Includes Errata dated June 5, 1981.

NUREG-0490

Final Environmental Statement
related to the operation of San Onofre Nuclear Generating Station, Units 2 and 3

Docket Nos. 50-361 and 50-362

Southern California Edison Company
San Diego Gas & Electric Company
The City of Riverside
The City of Anaheim

U.S. Nuclear Regulatory Commission

Office of Nuclear Reactor Regulation

April 1981

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

JUN 5 1981

Docket Nos.: 50-361/362

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Gentlemen:

SUBJECT: ISSUANCE OF ERRATA TO FINAL ENVIRONMENTAL STATEMENT (SAN ONOFRE NUCLEAR GENERATING STATION, UNITS 2 AND 3)

The Nuclear Regulatory Commission has issued the enclosed errata to the Final Environmental Statement (FES) related to the San Onofre Nuclear Generating Station, Units 2 and 3. Although implicit in the FES, this errata clarifies the staff's consideration of reasonable alternatives to the proposed action. The enclosed discussion should be added to Section 10.1.

Sincerely,

Frank J. Miraglia

Frank J. Miraglia, Acting Chief
Licensing Branch No. 3
Division of Licensing

Enclosure:
Errata (20 copies)

cc: See next page.

ERRATA

FINAL ENVIRONMENTAL STATEMENT

SAN ONOFRE NUCLEAR GENERATING STATION, UNITS 2 AND 3

ALTERNATIVES TO THE PROPOSED ACTION

During the construction permit stage, the staff analyzed alternative sites, plant designs, and methods of power generation, including the alternative of not adding the production capacity. The staff concluded, based on its analysis of these alternatives, as well as on a cost-benefit basis, that additional capacity was needed that a nuclear-fueled plant would be environmentally acceptable, and that SONGS, at a specified site and of a specified design, were acceptable from both economic and environmental perspectives. Since that time, construction of SONGS has been nearly completed and many of the economic and environmental costs associated with the construction of the facility have already been incurred and must be viewed as "sunk costs" in any prospective assessment.

The staff believes that the only reasonable alternative to the proposed action of issuance of operating licenses for SONGS appropriately considered at this stage is denial of the operating licenses for the facility, thereby not permitting the addition of the essentially built generating capacity to the applicant's generating system. Alternatives such as construction of the units at another site, extensive modifications to the facility, or construction of facilities utilizing different energy sources would each require additional construction activity with its accompanying economic and environmental costs. Therefore, unless major safety or environmental concerns resulting from operation of SONGS are revealed that were not evident and considered during the construction permit review, these alternatives are unreasonable as compared to operating the already constructed facility. No such concerns have been identified with respect to operation of SONGS.

The continued need for the capacity to be generated by SONGS is discussed in section 8 of this FES.

Accordingly, the staff concludes that the preferrable alternative is operation of SONGS.

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NUREG-0490

Final Environmental Statement

related to the operation of San Onofre Nuclear Generating Station, Units 2 and 3

Docket Nos. 50-361 and 50-362

Southern California Edison Company
San Diego Gas & Electric Company
The City of Riverside
The City of Anaheim

U.S. Nuclear Regulatory Commission

Office of Nuclear Reactor Regulation

April 1981

SUMMARY AND CONCLUSIONS

This Environmental Statement was prepared by the U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation (hereinafter referred to as the staff).

1. The action is administrative.

2. The proposed action is the issuance of Operating Licenses jointly to the Southern California Edison Company (SCE) and the San Diego Gas and Electric Company (SDG&E) for the startup and operation of Units 2 and 3 of the San Onofre Nuclear Generating Station, adjacent to San Onofre Unit 1, located on the Pacific coast in the State of California, County of San Diego (Docket Nos. 50-361 and 50-362).

   The City of Anaheim, California, and the City of Riverside, California, have recently been added as co-holders of the Construction Permits for San Onofre 2 and 3, and will soon request to be included as applicants for Operating Licenses. The four groups are co-owners of the facility, and are referred to herein as the applicant.

   Both units will employ pressurized water reactors to produce up to 3410 thermal megawatts (MWt) each. Steam turbine-generators will use this heat to provide a net power output of up to 1106 electrical megawatts (MWe) each. The exhaust steam will be cooled by once-through flow of water pumped from the Pacific Ocean and returned to it through a diffuser-type system.

3. The information in this statement represents the second assessment by the staff of the environmental impacts associated with the San Onofre Nuclear Generating Station, Unit Nos. 2 and 3, pursuant to the requirements of the National Environmental Policy Act (NEPA) of 1969 and 10 CFR Part 51 of the Commission's Regulations. After receipt of an application (1970) to construct this plant, the staff carried out a review of impacts that would occur during the construction and operation of this plant. This evaluation was issued as a Final Environmental Statement in March 1973. As a result of this environmental review, a staff safety review, an evaluation by the Advisory Committee on Reactor Safeguards, and a public hearing in San Diego, California during January 16-24, 1973 and May 14-22, 1973, and in San Clemente, California, during March 13-15, 1973, the U.S. Atomic Energy Commission (AEC) [now Nuclear Regulatory Commission (NRC)] issued permits in October 1973 for the construction of Units 2 and 3. As of December 1980, Unit 2 was approximately 97% complete and Unit 3 was approximately 68% complete. The applicant has applied for licenses to operate the nuclear units and has submitted the required safety and environmental reports to support this application (March 1977). The staff has reviewed the activities associated with the proposed operation of these units and their potential impacts, both beneficial and adverse, are summarized as follows:

   a. Cooling water heated to about 11°C (20°F) above inlet temperature will be discharged from each unit to the Pacific Ocean at a rate of about 53 m^3/s (846,000 gpm) (Sect. 3.2.2). The heated water may result in the destruction of at least a portion of the San Onofre Kelp Bed during the summer months. However, the long-term thermal impacts are not likely to be severe (Sect. 5.4.2.1) and violations of the state thermal standards are unlikely (Sect. 5.3.1).

   b. An impact on aquatic resources may occur in the cooling water intake structure through entrainment of plankton and impingement of fish. These losses are not expected to have a significant impact on the overall biotic populations in the area.

   c. Chemical effluents from Units 2 and 3 should cause only minimal impact in the area of the discharge, and no significant impact on the aquatic biota in the Pacific Ocean (Sect. 5.4.2.2).

   d. The program for operation and maintenance of transmission lines has been designed to reduce environmental impact. Existing transmission lines and towers will be used where possible. About 7.2 ha (17.8 acres) will be occupied by new towers, access roads, and switchyards (Sect. 2.2.2).

   e. About 16 ha (40 acres) of coastal land which could otherwise have been used primarily for recreation or maintained as wildlife habitat will be occupied by Units 2 and 3 (Sect. 2.2.2).

f. The removal of approximately 1.4 km (0.85 mile) of beach from unrestricted public use, as required by the Construction Permit, is a significant cost of operation.

g. No detectable impacts are anticipated from releases of radioactive materials as a consequence of normal operation (Sect. 5.5.1.6).

h. The risk associated with accidental radiation exposure is very low (Sect. 7).

i. Nothing of known local historic or archaeological interest will be disturbed on the plant site by the operation of Units 2 and 3. A survey along the transmission right-of-way evaluated 41 archaeological sites; of these 23 will be nominated for inclusion in the National Register of Historic Places (Sect. 5.2).

4. The following Federal and State agencies were asked to comment on the Draft Environmental Statement:

- Department of Agriculture
- Department of the Army (Corps of Engineers)
- Department of Commerce
- Department of Energy
- Department of the Interior
- Department of Health, Education and Welfare
- Department of Housing and Urban Development
- Department of Transportation
- Environmental Protection Agency
- Federal Energy Regulatory Commission
- Advisory Council on Historic Preservation
- California Department of Health (Water Pollution Control Commission, Air Pollution Control Commission, Occupational Health Office)
- California Department of Natural Resources
- California Department of Parks and Recreation

Comments on the Draft Environmental Statement were received from the following:

- Department of Agriculture, Economics, Statistics, and Cooperatives Service
- Department of Agriculture, Science and Education Administration
- Department of Agriculture, Soil Conservation Service
- Department of the Army, Corps of Engineers
- Department of Commerce
- Department of Energy, Federal Energy Regulatory Commission
- Department of Health, Education and Welfare
- Department of Housing and Urban Development
- Department of the Interior
- Environmental Protection Agency
- Mr. Marvin I. Lewis
- Rourke and Woodruff Law Offices
- Richard J. Wharton
- Union of Concerned Scientists
- Southern California Edison Company
- Frank H. Grundel
- San Diego Association of Governments

Copies of these comments are appended to this Final Environmental Statement as Appendix A. The staff has considered these comments, and the responses are located in Section 11.

5. This Final Environmental Statement was made available to the public, to the Environmental Protection Agency, and to other specified agencies in April 1981.

6. On the basis of the analysis and evaluation set forth in this statement, and after weighing the environmental, economic, technical and other benefits against environmental costs and after considering available alternatives at the construction stage, it is concluded that the action called for under NEPA and 10 CFR Part 51 is the issuance of operating licenses for Units 2 and 3 of the San Onofre Nuclear Generating Station subject to the following conditions for the protection of the environment:

   (A) License Conditions
   Before engaging in activities that may result in a significant adverse environmental impact that was not evaluated or that is significantly greater than evaluated in this Environmental Statement, the licensee shall provide written notification of such activities to the Office of Nuclear Reactor Regulation and receive written approval from that office before proceeding with such activities.

   (B) Significant Environmental Technical Specification Requirements

      (1) If, during the operating life of the Station, effects or evidence of potential irreversible damage are detected, the licensee will provide to the staff an analysis of the problem and a proposed course of action to alleviate the problem.

      (2) The licensee will carry out the operational environmental monitoring programs outlined in Section 6.

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FOREWORD

This environmental statement was prepared by the U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation (hereinafter referred to as the staff) in accordance with the Commission's regulations, 10 CFR 51, which implement the requirements of the National Environmental Policy Act of 1969 (NEPA).

The NEPA states, among other things, that it is the continuing responsibility of the Federal government to use all practicable means, consistent with other essential considerations of national policy, to improve and coordinate Federal plans, functions, programs, and resources to the end that the Nation may:

- Fulfill the responsibilities of each generation as trustee of the environment for succeeding generations.
- Assure for all Americans safe, healthful, productive, and aesthetically and culturally pleasing surroundings.
- Attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences.
- Preserve important historic, cultural, and natural aspects of our national heritage, and maintain, wherever possible, an environment that supports diversity and variety of individual choice.
- Achieve a balance between population and resource use which will permit high standards of living and a wide sharing of life's amenities.
- Enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources.

Further, with respect to major Federal actions significantly affecting the quality of the human environment, Sect. 102(2)(C) of the NEPA calls for preparation of a detailed statement on:

(i) the environmental impact of the proposed action;

(ii) any adverse environmental effects which cannot be avoided should the proposal be implemented;

(iii) alternatives to the proposed action;

(iv) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity; and,

(v) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

An environmental report accompanies each application for a construction permit or for a full-power operating license. A public announcement of the availability of the report is made. Any comments by interested persons on the report are considered by the staff. In conducting the required NEPA review, the staff meets with the applicant to discuss items of information in the environmental report, to seek new information from the applicant that might be needed for an adequate assessment, and generally to ensure that the staff has a thorough understanding of the proposed project. In addition, the staff seeks information from other sources that will assist in the evaluation and visits and inspects the project site and surrounding vicinity. Members of the staff may meet with state and local officials who are charged with protecting state and local interests. On the basis of all the foregoing and other such activities or inquiries as are deemed useful and appropriate, the staff makes an independent assessment of the considerations specified in Sect. 102(2)(C) of the NEPA and 10 CFR Part 51.

This evaluation leads to the publication of a draft environmental statement, prepared by the Office of Nuclear Reactor Regulation, which is then circulated to Federal, state, and local governmental agencies for comment. A summary notice of the availability of the applicant's environmental report and the draft environmental statement is published in the Federal Register. Interested persons are also invited to comment on the proposed action and on the draft statement.

After receipt and consideration of comments on the draft statement, the staff prepares a final environmental statement, which includes a discussion of questions and concerns raised by the comments and the disposition thereof; a final benefit-cost analysis, which considers and balances the environmental effects of the facility and the alternatives available for reducing or avoiding adverse environmental effects with the environmental, economic, technical, and other benefits of the facility; and a conclusion as to whether – after the environmental, economic, technical, and other benefits are weighed against environmental costs and after available alternatives have been considered – the action called for, with respect to environmental issues, is the issuance or denial of the proposed permit or license or its appropriate conditioning to protect environmental values. This final environmental statement and the safety evaluation report prepared by the staff are submitted to the Atomic Safety and Licensing Board for its consideration in reaching a decision on matters in controversy regarding the application. The same format as used in the Draft Environmental Statement is used in this Final Statement to facilitate its review.

This environmental review deals with the impact of operation of San Onofre Nuclear Generating Station Units 2 and 3 (SONGS 2 & 3). Assessments that are found in this statement supplement or modify those described in the Final Environmental Statement (FES-CP) that was issued in March 1973 in support of issuance of construction permits for the units. The information found in the various sections of this Statement updates the FES-CP in four ways: (1) by identifying differences between environmental effects of operation (including those which would enhance as well as degrade the environment) currently projected and the impacts that were described in the preconstruction review, (2) by reporting the results of studies that had not been completed at the time of issuance of the FES-CP and that were required by the NRC staff to be completed before initiation of the operational review, (3) by evaluating the applicant's preoperational monitoring program and by factoring the results of this program into the design of a postoperational surveillance program and into the development of environmental technical specifications, and (4) by identifying studies being performed by the applicant that will yield additional information relevant to the environmental impacts of operating SONGS 2 & 3.

Copies of this statement are available for inspection at the Commission's Public Document Room, 1717 H Street, N.W., Washington, D.C.; the Mission Viejo Branch Library, 24851 Chrisanta Drive, Mission Viejo, California; and the NRC Office of Inspection and Enforcement, 1990 N. California Boulevard, Walnut Creek, California. Copies of this statement may be obtained as indicated on the inside front cover. Mr. Dino C. Scaletti is the NRC Project Manager for this statement. Mr. Scaletti may be contacted at (301) 492-8443.

1. INTRODUCTION

1.1 HISTORY

On May 28, 1970, the Southern California Edison Company and the San Diego Gas and Electric Company filed an application with the Atomic Energy Commission (now Nuclear Regulatory Commission) for permits to construct San Onofre Nuclear Generating Station Units 2 and 3 (SONGS 2 & 3). Construction Permits Nos. CPPR-97 (Unit 2) and CPPR-98 (Unit 3) were issued on October 18, 1973, following reviews by the AEC regulatory staff and the Commission's Advisory Committee on Reactor Safeguards, as well as a public hearing before an Atomic Safety and Licensing Board in San Diego and San Clemente, California on January 16 to 24, March 13 to 15, and May 14 to 22, 1973. An additional session of the hearing was held in Los Angeles, California on May 19, 20, and 21, 1976. The conclusions reached in the staff's environmental review were issued in a Final Environmental Statement (FES-CP) in March 1973.

As of December 1980, construction of Unit 2 was about 97% complete and construction of Unit 3 was about 68% complete. Each unit has a pressurized-water reactor that will produce up to 3410 MWt and a net electrical output of up to 1106 MWe.

In November 1976 Southern California Edison Company and San Diego Gas and Electric Company submitted an application including a Final Safety Analysis Report (FSAR) and Environmental Report (ER) requesting issuance of operating licenses for Units 2 and 3. These documents were docketed on March 22, 1977, and the operational safety and environmental reviews were initiated at that time.

The City of Anaheim, California, and the City of Riverside, California have recently been added as co-holders of the Construction Permits for San Onofre 2 and 3 and will soon request to be included as applicants for Operating Licenses. The four groups are co-owners of the facility and are referred to herein as the applicant.

1.2 PERMITS AND LICENSES

The applicant has provided a status listing of environmentally related permits, approvals, licenses, etc., which are required from Federal, regional, state, and local agencies in connection with the proposed project (ER, Sect. 12). The staff has reviewed that listing. An amendment to the permit from the California Coastal Commission may be required to obtain approval for the modified exclusion area plan. The staff is not aware of any other potential non-NRC licensing difficulties that would significantly delay or preclude the proposed operation of the plant.

2. THE SITE

2.1 RESUME

The staff visited the SONGS site in May 1977 primarily to determine what changes had occurred at the site and in surrounding areas since the preconstruction environmental review in late 1972. In addition, more detailed information about the operation of SONGS 2 & 3 was obtained as a result of this visit.

Population distribution estimates have been updated and extended to the year 2020. The major land use change has been the construction of the plant itself. Transmission line routes have undergone some changes.

An updated description of the surface-water hydrology is given in Sect. 2.3.1.

The section on meteorology has been revised to include the results of recent observations.

Considerable additional field work and sampling is reflected in the description of terrestrial and aquatic ecology in Sect. 2.5.

2.2 REGIONAL DEMOGRAPHY AND LAND USE

2.2.1 Population change

Population for 1976 by sectors within 80 km (50 miles) of the plant and the projected population estimates to the year 2020 are provided in Tables 2.1-2 through 2.1-15 of the ER. The population within a 16-km (10-mile) radius of the site in 1976 was 57,241. By 1980 this population was expected to increase to 67,547 - an annual growth rate of 4.2% (ER, Sect. 2.1.3.2.1). The major cities in the area and their 1975 populations are San Clemente (20,794), 6.4 km (4 miles) northeast; San Juan Capistrano (13,658), 16.8 km (10.5 miles) northwest; Oceanside (54,900), 27.2 km (17 miles) southeast; and San Diego (1,518,000), 81.6 km (51 miles) southeast. Table 2.1 provides 1976 population data by sector within 16 km (10 miles) of the site.

Table 2.1. Population by sector and distance with 10 miles of San Onofre site (1976)

Sector	Distance (miles)						
	0 to 1	1 to 2	2 to 3	3 to 4	4 to 5	5 to 10	Total 0 to 10
W	0	0	0	0	0	0	0
WNW	0	0	0	0	0	0	0
NW	0	656	54	3532	5298	21,979	31,519
NNW	0	732	630	0	0	6,541	7,903
N	0	0	0	4300	0	519	4,819
NNE	0	0	0	0	0	0	0
NE	0	0	4600	0	0	0	4,600
ENE	0	0	0	0	0	0	0
E	0	0	0	0	4300		4,300
ESE	0	0	0	0	0	3,100	3,100
SE	0	0	0	0	0	1,000	1,000
SSE	0	0	0	0	0	0	0
Total	0	1388	5284	7832	9598	33,139	57,241

Source: ER, Table 2.1-2.

(To convert miles to kilometers, multiply by 1.6.)

Table 2.2 presents projected population and annual growth rates within 16 km (10 miles) of the plant between 1976 and 2020. The total percentage change in population for the area between 1976 and 2020 is projected to be 99.4%. These projections are based on surveys made by the Southern California Association of Governments, the Comprehensive Planning Organization of San Diego County, the California State Department of Finance, and the applicant (ER, Sect. 2.1.3.2.3).

Table 2.2. Projected population and annual growth rate within 16 km of the San Onofre site

Year	Projected population	Annual growth[a] (%)		Change (%)
1976	57,241	4.2		
1980	67,547			
1980	67,547	2.9		
1990	89,521			
1990	89,521	0.3	1.6	99.4
2000	91,949			
2000	91,949	1.0		
2010	101,945			
2010	101,945	1.1		
2020	114,139			

[a]Compounded annually.

Source: Adapted from ER, Table 2.1-8.

2.2.2 <u>Changes in land use</u>

Since issuance of the FES-CP in 1973, the construction of SONGS 2 & 3 is the only major change in land use in the site vicinity. Site preparation required the excavation of 16.39 ha (40.5 acres) of the San Onofre Bluffs, which otherwise could be used primarily for recreation. Most of this material was deposited on 34 ha (84 acres) at Japanese Mesa, a relatively flat area just north and across Interstate 5 from the site on Camp Pendleton Marine Base (ER, Sect. 4.1.2). In addition, about 304.8 m (1000 ft) of beach front has remained closed except as a passageway during the construction period (ER, Appendix 12-B, p. 7).

The area within an 8-km (5-mile) radius of the site occupies parts of two counties. The part of this area that lies in Orange County is entirely within San Clemente. The predominant land use in San Clemente is single family residential, light commercial, and recreational. Industrial land use in San Clemente is limited to light industry only. Because the available developable land is steep, future development in that area is expected to be slow with only low residential densities permitted by the city (ER, Sect. 2.1.4.3.1). In San Diego County, the 8-km (5-mile) radius area lies within Camp Pendleton Marine Base. About 95% of Camp Pendleton is unimproved land that is used for military purposes, recreation, and conservation (FES-CP, Sect. 2.2.2). Figure 2.1-12 of the ER provides a detailed land use map of the area within an 8-km (5-mile) radius of the site.

Heavy-haul components for the plant arrive by barge or by vessel at the Del Mar Boat Basin near Oceanside, about 22.5 km (14 miles) south of the site (ER, Suppl. 2, Item 37). The haul route, which was not available at the time the FES-CP was issued, required that a road be cut through the bluffs between the beach and Highway 101, about 11 km (7 miles) north of the Del Mar Boat Basin (ER, Suppl. 2, Item 37).

The description of the transmission lines as presented in Sect. 3.7 of the FES-CP has been modified (Sect. 3.2.5). No new rights-of-way were required: about 5.2 ha (12.8 acres) will be used for new tower bases and for access-road extensions, and 2 ha (5 acres) of land will be covered by the Talega Substation (ER, Suppl. 2, Item 36). Three changes in land use adjacent to the San Onofre-Santiago transmission line route have occurred since the issuance of the FES-CP: (1) construction of a paved road immediately adjacent to a significant portion of the proposed transmission line, (2) bulldozing of a firebreak adjacent to the transmission line on Camp Pendleton Marine Base, and (3) active operation of a large aggregate borrow site adjacent to the line in a third location (ER, Appendix 6A).

