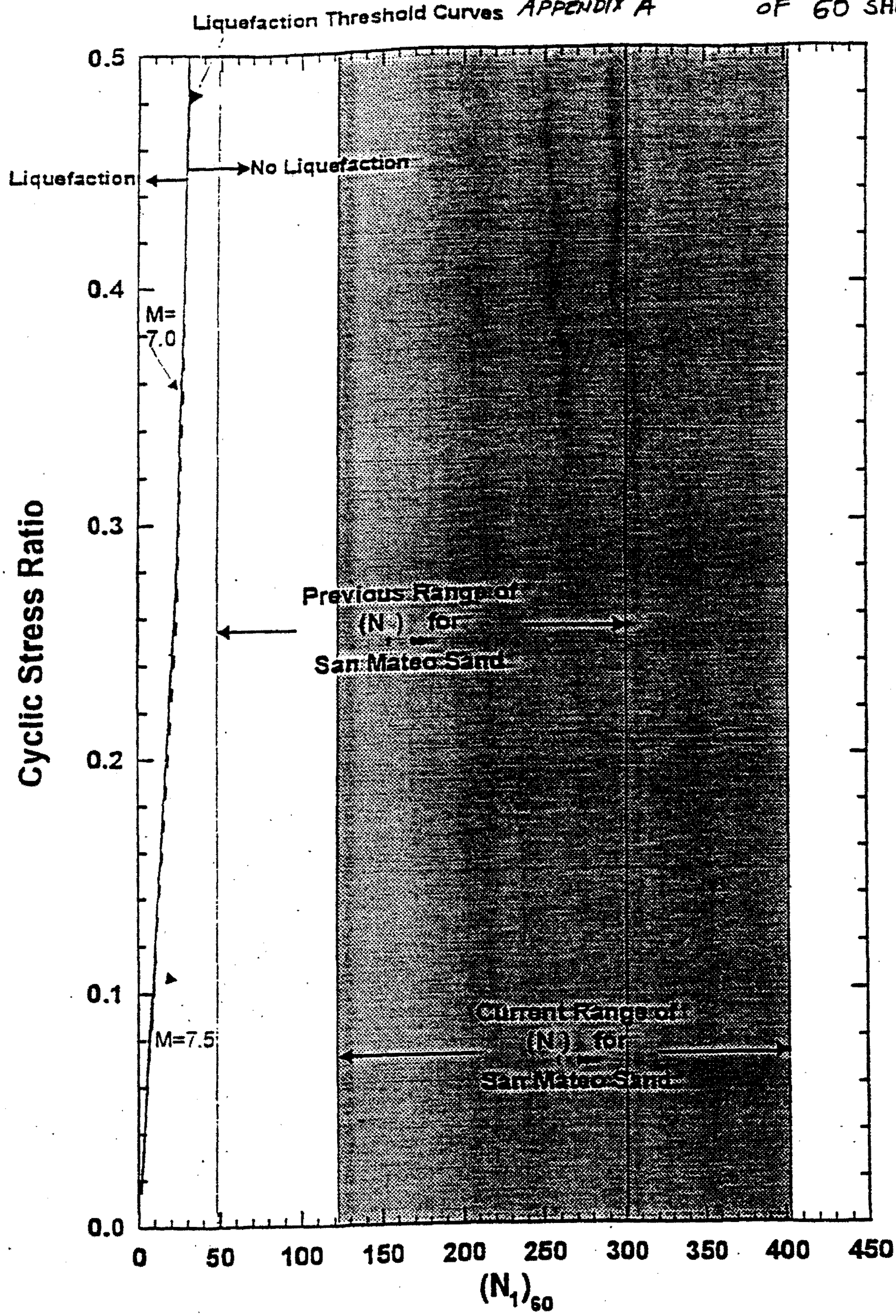
Exhibit 12
E-00-014



Comparison of Cyclic Resistance vs. Liquefaction Threshold for San Mateo Sand			
Project No. 954E181	Date: SEPT 1995	Project: SONGS CASK STORAGE	Fig. 5.3

Woodward-Clyde Consultants

Exhibit 13
E-00-014

CALCULATION SHEET

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Project or DCP/MMP ____________ Calc No. ____________

Subject CALCULATION OF ULTIMATE BEARING CAPACITY Sheet No. ______

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
	T. Yee	2/15/01							

REV. INDICATOR

ULTIMATE STATIC BEARING CAPACITY

$$q_u = cN_c\zeta_c + qN_q\zeta_q + \tfrac{1}{2}\gamma BN_\gamma\zeta_\gamma$$

where:

q_u = ultimate bearing capacity

c = cohesion = 800 lb/ft^2 *

γ = unit weight = 130 lb/ft^3 *

q = overburden (conservatively ignore)

N_c, N_q, N_γ = bearing capacity factors = 95.7, 81.3, 100.4 **

B = foundation width = 67' (minimum SONGS building width)

ζ_c, ζ_q, ζ_γ = shape factors = 1.3, 1, .8 for square footing

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* San Mateo sand properties
$\phi = 41°$

** Factors from J. Bowles, "Foundation Analysis and Design," Third Edition, 1982. (Table 4-2) Values are for $\phi = 40°$.

Ignore overburden

$$q_u = .800(95.7)1.3 + 0 + \tfrac{1}{2}(.130)67(100.4)(.8)$$
$$= 449 \text{ ksf}$$

Exhibit 14
E-00-014

SCE 26-426 NEW 4/90

Q.1 Although data were provided that address soil properties according to a "Seismic System Analysis" in the document entitled "Foundation and Soil Properties, Independent Spent Fuel Storage Installation, San Onofre Nuclear Generating Station Unit 1," no data were provided that demonstrate the stability of the pad foundation for general or localized shear failure under static conditions. Such data would be useful.

A.1 SCE constructed SONGS Units 1, 2, and 3 in accordance with the seismic standards established by the U.S. Nuclear Regulatory Commission (NRC). The NRC performed a comprehensive evaluation of the soil properties and stability of the site foundation prior to issuing the operating licenses for these units, in part, for the purposes of assuring stability and structural integrity, and assuring that the units do not create or contribute to erosion, geologic instability, or destruction of the site or surrounding area. The results of the NRC's evaluation is NUREG-0712, NUREG-0712 Safety Evaluation Report related to the operation of San Onofre Nuclear Generating Station Units 2 and 3, dated February 1981, which was provided in pertinent part in Enclosure 2 of SCE's December 21, 2000 letter to Mr. Dan Chia.

The uniform static bearing load of the storage modules and pad on the soil will be about 1.75 ksf. The ultimate bearing capacity of San Mateo sand was computed for the most heavily loaded structures at SONGS and is greater than 400 ksf. The ultimate bearing capacity was determined using the soil properties and building parameters given in UFSAR Section 2.5.4.10.3, page 2.5-215 (which was provided in Enclosure 3 of the December 21, 200 letter and is included in Document 1 of this transmittal).

SCE will construct the temporary spent fuel storage facility on a portion of the site licensed by the NRC for the construction of the nuclear units. SCE will design and construct this facility to meet the NRC seismic standards for such facilities. These standards are included in 10 C.F.R. 72, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High Level Radioactive Waste", Regulatory Guide 1.60, "Design Response Spectra for Seismic Design of Nuclear Power Plants", and NUREG 1536, "Standard Review Plan for Dry Cask Storage Systems". These federal design standards ensure the protection of public health and safety relative to the nuclear fuel and fully bound standards used in industrial construction, including PRC Section 30253.

INFORMATION ONLY

CALCULATION TITLE PAGE

ICCN NO./ PRELIM. CCN NO. N\A	PAGE OF

Calc No. C-296- 01.04 DCP/FIDCN/ FCN No. & Rev. ______

CCN CONVERSION:
CCN NO. CCN-

Subject : ISFSI Foundation Design — Sheet 1 of 10

System Number/Primary Station System Designators 2126 / XA1 — SONGS Unit 1 — Q-Class II

Tech. Spec./LCS Affecting? ● NO ○ YES Section No. ______ Equipment Tag No. ______

Site Programs/Procedure Impact? ● NO ○ YES, AR No. ______

CONTROLLED COMPUTER PROGRAM/ DATABASE	☐ PROGRAM ☐ DATABASE N/A According to SO123-XXIV-5.1	PROGRAM/ DATABASE NAME(S) ☐ ALSO, LISTED BELOW	VERSION/ RELEASE NO. (S)

RECORD OF ISSUES

REV. DISC	DESCRIPTION	TOTAL SHTS. LAST SHT	PREPARED (Print name/sign/date)	APPROVED (Signature/date)	
A	Original Issue for Information	10	ORIG. Peter Riehm	FLS Torrey Yee 11-17-00	OTHER
CIVIL		10	IRE John Stoessel 9/22/00	OTHER	OTHER
			ORIG.	FLS	OTHER
			IRE	OTHER	OTHER
			ORIG.	FLS	OTHER
			IRE	OTHER	OTHER
			ORIG.	FLS	OTHER
			IRE	OTHER	OTHER

Space for RPE Stamp, identify use of an alternate calc., and notes as applicable.

REGISTERED PROFESSIONAL ENGINEER
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Torrey Yee
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Exp. 3-31-02
11-17-00
CIVIL
STATE OF CALIFORNIA

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This calc. was prepared for the identified DCP/FCN. DCP/FCN completion and turnover acceptance to be verified by receipt of a memorandum directing DCN Conversion. Upon receipt, this calc. represents the as-built condition. Memo date. ______ by ______.

CALCULATION CROSS-INDEX

ICCN NO./ PRELIM. CCN NO.	PAGE ____ OF ____
	CCN CONVERSION: CCN NO. CCN-

Calculation No. C-296 - 01.04 Sheet No. 2 of ____

Calc. rev. number and responsible FLS initials and date	INPUTS These interfacing calculations and/or documents provide input to the subject calculation and if revised may require revision of the subject calculation.		OUTPUTS Results and conclusions of the subject calculation are used in these interfacing calculations and/or documents.		Does the output interface calc/ document require change?	Identify output interface calc/document CCN, DCN, TCN/Rev., FIDCN, or tracking number.
	Calc / Document No.	Rev. No.	Calc / Document No.	Rev. No.	YES / NO	
0	S01-207-1-C11 C-296-1.01 C-296-01.02 S01-207-1-M135	4 0 0 0	None		N/A	
	INFORMATION ONLY					

SCE 26-424 REV. 3 8/99 [REFERENCE: SO123-XXIV-7.15]

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(UNTITLED) DevID: -1.0000 Printed: 09/22/00

EC&FS DEPARTMENT

CALCULATION SHEET

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Subject 1SB1 FOUNDATION DESIGN Sheet 3 of ____

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	P. BARAN		JCI	9/22/00					

REV INDICATOR

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2.	Results / Conclusions	4
3.	Assumptions	4
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5.	Methodology	4
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INFORMATION ONLY

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	P. BARAN		JC/	9/22/00					

REV INDICATOR

1. Introduction / Purpose

The purpose of this calculation is to design the reinforced concrete pad for the storage modules of Independent Spent Fuel Storage Installation (ISFSI). There are multiple storage modules placed on the concrete pad and they are connected together to form a single structure.

2. Results / Conclusions

Design loads are based on seismic accelerations of 1.5g horizontal and 1.0g vertical.

ISFSI concrete pad : 3'-0 thick
Moment (Capacity) = 268 foot kips > Moment (Design Load) = 260 ft kips
Allowable Soil Bearing = 23.5 ksf >Soil Bearing (Design) = 10.11 ksf

3. Assumptions - Stated in calculation.

4. Design Inputs

Module weight = 400 + 70 = 470 kips with back wall (SO1-207-1-C11, Rev. 4, Table H1 and page H9). Used 471 kips in this calculation which is conservative.

Concrete compressive strength = 4000 psi; Fy = 60 ksi for A615, Grade 60

Seismic load: DBE 1.5g horizontal and 1.0g vertical (Reference TN West design spectra included in C-296-1.01, Rev. 0). SONGS requirements are actually based on a 0.67g seismic event. The higher seismic accelerations were used to be consistent with the TN West design and are not a design basis for SONGS.

5. Methodology

The multiple storage modules are placed in a single row without any separation between them. The modules are not connected to the concrete pad. The ISFSI Pad Other Events Hazard Evaluation, Ref. 6.7, demonstrates that the seismic event bounds the other events applicable to the SONGS site. The configuration of the module array will tend to reduce the bending of the concrete pad in the area under the modules.

INFORMATION ONLY

5. Methodology (cont.)

Soil pressure is calculated by using a two-component horizontal seismic load of 1.5g and a vertical component of 1.0 g, and combining them by SRSS method. The reinforcing design is based on the moment calculated for a 10 feet cantilever one-way slab, loaded with the resultant of maximum soil pressure. Reinforced concrete design is in accordance with ACI 349.

The structural design and stability of the storage module are given in Ref. 6.4.