2.2.3 Changes in the local economy

Construction activity peaked in late 1979 with an estimated work force of about 3000. The applicant has estimated, after discussions with officials of the labor unions represented at SONGS 2 & 3, that 20%, or about 600 workers, relocated to the southern California area from other parts of the country (ER, p. S.2-167). Although all union craft workers at the site were hired from unions located within a 96-km (60-mile) radius of the site, all of the workers who relocated were travel card members who were assigned by the local unions to SONGS 2 & 3 after the local list was exhausted. Because the construction workers lived throughout the metropolitan areas of San Diego, Orange County, and Los Angeles, the impact of the workers' income was diffuse.

From 1974 through 1976 the applicant estimated that about $4.1 million was spent within a 48-km (30-mile) radius of the site for materials and services. These expenditures accounted for about 0.2% of the total forecast plant cost (ER, p. S.2-174).

2.3 WATER USE

2.3.1 Surface-water hydrology

The only significant water resource in the vicinity of SONGS is the Pacific Ocean. A few streams are located near the site, but these are intermittent.

The currents in the San Onofre vicinity are a superposition of many effects. This current system can be decomposed into individual components. The two most persistent components are the California Current and the tides.

The California Current is evident close to shore and north of Point Conception. However, south of this point the coastline recedes to the east, and water is available for entrainment from the east side of the current. This entrainment tends to make the California Current more diffuse south of Point Conception. Furthermore, the effect of this entrainment in addition to upwelling, winds, and baroclinic instabilities[1] can produce a counter-rotating eddy through the Channel Islands which is known as the Southern California Eddy; the nearshore northward flowing current is the Southern California Countercurrent. Observations indicate that this eddy can exist year-round; however, it is strongest in the fall and in the early winter.

Tides along the California coast are a mixed type with diurnal and semidiurnal components. The diurnal period lasts about 25 hr, and the semidiurnal period is about half the duration of the diurnal. As a result of tidal rotation, flood tide flows up the coast and ebb tide flows down the coast. A more detailed discussion of the tides in the San Onofre vicinity can be found in Sect. 2.6.3 of the FES-CP.

The total near-shore current is the sum of the large-scale current systems, the tides, and other effects such as local winds and offshore storms. The net result is a highly complex current structure that is quite variable in speed and direction. An additional complication is stratification. During the winter when vertical homogeneity exists, near-shore currents are fairly uniform with depth. However, during the summer the presence of the thermocline divides the water column so that only certain components of the net flow are uniform with depth. These components, such as tides, are driven over the entire water column. Surface driving forces (the wind) will penetrate the epilimnion; however, the thermocline represents a barrier to these stresses reaching the hypolimnion. The wind energy is then concentrated in the epilimnion, resulting in an increased intensity of wind-driven flow which can dominate all other components. In contrast, the hypolimnion is relatively free of wind effects and, therefore, is strongly influenced by the tides. The net result is a two-layered flow regime in which the flow in the two layers is only weakly correlated. This already-complicated flow structure can be altered by large amplitude internal waves. The breaking of these waves provides periodic vertical mixing.

A survey of the currents in the San Onofre area was conducted in 1972 by Intersea Research Corporation.[2] Data from this study have been analyzed by Koh and List.[3] From this analysis the following summary information has been extracted.

1. A net drift current can occur in a number of directions; however, the onshore/offshore component of the drift is necessarily smaller than the longshore component.

2. The longshore component of the drift changes direction every 3 to 6 days with downcoast flow typically having a longer duration.

3. The magnitude of the longshore drift is less than 30 cm/sec (0.6 knot).

4. The onshore/offshore component of drift is less than 15 cm/sec (0.3 knot).

5. An upcoast component of drift usually is associated with an onshore component of drift, and vice versa.

6. Both components of tidal flow are typically 10 cm/sec (0.2 knot).

The most detailed study of natural temperature variations in the San Onofre vicinity is that of Koh and List.[3] This study was based on daily temperature measurements from 1966 through 1970 taken at the ends of piers at Balboa, San Clemente, Oceanside, and La Jolla. These data were separated into three frequency ranges - low, middle, and high. The low-frequency component represents data averaged over two months, and it reflects seasonal variations. After removal of these low frequencies, the data were averaged over one week. This is the middle-frequency band, which represents variation within periods from one week to two months. The residual data, the high-frequency band, represents daily to weekly fluctuations. Figure 2.1 is a plot of temperature vs time for the three frequency bands and the raw data for San Clemente. The temperature ranges from 12.1°C (54°F) to 22.9°C (73°F). The low-frequency curve shows an annual temperature cycle with a maximum in midsummer and a minimum in midwinter.

As part of their analysis, Koh and List performed a correlation study among the temperature records from the various locations. Both the low- and middle-frequency ranges showed very high correlations at zero lag time between Oceanside and San Clemente. This indicates that the mechanisms influencing these frequency components have a length scale greater than the distance between the two sampling locations. Therefore, temperature variations at San Onofre within periods of one week or longer can be represented adequately by the corresponding temperature variations at either San Clemente or Oceanside. The correlation of the high-frequency components between these two stations is very weak, indicating that short-term temperature fluctuations are a spatially localized phenomenon. This fact is substantiated by near-surface-temperature measurements made from a moving boat which show that horizontal temperature variations of 1.1°C (2°F) over 1.6 km (1 mile) are not uncommon off the coast of southern California.[3]

An additional feature of the thermal structure in the San Onofre vicinity is vertical stratification. During the winter this region is, in general, isothermal over the water column. As warming progresses, a vertical temperature gradient is established and reaches a maximum in late summer. This natural gradient has been as much as 0.55°C/m (0.3°F/ft).

Ocean salinity in the San Onofre vicinity shows little spatial variation. An annual salinity cycle does exist as a result of annual cycles in the local meteorology and large-scale current systems. During this cycle, salinity typically ranges from 33 to 34 ppt, with the minimum occurring in winter and the maximum occurring in summer.

2.3.2 Groundwater hydrology

The average elevation of the water table at the beach line is +1.5m (+5 ft) mean lower low-water level (MLLW) with a slope of less than 1%; inland, the gradients range from 2 to 8% toward the ocean. Some groundwater can be obtained from the San Onofre Groundwater Basin, and it is used at Camp Pendleton Marine Base, but it is not a resource used by the Station. The Station obtains its domestic supply of freshwater from the Tri-Cities Municipal Water District.

2.3.3 Water quality

Dissolved oxygen concentration in southern California coastal waters ranges from about 5 to 13 mg/liter. Observations at the site vary from 5.4 to 10.0 mg/liter (2 to 3.6 grains/gal). The pH of southern California surface waters varies from 7.5 to 8.4 with a mean of about 8.0.

Measurements of coliform concentrations at the site were made during the period 1967 to 1975. Most of the measurements gave a mean probable number (MPN) of 4 to 43 colonies/100ml (1 to 13 colonies/oz). Only two measurements exceeded 43, and these occurred in 1972 and both gave a MPN value of 460 (140).

Turbidity in the vicinity of the site is due primarily to the suspension of bottom material in the surf zone. Outside the surf zone, turbidity generally decreases as distance from shore increases. Typical depths of Secchi Disc visibility range from 2 to 5 m (6.5 to 16 ft).[4] The vertical variation of turbidity is often quite complex, with alternating layers of clear and turbid water. Visible plumes of turbidity have been observed occasionally on the ocean surface in the vicinity of the Unit 1 offshore discharge structure. These plumes have been observed and, depending on ambient conditions, are caused by the intake and subsequent discharge of naturally turbid water and the entrainment of naturally turbid water into the discharge stream as it moves towards the surface (ER, Sect. 2.4.3.8.2).

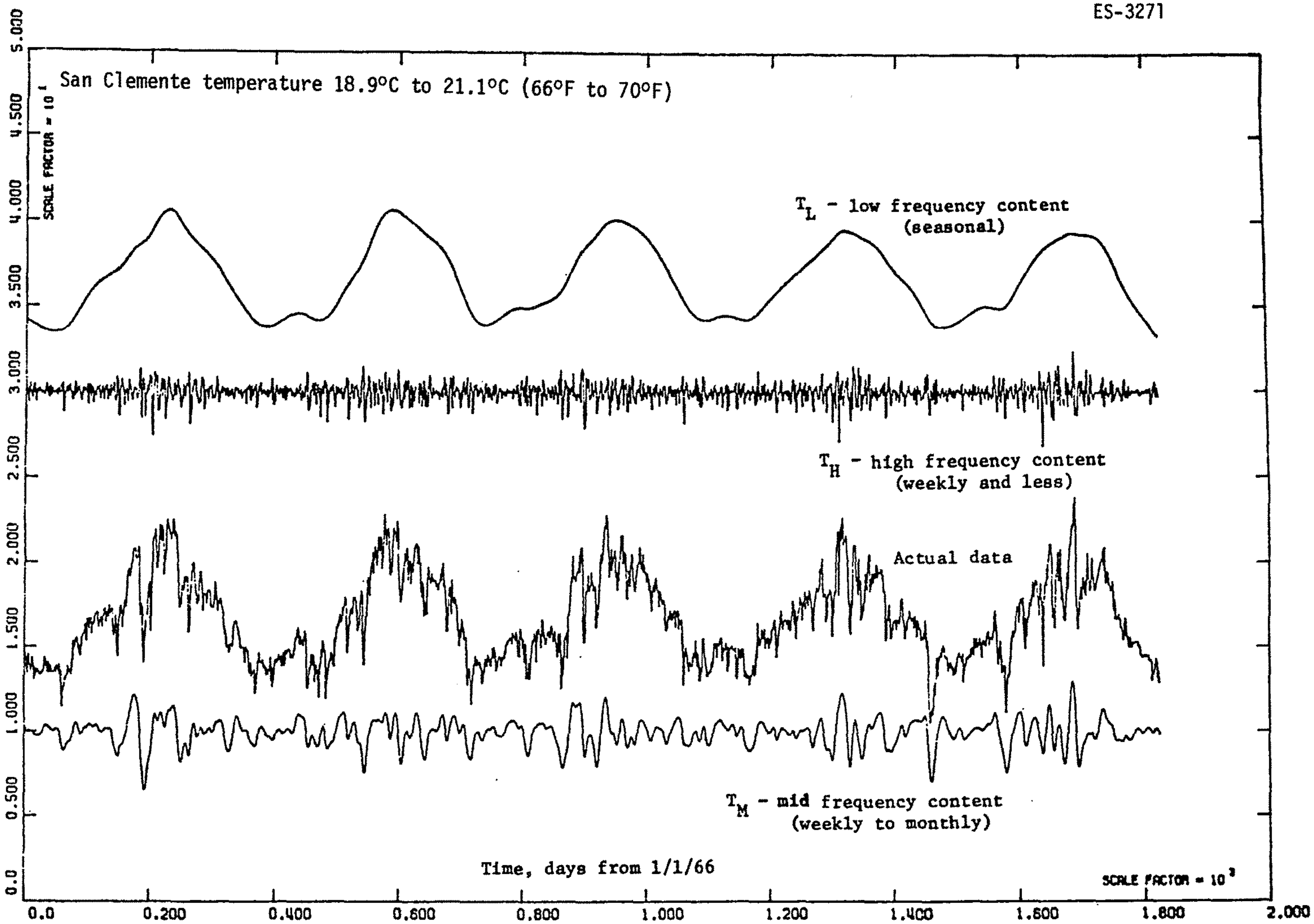

Fig. 2.1. Daily temperatures and decompositions into various frequency bands at San Clemente. Source: R. C. Y. Koh and E. J. List, *Report to Southern California Edison Company on Further Analysis Related to Thermal Discharges at San Onofre Nuclear Generating Station*, Sept. 30, 1974, Fig. 3.2.

2.3.4 Storm runoff

The probable maximum 1-hr thunderstorm rainfall is 17.8 cm (7.0 in). Much of the country to the north and east of the Station site drains into the San Onofre Creek, which flows into the ocean 2 km (1-1/4 miles) northwest of the site. The land immediately east of the site now drains into a 3.7-m-wide (12-ft-wide) ditch that parallels Interstate Highway 5 (I-5) just east of the Station. Both lanes of I-5 also drain into this ditch, which discharges into San Onofre Creek. Storm runoff from the hills above the site drains through one 182-cm-(72-in.-) and one 107-cm-(42-in.-)diam culvert that run north along the highway right-of-way and then turn under the site to the beach. The culverts and channel are designed for the runoff associated with a 1% chance (100-year) storm. To preclude flooding at the site during the occurrence of a probable maximum thunderstorm, an earthen dike will be constructed to the east side of I-5 to divert runoff and debris from the foothills area to San Onofre Creek.

2.4 METEOROLOGY

2.4.1 Regional climatology[5-9]

The climate of the coastal regions of southern California is strongly influenced by the Pacific Ocean. Summers are relatively cool with daytime temperatures averaging only in the low-to-mid-20s (°C) (70°F); daytime seabreezes are frequent. Outbreaks of hot, dry desert air from east of the coastal mountains (Santa Ana winds) may intrude onto the coastal plain several times each year, primarily in the fall, but temperatures exceed 32°C (90°F) usually less than five days annually. The proximity to the Pacific Ocean also results in mild winters, with daytime highs in the upper teens (°C) (60s°F) and nighttime lows around 5 to 10°C (40s°F). Temperatures below freezing are rare.

Precipitation along the coastal plain averages around 250 mm (10 in.) annually. The rainfall is very seasonally dependent with 85% of the total occurring from November through March; almost no rain falls during the summer months. Average relative humidities range from about 80% during the early morning hours of summer and fall, down to around 55% during winter afternoons.

2.4.2 Local meteorology[5,6,8,9]

The San Onofre site is located on the relatively narrow coastal plain, near the mouth of San Onofre Canyon. Coastal bluffs, nearby hills and valleys, and the Pacific Ocean contribute to the complexity of the site topography. Within 8 km (5 miles) of the site, elevations range from 525 m (1725 ft) above sea level [about 5.5 km (3.5 miles) east of the site] to sea level along the Pacific Ocean.

To assess the local meteorological characteristics of the San Onofre site, climatological data from San Diego, California [80 km (50 miles) southeast of the site]; from Los Angeles, California [95 km (60 miles) northwest]; and data collected onsite are available. These data are reasonably representative of the climatological conditions expected in the vicinity of the site.

In the site area, average daily maximum and minimum temperatures range between 25°C (77°F) and 18°C (64°F) in August, the warmest month, and between 18°C (65°F) and 8°C (46°F) in January, the coolest month. The extreme maximum temperature recorded was 44°C (111°F) at San Diego in September 1963; the extreme minimum temperature was -5°C (23°F) at Los Angeles in January 1937.

The area receives about 250 mm (10 in.) of rain annually; December, January, and February — the wettest three-month period — averages about 150 mm (6 in.), and June, July, and August combined averages less than 2.5 mm (0.1 in.). The maximum 24-hr rainfall recorded among these stations is 157 mm (6.2 in.) at Los Angeles in January 1956. Snowfall is a rarity, with a trace [less than 0.25 mm (0.01 in.)] being the most ever recorded. Heavy fogs [visibility of 0.4 km (0.25 mile) or less] occur on about 30 to 40 days each year along the coast with about half of the occurrences during October through January.

Windflow at the site has a strong diurnal dependence primarily due to the land-sea breeze effect. During daytime hours the windflow has a predominant onshore directional component, whereas at night windflow tends toward a seaward direction. Table 2.3 shows the wind direction with the greatest frequency of occurrence for each hour of the day for the three-year period of January 25, 1973, through January 24, 1976, as measured at the 10-m (33-ft) level of the onsite meteorological tower. Figure 2.2 shows the directional frequency of onsite winds. About 25% of the total windflow over the site was from the northeast and north-northeast (principally night-time offshore flow); 19% of the flow occurred from the west and west-northwest (daytime onshore flow). Winds were calm [windspeeds less than 0.34 m/sec (0.75 mph)] less than 1% of the time at the 10-m (33-ft) level.

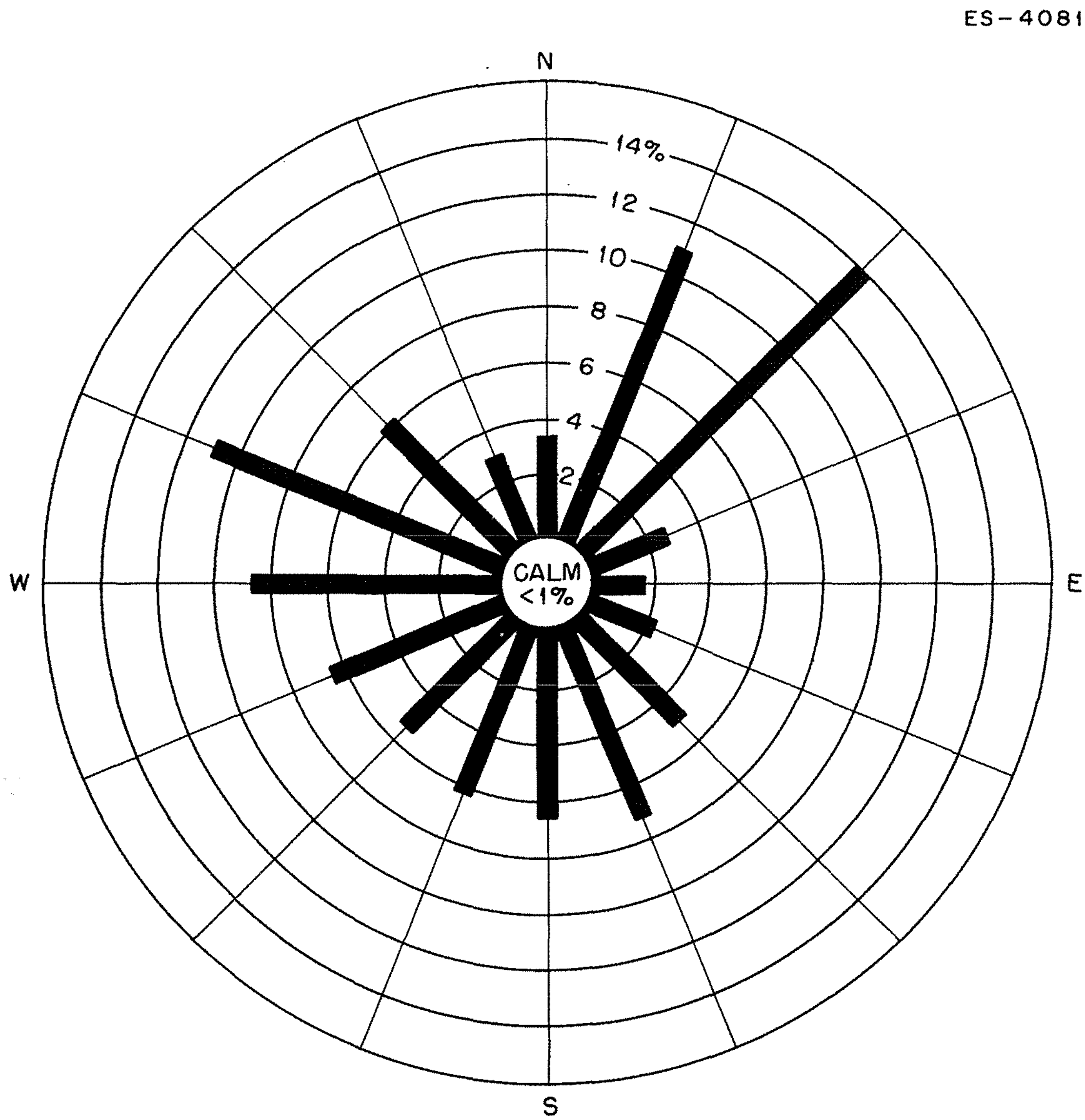

Fig. 2.2. Directional frequency of wind at the San Onofre site. Onsite data at 10 m (33 ft) above ground level, Jan. 25, 1973 through Jan. 24, 1976. Bars show the direction from which the wind blows. Calms are those winds with hourly average speeds less than 0.34 m/sec (0.75 mph).

Table 2.3. Wind direction with greatest frequency of occurrence by time of day at San Onofre Nuclear Generating Station

Data measured at 10-m (33-ft) level of onsite meteorological tower

Hour (AM)	Wind direction	Frequency (%)	Hour (PM)	Wind direction	Frequency (%)
1	NE	28	1	WNW	25
2	NE	26	2	WNW	27
3	NE	27	3	WNW	27
4	NE	28	4	WNW	27
5	NE	30	5	WNW	22
6	NE	30	6	WNW	16
7	NE	25	7	NW	14
8	NE	19	8	NE	13
9	S	12	9	NE	16
10	W	17	10	NE	20
11	W	20	11	NE	23
Noon	WNW	22	Midnight	NE	25

2.4.3 Severe weather[5-13]

Although infrequent, thunderstorms, tornadoes, tropical cyclones, and dust storms can affect the site area. Thunderstorms occur less than 5 days annually. Tropical storms are also rare in the site area, with a storm entering the region less than once every 10 years. The "fastest mile" of wind recorded at Los Angeles was 28 m/sec (62 mph) (March 1952). Snow, glaze, and hail are almost nonexistent in the site vicinity.

Between 1952 and 1975, 23 tornadoes and 21 waterspouts were reported within a 34,000-km^2 (13,000-mi^2) area containing the site. Staff analysis of these tornado data indicates that the mean path area of a tornado in this region is about 0.3 km^2 (0.1 mi^2). Using the methods of Thom, this results in a recurrence interval of 70,000 years for a tornado or waterspout at the plant site.

Dust storms are relatively infrequent within the site region; between 1940 and 1970, dust or blowing dust and sand reduced visibility to under 11 km (7 miles) about 1 hr annually. About 8 days each year there is a high meteorological potential for air pollution.

2.4.4 Atmospheric dispersion[5,6,14,15]

Southern California Edison Company (SCE) has provided joint frequency distributions of wind speed and direction by atmospheric stability class, based on the vertical temperature gradient, collected onsite during the period January 25, 1973 to January 25, 1976. The distributions were for wind speed and direction measured at both the 10- and 40-m (33- and 131-ft) levels with the vertical temperature difference between the 6.1- and 36.6-m (20- and 120-ft) levels. SCE has also conducted a tracer test program to assess the atmospheric dispersion in the landward directions at the San Onofre site. Section 6.2.5 describes the onsite meteorological program and the tracer test program.

The staff has made reasonable estimates of average atmospheric dispersion conditions for SONGS 2 & 3 using an atmospheric dispersion model for long-term releases; this model is based on the "Straight-Line Trajectory Model" described in Regulatory Guide 1.111. The onsite tracer tests showed that ground-level relative concentrations normalized by windspeed were similar whether the source of release was elevated or ground level; thus it was assumed that all plant releases were from ground level. The calculations also include considerations of intermittent releases during more adverse atmospheric dispersion conditions than indicated by an annual average calculation as a function of total duration of release. The calculations include an estimate based on the criteria outlined in Regulatory Guide 1.111 of maximum increase in calculated relative concentration and deposition due to the spatial and temporal variation of the airflow not considered in the straight-line trajectory model. Radioactive decay of effluents and depletion of the effluent plume were also considered as described in Regulatory Guide 1.111.

In the evaluation, we used meteorological data collected onsite between January 25, 1973 and January 24, 1976. All releases were evaluated using joint frequency distributions of wind speed and direction measured at the 10-m (33-ft) level by atmospheric stability [defined by the temperature difference between the 36.6- and 6.1-m (120- and 20-ft) levels]. Data recovery for this time period was 88%.

Table 5.1 presents the calculated values of relative concentration (χ/Q) and relative deposition (D/Q) for specific points of interest.

2.5 SITE ECOLOGY

2.5.1 Terrestrial ecology

The FES-CP describes the terrestrial ecology of the San Onofre site (FES-CP, Sect. 2.8.1). Field work for this description, however, was conducted only during November 1971 and contained very little quantitative data. Consequently, the issuance of the construction permit was subject to the applicant's expansion of its current environmental monitoring program "to determine environmental effects which may occur as a result of site preparation and construction of Units 2 and 3, and to establish an adequate preoperational baseline by which the operational effects of Units 2 and 3 may be judged" (FES-CP, p. iv). In response, the applicant conducted terrestrial ecological studies for a period of 1 year on a 0.61-ha (1.5-acre) quadrat located immediately south of Units 2 and 3 construction site (ER, Appendix 2A). This monitoring program documented seasonal changes in the biotic communities over a 1-year time span and fulfilled the recommendations of NRC Regulatory Guide 4.11.

About 80% of the study area is in a natural plant community of coastal sage scrub, and the remaining 20% has been disturbed by man-related activities. Total cover on the study area ranged from 81 to 98%. The greatest cover was found in February, decreasing toward midsummer. Vegetative diversity in the coastal sage scrub community was relatively low; California sagebrush (*Artemesia californica*) was the dominant species (65% relative cover). Coyote bush (*Baccharis pilularis*) ranked second in the study area (9% relative cover) but had higher relative cover in the disturbed areas than in the climax stand. The applicant's survey suggests that surface disturbances significantly alter the composition of the coastal sage scrub community by encouraging the invasion of exotic perennial and annual plant species, especially mustards and grasses. Establishment of these plants occurred only in areas that have been disturbed (ER, Appendix 2A). As expected for this very small study area (0.61 ha), no endangered plant species were observed.

Fauna observed within the study area included 5 species of reptiles, 12 species of mammals, and 36 species of birds; no amphibians were sighted. None of the species observed in the study area are threatened or endangered as defined by the U.S. Department of the Interior[16] (ER, Sect. 2.2.1.2).

The endangered animal species[16] whose ranges include the vicinity of the plant and associated transmission lines are listed in Table 2.4. Two of these species have been observed by the applicant. The California brown pelican has occurred several times on the beach adjacent to the construction area (ER, Sect. 2.2.1.2), and the California least tern has a nesting colony located near the Del Mar Boat Basin, a facility used by the applicant to move heavy components (see Sect. 2.2.2).

Examination of the geographical distributions[17,18] of the 266 endangered plant species in California[19] indicates that 26 of these species occur in those counties (Orange and/or San Diego) traversed by the transmission lines (Table 2.5). No endangered plant species, however, were observed during the applicant's biological study of the San Onofre-Santiago transmission line route.[20] Biological surveys of the other transmission line routes have not been conducted, but no habitats adjacent to or within the transmission line right-of-way have been classified by state or Federal authorities as being critical to any endangered species (ER, Suppl. 1, Item 22).

2.5.2 Aquatic ecology

The aquatic ecology of the site was described in the FES-CP issued in March 1973, and was based on descriptive data obtained from literature concerning the southern California coast. The FES-CP site description contained minimal baseline information on spatial and temporal differences in species occurrences and population densities. The data obtained since issuance of the FES-CP is primarily from three sources: (1) a thermal effects study performed jointly by Environmental Quality Analysts, Inc., and Marine Biological Consultants, Inc., in 1973 using data and results obtained from 1964-72 by Bendix Marine Advisers, Inc., and Intersea Research Corporation.[21] (2) the SONGS 1 Environmental Technical Specifications (ETS) monitoring program begun in November 1974, conducted by the Lockheed Aircraft Service Company's Department of Marine biology,[22-27]

Table 2.4. Endangered animal species[a] whose ranges include Orange and San Diego counties, California

Common name	Scientific name	Habitat	Reason for decline
California brown pelican	*Pelecanus occidentalis californicus*	Pacific coast from Canada to Mexico	Egg shell thinning due to pollutants such as DDT
California least tern	*Sterna albifrons brownii*	Pacific coast from S. San Francisco Bay, California, to S. Baja, California	Loss of nesting habitat (sandy beaches) due to increased human activity
American peregrine falcon	*Falco peregrinus anatum*	Coast and higher mountains inland	Egg shell thinning due to DDT; human disturbance
Southern bald eagle	*Haliaeetus leucocephalus leucocephalus*	Estuarine areas and inland around large lakes, reservoirs, and wetlands	Disturbance of nesting birds; illegal shooting; loss of nest trees; contamination of food chain by persistent pesticides
Light-footed clapper rail	*Rallus longirostris levipes*	Coastal salt marshes	Destruction of its natural habitat by filling for housing and industrial use, marine development, and water pollution destroying food species and/or habitat

[a]U.S. Department of the Interior, "Endangered and Threatened Wildlife and Plants," 41 F.R. 47180–47198.

Table 2.5. Endangered plant species of Orange and San Diego counties, California

Plant name[a]		Habitat and geography[a]
Scientific	Vernacular	
Acanthomintha ilicifolia	San Diego thornmint	Clay depressions on mesas and slopes; coastal sage scrub, chaparral; SW San Diego County
Arctostaphylos glandulosa var. *crassifolia*	Thickleaf manzantia	Sandy mesas and bluffs; chaparral; coast of San Diego County
Aster chilensis		Dry banks, grassy fields, etc., sea level to 5000 ft; many plant communities; mountains of San Diego County to Santa Barbara County
Astragalus tener titi	Coastal dunes rattleweed	Sandy places near the coast; coastal strand; near San Diego
Berberis nevinii	Nevin's bayberry	Sandy and gravelly places below 2000 ft; coastal sage scrub, chaparral; San Diego County
Brodiaea filifolia	Thread-leaved brodiaea	Heavy clay soil below 2000 ft; coastal sage scrub, chaparral; San Diego County
Brodiaea orcuttii	Orcutt's brodiaea	Near streams and around vernal pools and seeps, up to 5500 ft; chaparral; Yellow Pine Forest, San Diego County
Chorizanthe orcuttiana	Orcutt's chorizanthe	Sandy places; coastal sage scrub; San Diego County
Cordylanthus maritimus ssp. *maritimus*	Salt marsh bird's beak	Coastal salt marsh; Lower California to Oregon
Dicentra ochroleuca	Yellow dicentra	Occasional in dry disturbed places below 3000 ft; chaparral; Santa Ana and Santa Ynez mountains
Dichonda occidentalis	Western dichondra	Mostly dry sandy banks in brush or under trees; coastal sage scrub, chaparral, southern oak woodland; coastal San Diego and Orange counties
Dudleya multicaulis	Many-stemmed dudleya	Dry stony places below 2000 ft; coastal sage scrub, chaparral; San Onofre Mountain, Orange and San Diego counties
Dudleya stolonifera	Laguna Beach dudleya	Cliffs in coastal sage scrub; canyons near Laguna Beach, Orange County
Eryngium aristulatum var. *parishii*	San Diego coyote-thistle	Vernal pools; chaparral; San Diego region
Ferocactus viridescens	San Diego barrel cactus	Dry hills; coastal sage scrub, valley grassland; around San Diego, NW Lower California
Galium angustifolium ssp. *borregoense*		Creosote bush scrub; Borrego Valley, E. San Diego County
Githopsis filicaulis (last reported in 1884)	Mission Canyon blue-cup	Mission Canyon, San Diego
Hemizonia conjugans	Otay tarweed	Mesas; coastal sage scrub; SW San Diego County
Hemizonia floribunda	Tecate tarweed	Dry slopes and valleys below 3500 ft; coastal sage scrub, chaparral; S. San Diego County, N. Lower California
Limnathes gracilis var. *parishii*	Parish slender meadow-foam	Moist lake shores and wet places from 4500 to 5000 ft; Yellow Pine Forest; Cuyamaca and Laguna mountains
Monardella linoides ssp. *viminea*		Rocky washes below 1000 ft; coastal sage scrub, chaparral; SW San Diego County
Monardella macrantha var. *halli*	Hall's monardella	San Gabriel and San Bernardino mountains to Cuyamaca and Santa Ana mountains
Nolina interrata	San Diego nolina	Dry slope; chaparral; W. of Dehesa School, 8 miles east of El Cajon, San Diego County
Orcuttia californica var. *californica*	California orcuttia	Drying mud flats; valley grassland; San Diego County
Poa atropurpurea	San Bernardino bluegrass	Meadows and grassy slopes from 6000 to 7000 ft; Montane Coniferous Forest; San Diego County
Pogogyne abramsii	San Diego pogogyne	Beds of dried pools; chaparral, coastal sage scrub; mesas from San Diego to Miramar

[a]Nomenclature, habitat, and geography from P. A. Munz, *A Flora of Southern California*, University of California Press, Berkeley, Calif., 1974; and W. R. Powell, Ed., *Inventory of Rare and Endangered Vascular Plants of California*, Special Publication No. 1, Berkeley, Calif., 1974.

Source: U.S. Department of the Interior, "Endangered and Threatened Species, Plants," 41 F.R. 24542–24572.

(To convert ft to m, multiply by 0.3048.)

and (3) the Annual Report to the California Coastal Commission, August 1976-1977, by the Marine Review Committee,[28] a special study group established by the California Coastal Commission to estimate the consequences of operating SONGS 2 & 3. Because the ETS program contains the most recent data, included seasonal fluctuations in species occurrences and population densities, and evaluated the effects of SONGS 1 operation on the local marine environment, the description of the site aquatic ecology that follows is based on these data (obtained from November 1974 through December 1976). SONGS 2 & 3 are adjacent to SONGS 1, on the same site. Additionally, the effects of SONGS 1 operation are now a part of the environment of SONGS 2 & 3 and should therefore be included in a complete description of the site ecology.

The biotic communities relevant to an adequate description of the site ecology are the plankton, nekton, benthic, kelp, and intertidal communities.

2.5.2.1 Plankton

Bimonthly plankton sampling was conducted four times in 1975 and six times in 1976 at seven stations along the 10-m (33-ft) contour from 2.4 km (1.5 miles) upcoast to 6.7 km (4.2 miles) downcoast of the SONGS 1 intake/ discharge line (Fig. 2.3).

Phytoplankton

1975 Data. The 84 phytoplankton taxa recorded in the 1975 surveys are similar to those found in previous studies.[25] The phytoplankton was dominated numerically by dinoflagellates. Prorocentrum micans was the most abundant species, constituting 30 to 90% of the samples.[22] Other abundant organisms included Prorocentrum spp., Ceratium sp. A, and Ceratium sp. B. Several species of Peridinium and Dinophysis were also present. The number of taxa per station within each survey was relatively uniform. A complete list of phytoplankton taxa recorded during 1975 is given by station and survey in Appendix VIII, Table 2, p. 217 of ref. 25.

Chlorophyll α concentrations ranged from 0.24 to 2.32 mg/m^3 (0.004 to 0.04 grains/250,000 gal) during the four 1975 surveys.[25] Differences in chlorophyll α concentrations between stations were not significant. Differences were significant, however, between depths and between surveys; chlorophyll α concentrations were significantly greater at the 8-m (26-ft) depth, and the mean concentrations of September were significantly greater than those of the other survey months - May, July, and November.

Phaeopigment concentrations ranged from 0.08 to 1.23 mg/m^3 (0.076 to 0.174 grains/250,000 gal) during the four 1975 surveys.[25] Station differences were not significant, but differences in mean concentrations between surveys and between depths were significant. As with chlorophyll α, phaeopigment concentrations were greater at 8 m (26 ft) than at 1 m (3.3 ft), and the September survey showed the highest phaeopigment concentrations of all four surveys.

1976 Data. In 1976, 128 species or higher taxa of phytoplankton were reported from the six surveys conducted (Table II-2, pp. 11-13 of ref. 26). These taxa consisted of species when identifiable and higher taxa (genera, families, etc.) when identification to the species level could not be made. The taxa representing greater than 30% of any given sample by number were Nitzschia spp. (March and November), an unidentified pennate diatom (January, March, July, September, and November), Gonyaulax spp. (January and March), and Prorocentrum micans (May).[27]

Normal vertical distribution patterns were observed in 1976, as in 1975, with higher concentrations of chlorophyll α and phaeopigments again measured in the lower half of the 10-m (33 ft) water column. However, relatively high values of chlorophyll α were found during the January and May surveys in 1976, whereas in 1975, chlorophyll α concentrations were moderate in May and high in September. Also in contrast to 1975, there was no consistent vertical separation of diatoms from dinoflagellates.

Slightly higher surface temperatures at plankton stations nearest SONGS 1 during some surveys had no apparent effect on the distribution and abundance of phytoplankton; rather, distribution and abundance were apparently the result of natural spatial and temporal variation.[27]

Zooplankton

1975 Data. Zooplankton species encountered in the four 1975 surveys were common to the neritic waters of southern California.[22] A master species list of zooplankton found in the surveys is presented in Appendix VIII, Table 2, p. VIII-30 of ref. 22. The most common group consisted of copepodids of Acartia spp., usually accounting for more than 50% of the total number of individuals sampled.[22] Other species that commonly occurred in the samples were Paracalanus parvus copepodids, Oikopleura spp., Evadne nordmanni, Labidocera trispinosa copepodids,

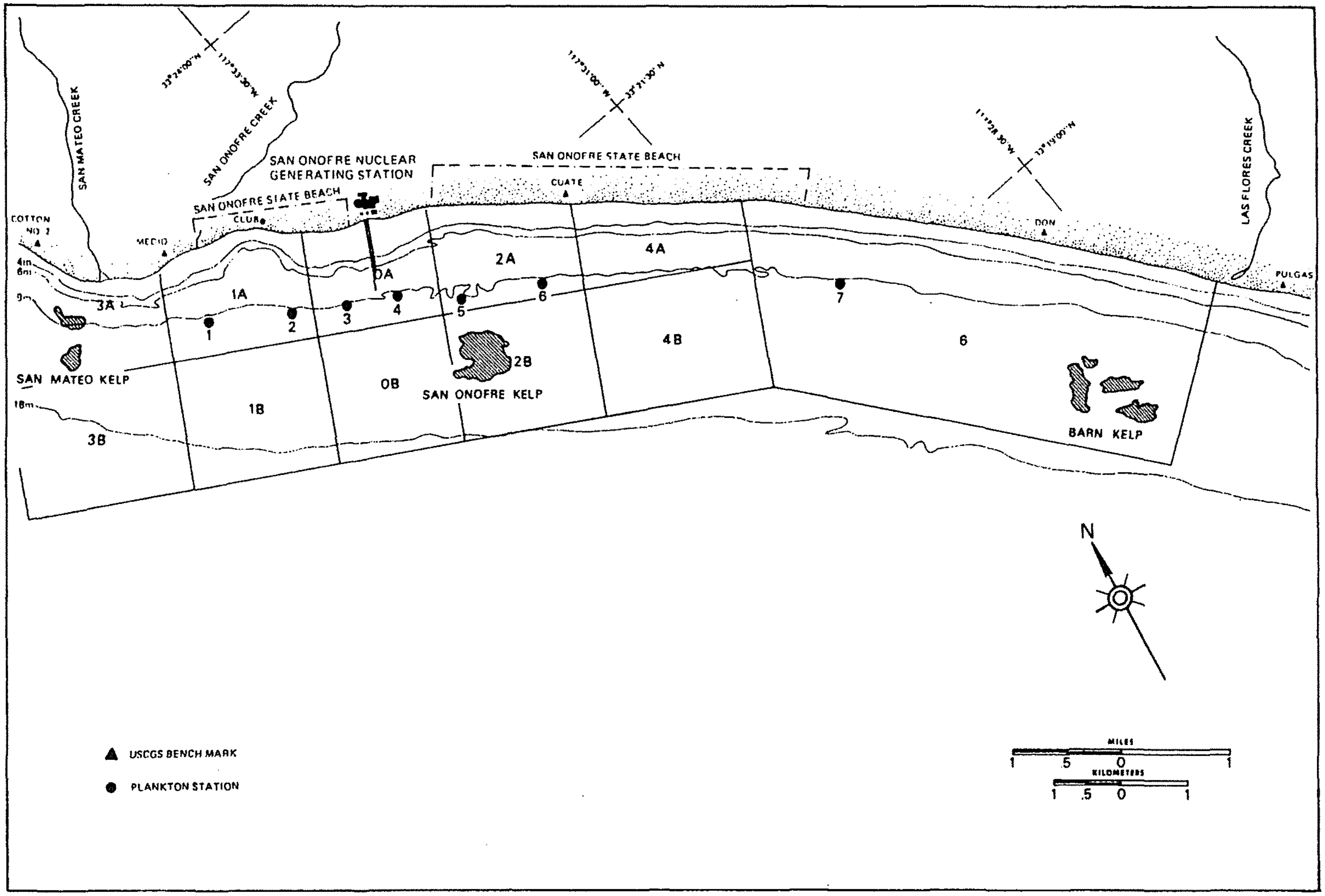

Fig. 2.3. Environmental Technical Specifications plankton station locations and environmental surveillance zones, San Onofre Nuclear Generating Station Unit 1. Source: Lockheed Center for Marine Research, *San Onofre Nuclear Generating Station Unit 1, Environmental Technical Specifications, Annual Operating Report, Vol. IV, Biological Data Analysis — 1976*, June 1977.

Sagitta euneritica, and Acartia tonsa. Less abundant species were adult Paracalanus parvus, cyphonautes larvae, Acartia clausi, and Clausocalanus spp. copepodids. Other species present usually accounted for less than 1% of any sample.[22]

Sampling stations were best differentiated by the distribution of five species: Sagitta euneritica, Corycaeus amazonicus, Oithona spp. copepodites, euphausiid larvae, and Podon polyphemoides. A clear separation of the stations, however, was not obtained, which suggests that no strong processes in the area acted to partition the environment.[25]

Total abundance per sampling station ranged from 600 to 10,900 per m^3 (568 to 10,322 per 250,000 gal) (Fig. 2.4), and total number of taxa ranged from 36 to 65 during the four surveys of 1975.[25] The number of taxa at station 4 near the SONGS 1 discharge was significantly higher than at all the other stations (Fig. 2.4).

1976 Data. In 1976, 115 species or higher taxa were reported from the six surveys performed (Table II-2, pp. 7-10 of ref. 26). Sixteen taxa were considered predominant because they were numerically dominant (number one in rank) during at least one survey, or because they represented more than 1% of the total number of individuals during the year.[27] These sixteen taxa constituted 90% of the total individuals recorded for the year.[27] The seasonal distribution of each of these taxa during the 1976 surveys is shown in Fig. 2.5. Significant differences were found among stations for all but five of the taxa, and significant differences were found between depths for all but six of them. All of these taxa exhibited significant differences among surveys.

Normal vertical distribution patterns were also observed in 1976, as in 1975, with higher concentrations of zooplankton observed in the lower half of the 10-m (33-ft) water column.

Although higher concentrations of zooplankton were measured near SONGS 1 in 1975, no effect of SONGS 1 was indicated by the 1976 studies. Even though water temperatures during the 1976 November survey (when SONGS 1 was off-line) were unusually warm for the season, the distribution and abundance of zooplankton, as with the phytoplankton, were apparently the result of natural spatial and temporal variation.[27]

2.5.2.2 Nekton

1975 Data

Quarterly nekton sampling was conducted in 1975 at six stations — three stations in the area of the SONGS 1 discharge (zone 0A) and three stations about 6706 m (22,000 ft) downcoast (zone 6) (Fig. 2.6). The downcoast stations (zone 6) acted as control areas not under the influence of the SONGS 1 discharge.