6. References

6.1 SO1-207-1-C11, Rev. 4, DSC/AHSM/0S197 Cask Component Weights, Mass Properties, and Lift Weight Calculation and Evaluation by TN West

6.2 SCE Calculation C-296-1.01, Rev. 0, Seismic Response of ISFSI Pad

6.3 ACI Manual Of Concrete Practice-Code Requirements for Nuclear Safety Related Concrete Structures (ACI-349)

6.4 SO1-207-1-M135, Rev. 0, Safety Analysis Report for the Standardized Advanced NUHOMS Horizontal Modular Storage System for Irradiated Nuclear Fuel, by TN West

6.5 SONGS 2&3 Preliminary Safety Analysis Report, Appendix 2B, Seismic and Foundation Studies for Proposed Units 2 and 3, San Onofre Nuclear Generating Station - Dames and Moore

6.6 Designing Floor Slabs on Grade Design Manual

6.7 SCE Calculation C-296-01.02, Rev. 0, ISFSI Pad Other Events Hazard Evaluation

7. Nomenclature

ISFSI - Independent Spent Fuel Storage Installation
AHSM - Advanced Horizontal Storage Module
TNW - TransNuclear West
SRSS- Square Root of the Summation of Squares
g - Acceleration of Gravity
q - Soil pressure

EC&FS DEPARTMENT

CALCULATION SHEET

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Subject ISFSI FOUNDATION DESIGN Sheet 6 of ____

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
	P.B. [illegible]	9/22/00	JCS	9/21/00					

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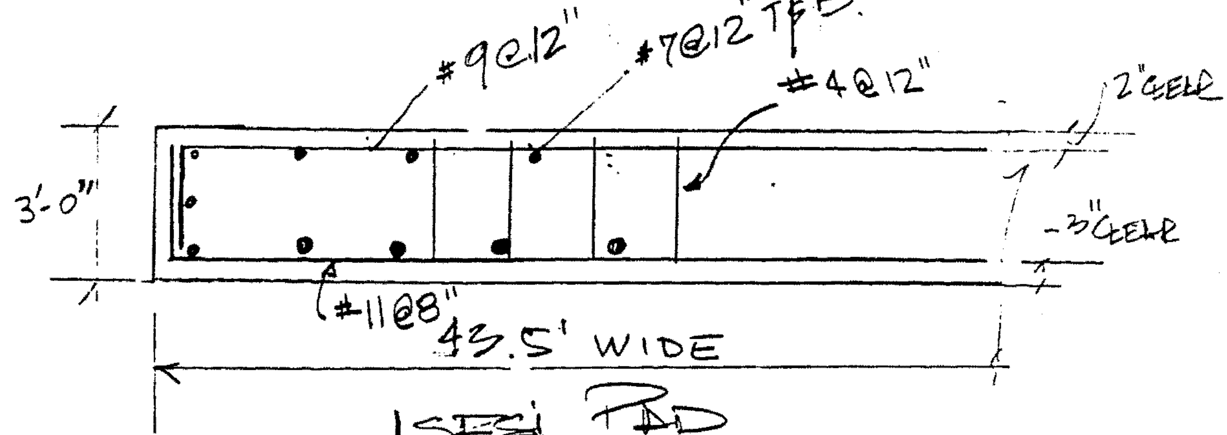
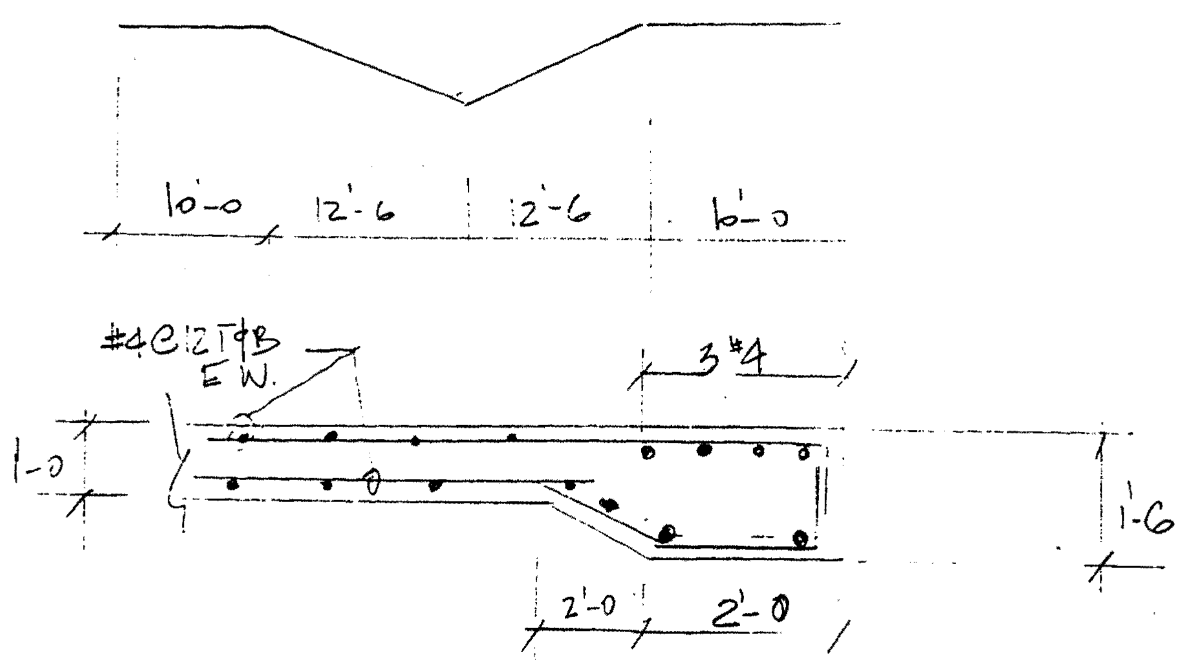


ISFSI PAD

TYPICAL SECTION

INFORMATION ONLY



SLAB ON GRADE

CALCULATION SHEET

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CCN CONVERSION:
CCN NO. CCN -

Project or DCP/FCN ______ Calc No. C-2016-01.04

Subject ISFSI FOUNDATION DESIGN Sheet 7 of ____

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	P. Barlow		JCL	9/20/00					

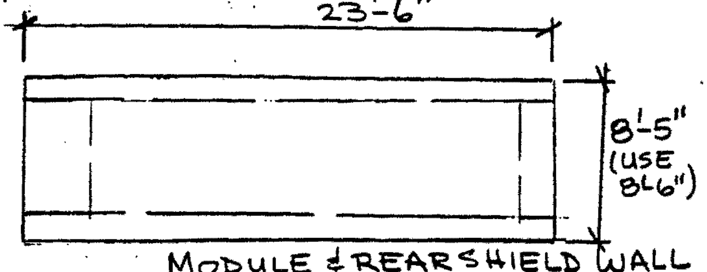
REV INDICATOR

ISFSI FOUNDATION DESIGN

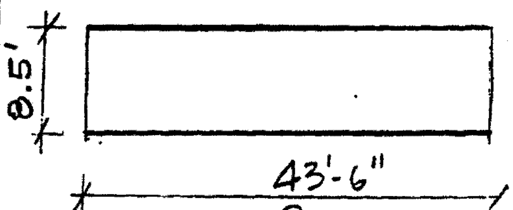
MODULE WEIGHT = 400k ⟶ FOR REF SEE S01-207-1-C11, TABLE H1

PAD SIZE FOR A SINGLE MODULE

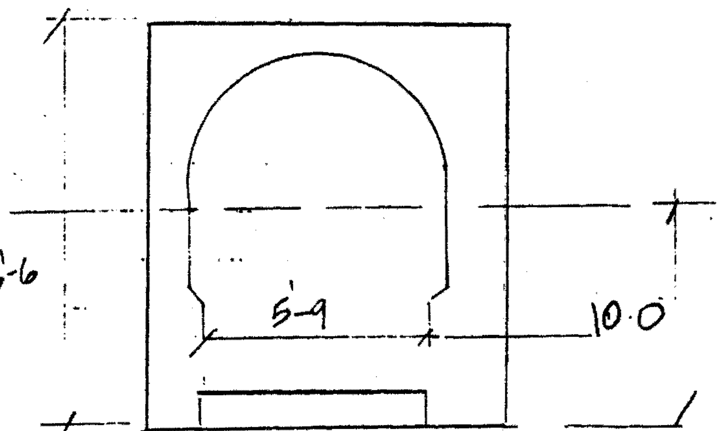
USE 43.5' x 8.5' x 3.0'



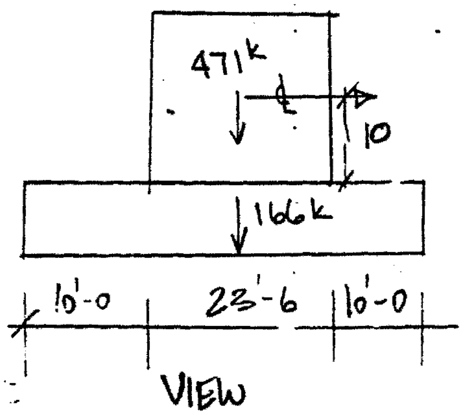
MODULE & REAR SHIELD WALL PLAN



PLAN



MODULE SECTION



VIEW

REAR SHIELDING WALL WT:

$18.5 \times 3 \times 8.5 = 71k$

TOTAL MODULE WT. = $400 + 71 = 471$ k
(INCLUDING REAR SHIELD WALL)

INFORMATION ONLY

WEIGHT OF FDN = $43.5 \times 3 \times 8.5 \times .15 = 166$ k

$\therefore \Sigma_W = 471 + 166 = 637$ k MODULE + PAD

EC&FS DEPARTMENT

CALCULATION SHEET

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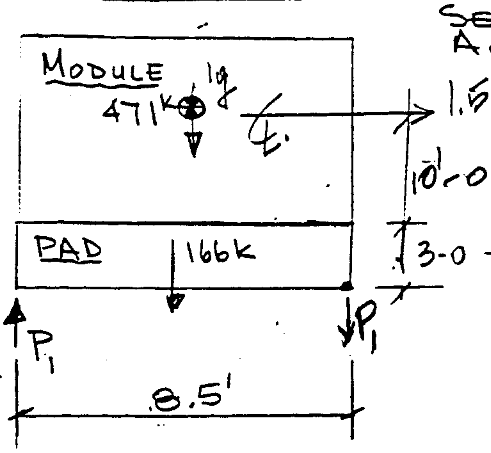
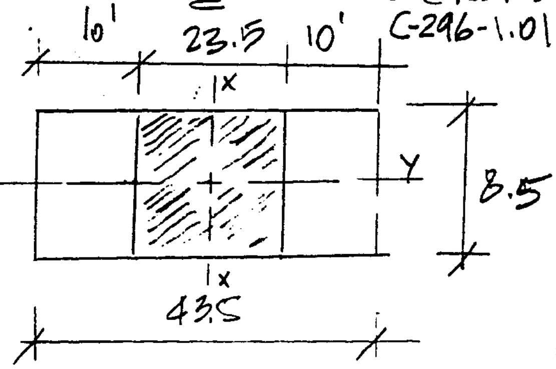
	BARAN		JCI	9/22/00					

REV INDICATOR

CHECK SOIL PRESSURE DUE TO SEISMIC & DEAD WEIGHT OF MODULE



SEISMIC ACCELERATION 1.5g horizontal, 1.0g vertical REF: C-296-1.01



DEAD LOAD SOIL PRESSURE: $q_{DL} = \frac{V}{A} = \frac{637}{8.5 \times 43.5} = 1.72$ ksf

SEISMIC VERTICAL: $q_z = 1g \times 1.72 = 1.72$ ksf

SEISMIC SOIL PRESSURE ABOUT X-X

$$OTM_x = 1.5g \times 471 \times 13 + 1.5g \times 166 \times 1.5$$
$$= 9558 \text{ k-ft}$$

$$e_x = \frac{OTM}{V} = \frac{9558}{637} = 15.0' > \frac{L}{6} = \frac{43.5}{6} = 7.25'$$

$$q_x = \frac{2V}{3B(\frac{L}{2} - e)} = \frac{2 \times 637}{3(8.5)(\frac{43.5}{2} - 15)} = 7.4 \text{ ksf}$$

SEISMIC SOIL PRESSURE ABOUT Y-Y

INFORMATION ONLY

SINCE THE MODULES ARE TIED TOGETHER, THE SOIL PRESSURE WILL BE BASED ON 10 MODULES. ACTUALLY, 19 MODULES ARE PLANNED FOR SONGS 1.

$$OTM_y = 10[1.5 \times 471 \times 13 + 1.5 \times 166 \times 1.5] = 95{,}580 \text{ k-ft}$$

$$e_y = \frac{95580}{10 \times 637} = 15' > \frac{L}{6} = \frac{10 \times 8.5}{6} = 14.17'$$

$$q_y = \frac{2 \times 637(10)}{3(43.5)(\frac{85}{2} - 15)} = 3.55 \text{ ksf}$$

EC&FS DEPARTMENT
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	F.Brown		JCS	9/22/00					

REV INDICATOR

TOTAL SOIL PRESSURE

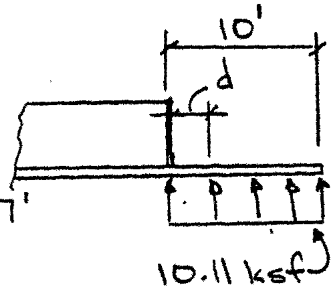
$$\therefore\ q_{TOT} = q_{DL} + \left[q_x^2 + q_y^2 + q_z^2\right]^{1/2} = 1.72 + \left[7.4^2 + 3.55^2 + 1.72^2\right]^{1/2}$$

$$= 1.72 + 8.39 = 10.11 \text{ ksf} < 15.63 \times 1.5 = 23.5 \text{ ksf}$$

Allowable soil bearing at 3' embedment and 50% increase for seismic loads. (SONGS 2&3 PSAR Appendix 2B)

CONCRETE DESIGN (ACI 349)

ASSUME 10'-0 DEPTH FROM MODULE TO THE EDGE CANTILEVER



$$d = \frac{32}{12} = 2.67'$$

pad wt.

$$M_{@d} = \frac{qL^2}{2} = \frac{(10.11 - .45)(10 - 2.67)^2}{2}$$

INFORMATION ONLY

$$= 260 \text{ k-ft/ft}$$

Based on $A_s = 2.34 \text{ in}^2/\text{ft}$ (see below) : $M_{CAP} = A_s a_u d = 2.34(3.58)32 = 268 \text{ k-ft/ft}$

$$V_{SHEAR/FOOT} = (10.11 - .45)(10 - 2.67) = 70.8 \text{ k/ft}$$

$$A_s = \frac{M}{a_u d} = \frac{260}{3.58(32)} = 2.27 \frac{\text{in}^2}{\text{ft}}$$ USE #11@8" $A_s = 2.34 \text{ in}^2/\text{ft}$

$$K_u = \frac{M_u}{F} = \frac{260}{1.024} = 254 \rightarrow a_u = 3.58 \qquad F = \frac{bd^2}{12000} = \frac{12 \times 32^2}{12000} = 1.024$$

(ACI Design Handbook, Flexure 1.2)

CALCULATION SHEET

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	P. Brown		JC	9/22/00					

REV INDICATOR

$v_u = \dfrac{70.8}{12 \times 32} = .184\,ksi > .108\,ksi$

$v_c = 2 \times .85\sqrt{4000} \cong 108\,psi$

Provide shear reinforcement:

$V_s = .184 - .108 = .076\ ksi$

Try #4 : $A_v = .20\ in^2$

Spacing:

$s = \dfrac{A_v f_y}{v_s b} = \dfrac{.20 \times 60}{.076 \times 12}$

$= 13.2''$

∴ Use #4 @ 12" o.c. shear reinforcing in the area 4' to 10' from the edges of the pad.