A total of 3206 individuals representing 49 species or higher taxa were taken during the four 1975 surveys.[25] The most abundant fish was the queenfish (Seriphus politus), which accounted for nearly twice the number of individuals in the year's catch than the second most abundant species. Other abundant fish were the walleye surfperch (Hyperprosopon argenteum), white croaker (Genyonemus lineatus), spotfin croaker (Roncador stearnsii), jacksmelt (Atherinopsis californiensis), and white surfperch (Phanerodon furcatus). Fourteen species were both abundant and common. Five of the 14 species displayed significant differences in their distributions between zones; four of these — jacksmelt, white seabass (Cynoscion nobilis), white croaker, and queenfish - were significantly more abundant in zone 0A, and the pile surfperch (Damalichthys vacca) was more abundant in zone 6.

The variability observed in abundance between zones was influenced significantly by the distribution of four species: white seabass, white croaker, white surfperch, and California corbina (Menticirrhus undulatus). The white seabass and white croaker were significantly more numerous in zone 0A, and the California corbina and white surfperch were significantly more numerous in zone 6.

The number of individuals and number of taxa also varied significantly among surveys. However, the degree of similarity of species composition within zones did not differ significantly from the degree of similarity between zones.

1976 Data

A taxonomic summary of the 1976 nekton sampling data by station and by survey can be found in Table III-4, pp. 17-18 of ref. 26. A total of 46 species was reported from these surveys. Seven species — queenfish, white croaker, white surfperch, walleye

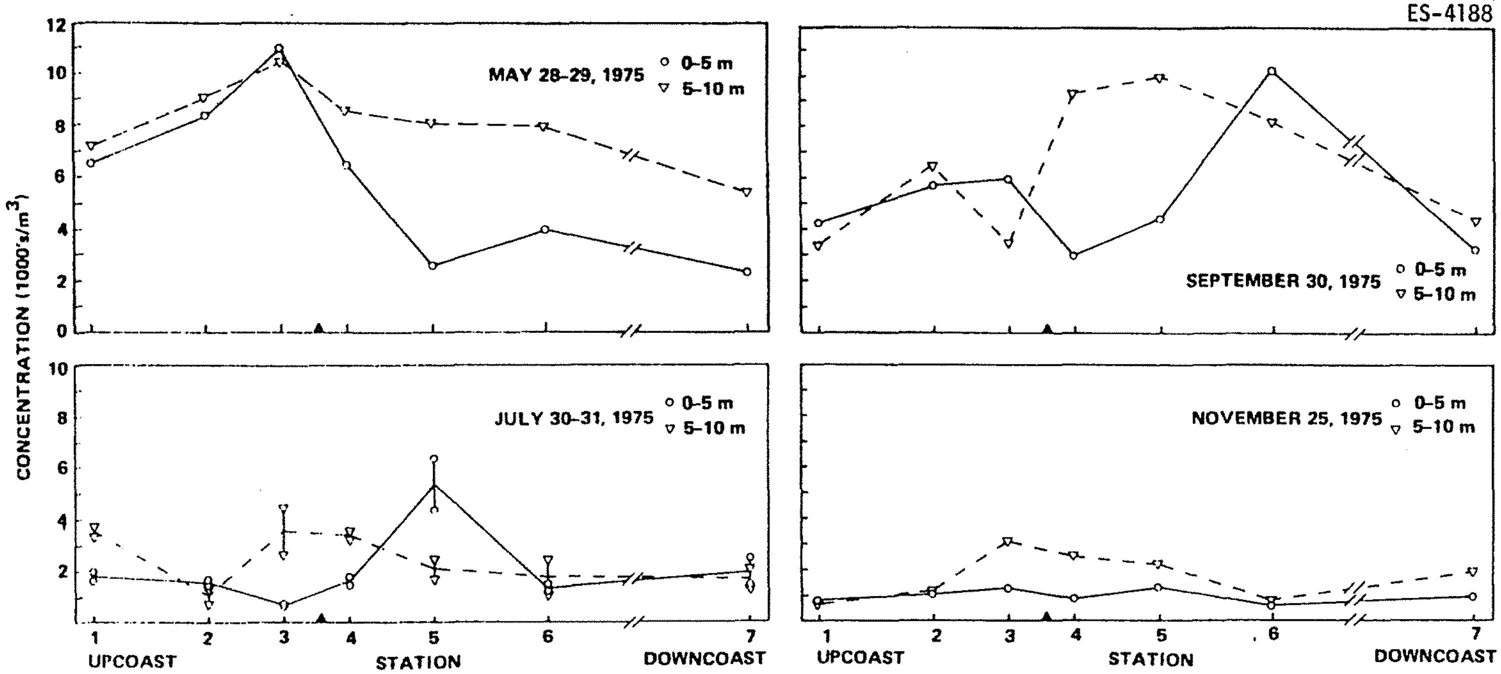

Fig. 2.4. Zooplankton concentrations from 1975 surveys. Open circles (o) and triangles (▽) indicate values from the upper and lower strata respectively. The relative distances of the plankton stations from SONGS 1 are shown. A solid triangle (▲) indicates the position of SONGS 1. A vertical bar connects the July replicates. Source: Lockheed Marine Biological Laboratory, *San Onofre Nuclear Generating Station Unit 1, Annual Analysis Report, Environmental Technical Specifications, January-December 1975*, 1976.

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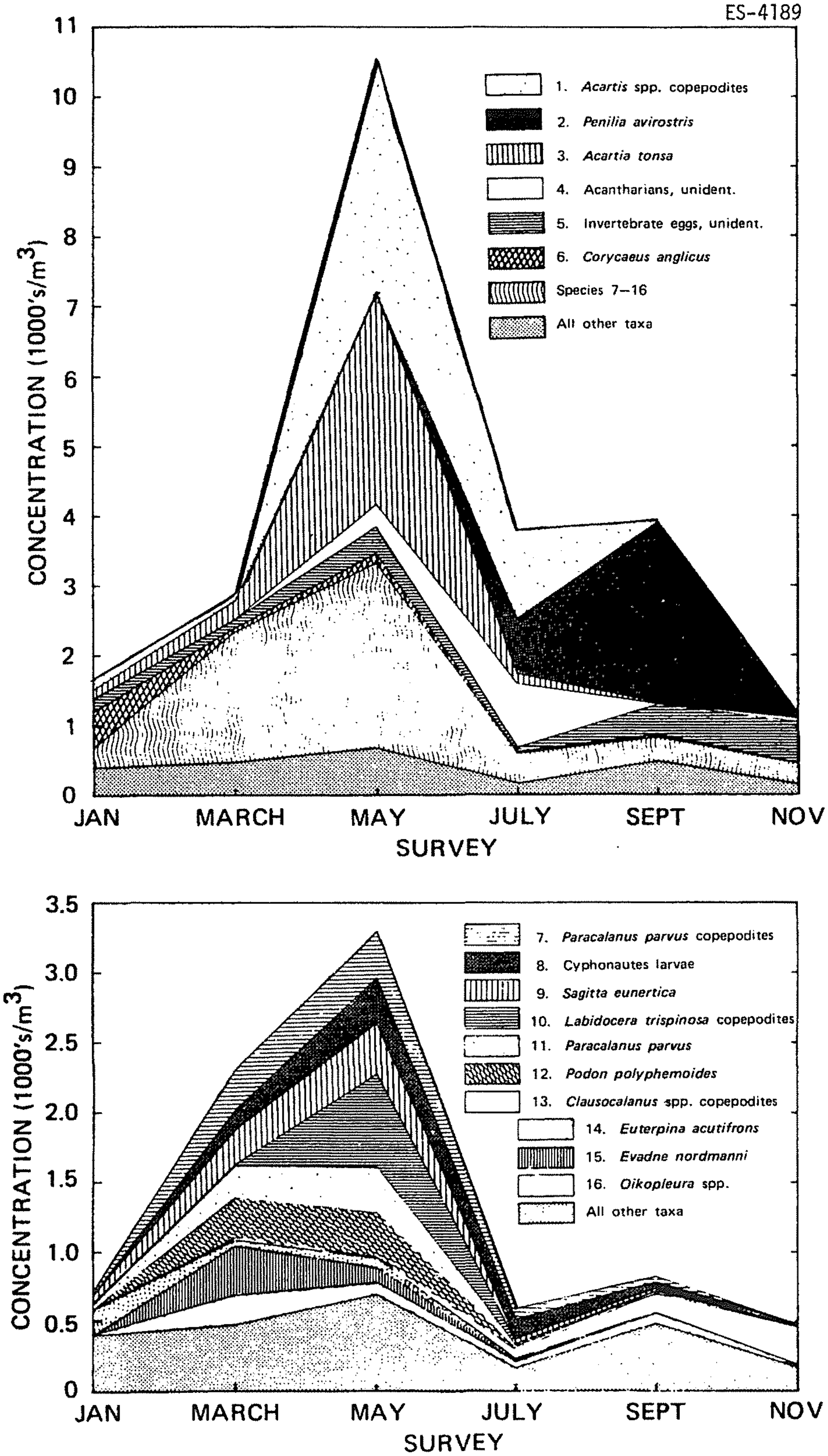

Fig. 2.5. Seasonal distribution of the 16 most abundant zooplankton taxa in 1976. Means of abundance during each survey are plotted. Source: Lockheed Center for Marine Research, *San Onofre Nuclear Generating Station Unit 1, Environmental Technical Specifications, Annual Operating Report, Vol. IV, Biological Data Analysis — 1976*, June 1977.

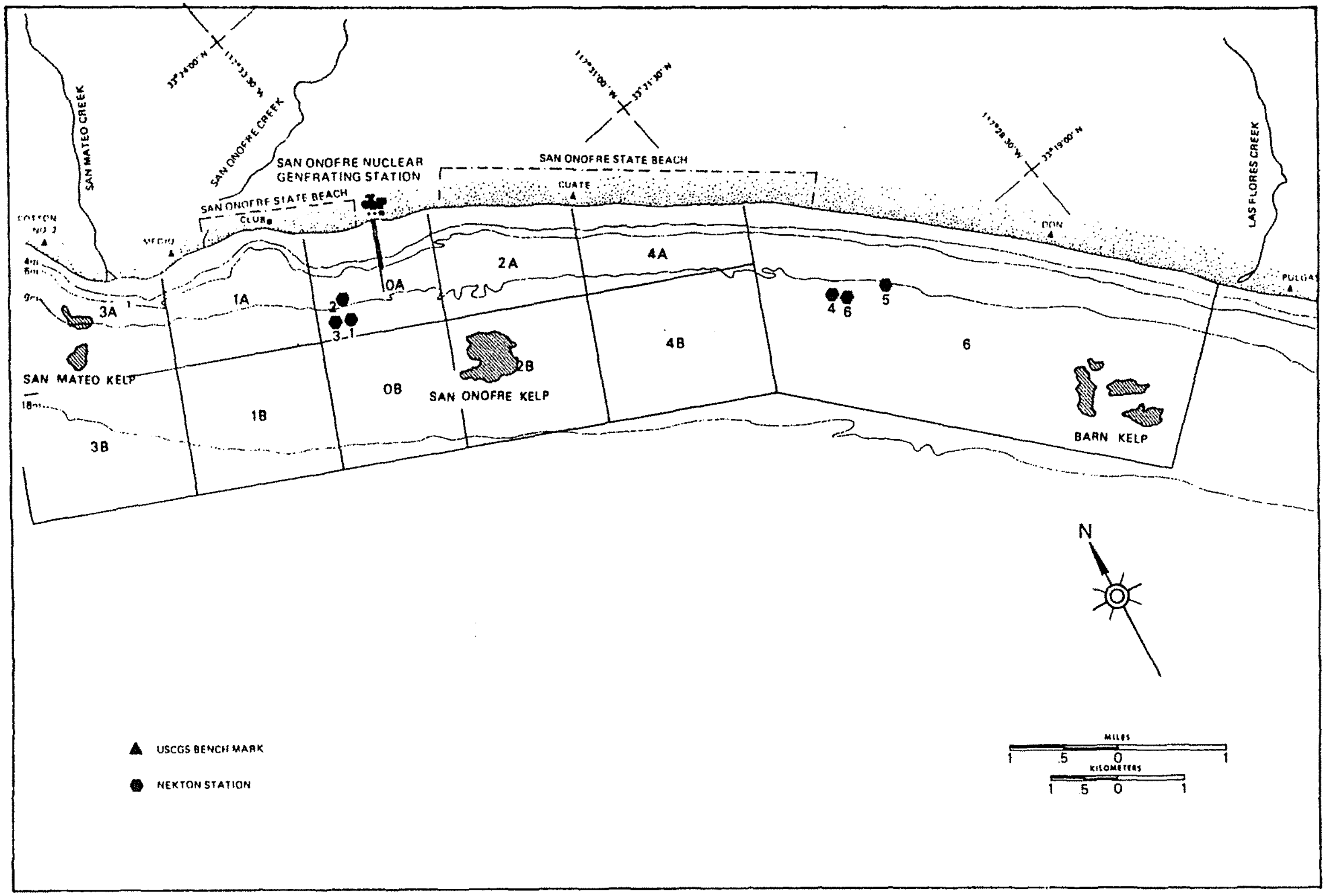

Fig. 2.6. Environmental Technical Specifications nekton station locations and environmental surveillance zones, San Onofre Nuclear Generating Station Unit 1. Source: Lockheed Center for Marine Research, *San Onofre Nuclear Generating Station Unit 1, Environmental Technical Specifications, Annual Operating Report, Vol. IV, Biological Data Analysis — 1976*, June 1977.

surfperch, black croaker (Chilotrema saturnum), spotfin croaker, and half moon (Medialuna californiensis) were captured in both zones.[27] As a group, these seven species accounted for 81.3% of the total catch for the year.[27] The first five of these species were tested for significant differences between zones and among surveys. Only the queenfish and white croaker showed a significant difference between zones, being significantly more abundant in zone 0A than in zone 6. The remaining three species did not differ significantly between zones.

In contrast, six predominant species in 1975 (bottom nets) contributed 82.3% of the individuals collected.[25] Of the predominant species netted in both years, only the queenfish and white croaker were significantly more abundant in zone 0A than in zone 6 during both years of the survey.

The spatial distribution of the queenfish, white croaker, and white surfperch differed significantly among the 1976 surveys. Temporally, the queenfish was found to be most abundant during the December survey and least abundant during the March survey. The white croaker was significantly more abundant during the December and March surveys than during the September and June surveys, and the white surfperch was significantly more abundant in the December catch than during all of the other 1976 surveys.

Significant differences were observed in the number of species between zones, with the number in zone 0A being significantly greater than the number in zone 6. Four species best discriminated between zones 0A and 6: white seabass, white croaker, yellowfin croaker (Umbrina roncador); and white surfperch.

There was also a significant difference among survey periods, with the number of species taken in March being significantly less than the number taken during all of the other surveys, which were not significantly different from each other.

The significant difference found in both number of individuals and number of species among surveys in 1976 was also found in 1975 although no obvious trend in species diversity was revealed (Fig. 2.7). On the other hand, a high similarity within zones existed during 1976; the 1975 data indicated similar but less distinct patterns.

The data suggest that the areas sampled in the two zones may support somewhat different nekton communities. Physical differences between the zones which may also affect the nekton results include the presence of the intake and discharge structures at SONGS 1 and riprap material in zone 0A, general differences in substrate type and composition between the zones, turbidity, and the presence of a dense stand of the phaeophyte Cystoseria spp. in the area of the zone 0A nekton stations. Temperature data collected during bimonthly cruises and nekton surveys revealed no obvious differences between zones, which indicates that temperature is not an important factor.

Fisheries statistics

Commercial and sport fisheries catch data for 1974 from the California Department of Fish and Game statistical blocks in the vicinity of SONGS 1 (Fig. 2.8) revealed that the number of fish per block ranged from 16,601 in block 737 to 123,246 in block 756.[27] With the exception of block 801, all of the blocks examined measured an increase in catch per unit effort between 1973 and 1974. However, the magnitude of the increase was small in comparison to the decrease shown by all of the blocks over the past 13 years.

The 1974 commercial catch reported a total of 46 taxa from the five blocks surrounding San Onofre.[27] The only taxon common to all five blocks was the Pacific bonito (Sarda chiliensis). Each of the five blocks yielded catches at about the expected level, based on the size of the blocks and the amount of coastline encompassed.[27]

2.5.2.3 Benthos

1975 Data

Three surveys conducted in 1975 at 11 benthic stations (Fig. 2.9) revealed a total of 160 species or higher taxa of epibenthic macrobiota (Tables X-1 to X-11, pp. X-12 to X-43 of ref. 22). The taxa represented members of 11 major taxonomic groups. Within zones not associated with kelp beds (zones 0A and 6), the flora was dominated by rhodophyte taxa throughout the year. Mollusks were the dominant fauna during April and October, whereas molluscan and chordate taxa occurred in similar numbers during the July sampling period. Rhodophytes were also the dominant floral component and mollusks were the dominant faunal component of the kelp bed biota at all kelp bed stations during all survey periods.

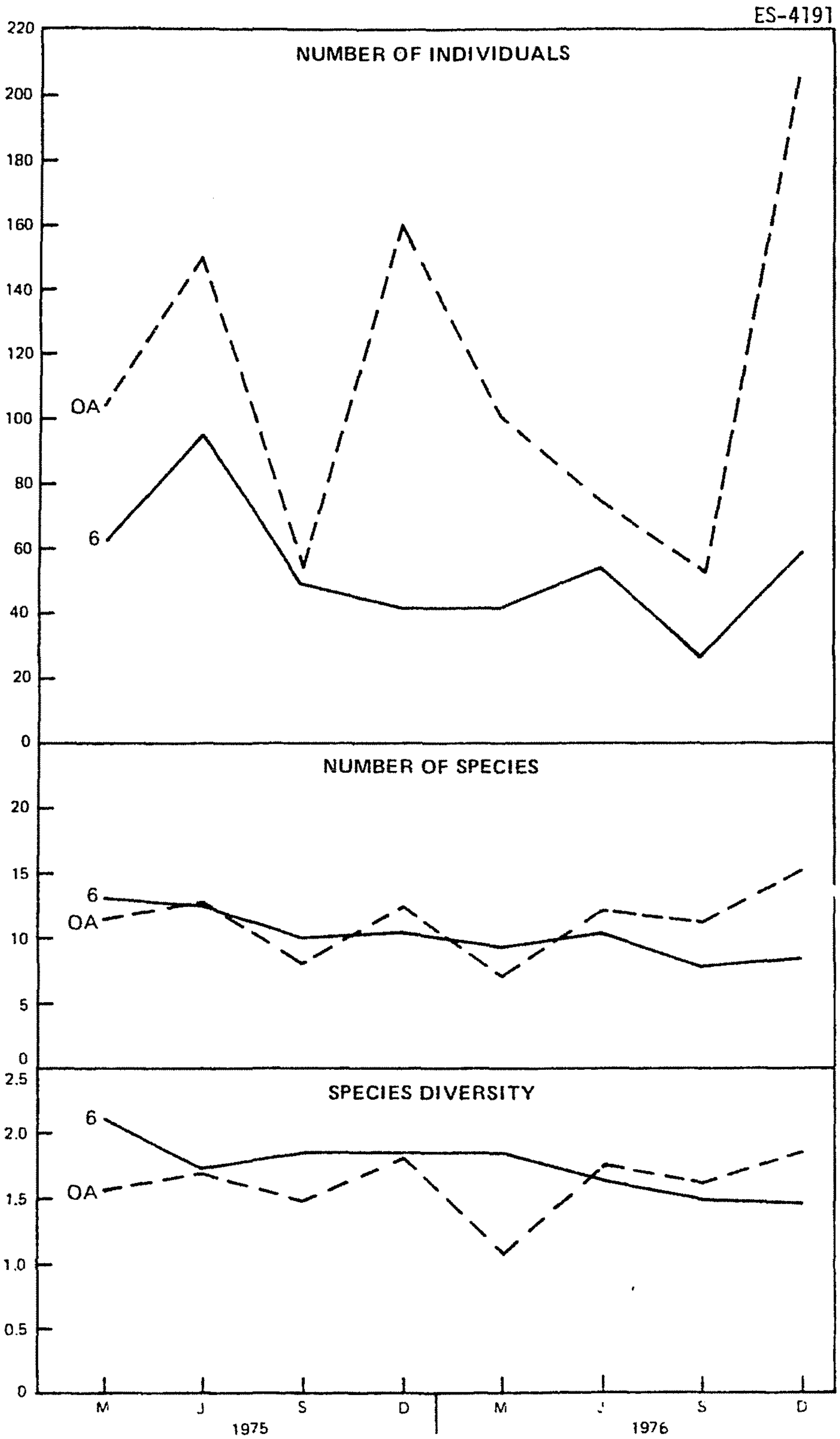

Fig. 2.7. The mean number of individuals and species per net by zone and species diversity of zones OA and 6 by survey during 1975 and 1976. Source: Lockheed Center for Marine Research, *San Onofre Nuclear Generating Station Unit 1, Environmental Technical Specifications, Annual Operating Report, Vol. IV, Biological Data Analysis — 1976,* June 1977.

The species whose distribution best discriminated between zones 0A and 6 were the anthozoan Muricea californica, which occurred mostly in zone 6; the rhodophyte Prionitis spp., which was absent from zone 6; the holothuroid Parastichopus parvimensis, which occurred only in zone 6; and the gastropod Astrea undosa, which was observed only in zone 0A.