INFORMATION ONLY

Foundation and Soil Properties
Independent Spent Fuel Storage Installation
San Onofre Nuclear Generating Station Unit 1

Reference: EQE Report No. 201038.02-R-001, "Soil-Structure Interaction of the Independent Spent Fuel Storage Installation for San Onofre Nuclear Generating Station, Unit 1," April 3, 2000.

The location of the Independent Spent Fuel Storage Installation (ISFSI) will be at the existing site of the decommissioned Unit 1 plant at San Onofre. The ISFSI pad size will be about 43'- 6" wide by 188 feet long by 3 feet thick. The pad will support 19 spent fuel cask modules and may be expanded in the future to allow for additional modules. The pad will be constructed with reinforced concrete that has a minimum compressive strength of 4000 psi.

The soil beneath the pad is a very dense well graded sand of the San Mateo Formation with a depth of about 900 feet under the plant. The soil properties are given in Tables 1 through 6, and Figures 1 through 6, and represent the parameters used in the soil-structure interaction analysis of the San Onofre ISFSI pad (Reference). Table 1 is the low strain best estimate soil properties. Two bounding cases were defined in accordance with NRC NUREG-0800, Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants, Section 3.7.2, Seismic System Analysis, to account for possible variations in soil properties. An upper bound case was obtained by scaling the best estimate soil modulus by 2, and a lower bound estimate was obtained by scaling the best estimate soil modulus by 0.5. The P wave velocity for the saturated layers was kept constant since it corresponds to the velocity in water. Table 2 gives the low strain lower and upper bound soil properties. The shear modulus and shear wave velocity profiles for the three low strain soil cases are shown in Figures 1 and 2. Shear modulus and soil damping relationships with shear strain are given in Table 3 and shown in Figure 3.

Since the strain compatible upper bound soil properties were lower than the low strain best estimate properties, a strain compatible soil profile was developed and the shear wave profiles are given in Table 4 and shown in Figure 4. The strain compatible soil damping ratios are given in Table 5 and shown in Figure 5. The strain compatible P wave velocity profiles are given in Table 6 and shown in Figure 6.

Also included are the results of the soil-structure interaction analysis. Figures 7 through 9 show the comparisons of the TN-West design response spectra for the storage modules with the seismic demand of the San Onofre site specific Design

Basis Earthquake (0.67g ZPA) at the pad. The figures demonstrate that the seismic design of the TN-West dry storage system will bound the seismic requirements at San Onofre.

Table 1

LOW STRAIN BEST ESTIMATE SOIL PROPERTIES

Layer	Thickness (ft) (Surface at 15.75')	Shear Modulus (ksf)	Vs (1) (fps)	Unit Weight (kcf)	Poisson's ratio	Vp (2) (fps)
1	3.50	3,599.27	930.00	0.134	0.35	1,935.95
2	3.50	3,599.27	930.00	0.134	0.35	1,935.95
3	3.75	3,599.27	930.00	0.134	0.35	1,935.95
4	5.00	4,337.14	1,002.36	0.139	0.48	5,000.00
5	5.00	4,991.60	1,075.33	0.139	0.48	5,000.00
6	5.00	5,605.60	1,139.55	0.139	0.48	5,000.00
7	5.00	6,187.62	1,197.24	0.139	0.48	5,000.00
8	5.00	6,743.43	1,249.86	0.139	0.48	5,000.00
9	5.00	7,277.19	1,298.38	0.139	0.48	5,000.00
10	5.00	7,792.04	1,343.53	0.139	0.48	5,000.00
11	5.00	8,290.41	1,385.83	0.139	0.48	5,000.00
12	5.00	8,774.22	1,425.69	0.139	0.48	5,000.00
13	5.00	9,245.03	1,463.44	0.139	0.48	5,000.00
14	5.00	9,704.15	1,499.34	0.139	0.48	5,000.00
15	5.00	10,152.65	1,533.59	0.139	0.48	5,000.00
16	5.00	10,591.45	1,566.38	0.139	0.48	5,000.00
17	5.00	11,021.34	1,597.86	0.139	0.48	5,000.00
18	5.00	11,443.01	1,628.14	0.139	0.48	5,000.00
19	5.00	11,857.04	1,657.33	0.139	0.48	5,000.00
20	5.00	12,263.96	1,685.53	0.139	0.48	5,000.00
21	10.00	12,862.03	1,726.14	0.139	0.48	5,000.00
22	10.00	13,638.50	1,777.48	0.139	0.48	5,000.00
23	10.00	14,393.46	1,826.01	0.139	0.48	5,000.00
24	10.00	15,129.11	1,872.09	0.139	0.48	5,000.00
25	10.00	15,847.28	1,916.01	0.139	0.48	5,000.00
26	15.00	16,722.77	1,968.22	0.139	0.48	5,000.00
27	H. S. (-160.75' ->)	17,744.05	2,027.43	0.139	0.48	5,000.00

(1) Lower limit for Vs = 930 fps
(2) Layers below water table, Vp = 5,000 fps (P wave velocity in water)

Table 2

LOW STRAIN LOWER AND UPPER BOUND SOIL PROPERTIES

Layer	Thickness (ft) (Surface at 15.75')	L.B. Shear Modulus (ksf)	L.B. Vs (fps)	U.B. Shear Modulus (ksf)	U.B. Vs (fps)
1	3.50	1,799.64	657.61	7,198.54	1,315.22
2	3.50	1,799.64	657.61	7,198.54	1,315.22
3	3.75	1,799.64	657.61	7,198.54	1,315.22
4	5.00	2,168.57	708.77	8,674.27	1,417.55
5	5.00	2,495.80	760.37	9,983.20	1,520.74
6	5.00	2,802.80	805.78	11,211.21	1,611.56
7	5.00	3,093.81	846.58	12,375.24	1,693.16
8	5.00	3,371.71	883.78	13,486.85	1,767.57
9	5.00	3,638.60	918.09	14,554.38	1,836.19
10	5.00	3,896.02	950.02	15,584.09	1,900.03
11	5.00	4,145.20	979.93	16,580.82	1,959.85
12	5.00	4,387.11	1,008.11	17,548.44	2,016.23
13	5.00	4,622.52	1,034.81	18,490.07	2,069.62
14	5.00	4,852.07	1,060.19	19,408.30	2,120.38
15	5.00	5,076.32	1,084.41	20,305.30	2,168.83
16	5.00	5,295.72	1,107.60	21,182.90	2,215.20
17	5.00	5,510.67	1,129.86	22,042.68	2,259.71
18	5.00	5,721.50	1,151.27	22,886.01	2,302.53
19	5.00	5,928.52	1,171.91	23,714.08	2,343.82
20	5.00	6,131.98	1,191.85	24,527.93	2,383.70
21	10.00	6,431.01	1,220.56	25,724.05	2,441.13
22	10.00	6,819.25	1,256.87	27,276.99	2,513.73
23	10.00	7,196.73	1,291.18	28,786.91	2,582.37
24	10.00	7,564.55	1,323.77	30,258.21	2,647.54
25	10.00	7,923.64	1,354.82	31,694.57	2,709.65
26	15.00	8,361.39	1,391.75	33,445.55	2,783.49
27	H. S. (-160.75' ->)	8,872.02	1,433.61	35,488.10	2,867.23

Table 3

SOIL DEGRADATION CURVES

Shear Strain (%)	G/GMAX	Soil Damping Ratio (%)
0.0001	1.000	2.061
0.0003	0.978	2.691
0.001	0.852	3.568
0.003	0.600	4.621
0.01	0.391	6.067
0.03	0.258	7.496
0.1	0.173	10.158
0.3	0.128	12.930
1.0	0.095	16.442
2.0	0.076	19.031
3.0	0.066	20.900
10.0 (1)	0.063 (1)	20.900 (1)

(1) These values were added to allow for larger deformation.

Table 4

STRAIN COMPATIBLE SHEAR WAVE VELOCITY

Layer	Thickness (ft)	Vs lower bound (strain comp.) (fps)	Vs best est. (strain comp.) (fps)	Vs upper bound (strain comp.) (fps)	Vs best est. (low strain) (fps)
1	3.50	376.53	649.40	1096.24	930.00
2	3.50	282.88	468.14	815.56	930.00
3	3.75	258.93	420.26	706.30	930.00
4	5.00	272.27	435.31	711.29	1002.36
5	5.00	282.29	453.55	739.86	1075.33
6	5.00	292.37	468.13	770.84	1139.55
7	5.00	303.64	484.66	802.93	1197.24
8	5.00	315.25	500.19	830.44	1249.86
9	5.00	326.79	515.02	851.11	1298.38
10	5.00	335.88	530.09	870.48	1343.53
11	5.00	344.06	544.96	888.00	1385.83
12	5.00	352.37	559.23	904.67	1425.69
13	5.00	360.50	572.94	920.16	1463.44
14	5.00	368.44	586.32	935.52	1499.34
15	5.00	376.22	599.22	951.48	1533.59
16	5.00	382.93	609.76	967.29	1566.38
17	5.00	389.23	618.62	982.74	1597.86
18	5.00	395.14	627.55	998.87	1628.14
19	5.00	401.25	636.34	1014.40	1657.33
20	5.00	407.83	645.38	1029.59	1685.53
21	10.00	416.82	658.88	1052.18	1726.14
22	10.00	426.44	676.23	1081.71	1777.48
23	10.00	436.11	692.98	1110.03	1826.01
24	10.00	445.82	707.37	1135.51	1872.09
25	10.00	455.34	720.19	1153.43	1916.01
26	15.00	466.15	736.26	1173.24	1968.22
H.S.		480.17	758.40	1208.53	2027.43

Table 5

STRAIN COMPATIBLE DAMPING RATIOS

Layer	Thickness (ft)	Damping Ratio Lower bound (strain comp.)	Damping Ratio Best estimate (strain comp.)	Damping Ratio Upper bound (strain comp.)	Damping Ratio Best estimate (low strain)
1	3.50	0.067	0.054	0.042	0.021
2	3.50	0.098	0.076	0.061	0.021
3	3.75	0.113	0.092	0.072	0.021
4	5.00	0.117	0.097	0.077	0.021
5	5.00	0.123	0.100	0.082	0.021
6	5.00	0.127	0.104	0.084	0.021
7	5.00	0.129	0.107	0.085	0.021
8	5.00	0.130	0.110	0.087	0.021
9	5.00	0.130	0.111	0.088	0.021
10	5.00	0.131	0.112	0.090	0.021
11	5.00	0.132	0.113	0.091	0.021
12	5.00	0.133	0.113	0.093	0.021
13	5.00	0.133	0.114	0.094	0.021
14	5.00	0.134	0.114	0.095	0.021
15	5.00	0.134	0.114	0.095	0.021
16	5.00	0.135	0.115	0.096	0.021
17	5.00	0.135	0.116	0.097	0.021
18	5.00	0.136	0.117	0.097	0.021
19	5.00	0.136	0.117	0.097	0.021
20	5.00	0.136	0.118	0.097	0.021
21	10.00	0.136	0.118	0.098	0.021
22	10.00	0.137	0.119	0.098	0.021
23	10.00	0.138	0.119	0.098	0.021
24	10.00	0.138	0.120	0.098	0.021
25	10.00	0.139	0.121	0.099	0.021
26	15.00	0.139	0.122	0.100	0.021
H.S.		0.139	0.122	0.100	0.021

Table 6

STRAIN COMPATIBLE P WAVE VELOCITY

Layer	Thickness (ft)	Vp lower bound (strain comp.) (fps)	Vp best est. (strain comp.) (fps)	Vp upper bound (strain comp.) (fps)	Vp best est. (low strain) (fps)
1	3.50	783.81	1351.84	2282.00	1935.95
2	3.50	588.86	974.50	1697.73	1935.95
3	3.75	539.00	874.84	1470.28	1935.95
4	5.00	3500.00	5000.00	5000.00	5000.00
5	5.00	3500.00	5000.00	5000.00	5000.00
6	5.00	3500.00	5000.00	5000.00	5000.00
7	5.00	3500.00	5000.00	5000.00	5000.00
8	5.00	3500.00	5000.00	5000.00	5000.00
9	5.00	3500.00	5000.00	5000.00	5000.00
10	5.00	3500.00	5000.00	5000.00	5000.00
11	5.00	3500.00	5000.00	5000.00	5000.00
12	5.00	3500.00	5000.00	5000.00	5000.00
13	5.00	3500.00	5000.00	5000.00	5000.00
14	5.00	3500.00	5000.00	5000.00	5000.00
15	5.00	3500.00	5000.00	5000.00	5000.00
16	5.00	3500.00	5000.00	5000.00	5000.00
17	5.00	3500.00	5000.00	5000.00	5000.00
18	5.00	3500.00	5000.00	5000.00	5000.00
19	5.00	3500.00	5000.00	5000.00	5000.00
20	5.00	3500.00	5000.00	5000.00	5000.00
21	10.00	3500.00	5000.00	5000.00	5000.00
22	10.00	3500.00	5000.00	5000.00	5000.00
23	10.00	3500.00	5000.00	5000.00	5000.00
24	10.00	3500.00	5000.00	5000.00	5000.00
25	10.00	3500.00	5000.00	5000.00	5000.00
26	15.00	3500.00	5000.00	5000.00	5000.00
H.S.		3500.00	5000.00	5000.00	5000.00

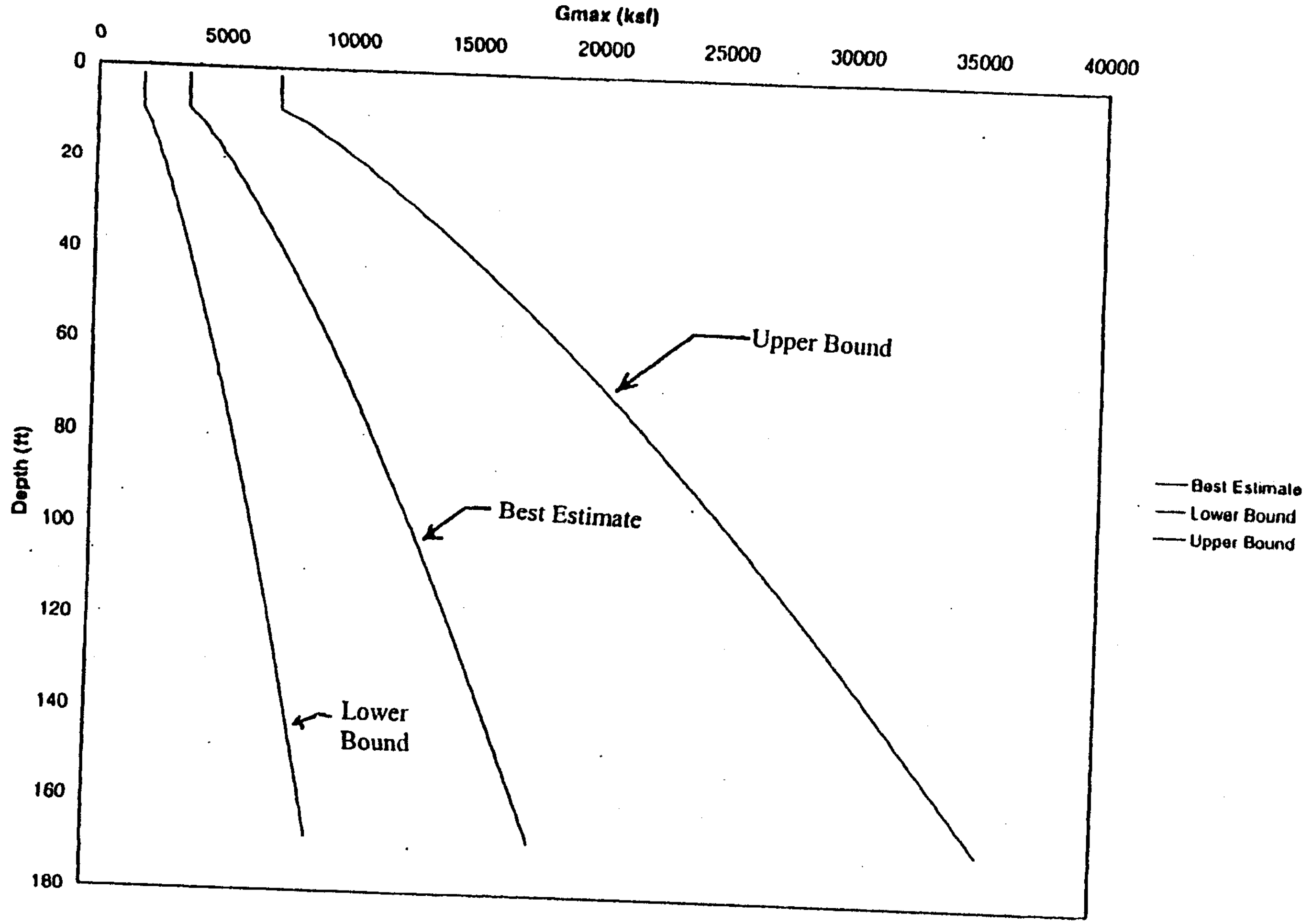


Figure 1: Low Strain Shear Modulus

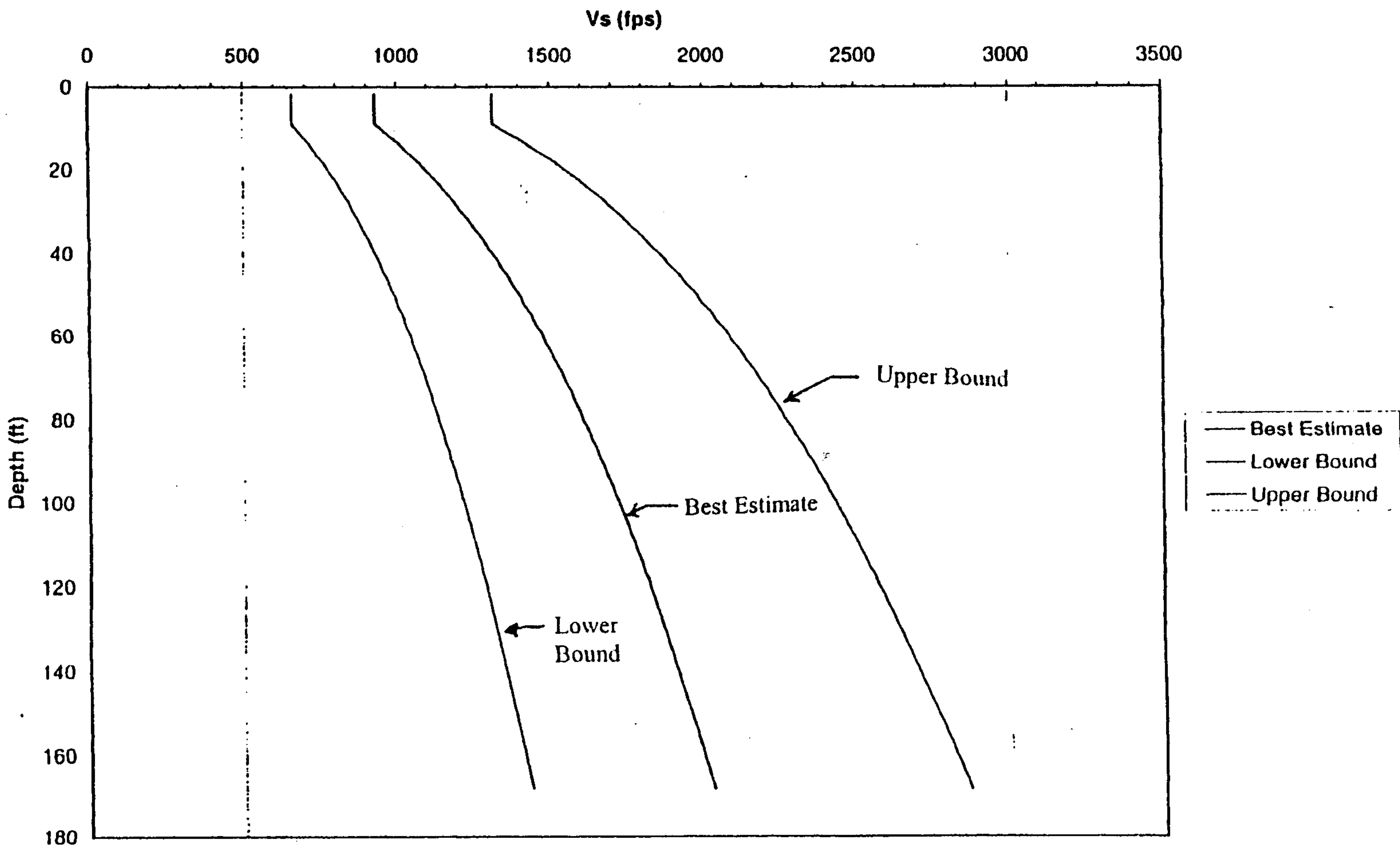


Figure 2: Low Strain Shear Wave Velocity

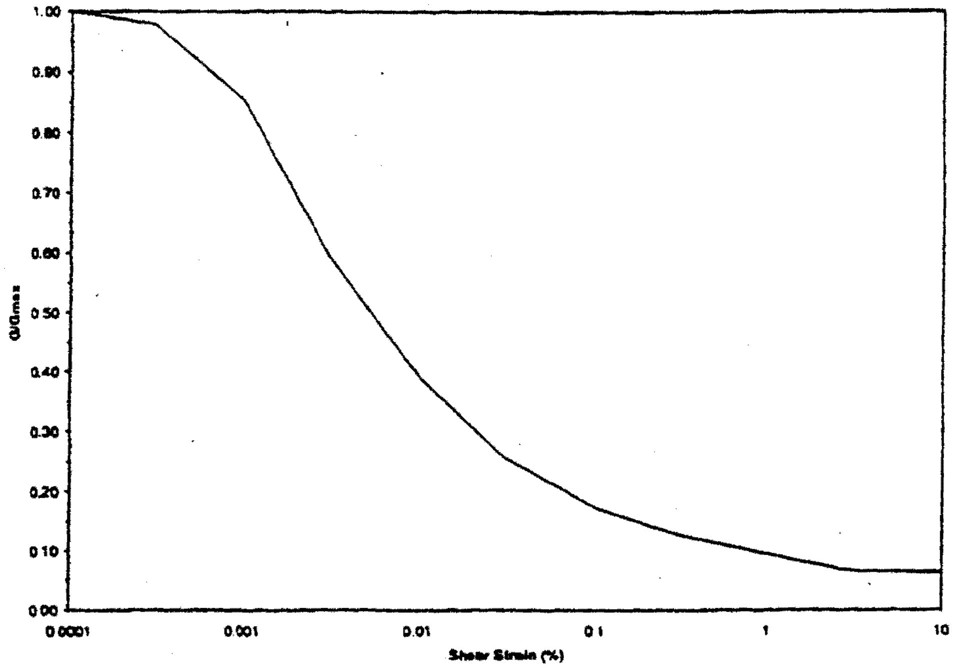


Figure 3a: Soil Shear Modulus Degradation Curve

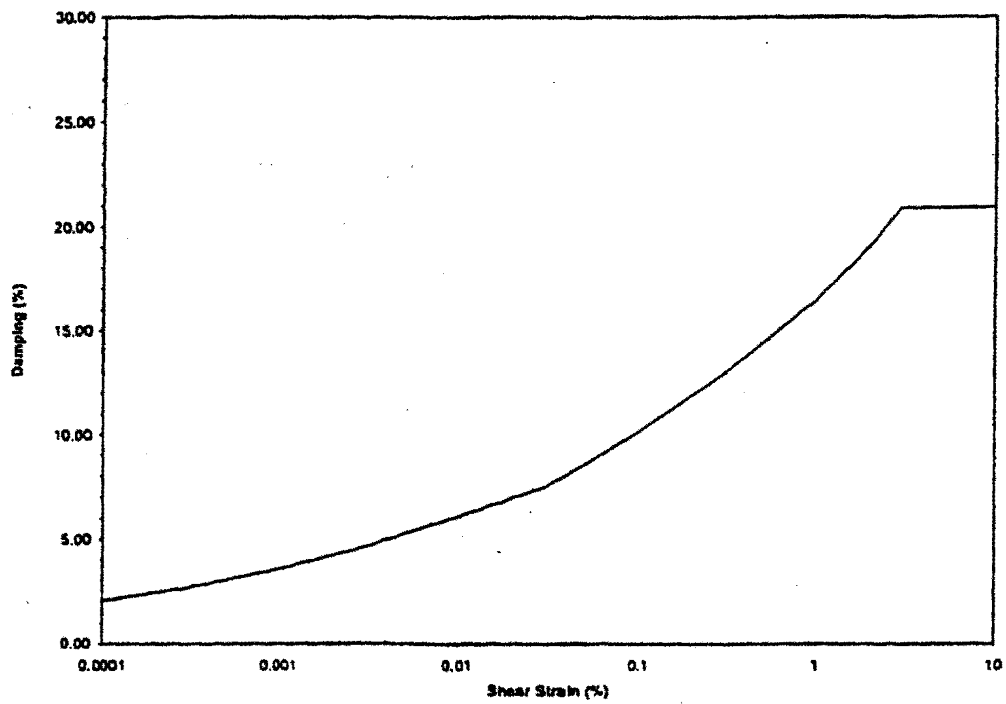


Figure 3b: Soil Material Damping Curve

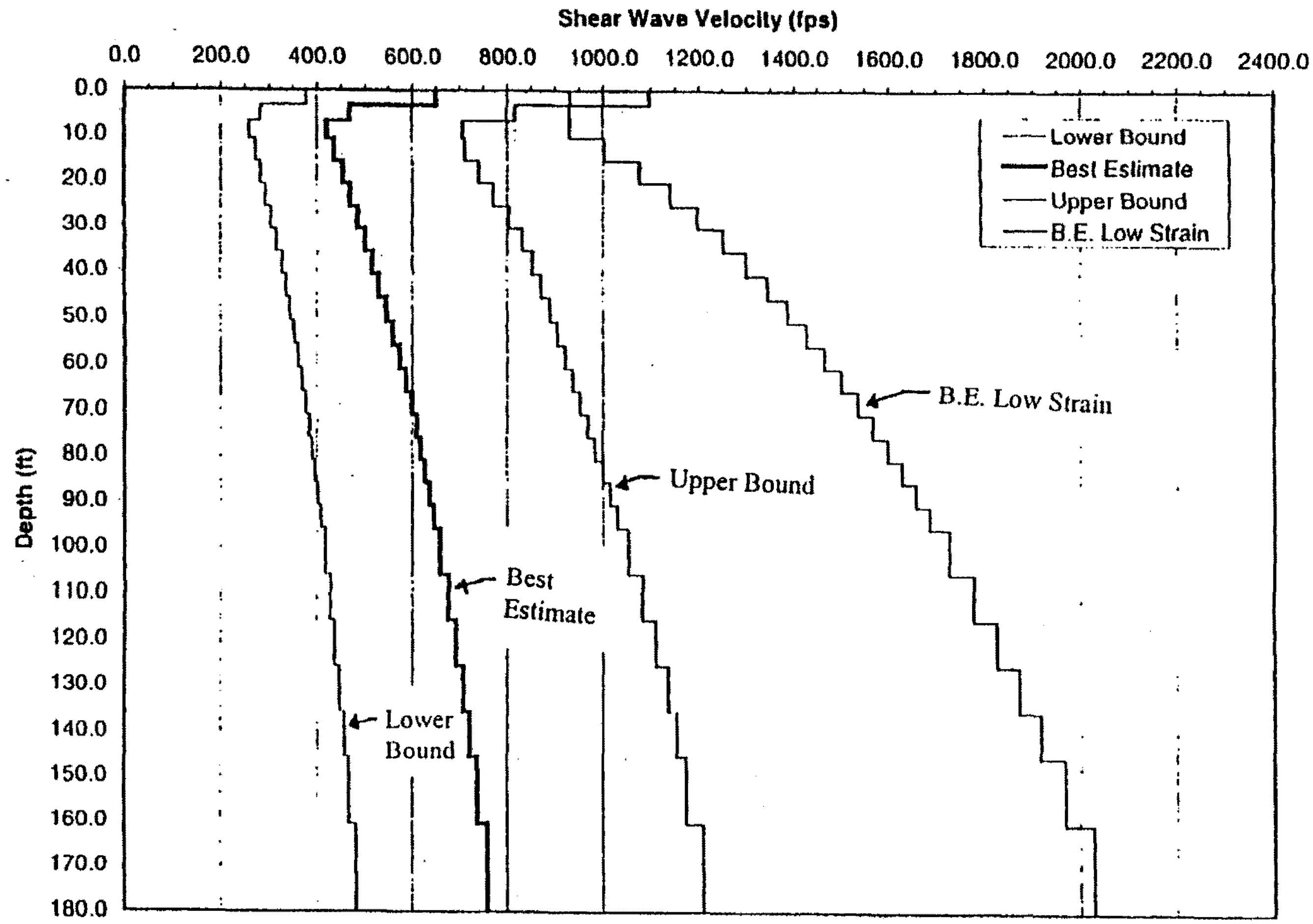


Figure 4: Strain Compatible Shear Wave Velocity