The trophic composition based on the number of taxa of the two zones not associated with kelp beds (zones 0A and 6) was similar among these zones and was dominated by suspension feeders and by primary producers during all surveys (Table 2.6).

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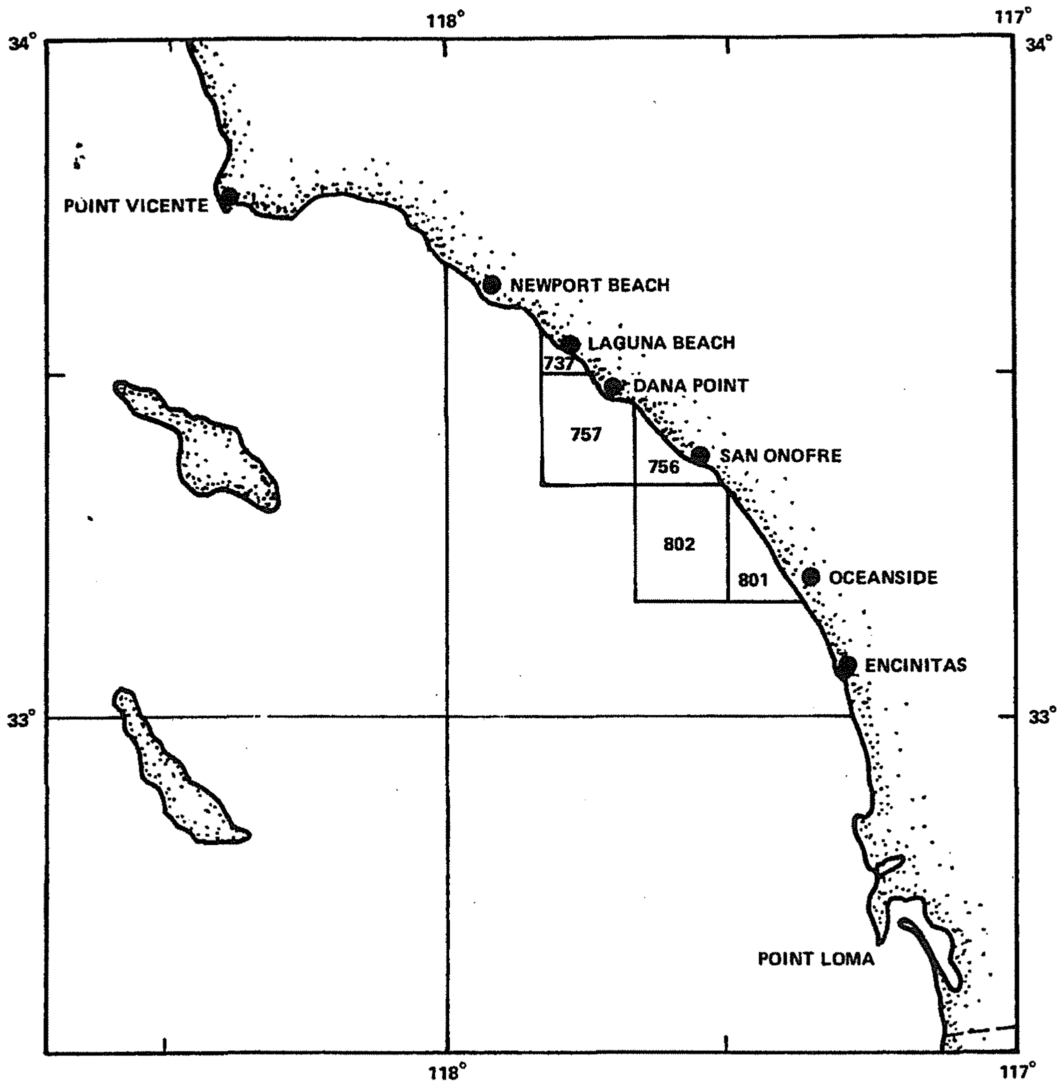

Fig. 2.8. California Department of Fish and Game catch statistic blocks in the vicinity of San Onofre. Source: Lockheed Center for Marine Research, *San Onofre Nuclear Generating Station Unit 1, Environmental Technical Specifications, Annual Operating Report, Vol. IV, Biological Data Analysis — 1976*, June 1977.

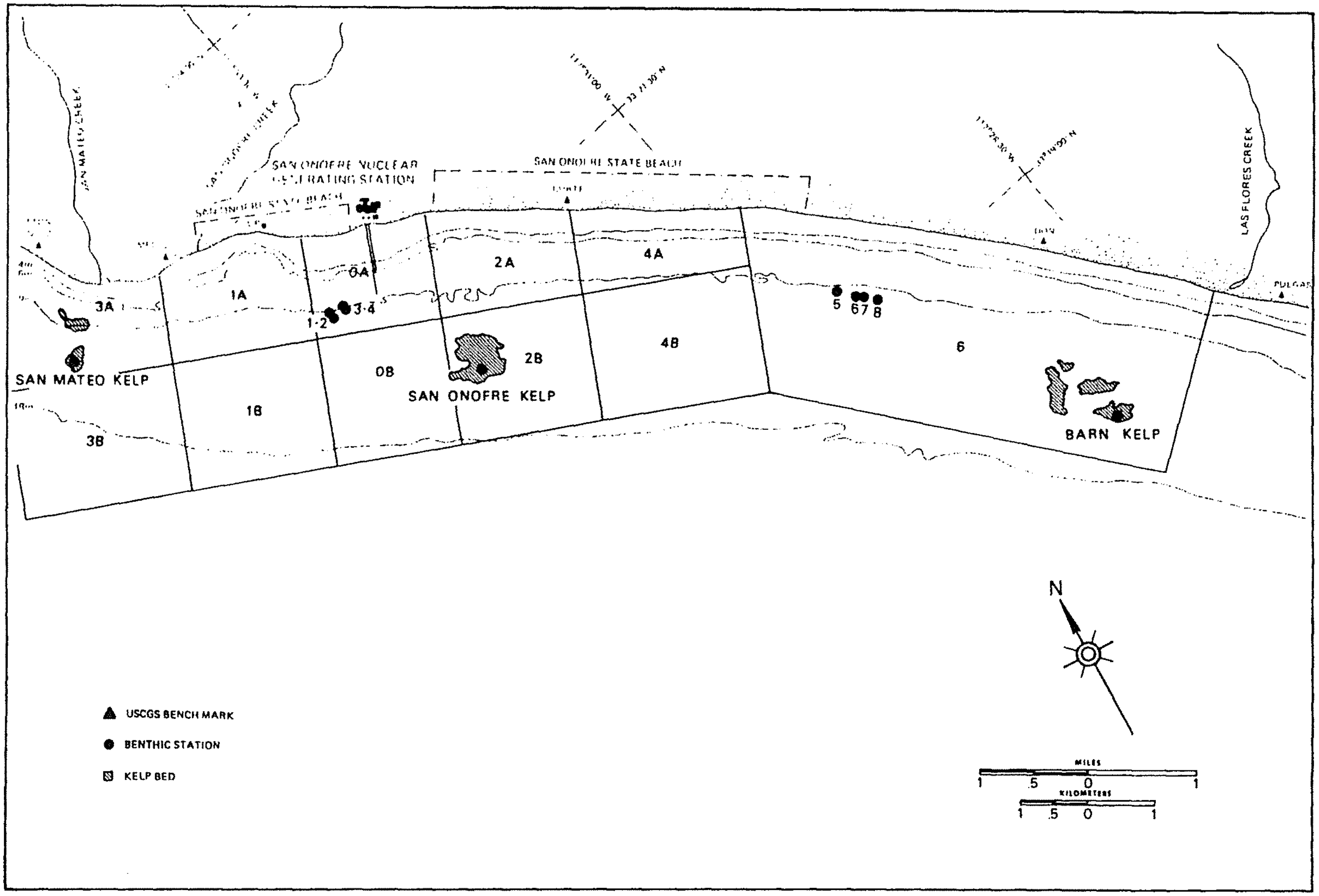

Fig. 2.9. Environmental Technical Specifications environmental surveillance zones, benthic station locations, San Onofre Nuclear Generating Station Unit 1. Source: Lockheed Center for Marine Research, *San Onofre Nuclear Generating Station Unit 1, Environmental Technical Specifications, Annual Operating Report, Vol. IV, Biological Data Analysis — 1976*, June 1977.

Table 2.6. Trophic composition (percent) of benthic taxa at discharge (zone 0A) and control (zone 6) based on the number of taxa of each trophic type present during 1975

Trophic types	April 10–18 Zone 0A	April 10–18 Zone 6	July 15–18 Zone 0A	July 15–18 Zone 6	October 13–17 Zone 0A	October 13–17 Zone 6
Primary producers	23	18	35	40	30	29
Suspension feeders	34	43	35	42	33	37
Grazers	10	3	12		12	5
Scavengers	13	13	7	10	12	11
Predators	20	22	12	7	13	18

Source: Lockheed Marine Biological Laboratory, *San Onofre Nuclear Generating Station Unit 1, Annual Analysis Report, Environmental Technical Specifications, January – December 1975*, 1976.

Kelp bed stations were best distinguished by four taxa: the gastropod *Cypraea spadicea*, which occurred only at San Onofre Kelp Bed; the anthozoan *Corynactis* spp., which occurred predominately at San Mateo and Barn kelp beds; the annelid *Spiochaetopterus costarum*, which did not occur at San Onofre Kelp Bed; and the white abalone, *Haliotis sorenseni*, which occurred only at San Onofre Kelp Bed. Twelve taxa were considered predominant at kelp bed stations: *Chelyosoma productum*, *Conus californicus*, *Corallina/Haliptylon*, *Corynactis* spp., Crustose corallines (unident.), *Dioptra* spp., *Leucilla nuttingi*, *Lytechinus pictus*, *Mitrella carinata*, *Muricea californica*, Pagurids (unident.), and *Rhodymenia* spp.

Trophic composition based on the number of taxa at the kelp bed stations was similar among stations and was dominated by suspension feeders (e.g., barnacles, which feed by filtering out suspended material) and primary producers (algae) during all surveys (Table 2.7).

Table 2.7. Trophic composition (percent) of benthic taxa at San Mateo (SMK), San Onofre (SOK), and Barn (BK) kelp beds based on the number of taxa of each trophic type present during 1975

Trophic types	April 10–18 SMK	April 10–18 SOK	April 10–18 BK	July 15–18 SMK	July 15–18 SOK	July 15–18 BK	October 13–17 SMK	October 13–17 SOK	October 13–17 BK
Primary producers	22	19	24	26	21	25	30	18	26
Suspension feeders	49	36	41	38	36	59	43	38	45
Grazers	2	17	9	8	12		7	10	4
Scavengers	12	12	9	12	12	9	7	12	10
Predators	15	17	17	16	18	6	12	22	16

Source: Lockheed Marine Biological Laboratory, *San Onofre Nuclear Generating Station Unit 1, Annual Analysis Report, Environmental Technical Specifications, January – December 1975*, 1976.

1976 Data

Diving surveys of the epibenthic macrobiota were conducted quarterly during 1976 at the same 11 benthic stations. A total of 159 species or higher taxa, which were members of 11 major taxonomic groups, were identified during the four surveys.[27] A taxonomic summary of these data by station and by survey is presented in Tables IV-1 and IV-2, pp. 21-28 of ref. 26. Zones 0A and 6 contained twelve predominant taxa whose combined abundance accounted for 84.3% of the total percent cover and 65.1% of the total enumerated individuals.[27] Seven of the twelve predominant taxa consisted of large taxonomic categories that were not field identifiable to a lower taxon. These seven taxa included parvosilvosa, unidentified ectoprocts, unidentified crustose coralline algae, and unidentified hydroids, rhodophytes, pelecypod siphons, and pagurids. These large taxonomic groups totaled 72% of the total percent cover and 20% of the total enumerated individuals for the entire year's data.[27] The magnitude of the abundances of these large taxonomic groups may be somewhat misleading, however, because each of these categories can contain members of several different species.[27]

The predominant taxa identified to at least the generic level consisted of *Rhodymenia* spp., *Bryopsis hypnoides*, *Diopatra ornata*, *Muricea californica*, and *Patiria miniata*. The distribution of these taxa among zones and stations is presented in Table V-12, p. 68 of ref. 27. The abundance of all of these taxa differed significantly between zones; *Rhodymenia* spp. and *Patiria miniata* were significantly more abundant in zone 0A, whereas *Bryopsis hypnoides*, *Diopatra ornata*, and *Muricea californica* were significantly more abundant in zone 6. None of these taxa differed significantly among surveys.

A greater degree of similarity in both species composition and abundance was found within zones than between zones. Distribution of the anthozoan *Murica californica* and the rhodophyte *Prionitis* spp. contributed the greatest to the differences between zones 0A and 6 in both years. Also in both 1975 and 1976, *M. californica* and the polychaete *Diopatra ornata* were significantly more abundant in zone 6. Species composition of the San Onofre Kelp Station was generally more similar to zone 0A stations than to the other kelp bed stations; this is much the same as the 1975 survey data.

No significant differences existed between zones or kelp bed stations in the distribution of taxa among trophic levels during 1975 or 1976.

Aerial infrared kelp survey

An aerial infrared kelp survey revealed that both Barn and San Onofre kelp beds showed a slight increase in total area during 1975 (Fig. 2.10). All of the kelp beds increased in size between February and May 1976 (Fig. 2.10). During the period May to September 1976, Barn and San Onofre kelp beds underwent an 80 and 92% decrease respectively.[27] At the time of the November 1976 survey, Barn Kelp Bed had increased to 77% of the area it had covered during the May survey, whereas San Onofre Kelp Bed again underwent a slight decrease.[27] San Mateo Kelp Bed remained essentially the same. The same general trends were encountered during mapping of the kelp beds by electronic positioning during 1975 and 1976 as part of the construction surveillance program for SONGS 2 & 3.

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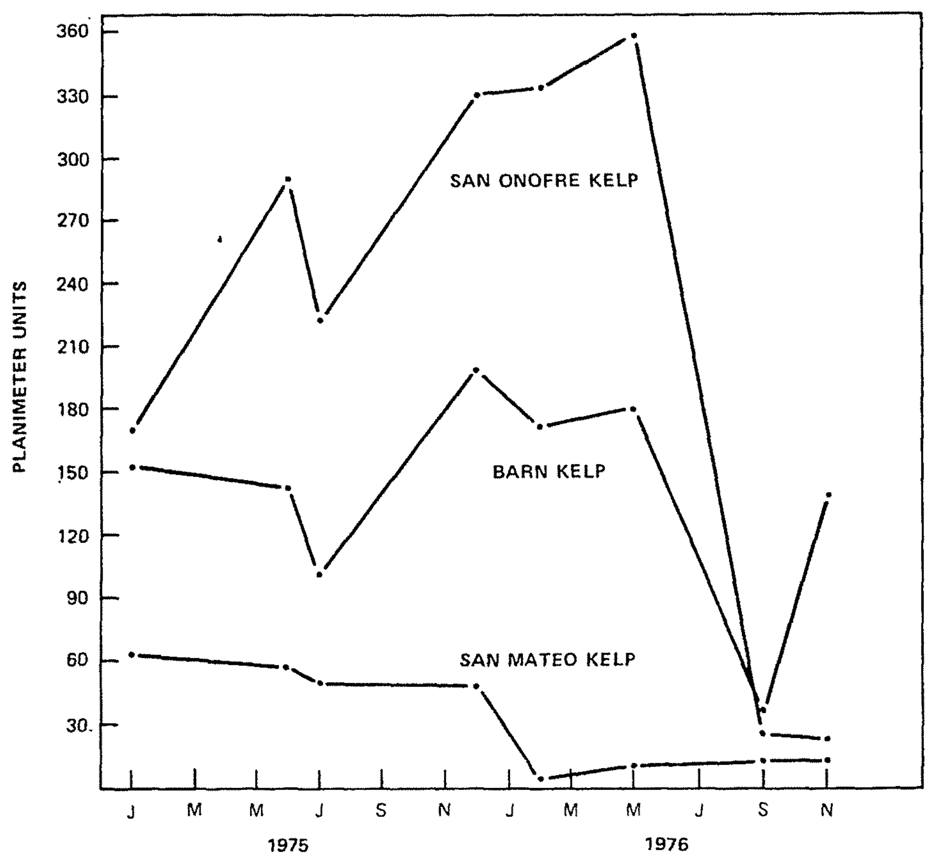

Fig. 2.10. Estimated relative total canopy area of San Mateo, San Onofre, and Barn kelp beds during 1975 and 1976, based on planimeter integration of aerial infrared photographs. Source: Lockheed Center for Marine Research, *San Onofre Nuclear Generating Station Unit 1, Environmental Technical Specifications, Annual Operating Report, Vol. IV, Biological Data Analysis — 1976*, June 1977.

Historical accounts of changes in kelp bed canopy areas throughout southern California have shown changes in magnitude equal to or much greater than those observed during this study, often over a short period of time.[27]

2.5.2.4 Intertidal community

1975 Data

During four intertidal surveys in 1975, 106 species or higher taxa representing 12 major taxonomic groups were observed at the five intertidal stations (Fig. 2.11).[25] These taxa are listed in Appendix XII, Tables 1 and 2, p. 246-52 of ref. 25. A comparison of the data collected in 1975 with historical data indicates that the fauna and flora encountered are typical inhabitants of this geographical area.[25] Phaeophytes, rhodophytes, and mollusks consistently exhibited the greatest number of taxa throughout the year at all stations. The distribution of five taxa were found to contribute significantly to the variability among stations: the rhodophytes *Corallina/Haliptylon*, *Pterocladia/Gelidium*, *Laurencia* spp.; the spermatophyte *Phyllospadix* spp.; and the anthozoan *Anthophleura* spp. Seventeen taxa, the majority of which were algae, were both common and abundant. The most abundant of these seventeen taxa were *Corallina/Haliptylon*, *Ulva* spp., and *Zonaria farolwii*.

Six predominant taxa exhibited distributions that varied significantly among stations, but no patterns that interrelated these differences were obvious. These six taxa were the anemone *Anthopleura* spp.; the rhodophytes *Corallina/Haliptylon*, *Lithothrix aspergillum*, *Pterocladia/Gelidium*; and the phaeophytes *Sargassum* spp. and *Zonaria farlowii*.

1976 Data

Quarterly intertidal sampling was also conducted in 1976. A taxonomic summary of these data by survey and station is presented in Table VI-1, pp. 35-38 of ref. 26.

Predominant taxa identified to at least the generic level were *Sargassum* spp., *Mitrella carinata*, *Macron lividus*, *Anthopleura elegantissima*, *Corallina/Haliptylon*, *Zonaria farlowii*, and *Dictyota/Pachydictyon*. The distribution of the abundance of these organisms for each station and for each survey is presented in Table VII-11, p. 104 of ref. 27. No significant differences were found in the abundance of *Dictyota/Pachydictyon*, *Macron lividus*, and *Mitrella carinata* among stations. The distribution of four taxa — *Corallina/Haliptylon*, *Zonaria farlowii*, *Sargassum* spp., and *Anthopleura elegantissima* — displayed statistically significant differences in abundance among stations. *Corallina/Haliptylon* was most abundant at station 5, *Zonaria farlowii* at stations 2 and 4, and *Sargassum* spp. was at station 3. The greatest number of *A. elegantissima* was observed at stations 1, 4, and 5.

The rhodophyte *Corallina/Haliptylon* contributed the most to the differences among stations during both 1975 and 1976 and was also predominant both years. During both years this taxon was more abundant at the station farthest downcoast of the SONGS 1 discharge and least abundant at the two stations upcoast of the discharge. Three other predominant taxa, *Sargassum* spp., *Zonaria farlowii*, and *Anthopleura elegantissima* exhibited statistically significant differences in abundance among stations during both 1975 and 1976. *Dictyota/Pachydictyon* exhibited no statistically significant differences in abundance among stations during either year.

No statistically significant difference in the distribution of taxa among trophic types existed among intertidal stations during either year. During both years, the intertidal communities of all stations were dominated by primary producers (algae).

The study area is accessible to considerable human intervention in the form of organism collecting in the tide pools, clam digging, surfing, and walking through intertidal cobble beds. Because of their accessibility via public roads, the stations nearest and upcoast of the generating station receive the heaviest use; the other stations receive less use because they are accessible only via hiking trail or the beach. Overall beach use in the study area is indicated by the San Onofre Beach State Park (which includes the study area) estimates of park use for 1976, which indicate that 378,483 people used the beach in the study area. The study area is also used heavily by clam diggers collecting littleneck clams, because this area is probably one of the most extensive and productive in the state. The large excavations and overturned cobble that result from clam digging may have considerable effect on the intertidal biota by disturbing habitats and interfering with mating activities.

Aerial infrared survey data on three occasions in 1976 revealed possible shore impingement of the 0.6°C (1°F) elevated temperature field at the four stations nearest the generating station. The 2°C (4°F) elevated field appeared to contact the shore immediately upcoast of the generating station but did not impinge on any intertidal cobble stations. Shore impingement of the elevated temperature field was not indicated in 1975.