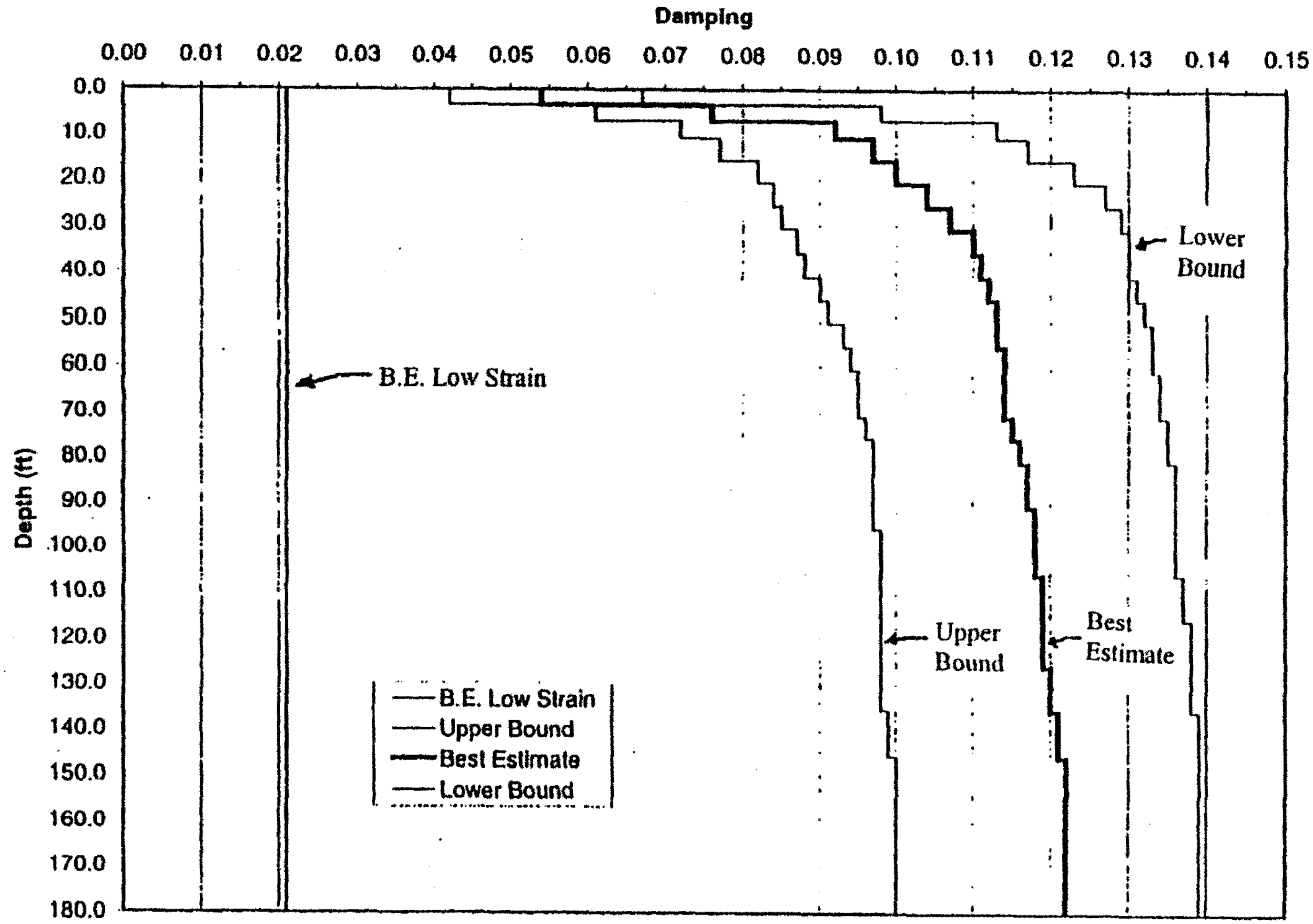


Figure 5: Strain Compatible Damping Ratios

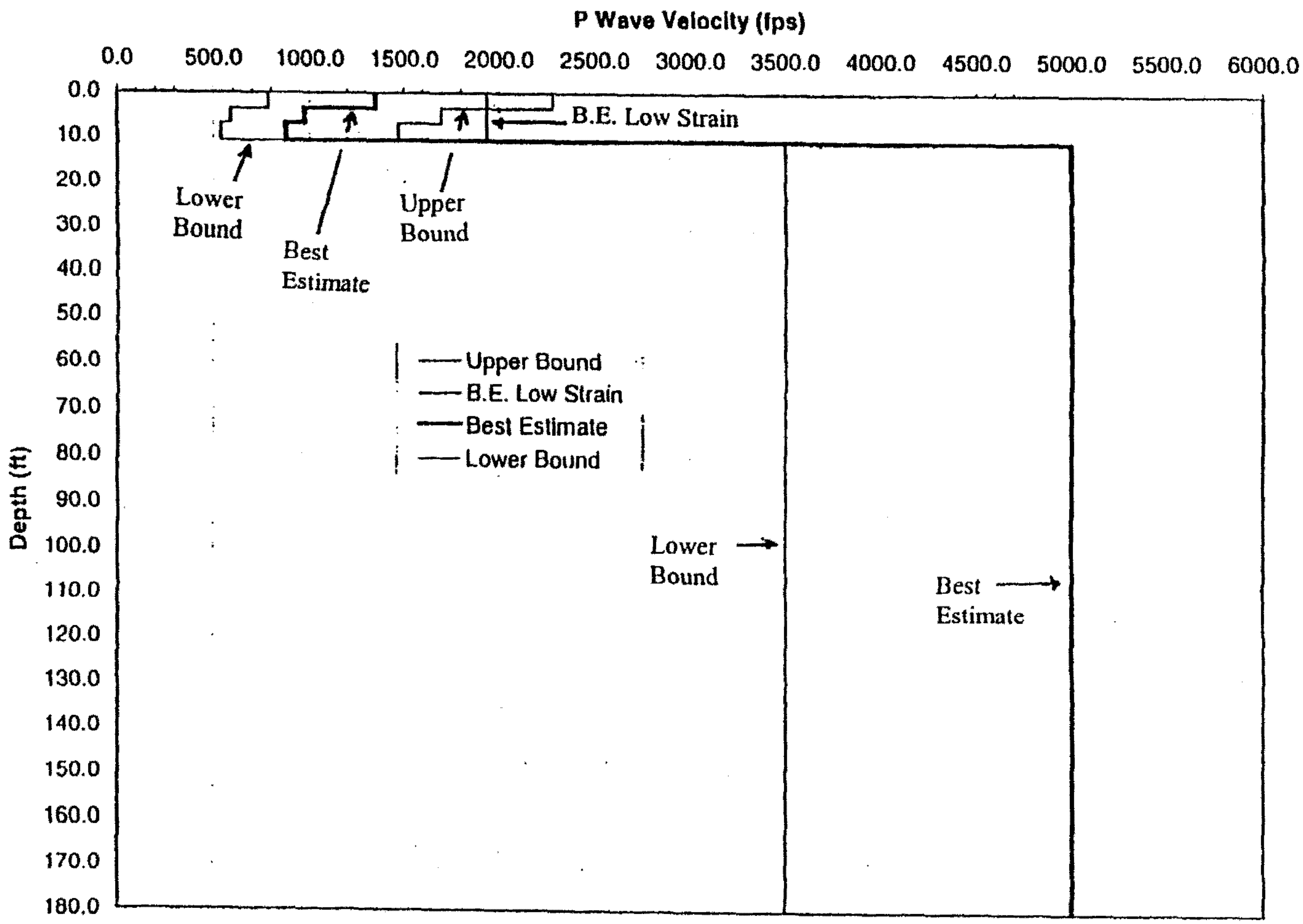


Figure 6: Strain Compatible P Wave Velocity

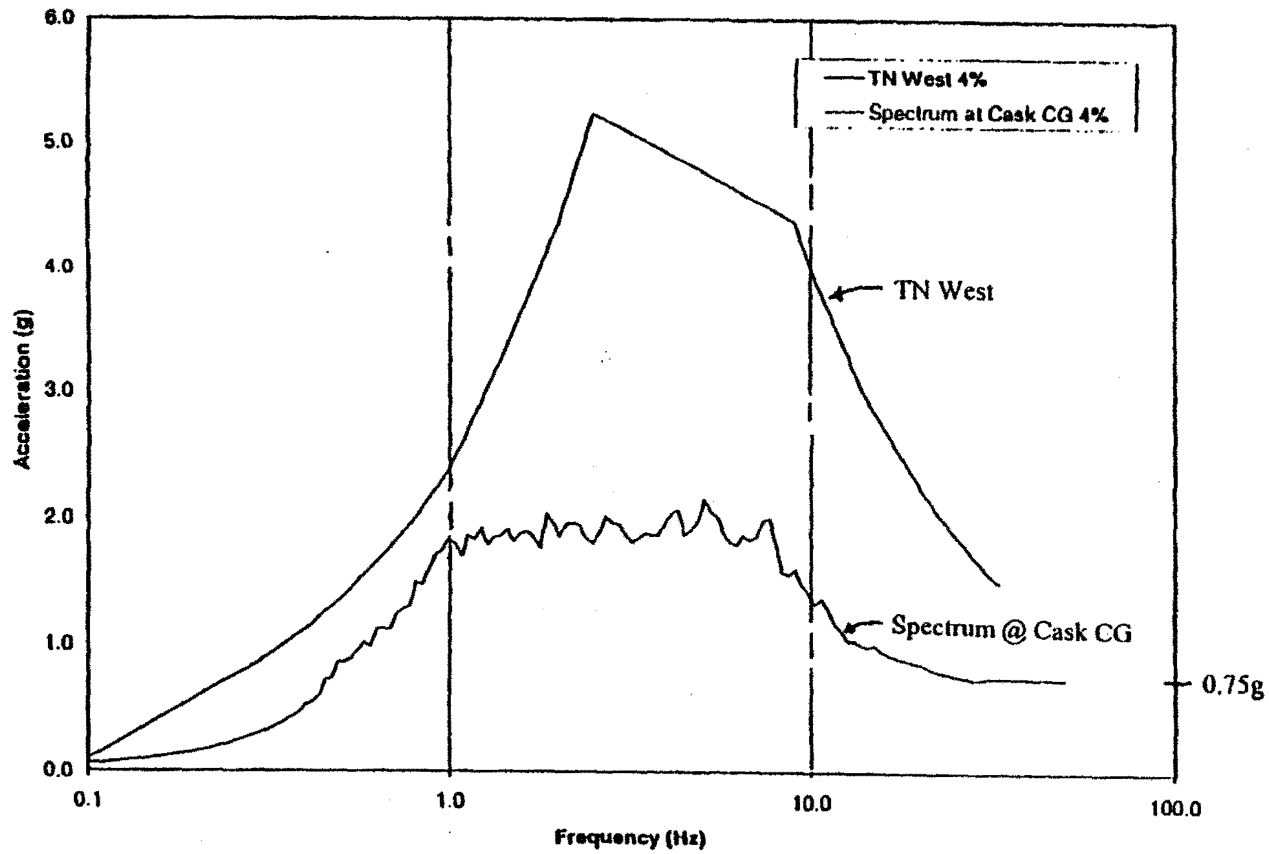


Figure 7: TN West Vs SSE Casks CG Spectra – Horizontal Longitudinal Direction

Frequency, Acceleration values for CG Spectrum contained in SO1-207-1-C31, R1 on sheet 2450

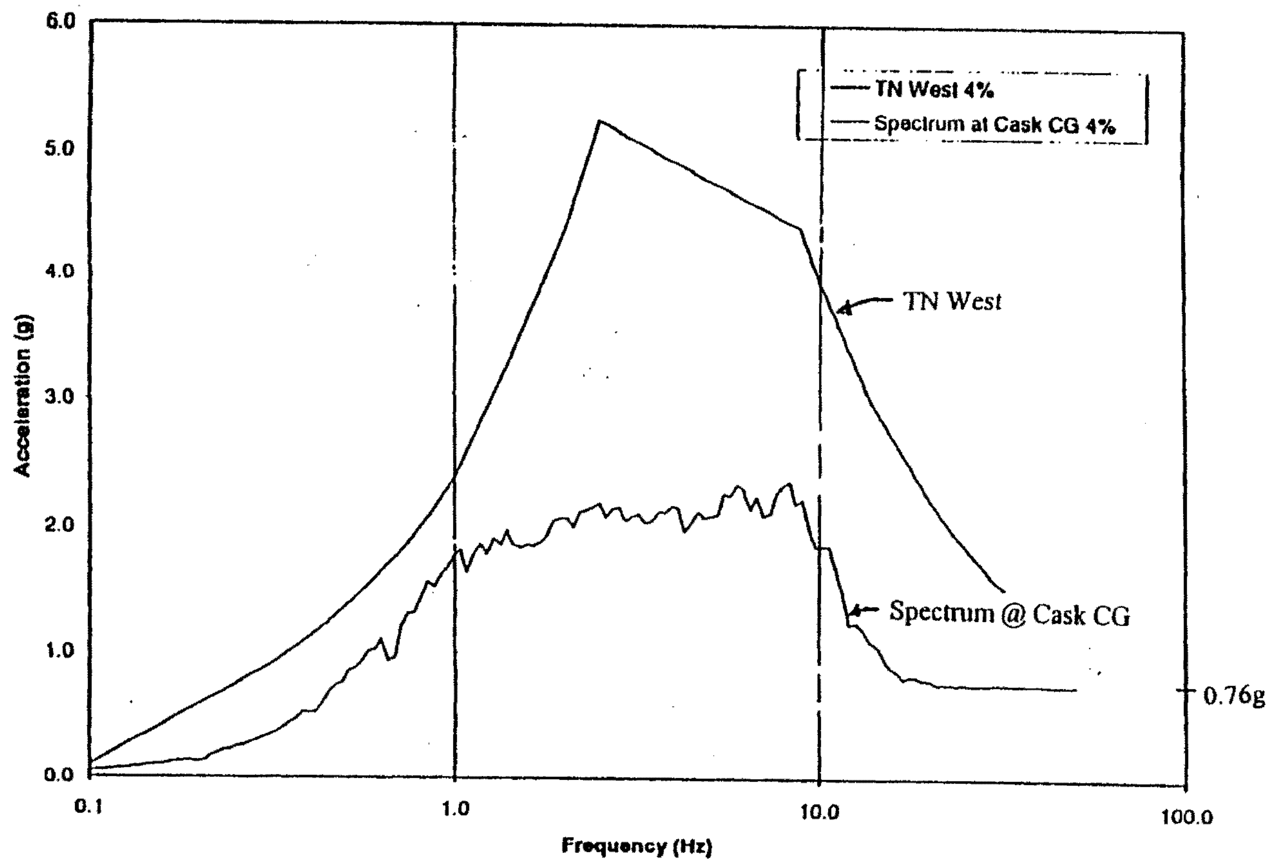


Figure 8: TN West Vs. SSE Casks CG Spectra – Horizontal Transverse Direction

Frequency, Acceleration values for CG Spectrum contained in SO1-207-1-C31, R1 on sheet 2450

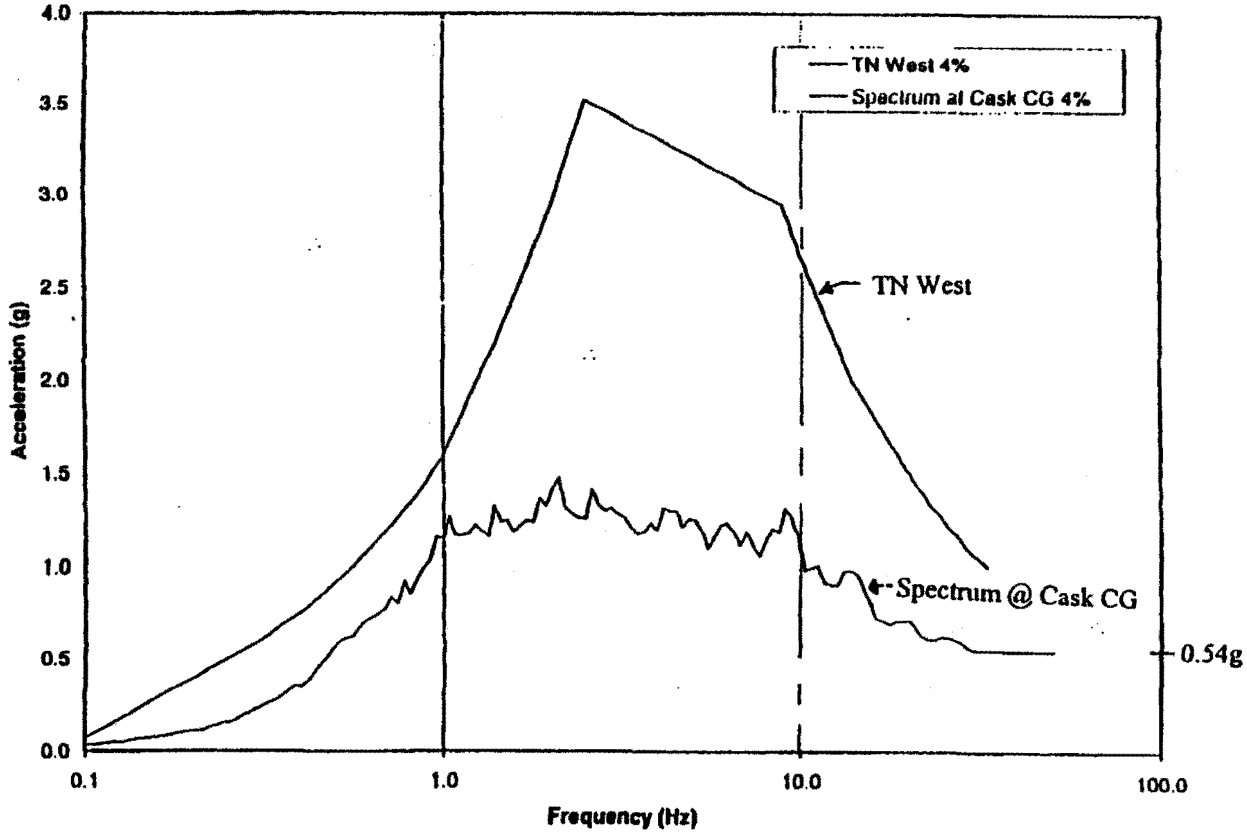
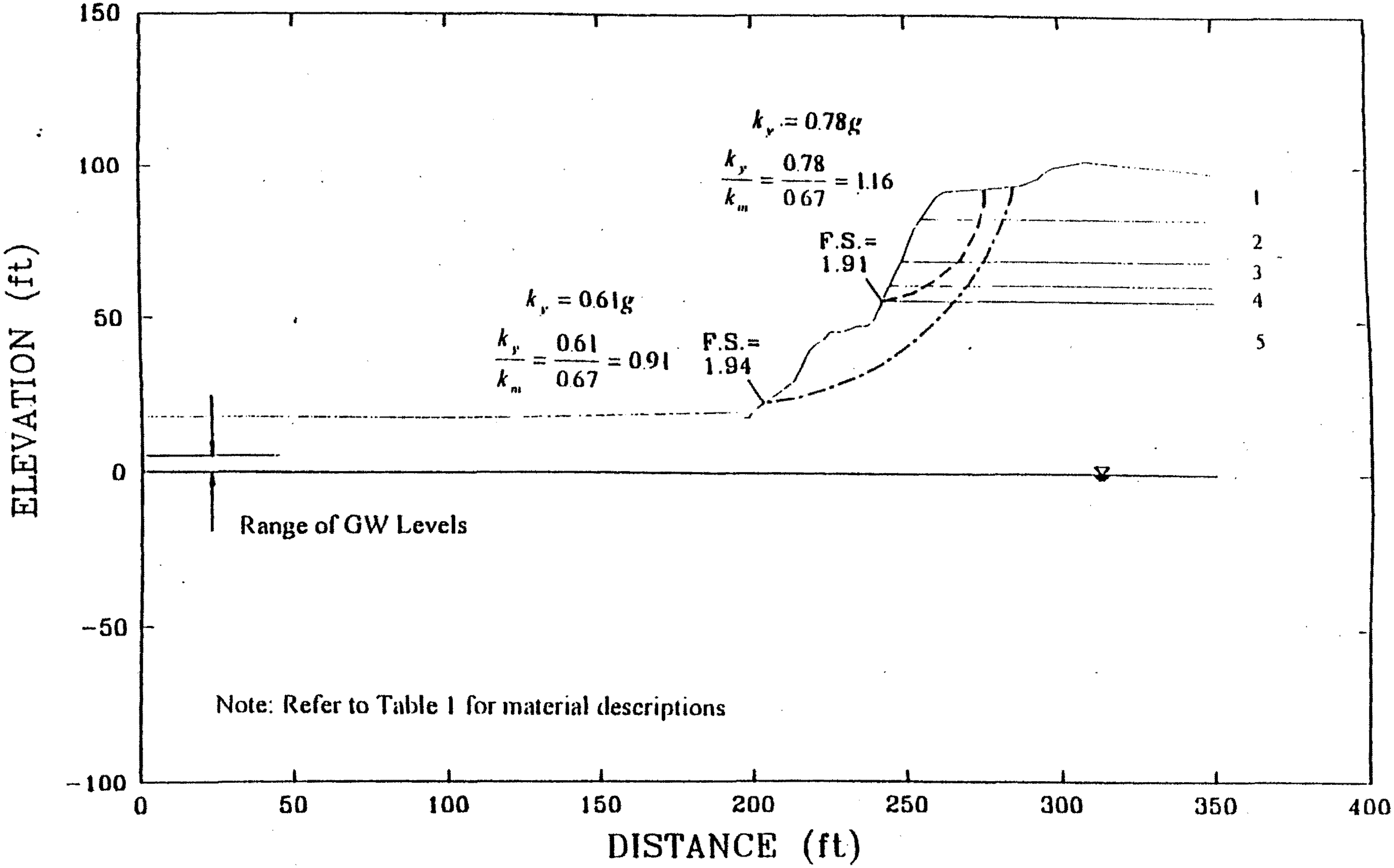


Figure 9: TN West Vs. SSE Casks CG Spectra – Vertical Direction

Frequency, Acceleration values for CG Spectrum contained in SO1-207-1-C31, R1 on sheet 2450