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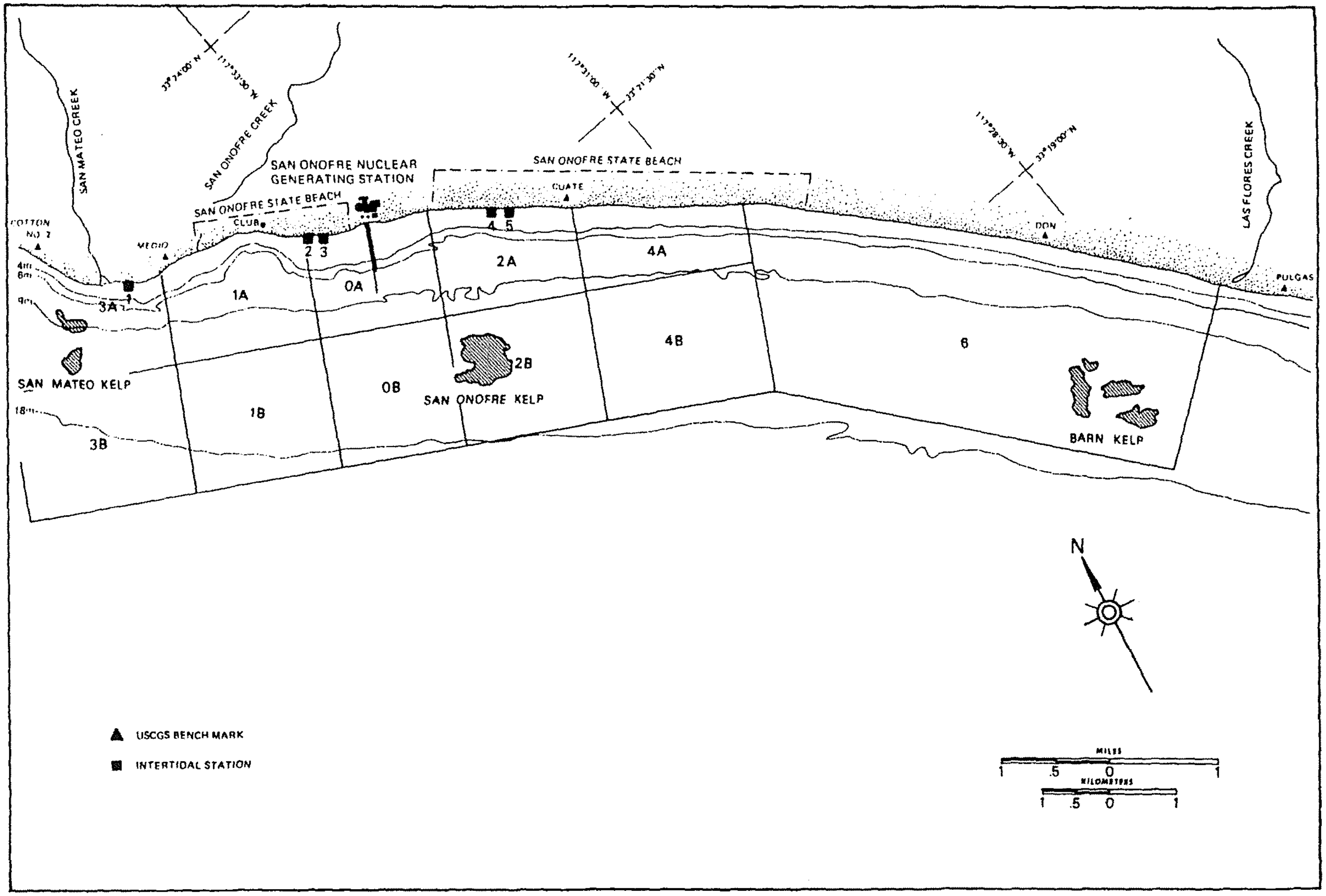

Fig. 2.11. Environmental Technical Specifications intertidal station locations and environmental surveillance zones, San Onofre Nuclear Generating Station Unit 1. <u>Source</u>: Lockheed Center for Marine Research, *San Onofre Nuclear Generating Station Unit 1, Environmental Technical Specifications, Annual Operating Report, Vol. IV, Biological Data Analysis — 1976*, June 1977.

Based on a comparison of the abundance of predominant taxa among stations and the similarity of stations during the study, the intertidal communities under study did not display a great deal of temporal variation during either 1975 or 1976. Minimal differences were detected among surveys with respect to the abundance of predominant taxa. These differences did not appear related to the offline condition of the generating station which occurred during two of four surveys.

2.6 BACKGROUND RADIOLOGICAL CHARACTERISTICS

The Environmental Protection Agency[29] has reported average background radiation dose equivalents for California as 96.6 millirems per person per year. The average background for San Diego is 104.6 millirems per person per year. (This is higher than the state average because of natural radioactivity in granitic rocks in the area.) Of the total for California, 42.2 millirems per person per year was attributed to cosmic radiation. Of this total external gamma radiation (primarily from K-40 and the decay products of the uranium and thorium series) was estimated at 36.4 millirems per person per year. The remainder of the whole body dose is due to internal radiation (mostly H-3, C-14, K-40, Ra-225, and Ra-228 and their decay products), which was estimated to average 18 millirems per person per year.

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***Available from NTIS only.

3. THE PLANT

3.1 RESUME

The domestic water supply and service water system will now be supplied by the Tri-Cities Municipal Water District rather than obtained from flash boilers as previously contemplated (Sect. 3.2.1). The major design changes that have environmental effects relate to the heat dissipation system. The revised heat dissipation system is described in Sect. 3.2.2. These revisions and others result in a change in the chemical effluents and are discussed in Sect. 3.2.4.1. Changes in the radioactive waste treatment systems are described in Sect. 3.2.3. Significant changes have occurred in the transmission lines; the revised transmission line system is described in Sect. 3.2.5.

3.2 DESIGN AND OTHER SIGNIFICANT CHANGES

3.2.1 Plant water use

Both fresh water and seawater will be used at SONGS 2 & 3. About 0.05 m^3/sec (1.65 cfs) of fresh water will be supplied by the Tri-Cities Municipal Water District for the domestic water supply system and service water system. The major portion of the domestic water requirement will be used for landscaping and associated functions. The service water system will provide water to miscellaneous systems and equipment throughout the operating areas. A large amount of this fresh water will be used at the intake screenwell area for cooling of pump bearings.

The source of seawater is the Pacific Ocean. Cooling water will be withdrawn from the ocean at a rate of 53.5 m^3/sec (1887 cfs). This water will be used for turbine plant cooling, component cooling, main condenser cooling, and for the fish handling system. The turbine plant and component cooling water systems are closed-cycle systems. Heat is transferred to the seawater by heat exchangers.

Further details of the plant water use are given in Fig. 3.1.

3.2.2 Heat dissipation system

Plant waste heat will be dissipated by means of a separate once-through cooling system for each unit. About 53.5 m^3/sec (1887 cfs) of seawater per unit is withdrawn from the ocean through a velocity-cap-type submerged intake, located about 975 m (3200 ft) from shore. The velocity cap is circular with a 15-m (50-ft) diameter. The lower lip of the cap is 2.7 m (9 ft) from the ocean bottom, and the interior separation of the upper and lower lip is 2.1 m (7 ft). The intake velocity will be about 0.5 m/sec (1.7 fps). The total water depth at the intake region is 9.1 m (30 ft). The intake structure is illustrated in Fig. 3.2.

Each unit has a Seismic Category I auxiliary intake structure to provide emergency core cooling. These structures are located approximately 32 m (100 ft) shoreward of the primary intake structures. Each structure has a 3.66 m (4-ft) ID vertical riser that extends upward from the intake conduit and is equipped with a velocity cap that is similar in design to that of the primary system. During normal operating conditions, water is estimated to enter the structure at 0.38 m/sec (1.3 fps). Details of these structures are shown in Fig. 3.2.

After passing through the intake, the cooling water for each unit will travel to the plant via a 5.5-m (18-ft) ID pipe that becomes a 4.9-m (16-ft) square box conduit at the shoreline. Here, water is delivered to a forebay leading to the intake structure screenwell. The water will then pass through a series of baffles as the channel widens to about 12.5 m (41 ft). At this point, the channel narrows and the main volume of water turns through an angle of 70°, where it passes through six adjacent sets of traveling bars and screens. A small volume of water does not turn towards these bars and screens but continues along the narrowing channel and enters the fish collection chamber.

Each screenwell is outfitted with traveling bar racks behind which are 1-cm (3/8-in.) mesh traveling screens. In the forebay behind the traveling screens are four 1/4-capacity vertical, wet pit,

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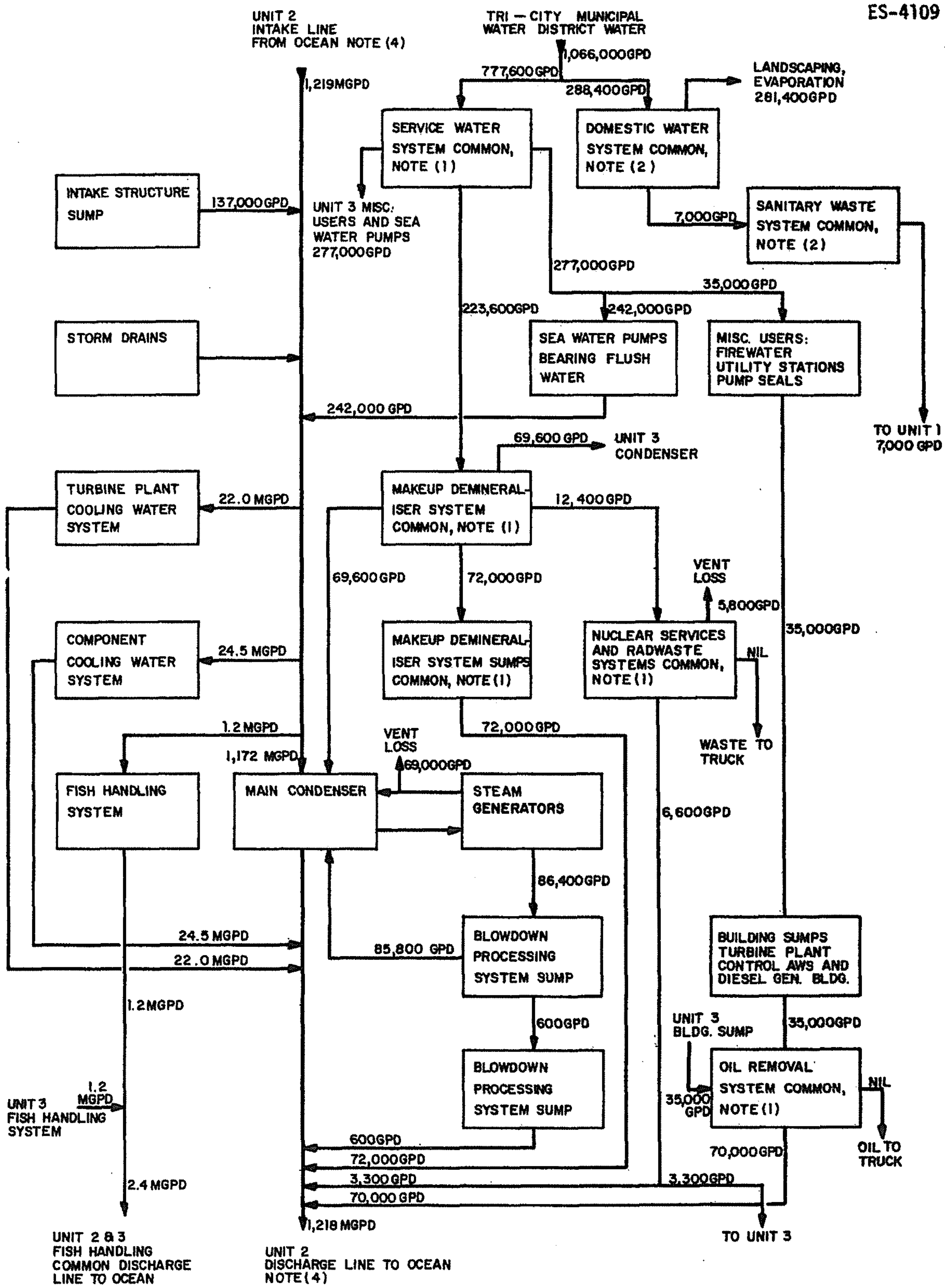

Notes: (1) Common system, serves Units 2&3
(2) Common system, serves Units 2&3, AWS bldg
(3) MGPD, millions of gallons per day
(4) Unit 3 flows are same as Unit 2
(5) To convert GPD to liters per day, multiply by 3.7854

Fig. 3.1. Plant water use. Source: ER, Fig. 3.3-1.

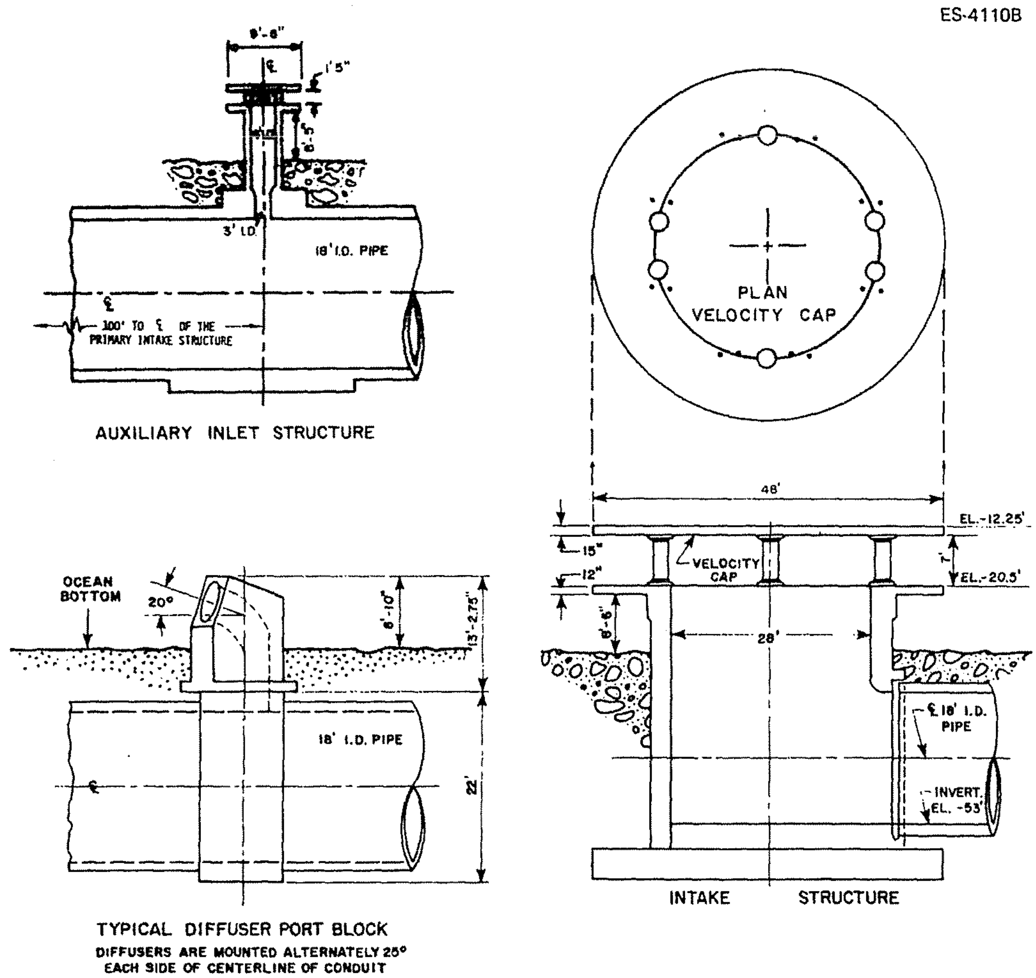

Fig. 3.2. Design details of the velocity-cap intake structure and typical diffuser port. Source: ER, Fig. 3.4-2.
(To convert ft to m, multiply by 0.3048.)

circulating water pumps. These pumps provide 50.3 m^3/sec (1775 cfs) of water to a two-shelled condenser. This water experiences an 11.1°C (20°F) temperature rise across the condenser. About 2.1 m^3/sec (75.8 cfs) of water is withdrawn prior to reaching the condenser for use in the turbine plant cooling loop and the fish return systems. Details of the intake screenwell structure are shown in Fig. 3.3.

After passing through the condenser, the heated water will pass through the Amertap strainer, which collects the Amertap balls used for cleaning the condenser tubes. Subsequently, this heated water is supplemented by 1.1 m^3/sec (37.9 cfs) of water from the turbine plant cooling system and screenwashing. The water then passes into a seal well weir chamber designed to ensure proper siphon flow through the condenser. This chamber terminates into a 4.9-m (16-ft) square box conduit to which 1.1 m^3/sec (37.9 cfs) of nuclear component cooling water flow is added. At the shoreline, this square conduit joins a 5.5-m (18-ft) ID buried pipe that conveys the heated water to the diffuser.

The diffuser for each unit is about 762 m (2500 ft) in length, and each diffuser has 63 ports spaced 12 m (40 ft) apart. Each port extends 1.8 m (6 ft) from the bottom and is oriented from the horizontal at an angle of 20°. The ports are alternately aligned at angles of ±25° from the offshore direction. The port throat diameter will vary from 56 cm (22 in.) to 61 cm (24 in.), and the maximum discharge velocity from any port will be 4 m/sec (13 fps). The Unit 3 diffuser begins about 1150 m (3800 ft) from shore, and the Unit 2 diffuser begins about 1950 m (6400 ft) from shore. The Unit 2 diffuser is located about 220 m (722 ft) upcoast of the Unit 3 diffuser.

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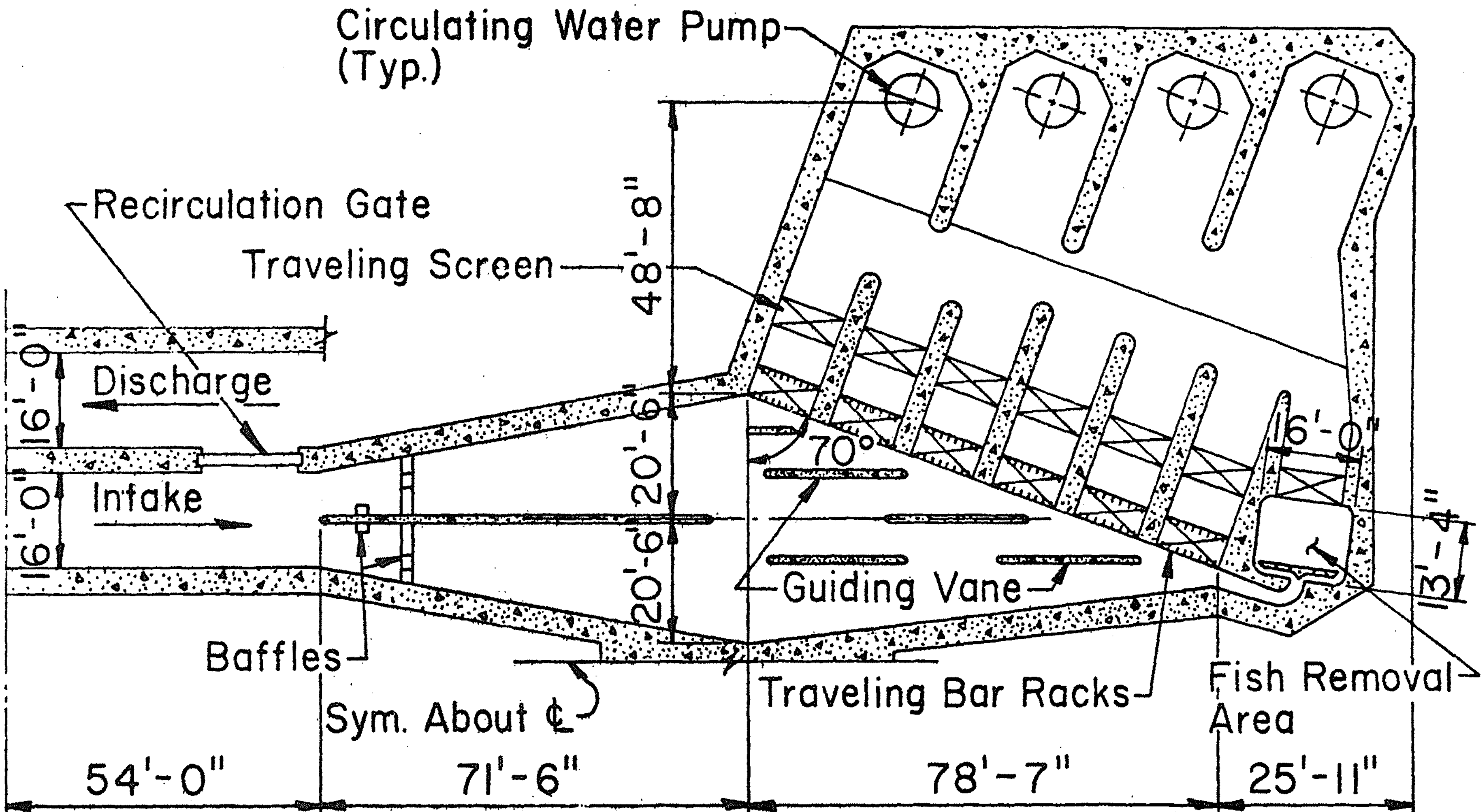

Fig. 3.3. Design details of the intake screenwell area. Source: ER, Fig. 3.4-3. (To convert ft to m, multiply to 0.3048; to convert in. to mm, multiply by 25.4.)

To control biofouling, the circulating water system is designed to allow heated water to reach all portions of the system. To accomplish this, an intake/discharge crossover gate allows seawater to be drawn into the plant through the diffusers and the heated water to be discharged via the intake. To achieve the temperature required to control biofouling, each unit has a recirculation and crossover gate. This system allows the cooling water requirement to be reduced by recirculating a portion of the heated water through the condenser. The temperature rise will be proportional to the degree of recirculation. During diffuser heat treatment, the circulating water follows the normal path but with recirculation. Intake heat treatment is performed by opening the intake/discharge crossover gate to reverse the flow direction, as well as to allow recirculation. Circulating water flow paths for the various plant operations are shown in Fig. 3.4.