CALC C-296-01-03 SHT A-40
APPENDIX A

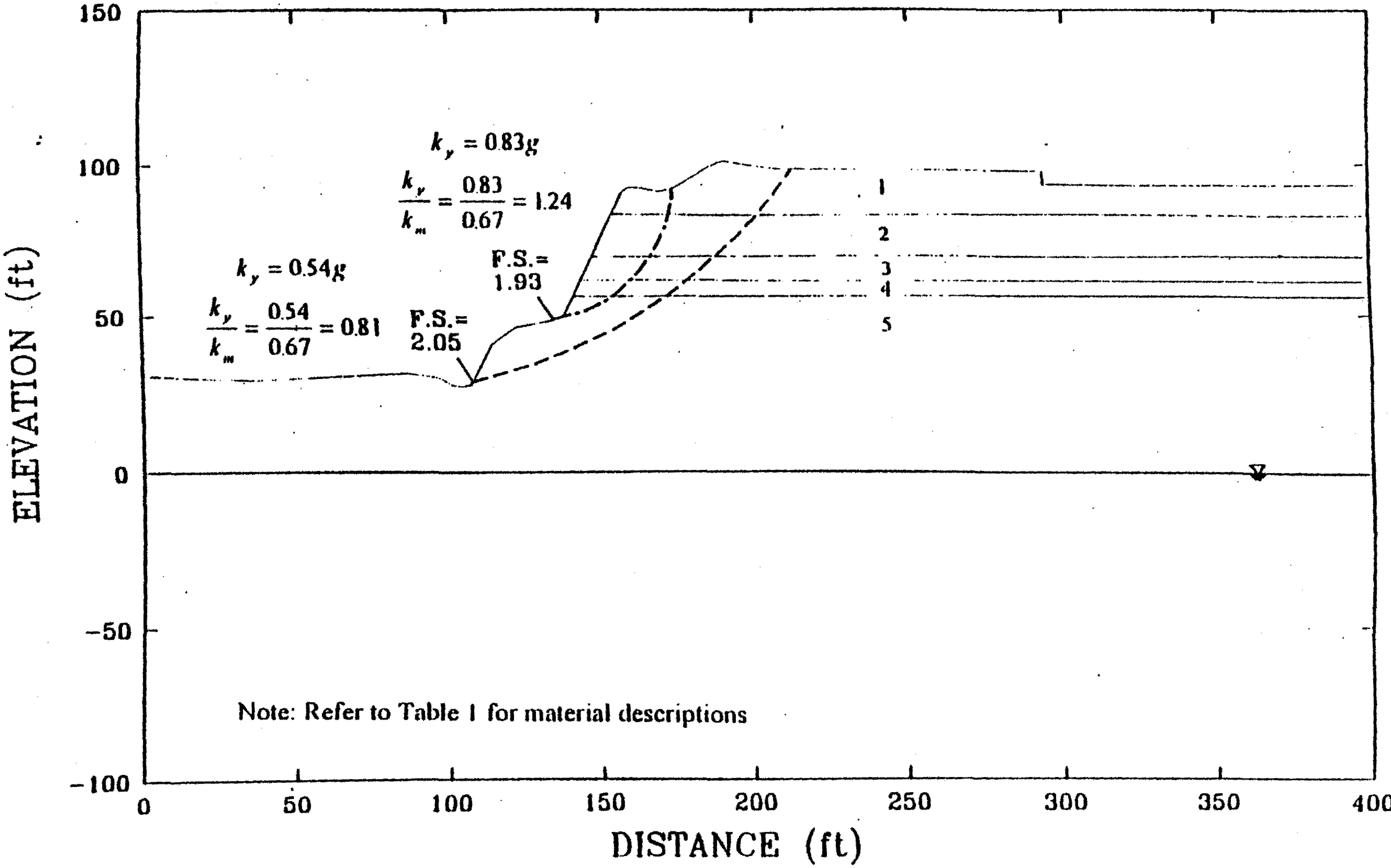
Exhibit 18
E-00-014

File : A-A-F.PLT, 09-26-1995

Run By: P.TAN

SECTION A–A' – SLOPE STABILITY FACTOR OF SAFETY

Project No.: 954E181	Date: SEP 95	Project: SONGS CASK STORAGE	Fig. 4.1



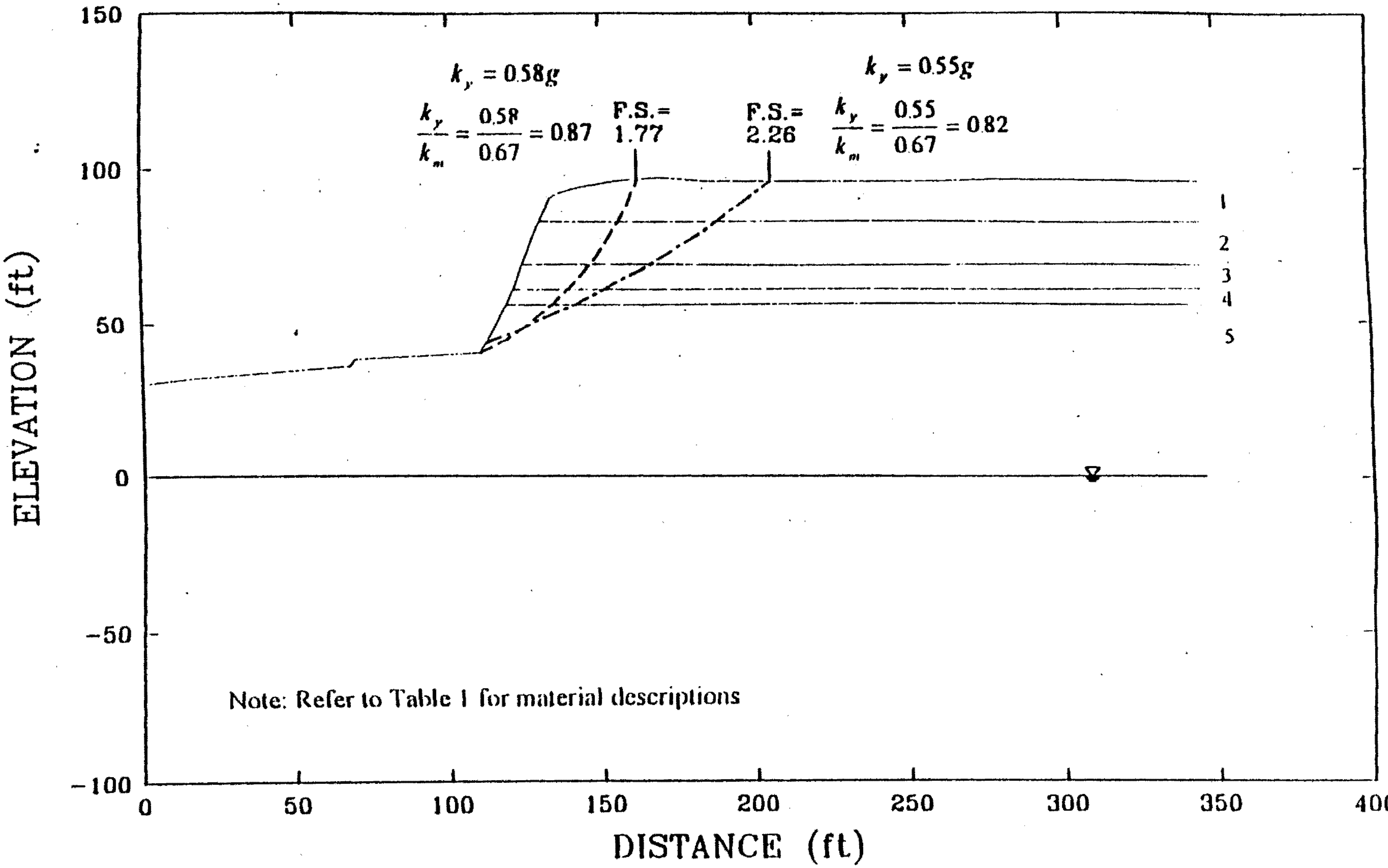
CALC C-296-01.02 SHT A-41
APPENDIX A

File : B-B2.PLT, 09-28-1995

Run By: P.TAN

SECTION B−B' − SLOPE STABILITY FACTOR OF SAFETY

Project No.: 954E181	Date: SEP 95	Project: SONGS CASK STORAGE	Fig. 4.2



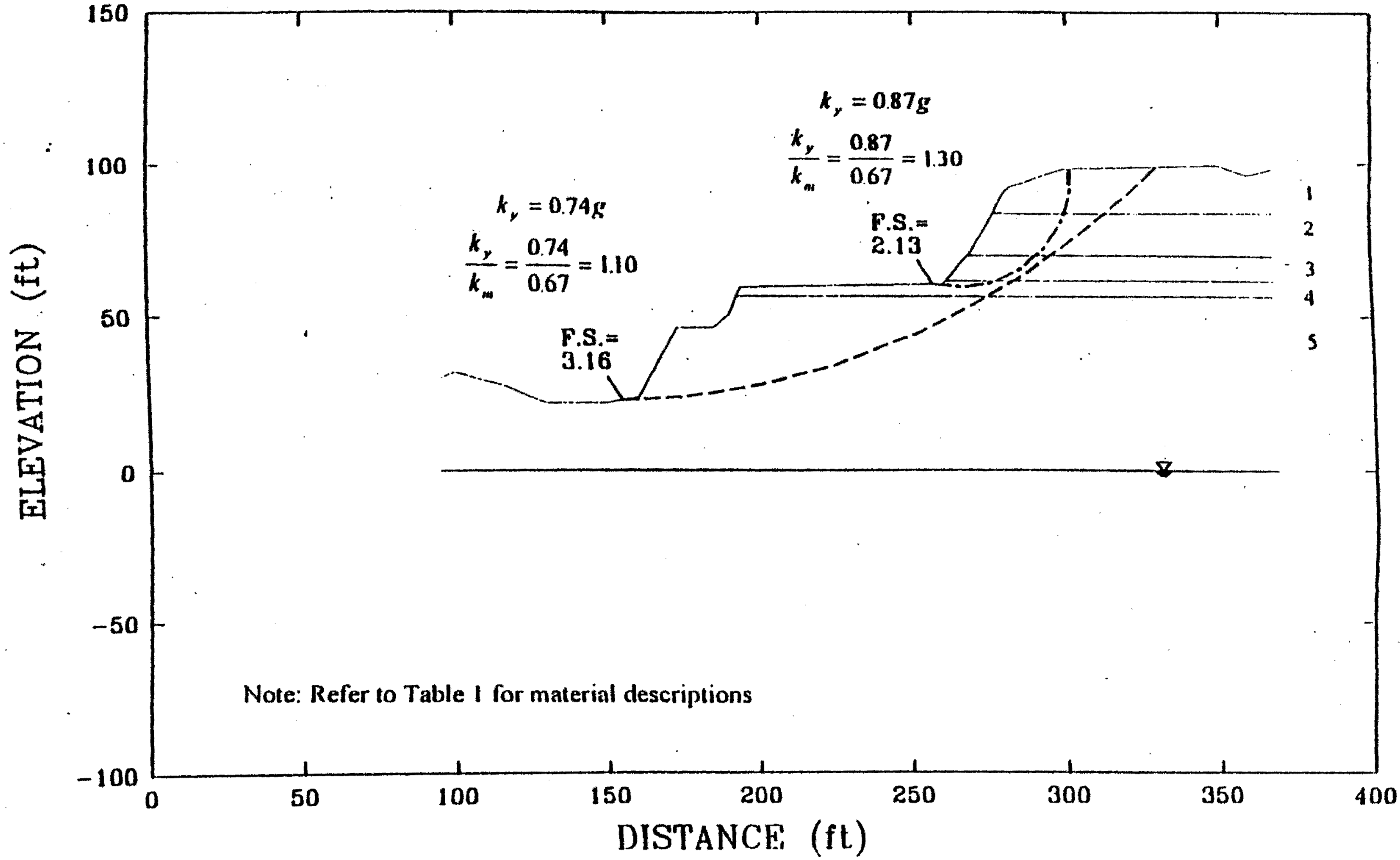
CALC C-296-01.02 SHT A-42
APPENDIX A

File : C-C1.PLT, 09-28-1995

Run By: P.TAN

SECTION C−C′ − SLOPE STABILITY FACTOR OF SAFETY

Project No.: 954E181	Date: SEP 95	Project: SONGS CASK STORAGE	Fig. 4.3



File : D-D4.PLT, 09-28-1995

Run By: P.TAN

SECTION D-D' - SLOPE STABILITY FACTOR OF SAFETY

Project No.: 954E181	Date: SEP 95	Project: SONGS CASK STORAGE	Fig. 4.4

CALC C-296-01.03 SHT A-43
APPENDIX A

DRAFT TRUST AGREEMENT

This trust agreement (the "Agreement") is entered into as of ____________, 2001 by and between City National Bank, national association (the "Trustee"), and Southern California Edison Company, (the "Company"), also collectively referenced to herein as the "Parties."

ARTICLE I
TRUST FUND

1.1 Establishment of Trust. This "SONGS ISFSI Yard Sump Maintenance Trust Account" (the "Trust Account") is established by the Company pursuant to the requirements of the California Coastal Commission. All funds deposited in the Trust Account are held in trust and shall be disbursed only for expenditures for storm water sump monitoring and maintenance, consistent with Special Condition 2 of Coastal Development Permit E-00-014, on the project site at the San Onofre Nuclear Generating Station ("SONGS"). The term of the Trust Account will be from _______________, 2001 through December 31, 2022 unless terminated sooner as provided in Section 8.2.

1.2 Funding of Trust. The Trust Account will be established within thirty (30) days after receipt by the Company of the California Coastal Commission coastal development permit for the SONGS 2 and 3 spent fuel storage facility and prior to commencing construction of said facility. A deposit of $136,000 will be made by the Company to the Trust Account at its inception, which amount is the estimated present value of the sump monitoring and maintenance costs plus the estimated present value of the expenses of the Trustee for the term of the Trust Account.

1.3 Disbursement of Funds. The Company represents that requests by it for disbursement of funds pursuant to Section 2.2.1 herein, shall be made in accordance with Section 1.1 herein. Disbursement requests from the Company to the Trustee will be accompanied by either (i) a vendor invoice if the work has been performed by a third-party, or (ii) documentation of Company costs if the work is performed by the Company. The Company will establish separate accounting mechanisms to identify and capture costs related to the SONGS ISFSI Yard Sump Maintenance project.

1.4 Separate Funds of the Trust Account. The Company may direct the Trustee to establish one or more funds to hold such portions of the assets of the Trust Account as the Company shall direct, along with the earnings and profits thereon.

ARTICLE II
THE TRUSTEE

2.1 Scope of Powers, Duties and Obligations of the Trustee. Subject to the Company's directions, the Trustee has whatever powers are conferred by law and which are required to discharge its obligations and exercise its rights under this Agreement, including but not limited to the powers specified in Section 2.2, and the powers and authority granted to the Trustee under other provisions of this Agreement. The Trustee shall have no duties or obligations except those specifically set forth in this Agreement.

2.2 Powers Exercisable by the Trustee, Subject to this Agreement. The Trustee is authorized and empowered to exercise the following powers, subject to the limitations contained in this Agreement:

2.2.1 To disburse, distribute or otherwise make payment as requested by the Company pursuant to Instructions given under Section 4.1 herein, provided that unless Company Instructions requesting same-day funding are received by the Trustee, in writing, no later than 9:00 am (California time) of such day, such Instructions will be acted upon by the Trustee on the following business day.

2.2.2 To register any investment held in the Trust Account in its own name or in the name of a nominee and to hold any investment in bearer form. The books and records of the Trustee shall show that all such investments are part of the Trust Account. The Trustee shall be liable for all acts of its nominee.

2.2.3 To utilize registered securities depositories to hold assets of the Trust Account, provided however that the Trustee shall not be relieved of any fiduciary responsibility with respect to the assets so held.

2.2.4 To employ agents, including public accountants and legal counsel (which may be counsel for Company), as it shall determine appropriate, and to pay their reasonable expenses and compensation from Trust Account;

2.2.5 To rely on Company to defend and litigate, or settle, at their expense, any suit brought against the Trust Account or any order sought to be satisfied out of the Trust Account, without duty on the Trustee beyond forwarding related papers to Company and complying with any final order to the extent of the Trust Account;

2.2.6 To withhold from taking any action until it receives proper written notice of an occurrence of an event affecting this Trust Account;

2.2.7 To treat as genuine, sufficient and correct, in form, execution and validity, and as the document it purports to be, and from the party it purports to be from, any notice, instruction, letter, paper, telex or other document purported to be furnished to Trustee by Company and believed by Trustee to be both genuine and to have been transmitted by the proper party or parties, and Trustee shall have no liability with respect to any action taken or foregone by Trustee in good faith in reliance on such document;

2.2.8 To deposit the Trust Account assets, after reduction for Trustee's accrued fees and expenses, in an interest bearing passbook savings account with Trustee's commercial department requiring the signatures of Company, should Company not appoint a successor trust holder for the Trust Account within fifteen (15) days following the resignation or removal of Trustee;

2.2.9 To be fully released and discharged from any obligation to perform any further duties imposed upon it with respect to this Trust Account following its resignation or removal and the appointment of a successor or the deposit of the Trust Account assets under Paragraph 2.2.8, above; and

2.2.10 To be free from any liabilities or change in duties, other than as may be specifically described elsewhere herein, for the action or inaction of a party to this Agreement, or any other party, or the occurrence or non-occurrence of an event outside of this Trust.

ARTICLE III
INVESTMENT OF THE TRUST FUND

3.1 Permitted Investments. The Trustee shall invest and reinvest the principal and accumulated income of the Trust Account in one or more federally-insured Certificates of Deposit or U.S.

Government Treasury Bills through a federally-insured bank (including the Trustee).

3.2 Trustee Not Responsible For Investment Advice. The Trustee assumes no responsibility for advising the Company, or its Representative, with respect to the investment and reinvestment of the Trust Account. The Trustee shall as promptly as possible comply with any direction given by the Company or its Representative; provided, however, that the Trustee shall have no duty to take any action which, in the Trustee's opinion, would expose the Trustee to liability unless and until the Company indemnifies the Trustee to its satisfaction. The Trustee shall neither be liable in any manner nor for any reason for any losses or other unfavorable investment results arising from its compliance with such direction, nor be liable for failing to invest any assets of the Trust Account in the absence of written investment directions regarding such assets.

3.3 Delegation of Responsibility and Authority for Investment of Trust Account. The Company may by written resolution delegate its authority over the investments of the Trust Account to its designated representative ("Representative"), and Trustee shall accept Representative's instructions to invest and reinvest the assets of all or any portion of the Trust Account. The Company may revoke the delegation of any such investment responsibility and authority by written notice to the Trustee, and Representative may relinquish such responsibility and authority by written notice to the Company and Trustee.

3.4 Notification of Rights Regarding Securities. Following receipt of information, the Trustee will notify the Company of any conversion, redemption, exchange, subscription or other right relating to any securities purchased hereunder of which notice was given after the acquisition of such securities by the Trustee, and the Trustee shall have no obligation to exercise any such right unless it is instructed by the Company or its Representative in writing to exercise such right, within a reasonable time prior to the expiration of such right.

3.5 Uninvested Cash. Subject to the directions of the Company, or its Representative, the Trustee may hold any or all of the Trust Account in cash, uninvested and nonproductive of income. The Trustee shall not be required to pay interest on any cash so held uninvested. The Trustee may deposit cash awaiting investment or distribution in any interest-bearing account in any Bank (including the Trustee), subject to the collateral requirements set forth in Section 3.1 above.

3.6 Shareholder Communications. The Company directs the Trustee not to disclose to any company requesting shareholder information the name and the address of the Company or the share position of the securities of the inquiring company in the Trust Account.

ARTICLE IV
TRUSTEE NOTICES AND INSTRUCTIONS

4.1 Instructions; Notices. Except as hereafter provided, any directions, instructions or notices which the Company or any other duly authorized person is required or permitted to give to the Trustee under this Agreement (the "Instructions") shall be in writing and shall be deemed effective upon receipt by the Trustee; provided, however, that the Trustee in its discretion may act upon oral Instructions if it believes them to be genuine, but the Trustee shall not be required to do so. If the Trustee requires, all oral Instructions are to be promptly confirmed in writing, but the Trustee shall not be liable for any action or any failure to act in accordance with oral Instructions, even though it fails to receive written confirmation from the Company. The Trustee shall be provided with specimen signatures of the authorized representatives of the Company. The Trustee shall be entitled to rely in good faith upon any Instructions signed by any authorized representative of the Company, and shall incur no liability for following such directions. Any written notices, affidavits or other communications hereunder shall be deemed to have been duly given if delivered or mailed first class, certified mail, postage prepaid, addressed as follows:

City National Bank, national association
Attn: Sue Behning/VP
1950 Avenue of the Stars, 2nd floor
Los Angeles, CA 90067
Tel: (310) 282-2921
Fax: (310) 282-2936

Southern California Edison Company
Attn: Tim Bint, Cash Manager
2244 Walnut Grove Ave., Quad 2A - 210
Rosemead, CA 91770
Tel: (626) 302-4476
Fax: (626) 302-6823

4.2 Photostatic Teletransmission. The transmission of the Instructions by photostatic teletransmission with duplicate or facsimile signatures shall be an authorized method of communication until the Trustee is notified by the Company to the contrary.

4.3 Electronic Affirmation. Notwithstanding any other provision of this Article IV, the Trustee may settle securities trades effected by the Company through a securities depository that utilizes an institutional delivery system, in which event the Trustee may deliver or receive securities in accordance with appropriate trade reports or statements given to the Trustee by such depository without having received direct communications or instructions from the Company.

4.4 Additional Instructions. In any matter under this Agreement in which the Trustee is permitted or required to act upon Instructions, the Trustee, where it deems necessary, may request further Instructions from the person or entity giving the original instructions, or from the Company, as the case may be, and may defer any and all action pending receipt thereof.

ARTICLE V
COMPENSATION AND EXPENSES OF THE TRUSTEE

5.1 Trustee's fees will be as set forth on the fee schedule attached hereto, plus actual expenses incurred in performing its duties hereunder, and Trustee is hereby granted a lien on the Trust Account for such amounts. Any setup fee will be payable in advance. In addition, Trustee will receive its usual sweep fee for any Trust Account assets, which are invested in a sweep vehicle selected by the Company. Unless other payment arrangements are set forth herein or are agreed to by Trustee in writing, Trustee may disburse from the Trust Account sufficient funds to pay its compensation and expenses. If at any time cash is not available in the Trust Account to pay the Trustee's compensation and expenses, then Trustee may bill Company for such amounts. The fee schedule will be subject to periodic revision as the Company and the Trustee shall mutually agree.

ARTICLE VI
RECORDS AND ACCOUNTS

6.1 Accurate Records and Accounts. The Trustee shall keep accurate records and accounts with respect to all cash and other assets held by it in the Trust Account, and all receipts and disbursements and other transactions involving such cash, securities and other assets. The Company shall have access to all such accounts, books and records at all reasonable times. All such accounts, books and records shall be open for inspection and audit at all reasonable times by the Company or by any person or persons duly authorized by the Company.

6.2 Periodic Reports. The Trustee shall furnish the Company and any third party with such periodic reports, as the Company and the Trustee shall mutually agree, setting forth all receipts, disbursements and transactions effected by the Trustee.

6.3 Principal and Income. Except as otherwise specifically provided in this Agreement, the determination of all matters with respect to what is principal or income of the Trust Account and the apportionment and allocation of receipts and disbursements between these accounts (if any), shall be governed by the provisions of the California Revised Uniform Principal and Income Act from time to time existing. Any such matter not provided for herein or in the California Revised Uniform Principal and Income Act shall be determined by the Trustee in the Trustee's discretion.

6.4 Income Tax Reporting: Company assumes all duty to file any and all tax reports and returns, except as noted below, as well as full responsibility for the payment of all taxes assessed on or with respect to any Trust Property and all taxes due on the income collected for Company on any and all transactions with respect to any Trust Property. For purposes of IRS Form 1099 which Trustee may be required to prepare and file, all reportable income shall be reported to the IRS as being attributable to Company.

ARTICLE VII
RESIGNATION AND REMOVAL OF THE TRUSTEE

7.1 Resignation and Removal. The Trustee may resign at any time upon thirty- (30) days' written notice to the Company, unless a shorter period is acceptable to the Company. The Company may at any time remove the Trustee upon thirty- (30) days' written notice to the Trustee, unless a shorter period is acceptable to the Trustee.

7.2 Appointment of Successor. In the event of the removal or resignation of the Trustee, the Company shall, by the earlier to occur of either (i) 30 days after removal or resignation of the Trustee or (ii) prior to the date of the next disbursement of funds necessary for proper storm water sump monitoring and maintenance, consistent with Special Condition 2 of Coastal Development Permit E-00-014, appoint a successor which, upon its acceptance in writing of such appointment delivered to the Company and the former Trustee, shall be vested with all the rights, powers and duties of the Trustee under this Agreement, and the retiring Trustee shall be released and discharged from all further liability with respect to the Trust. The retiring Trustee shall transfer, assign and deliver to its successor all of the property then held by it under the Agreement, except such reasonable compensation and expenses in connection with the settlement of accounts and the delivery of the assets to the successor Trustee. After settlement of the retiring Trustee's final accounting, the retiring Trustee shall also transfer to the successor Trustee true copies of its records as relate to the Trust Account, as may be requested by the successor Trustee. The successor Trustee shall not be liable or responsible for anything done or omitted in the administration of the Trust Account pursuant to this Agreement prior to the date it shall have become Trustee, nor to audit or otherwise inquire into or take any action concerning the acts of any retiring Trustee.

7.3 Final Periodic Report. Within sixty (60) days after the transfer of the assets of the Trust Account to the successor Trustee, unless a different period is mutually agreed to, the Trustee shall file with the Company a final periodic report, covering the period since the close of the last periodic report.

7.4 Deemed Acceptance. In the absence of any exception thereto filed in writing with the Trustee within ninety (90) days after the date of filing with the Company, any periodic report filed with the Company shall constitute a final periodic report by and discharge of the Trustee from all claims and liabilities with respect to the acts and transactions as shown in such report, and shall be binding and conclusive upon all persons.

ARTICLE VIII
AMENDMENT AND TERMINATION

8.1 Amendment. This Agreement may be modified at any time by writing signed by the Parties.

8.2 Termination. The Agreement may be terminated at anytime by the Company with the express written consent of the Executive Director of the California Coastal Commission, consistent with the requirements of coastal development permit E-00-014. Should the Company decide to terminate this Agreement, it shall provide written notice of intent to terminate, together with evidence of the Executive Director of the California Coastal Commission's consent, to the Trustee no less than thirty (30) days prior to the desired termination date, provided, however, that this Agreement shall continue thereafter for such period as may be necessary for the complete divestiture of all cash, securities and other instruments held hereunder by the Trustee, but solely to the extent necessary to effect such complete divestiture. Upon such termination, all assets remaining in the Trust Account after payment of all expenses properly chargeable thereto shall be paid or distributed in accordance with written directions of the Company. Unless sooner terminated in accordance with other provisions hereof, any Trust created hereunder shall terminate December 31, 2022.

8.3 Final Periodic Report. Within sixty (60) days after the termination of the Trust Account, unless a different period is mutually agreed to by the Parties, the Trustee shall file with the Company a final periodic report, covering the period since the close of the last periodic report.

8.4 Deemed Acceptance. In the absence of any exception thereto filed in writing with the Trustee within ninety (90) days after the date of filing with the Company, any periodic report filed with the Company shall constitute a final periodic report by and discharge of the Trustee from all claims and liabilities with respect to the acts and transactions as shown in such report, and shall be binding and conclusive upon all persons.

8.5 Notification to the California Coastal Commission. The Trustee shall within three (3) business days of its sending or receiving amendments, termination notices and/or periodic reports under this Agreement, give copies thereof to the Executive Director of the California Coastal Commission. Such copies shall be deemed to have been duly given if delivered or mailed first class, certified mail, postage prepaid, addressed as follows:

California Coastal Commission
Attn: Executive Director
45 Fremont Street, Suite 2000
San Francisco, CA 94105-2219
Tel: (415) 904-5200
Fax: (415) 904-5400

ARTICLE IX
LIMITATION ON LIABILITY

9.1 Liability of Trustee. In performing any duties under this Agreement, Trustee shall not be liable for any damages, losses, or expenses, except for gross negligence or willful misconduct on the part of the Trustee. Trustee shall not incur any liability for: (a) any act or failure to act made or omitted in good faith, or (b) any action taken or omitted in reliance upon any instrument, including any written statement or affidavit provided for in this Agreement that the Trustee shall in good faith believe to be genuine, nor will the Trustee be liable or responsible for forgeries, fraud, impersonations or determining and verifying the scope of any representative authority, or any person acting or purporting to act on behalf of any party to this Agreement.

9.2 Indemnification by Company. Except to the extent attributable to Trustee's liability as set forth in Section 9.1 herein, Company further agrees to pay on demand, and to indemnify and hold Trustee harmless from and against, all costs, damages, judgments, attorneys fees, expenses, obligations and liabilities of any kind or nature which, in good faith, Trustee may incur or sustain in connection with or arising out of the Agreement, and Trustee is hereby given a lien upon all the rights, titles and interests of the Company in the Trust Account, to protect Trustee's rights and to indemnify and reimburse Trustee under this Agreement.

9.3 Force Majeure. The Trustee shall not be liable for any delay or failure to act as may be required hereunder when such delay or failure is due to fire, earthquake, any act of God, interruption or suspension of any communication or wire facilities or services, war, emergency conditions or other circumstances beyond its control, provided it exercises such diligence as the circumstances may reasonably require.

9.4 Scope. The Trustee shall have no duties or obligations hereunder except those specifically set forth herein, and such duties and obligations shall be determined solely by the express provisions of this Agreement.

9.5 Controversies.

9.5.1 Upon receipt of conflicting demands or notices relating to this Agreement, Trustee may, at its election, without liability to Company, do either or both of the following:

9.5.1.1 Withhold and stop all further proceedings in, and performance of, this Agreement, until such conflict is removed to Trustee's satisfaction;

9.5.1.2 File a suit in interpleader and obtain an order from the court requiring the parties to litigate their several claims and rights among themselves, in which case, Trustee shall be fully released and discharged from any obligation to perform any further duties imposed upon it with respect to this Agreement, and the parties shall pay Trustee all costs, expenses and reasonable attorney fees expended or incurred by it, the amount thereof to be fixed and a judgment thereof to be rendered by the court in such suit.

9.5.2 Any dispute arising out of or relating to this Agreement, including a breach of this Agreement, will be decided by reference under California Code of Civil Procedure Section 638 and related sections. A referee, either an active attorney or retired judge, will be selected according to the procedures of the American Arbitration Association and then appointed by the court in which the action regarding the dispute or controversy originated. The dispute will be submitted to the referee for determination in place of a trial before a judge and jury.

9.6 Legal Counsel. The Trustee may consult with, and obtain advice from, legal counsel of its own selection as to the construction of any of the provisions of this Agreement or the Trustee's obligations and duties, and shall incur no liability in acting in good faith in accordance with the reasonable advice and opinion of such counsel.

ARTICLE X
MISCELLANEOUS

10.1 Governing Law. This Agreement shall be governed, construed, regulated and administered under the laws of the State of California.

10.2 Invalid Provisions. It is not the intention of the Parties to violate any statute, regulation, ruling, judicial decision, or other legal provision applicable to this Agreement or the performance thereof. If any term of this Agreement, or any act or omission in the performance thereof, is or becomes violative of any such provision, such term, act or omission shall be of no force or effect and any such term shall be severed from this Agreement. Any such invalid term, act or omission shall not affect the validity of any other term of this Agreement that is otherwise valid, nor the validity of any otherwise valid act or omission in the performance thereof, unless such invalidity prevents accomplishment of the objectives and purposes of this Agreement. In the event any such term, act or omission is determined to be illegal or otherwise invalid, the necessary steps to remedy such illegality or invalidity shall be taken immediately by the Parties.

10.3 Counterparts. This Agreement may be executed in several counterparts, each of which shall be deemed an original, and said counterparts shall constitute but one and the same instrument, which may be sufficiently evidenced by any one counterpart.

10.4 Successors and Assigns. This Agreement shall inure to the benefit of, and be binding upon, the Parties hereto and their successors and assigns, except as is expressly provided to the contrary herein.

IN WITNESS WHEREOF, the Parties hereto have caused this Agreement to be executed by their respective duly authorized officers on the dates set forth below.

COMPANY
Southern California Edison Company

Date: __________

By ____________________________

Title: ____________________________

TRUSTEE
City National Bank, national association

Date: __________

By ____________________________

Title: ____________________________

TRUST ACCOUNT #: ________________