A fish return system minimizes the mortality of fish that have reached the intake screenwell area. The louvered bar racks are designed and oriented in such a way that the fish are encouraged to follow a narrowing channel terminating at a fish holding chamber. This chamber is equipped with a vertical elevator basket that periodically rises slowly from the bottom to capture the fish in the chamber. Subsequently, the fish are flushed from the basket with seawater into a 1.2-m (48-in.) diameter pipe, which returns them to the ocean via an offshore submarine outfall.

3.2.3 Radioactive waste systems

During the operation of SONGS 2 & 3 radioactive material will be produced by fission and by neutron activation of corrosion products in the reactor coolant system. From the radioactive material produced, small amounts of gaseous and liquid radioactive wastes will enter the waste streams. These streams will be processed and monitored within the station to minimize the quantity of radioactive nuclides ultimately released to the atmosphere and to the Pacific Ocean.

The waste handling and treatment systems to be installed at the station are discussed in the applicant's Final Safety Analysis Report (FSAR) and in the ER. Information submitted to meet the requirements of Appendix I to 10 CFR Part 50 is contained in both the FSAR and ER. In these documents, the applicant has presented an analysis of the radioactive waste treatment systems and has estimated the annual release of radioactive waste materials in liquid and gaseous effluents resulting from normal operation.

In the following paragraphs, the radioactive waste treatment systems are described, and an analysis is given based on the staff's model of the applicant's proposed radioactive waste treatment systems. The staff's model has been developed from a review of available data from operating nuclear power plants, adjusted to apply over a 30-year operating life. The reactor coolant activities and flow rates used in the staff's analyses are based on experience and data from operating reactors. As a result, the parameters used in the model and the calculated releases vary somewhat from those used in the applicant's evaluation.

On April 30, 1975, the NRC announced its decision in the rulemaking proceeding (RM 50-2) concerning numerical guides for design objectives and limiting conditions for operation to meet the criterion "as low as is reasonably achievable" for radioactive material in light-water-cooled nuclear power reactor effluents. This decision is implemented in the form of Appendix I to 10 CFR 50.[1] To effectively implement the requirements of Appendix I, the NRC staff has reassessed the parameters and mathematical models used in calculating releases of radioactive materials in liquid and gaseous effluents in order to comply with the Commission's guidance.

This guidance directed that current operating data, applicable to proposed radwaste treatment and effluent control systems for a facility, be considered in the assessment of the input parameters. These parameters, models, and their bases are given in NUREG-0017.[2]

By letter of February 25, 1976, the applicant was requested to submit additional information concerning the means proposed to keep levels of radioactive materials in effluents from SONGS 2 & 3 to unrestricted areas "as low as is reasonably achievable," in conformance with the requirements of Appendix I to 10 CFR 50. The applicant was also given the option of providing either a detailed cost benefit analysis or demonstrating conformance to the guidelines given in the September 4, 1975, Annex to Appendix I. The applicant chose to perform the cost-benefit analysis required by Sect. II.D of Appendix I to 10 CFR Part 50.

The staff performed an independent evaluation of the applicant's proposed methods to meet the requirements of Appendix I. The evaluation consisted of (1) a review of the information provided by the applicant, (2) a review of the applicant's proposed radwaste treatment and effluent control systems, (3) the calculation of new source terms based on models and parameters as given in NUREG-0017,[2] and (4) a cost-benefit analysis to determine the cost-effectiveness of proposed augments to the liquid and gaseous radwaste treatment systems.

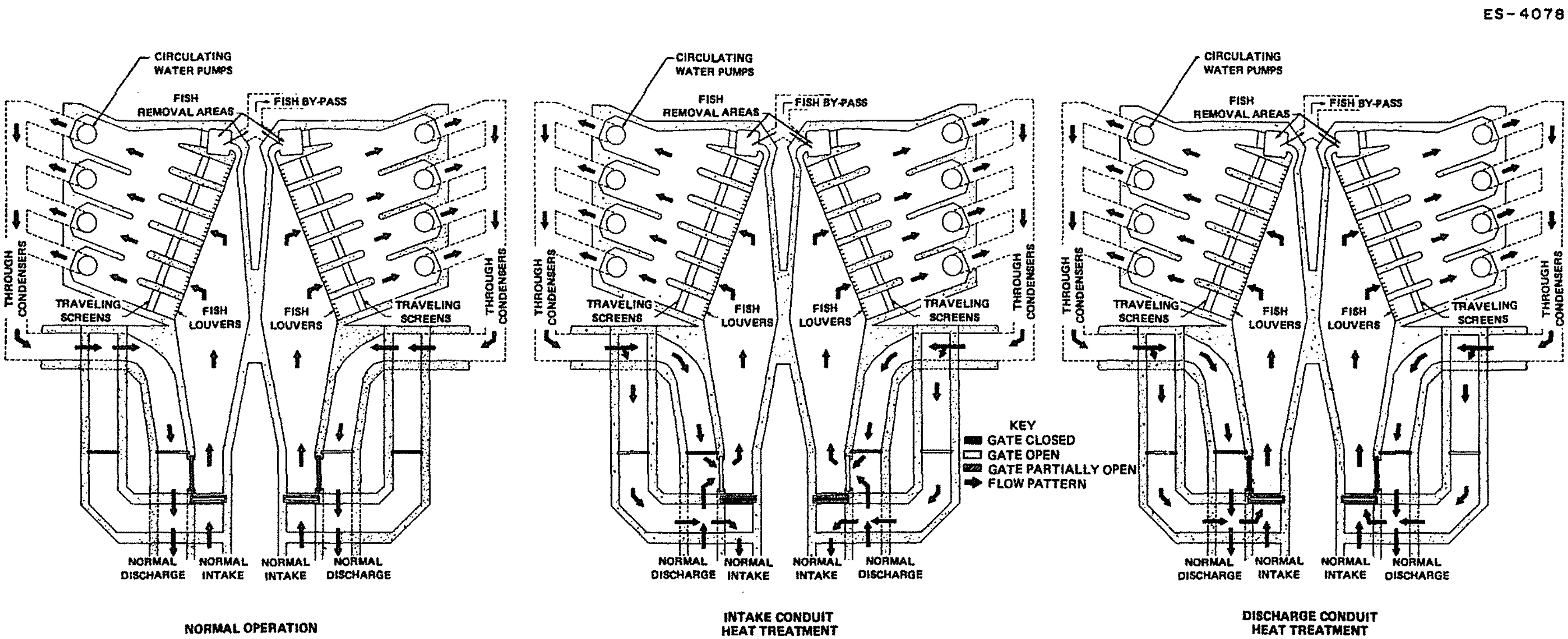

Fig. 3.4. Circulating water flow paths for normal plant operation, intake heat treatment, and discharge heat treatment. Source: Fig. 2-9 of *Thermal Effects Study Final Summary Report, San Onofre Generating Station Units 2 & 3 Volume 1*; Environmental Quality Analysts and Marine Biological Consultants, September 1973.

On the basis of the following evaluation, the staff concludes that the liquid and gaseous radio-active waste treatment systems for SONGS 2 & 3 are capable of maintaining releases of radioactive materials in liquid and gaseous effluents to "as low as is reasonably achievable" levels in accordance with 10 CFR Part 50.34a, and meet the requirements of Sect. II.A, II.B, II.C, and II.D of Appendix I to 10 CFR Part 50.[1]

3.2.3.1 Liquid radioactive waste treatment system

The liquid radioactive waste treatment system, which is shared by Units 2 and 3, will consist of equipment and instrumentation necessary to collect, process, monitor, recycle, or dispose of potentially radioactive liquid wastes generated during normal operation including anticipated operational occurrences. Liquid radioactive waste will be processed on a batch basis to permit optimum control of releases. Prior to release, samples will be analyzed to determine the types and amounts of radioactivity present; on the basis of the results, the waste will be recycled for reuse in the plant, retained for further processing, or discharged under controlled conditions to the Pacific Ocean via the circulating water outfall. A radiation monitor will automatically terminate liquid waste discharge if radiation measurements exceed a predetermined level in the discharge line. A schematic diagram of the liquid radioactive waste treatment system is given in Fig. 3.5.

The liquid radioactive waste treatment system will consist of the coolant radwaste (boron recovery) system, the miscellaneous (aerated) waste system, and the chemical waste system. The plant does not have a separate laundry and hot shower system; this function is combined in the aerated waste system.

The coolant radwaste system is shared by Units 2 and 3 and will process shim bleed and equipment drain wastes collected inside the reactor containment. The principal system components will be a gas stripper, four primary coolant radwaste holdup tanks, two preholdup demineralizers, two intermediate holdup tanks, two evaporator feed demineralizers, one evaporator, two polishing demineralizers, and two makeup storage tanks.

The miscellaneous liquid waste system will process non-reactor-grade liquid wastes, including floor drains, equipment drains containing non-reactor-grade water, and building sumps. After treatment these wastes will be transferred to the waste monitor tanks for reuse in the plant or for discharge to the Pacific Ocean via the circulating water outfall. The principal miscellaneous liquid waste system components will consist of one collection tank, four demineralizers, an optional evaporator, and two recycle monitor tanks. The liquid process stream may be routed through the optional evaporator if additional treatment is indicated.

The chemical waste system will process non-reactor-grade liquid wastes with high chemical content, including demineralizer regenerant solutions and laboratory drains. After treatment, these wastes will be transferred to the waste monitor tanks for reuse in the plant or for discharge to the Pacific Ocean via the circulating water outfall. The principal chemical waste system components will consist of one collection tank, an evaporator, two demineralizers, and two recycle monitor tanks.

The steam generator blowdown will be processed continually through a flash tank, with the liquid being cooled in a heat exchanger before passing through a filter and two demineralizers in series. The processed liquid is piped to the main condenser. The flashed steam is routed to the third point heater. The processed water will be reused in the plant, but may be discharged to the circulating water outfall under certain circumstances provided that radioactivity concentrations are below predetermined values.

Coolant radwaste system

Primary coolant will be withdrawn from the reactor coolant system at about 151 liters/min (40 gpm) and processed through the chemical and volume control system (CVCS). The letdown stream will be cooled, reduced in pressure, filtered, and processed through one of two mixed bed demineralizers. At the end of core cycle life this letdown stream will be passed through an anion demineralizer to remove boron when the feed and bleed mode of operation is not practicable. Radionuclide removal by the CVCS was evaluated by assuming 151-liters/min (40-gpm) letdown flow at primary coolant activity (PCA) through one mixed bed demineralizer (Li_3BO_3 form), and a continuous 30-liters/min (8-gpm) flow through one mixed bed demineralizer (H_3BO_3 form) for lithium control. The CVSC will be used to control the primary coolant boron concentration by diverting a side stream of about 3,785 liters/day (1000 gpd) per reactor of the treated letdown stream to the shared coolant radwaste system as shim bleed.

The shim bleed from the letdown stream will be processed through two mixed bed demineralizers (Li_3BO_3 form) in series, through a gas stripper, and routed to one of four 227,124-liter (60,000-gal) radwaste primary holdup tanks. Valve leakoffs and equipment drain wastes in the

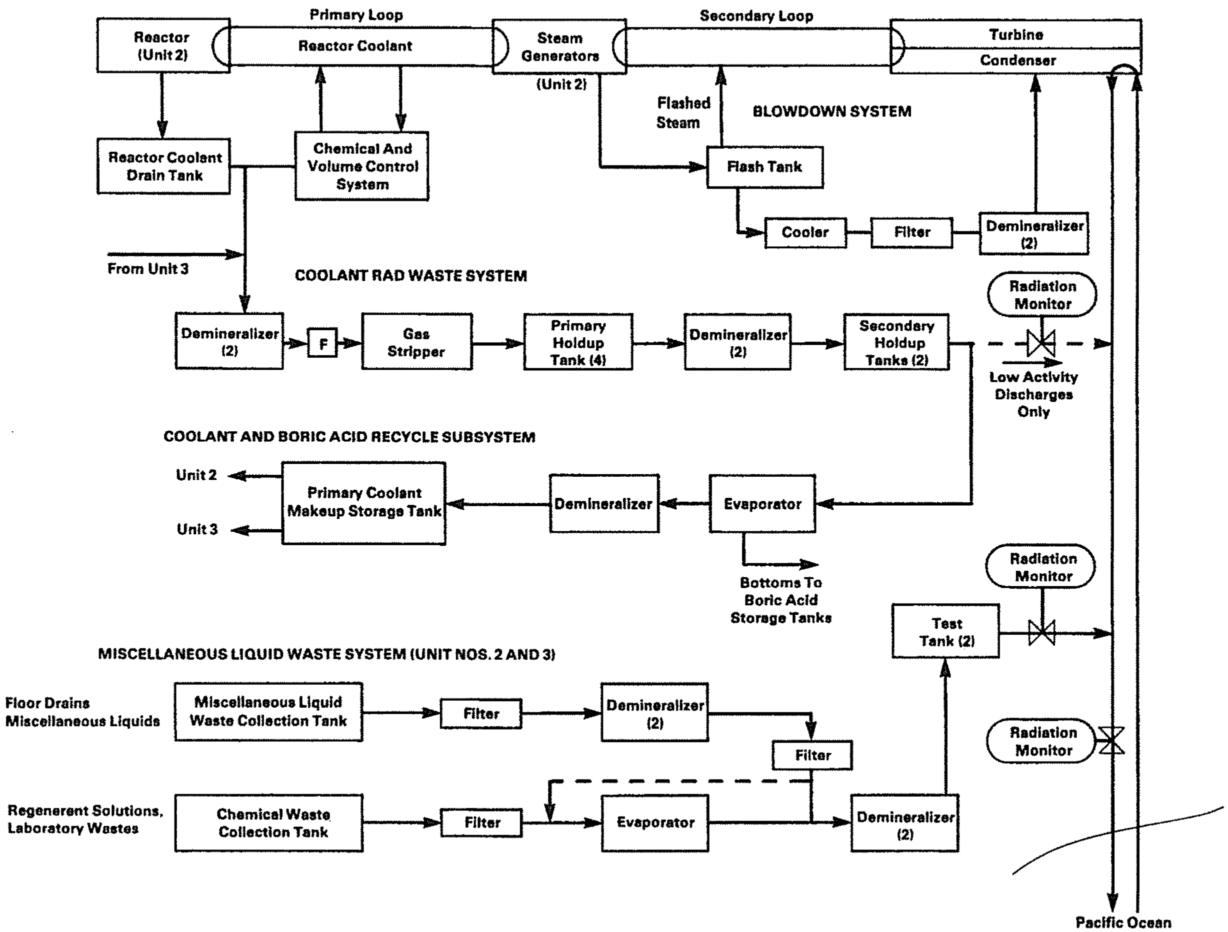

Fig. 3.5. SONGS 2 & 3 radioactive liquid waste treatment systems.

reactor containment, as well as excess spent fuel pit water, will be processed as above and will be transferred to the radwaste primary holdup tanks where it will be combined with the shim bleed. These streams will form the inputs to the coolant radwaste system and will be processed batchwise from the four radwaste primary holdup tanks. The combined streams are next processed batchwise through two mixed bed demineralizers (H_3BO_3 form) and routed to one of two 454,248-liter (120,000-gal) radwaste secondary holdup tanks. From the radwaste secondary holdup tanks, the processed liquid can be recycled to the reactor coolant makeup tank, can be discharged to the circulating water outfall if radioactivity concentrations are within established limits, or can be processed further through a boric acid evaporator and mixed bed deborating and polishing demineralizers.

In the latter mode of operation, the boric acid recovered in the evaporator bottoms can be recycled. Because the system is capable of continuously operating in the boron recovery mode with inputs from both Units 2 and 3, and because the staff's source term calculation assumes a failed fuel rate of 0.12%, the staff's evaluation was made on the basis of the system being operated in the boron recycle mode. The staff calculated the collection time in a radwaste secondary holdup tank to be about 38 days, based on a combined input flow rate of 9463 liters/day (2500 gpd) from Units 2 and 3. Based on an assumption of 80% tank capacity and process flow rate of 189 liter/min (50 gpm), the staff calculated the decay time during processing to be about 1.3 days. If the radioactivity is below predetermined value, the treated stream may be pumped to the waste monitor release tank and discharged. The staff assumed that 10% of the treated stream will be discharged to the circulating water outfall and to the Pacific Ocean because of anticipated operational occurrences and for tritium inventory control. The decontamination factors listed in Table 3.1 were applied for radionuclide removal in the coolant radwaste system. The concentrated bottoms from the evaporator and the spent resins from the demineralizers will be transferred to the radioactive solid waste system for disposal by burial offsite.

Miscellaneous liquid waste system

The miscellaneous liquid waste system of the liquid radioactive waste treatment system is designed to collect and treat non-reactor-grade water for reuse within the plant from auxiliary building sumps, the containment sumps, and other miscellaneous sources. These wastes will be collected in a shared 22,712-liters (6000-gal) waste holdup tank at an input flow rate of about 5300 liters/day (1400 gpd) per unit. The staff calculated the collection time to be about 1.7 days. The wastes will be processed through four series connected mixed bed demineralizers and collected in a 94,635-liter (25,000-gal) test tank. The staff calculated the decay time during processing to be about 0.03 days. If necessary, the stream can be diverted to the evaporator in the chemical waste system for additional treatment.

The decontamination factors listed in Table 3.1 were applied for radionuclide removal in the miscellaneous liquid waste system of the liquid waste treatment system. The contents of the treated stream will be sampled periodically, recycled for further treatment, recycled for in-plant use, or discharged. The staff assumed that 100% of the treated stream will be released to the Pacific Ocean.

Evaporator bottoms and spent resins will be transferred to the radioactive solid waste system for disposal by burial offsite.

Chemical waste system

The chemical waste system of the liquid radioactive waste treatment system is designed to collect and treat non-reactor-grade liquid wastes from laboratory drains and from the regeneration of demineralizers. These wastes will be collected in a shared 94,635-liter (25,000-gal) chemical waste tank and sampled and analyzed. The wastes will be treated through the chemical waste system evaporator and two series connected mixed bed demineralizers prior to entering the waste monitor tanks. The staff calculated the collection time to be about 25 days, based on an input flow of about 1514 liters/day (400 gpd) per unit, and a decay time during processing of about 0.1 day.

Turbine building drain

The turbine building drains will be released through a radiation monitor to the Pacific Ocean via the circulating water outfall without treatment. The monitor will automatically terminate liquid discharge if radioactivity exceeds a predetermined level. The staff assumed a release of 27,255 liters/day (7200 gpd) per reactor and that the wastes will be discharged without processing.

Table 3.1. Principal parameters and conditions used in calculating releases of radioactive material in liquid and gaseous effluents from SONGS 2 & 3

Reactor power level, MWt	3600
Plant capacity factor	0.80
Failed fuel, percent	0.12[a]
Primary system:	
Mass of coolant, lb	5.6×10^5
Letdown rate, gpm	40
Shim bleed rate, gpd	1×10^3
Leakage to secondary system, lb/day	100
Leakage to containment building	*b*
Leakage to auxiliary building, lb/day	160
Frequency of degassing for cold shutdowns, per year	2
Secondary system	
Steam flow rate, lb/hr	1.5×10^7
Mass of liquid steam generator, lb	1.7×10^5
Mass of steam/steam generator, lb	1.2×10^4
Secondary coolant mass, lb	2.2×10^6
Rate of steam leakage to turbine building, lb/hr	1.7×10^3
Containment building volume, ft^3	2×10^6
Annual frequency of containment purges, shutdown	4
Containment low volume purge rate (cfm)	2000
Iodine partition factors, gas/liquid	
Leakage to auxiliary building	0.0075
Leakage to turbine building	1.0
Main condenser/air ejector, volatile species	0.15

Liquid radwaste system decontamination factors (DF)

	Coolant radwaste system (CRS)	Miscellaneous liquid-waste system	Chemical-waste system
I	1×10^5	1×10^3	1×10^4
Cs, Rb	2×10^5	2×10^1	1×10^5
Others	1×10^6	1×10^3	1×10^5

	All nuclides except iodine	Iodine
Radwaste evaporator DF	10^4	10^3
Coolant radwaste system evaporator DF	10^3	10^2

	Anions	Cs, Rb	Other nuclides
Boron recycle feed demineralizer DF, H_3BO_3	10	2	10
Primary coolant letdown demineralizer DF, Li_3BO_3	10	2	10
Evaporator condensate polishing demineralizer, H^+OH^-	10	10	10
Mixed-bed radwaste demineralizer	10^2(10)	2(10)	10^2(10)
Steam generator blowdown demineralizer	10^2(10)	10(10)	10^2(10)
Containment building internal recirculation system charcoal filter DF, iodine removal			10
Main condenser air-removal system charcoal bed DF, iodine removal			10

[a]This value is constant and corresponds to 0.12% of the operating power fission product source term as given in NUREG-0017 (April 1976).

[b]One percent per day of the primary coolant noble gas inventory and 0.001% per day of the primary coolant iodine inventory.

(To convert lb to kg, multiply by 0.4536; to convert gals to liters, multiply by 3.7854; to convert ft^3 to m^3, multiply by 0.0283.)

Steam generator blowdown

The steam generator blowdown system for Units 2 and 3 will continuously process steam generator blowdown at an average flow rate of 325,545 liters/day (86,000 gpd) per reactor (design flow rate is 1136 liters/min (300 gpm)). The blowdown from the two steam generators for each unit will be directed to a common flash tank. The liquid will be cooled, filtered, and treated through two series connected demineralizers before being returned to the main condenser. The flashed steam will be condensed in the main condenser hotwell. The staff did not consider any direct releases from this system to the environment.

Liquid waste summary

Based on the staff's evaluation of the radioactive liquid waste treatment systems and the parameters listed in Table 3.1, the staff calculated the release of radioactive materials in liquid waste effluent to be about 1.1 Ci per year per reactor, excluding tritium and dissolved gases. The staff estimates that about 300 Ci per year per reactor of tritium will be released to the Pacific Ocean. In comparison, the applicant estimated a release of radioactive material in liquid effluent, exclusive of tritium, to be about 0.67 Ci per year per reactor and a tritium release of 710 Ci per year per reactor. The differences between the staff's values and those of the applicant lie principally in assumptions as to the parameters used for each radwaste system component and the distribution of tritium between gaseous and liquid releases. The staff's calculations of the radionuclides expected to be released annually from SONGS 2 & 3 are given in Table 3.2.

On the basis of the calculated releases of radioactive materials in liquid effluents given in Table 3.2, the staff calculated the annual dose or dose commitment to the total body or to any organ of an individual in an unrestricted area, as shown in Table 5.3, to be less than 3 millirem per reactor and 10 millirem per reactor, respectively, in conformance with Sect. II.A of Appendix I to 10 CFR Part 50.

Cost-benefit analysis of liquid radwaste system augments

The staff evaluated potential liquid radwaste system augments based on a study of the applicant's system designs, the population dose information provided in Table 5.3 of this statement, a value of $1000 per total body man-rem and $1000 per man-thyroid-rem for reductions in dose by the application of augments, and the methodology presented in Regulatory Guide 1.110.[3]

The principal parameters used in this cost-benefit analysis are: (1) labor cost correction factor, FPC Region VIII, 1.2 (Regulatory Guide 1.110[3]); (2) indirect cost factor, 1.75 (Regulatory Guide 1.110[3]); (3) cost of money, 15%; and (4) capital recovery factor, 0.0806 (Regulatory Guide 1.110[3]).

The calculated total body and thyroid doses from liquid releases to the projected population within a 80 km (50-mile) radius of the station, when multiplied by $1000 per total body man-rem and $1000 per man-thyroid-rem, resulted in cost-assessment values of $170 per year per unit and $140 per year per unit respectively. Potential radwaste system augments were selected from the list given in Regulatory Guide 1.110.[3] The most effective augment was the optional use of an existing 0.189 liters/min (50-gpm) evaporator in the miscellaneous liquid waste system; however, the calculated total annualized cost of $80,000 for operation and maintenance of the augment exceeded the cost-assessment values of $170 per unit for the total body man-rem dose and $140 per unit for the man-thyroid-rem dose. The staff concludes, therefore, that there are no cost-effective augments to reduce the cumulative population dose at a favorable cost-benefit ratio, and that the proposed liquid waste management system meets the requirements of Sect. II.D of Appendix I to 10 CFR Part 50.

3.2.3.2 Gaseous radioactive waste treatment system

The gaseous radioactive waste treatement and building ventilation exhaust systems will be designed to collect, store, process, monitor, recycle, and/or discharge potentially radioactive gaseous wastes that will be generated during normal operation including anticipated operational occurrences. The system will consist of equipment and instrumentation necessary to reduce releases of radioactive gases and particulates to the environment.

The principal source of radioactive gaseous wastes are the gaseous waste processing system, condenser vacuum pump, and ventilation exhausts from the auxiliary, radwaste, fuel handling, containment, and turbine buildings. The principal system for treating gaseous wastes stripped from the primary coolant will be the gaseous waste processing system (GWPS). The GWPS will be a once-through nitrogen system containing a surge tank, two compressors, and six pressurized storage tanks. The off-gas from the main condenser air ejector will be processed through HEPA

Table 3.2. Calculated releases of radioactive materials in liquid effluents from SONGS 2 & 3

Nuclide	Curies per year per unit
Corrosion and activation products	
Cr-51	5.6(−4)
Mn-54	9(−5)
Fe-55	4.9(−4)
Fe-59	3(−4)
Co-58	4.8(−3)
Co-60	6.1(−4)
Np-239	2.5(−5)
Fission products	
Br-83	7(−5)
Rb-86	1.1(−3)
Rb-88	1.4(−2)
Sr-89	1(−4)
Sr-91	4(−5)
Y-91m	3(−5)
Y-91	2(−5)
Zr-95	2(−5)
Nb-95	1(−5)
Mo-99	1.9(−2)
Tc-99m	1.5(−2)
Ru-103	1(−5)
Rh-103m	1(−5)
Te-127m	8(−5)
Te-127	1.1(−4)
Te-129m	4.1(−4)
Te-129	2.8(−4)
I-130	1.9(−4)
Te-131m	4(−4)
Te-131	7(−5)
I-131	8.1(−2)
Te-132	6.2(−3)
I-132	7.8(−3)
I-133	5.3(−2)
I-134	2.3(−4)
Cs-134	3.5(−1)
I-135	9.5(−3)
Cs-136	1.7(−1)
Cs-137	2.5(−1)
Ba-137m	1.6(−1)
Ba-140	6(−5)
La-140	4(−5)
Ce-141	2(−5)
Pr-143	1(−5)
All others	5(−5)
Total, except H-3	1.1
H-3	300

filters and charcoal absorbers prior to release to the environment. The containment building atmosphere will be recirculated through HEPA filters and charcoal absorbers prior to release to the environment. Ventilation exhaust air from the auxiliary building and the fuel handling area will not be processed prior to release to the environment. The turbine building ventilation exhaust air will be released to the environment without treatment. The gaseous waste and ventilation treatment systems are shown schematically in Fig. 3.6.

Gaseous waste processing system (GWPS)

The GWPS will be designed to collect and process gases stripped from the primary coolant in the CVCS, coolant radwaste system, and miscellaneous tank cover gases. The GWPS is shared between Units 2 and 3. The GWPS will contain an inventory of nitrogen and hydrogen which will act as a carrier gas to transport radioactive gases removed from the primary coolant. Hydrogen and nitrogen cover gases from the volume control and reactor coolant drain tanks, and gases stripped in the coolant radwaste system degasifier will be collected, compressed, and stored in one of six pressurized storage tanks. The storage tanks will collect and store gases to allow short-lived radionuclide decay. After holdup, the gases will be discharged to the environment.

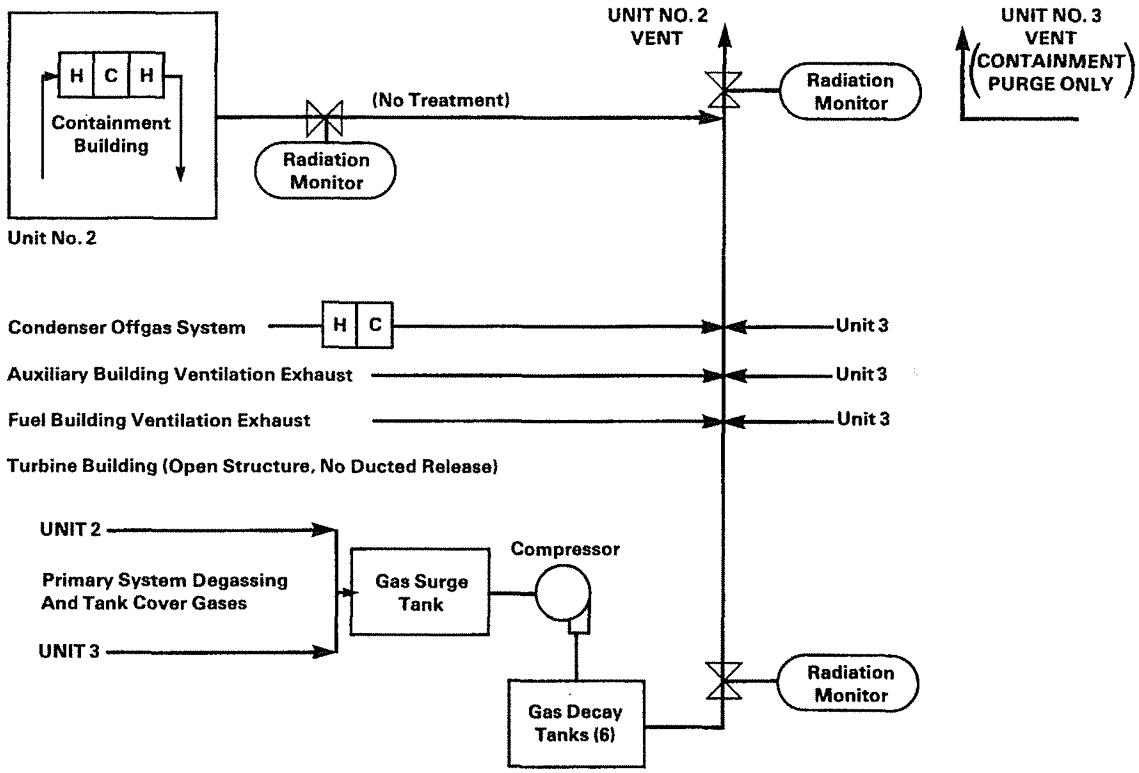

Fig. 3.6. SONGS 2 & 3 radioactive gaseous waste treatment systems.

In its evaluation, the staff assumed three tanks for storage, with two tanks held in reserve for back-to-back shutdowns, and one tank in the process of filling. Each tank has a volume of 14.16 m^3 (500 ft^3) and operates at 300 psig. On this basis, the staff calculated a holdup time of 90 days prior to discharge of gases to the environment.

Containment ventilation system

Radioactive material will be released inside the containment when primary system leakage occurs. The staff assumed on the basis of system parameters that the containment will be purged continuously during power operations at 56.6 m^3/min (2000 cfm) and in addition will have four high volume shutdown purges per year at 1132 m^2/min (40,000 cfm). Prior to purging, the containment atmosphere will be recirculated through HEPA filters and charcoal absorbers. The staff assumed radionuclide removal during the recirculation phase to be based on a flow rate of 453 m^3/min (16,000 cfm), system operation for 16 hr, a mixing efficiency of 70%, a particulate decontamination factor of 100 for HEPA filters, and an iodine decontamination factor of 10 for charcoal absorbers. The purge exhaust gases are released without filtration or other treatment.

Ventilation releases from other buildings

Radioactive materials will be released into the plant atmosphere due to leakage from equipment transporting or handling radioactive materials. Ventilation air from the auxiliary building and fuel building is not processed prior to release. The staff estimated that 72.58 kg (160 lb) of primary coolant per day will leak to the auxiliary building with an iodine partition factor of 0.0075. Small quantities of radionuclides will be released to the open turbine building, based on an estimated 771 kg/hr (1700 lb/hr) of steam leakage. The open turbine building releases will be released directly to the environment.

Main condenser air ejector

Off-gas from the main condenser air ejectors will contain radioactive gases as a result of primary to secondary leakage. In its evaluation, the staff assumed a primary to secondary leak rate of 45 kg/day (100 lb/day). Noble gases and iodine will be contained in steam generator leakage and released to the environment through the main condenser air ejectors in accordance with the partition factors listed in Table 3.1. The air ejector exhaust will be released to the environment through HEPA filters and charocal absorbers.

Gaseous waste summary

Based on the staff's evaluation of the gaseous radioactive waste treatment and building ventilation systems and the parameters listed in Table 3.1, the staff calculated the release of radioactive materials in gaseous effluents to be about 15,000 Ci per year per unit for noble gases and 0.44 Ci per year per unit for iodine-131. In comparison, the applicant estimated a release of 8600 Ci per year per unit for noble gases and 0.096 Ci per year per unit for iodine-131. The staff estimated a release of 0.39 Ci per year per unit of particulates and 1100 Ci per year per unit of tritium. The applicant estimated a release of 0.2 Ci per year per unit of particulates and 710 Ci per year per unit of tritium.

The staff's calculated annual releases of radioactive materials in gaseous effluents from radionuclides expected to be released annually from SONGS 2 & 3 are given in Table 3.3. Based on the calculated releases of radioactive materials in gaseous effluents given in Table 3.3, the staff calculated the annual air in an unrestricted area, as shown in Table 5.3. to be less than 10 millirads per reactor for gamma radiation or 20 millrads per reactor for beta radiation and the annual external doses to the total body and skin of an individual in an unrestricted area to be less than 5 millirems and 15 millirems, respectively, and an organ dose of less than 15 millirems per reactor for radioiodine and radioactive particulates in conformance with Sect. II.B and II.C of Appendix I to 10 CFR 50.

Table 3.3. Calculated releases of radioactive materials in gaseous effluents from SONGS 2 & 3 (Curies per year per unit)

Nuclide	Decay tanks	Reactor building	Auxiliary building	Turbine building	Air ejector	Total
Kr-83m	*a*	2	*a*	*a*	*a*	2
Kr-85m	*a*	24	2	*a*	2	28
Kr-85	430	170	5	*a*	3	610
Kr-87	*a*	5	1	*a*	*a*	6
Kr-88	*a*	30	4	*a*	3	37
Kr-89	*a*	*a*	*a*	*a*	*a*	*a*
Xe-131m	*a*	90	3	*a*	2	95
Xe-133m	*a*	140	5	*a*	3	150
Xe-133	*a*	13,000	410	*a*	260	14,000
Xe-135m	*a*	*a*	*a*	*a*	*a*	*a*
Xe-135	*a*	120	8	*a*	5	130
Xe-137	*a*	*a*	*a*	*a*	*a*	*a*
Xe-138	*a*	*a*	*a*	*a*	*a*	*a*
Total noble gases						15,000
I-131	*a*	0.35	0.08	0.0042	0.005	0.44
I-133	*a*	0.27	0.09	0.0033	0.0056	0.37
Mn-54	4.5(−3)[b]	2.2(−2)	1.8(−2)	*c*	*c*	4.4(−2)
Fe-59	1.5(−3)	7.4(−3)	6(−3)	*c*	*c*	1.5(−3)
Co-58	1.5(−2)	7.4(−2)	6(−2)	*c*	*c*	1.5(−2)
Co-60	7(−3)	3.3(−2)	2.7(−2)	*c*	*c*	6.7(−2)
Sr-89	3.3(−4)	1.7(−3)	1.3(−3)	*c*	*c*	3.3(−3)
Sr-90	6(−5)	2.9(−4)	2.4(−4)	*c*	*c*	5.9(−4)
Cs-134	4.5(−3)	2.2(−2)	1.8(−2)	*c*	*c*	4.4(−2)
Cs-137	7.5(−3)	3.7(−2)	3(−2)	*c*	*c*	7.4(−2)
Total particulates						1.2
H-3						1,100
C-14	7	1	*a*	*a*	*a*	8
Ar-41	*a*	25	*a*	*a*	*a*	25

[a] Less than 1 Ci/year for noble gases and carbon-14, less than 10^{-4} Ci/year for iodine.
[b] Exponential notation: 4.5(−3) = 4.5×10^{-3}.
[c] Less than 1% of total for this nuclide.

Cost-benefit analysis of gaseous radwaste system augments

The staff has evaluated potential gaseous radwaste system augments based on a study of the applicant's system designs, the population dose information provided in Table 5.3 of this statement, a value of $1000 per total body man-rem and $1000 per man-thyroid-rem for reductions in dose by the application of augments, and the methodology presented in Regulatory Guide 1.110.[3]

The calculated total body and thyroid doses from gaseous releases to the population within a 80 km (50-mile) radius of the station, when multiplied by $1000 per total body man-rem and $1000 per man-thyroid-rem, resulted in cost-assessment values of $21,000 per year per unit and $46,000 per year per unit respectively. Potential radwaste system augments were selected from the list given in Regulatory Guide 1.110. The most effective augment considered was the installation of charcoal adsorbers and HEPA filters on the containment mini-purge ventilation exhaust. The addition of this augment would result in a dose reduction of approximately 6.3 total-body man-rem and 23.8 thyroid man-rem with corresponding cost assessment values of $6,300 and $23,800, respectively. The calculated total annualized cost of $26,500 for the augment is more than the annual cost assessment values of $6,300 and $23,800 given above. The staff concludes, therefore, that there are no cost-effective augments to reduce the cumulative population dose at a favorable cost-benefit ratio, and the proposed gaseous waste treatment and ventilation systems meet the requirements of Sect II.D of Appendix I to 10 CFR Part 50.[1]

The staff concludes that the gaseous radwaste system for Units 2 and 3 is capable of maintaining releases of radioactive materials in gaseous effluents to "as low as is reasonably achievable" levels in accordance with 10 CFR Part 50.34a and meets the requirements of Appendix I to 10 CFR Part 50. The staff, therefore, concludes that the proposed system is acceptable.

3.2.3.3 Solid wastes

The solid waste system will be designed to process two general types of solid wastes: "wet" solid wastes which require solidification prior to shipment, and "dry" solid wastes which require packaging and, in some cases, compaction prior to shipment to a licensed burial facility. "Wet" solid wastes will consist mainly of spent filter cartridges, demineralizer resins, and evaporator bottoms which contain radioactive materials removed from liquid streams during processing. "Dry" solid wastes will consist mainly of low-activity ventilation air filters, contaminated clothing, paper, and miscellaneous items such as laboratory glassware and tools. Spent resins from the demineralizers will be collected in the spent resin storage tank. When the resin is to be packaged, it will be sluiced to a disposable liner and dewatered before solidification. The resin beads are solidified by filling the void spaces with urea formaldehyde and catalyst. A disposable paddle is used to agitate the mixture in the liner during the solidification process. Concentrated evaporator wastes will be collected in an evaporator bottoms tank, and then pumped batchwise through an inline mixer where they are blended with a urea formaldehyde solution. From the inline mixer, the mixture is sprayed into a disposal liner while a liquid catalyst is simultaneously sprayed into the liner by a separate nozzle to assure intimate mixing of the waste-urea formaldehyde solution and the catalyst.

On the basis of its evaluation and on recent data from operating plants, the staff has determined that about 425 m^3 (15,000 ft^3) per unit of "wet" solid wastes, containing about 1060 Ci of activity, will be shipped offsite annually. The principal radionuclides in the solid wastes will be long-lived fission and corrosion products, mainly Cs-134, Cs-137, Co-58, Co-60 and Fe-55. The applicant estimated the combined production of solid wastes from Units 2 and 3 to be 283 m^3/yr (10,000 ft^3/ year) of solidified wastes. The applicant calculated the total curie content of these solid wastes to be about 6500 Ci. The waste containers will be stored in a shielded area, as required, to reduce contact radiation levels.

Dry solid wastes will be packaged in cardboard boxes, wooden boxes, and special DOT-approved containers. Compressible wastes such as clothing and rags will be compressed prior to packaging. The staff estimates the dry solid wastes to total 283 m^3 (10,000 ft^3) per unit per year with a total activity content of less than 5 Ci. The applicant estimates the combined production of dry wastes from Units 2 and 3 to be 207 m^3/yr (7300 ft^3/year) with a calculated total curie content of about 21 Ci.

3.2.4 Chemical, sanitary, and other waste effluents

3.2.4.1 Chemical effluents

Several design changes have had significant impacts on chemical discharges. The condenser tubes are made of titanium (ER, Table 3.4-1) rather than of a copper-nickel alloy; this should eliminate the small amounts of copper and nickel in the discharge as described previously

(FES-CP, Sect. 3.5.1). An Amertap condenser tube cleaning system has been installed (ER, Sect. 3.4.4). In this system, sponge rubber balls are injected into the inlet piping of the condenser and are forced through the condenser tubes to scrape them clean. The balls are collected in the circulating water discharge conduit and are recirculated. This change helps to control fouling within the circulating water system and should reduce the frequency of chlorination necessary to maintain a clean condenser system. A makeup demineralizer system will replace the flash evaporators. Chemicals originally indicated as being discharged from the flash evaporators (FES-CP, Table 3.9) will not be discharged. A cellulose sealant for the circulating water system (FES-CP, Sect. 3.5.1) will not be used. Steam generator blowdown will be treated by filtration and demineralization and will be recycled to the condenser. Phosphates will not be added to the blowdown (FES-CP, Sect. 3.5.2), and the discharge of salts and heavy metal ions will be eliminated.

The only significant chemical discharge results from the use of sodium hypochlorite as a biocide. The chlorination system is common to both Units 2 and 3. The two units will not be treated at the same time. Hypochlorite solution will be injected into the circulating water pump discharge headers three times each day. Each injection will last about 15 min but will not exceed 90 min per unit per day. The chlorine residual in the circulating water discharge line is monitored by amperometric titration, and the addition of hypochlorite is adjusted to maintain a 0.5-mg/liter (1.89 grains/gal) maximum concentration of free available chlorine. The applicant estimates that this will result in a maximum free available chlorine concentration of 0.1 mg/liter (0.38 grains/gal) in the immediate vicinity of the discharge.

Other chemicals may be discharged at certain times. These chemicals generally will be discharged at low concentrations and, when mixed with the circulating water flow, represent a negligible concentration at the discharge to the ocean. During restarts the discharge of condensate from the hotwell may contain concentrations of several milligrams per liter of iron and copper. These substances will be reduced to negligible concentrations in the circulating water discharge. The discharge from the regeneration of demineralizers will contain sodium and sulfate ions; the concentrations at the discharge to the ocean will be less than 10 mg/liter (38 grains/gal) – negligible concentrations as compared to the natural concentrations in seawater. Small amounts of oil, not to exceed 5 mg/liter (19 grains/gal), will be discharged from the oil removal system and diluted to negligible concentration in the circulating water discharge. Various closed-loop cooling systems will be treated with potassium chromate to inhibit corrosion.

Offsite rainfall runoff from the coastal hills and from Interstate Highway 5 (I-5) is collected by the storm runoff drainage system for the highway. Part of this drainage is discharged directly to the ocean and part is discharged with the onsite plant drainage. Onsite plant drainage is collected in catch basins and is discharged with the circulating water discharge. Drainage collected in areas in which significant quantities of oil or grease might be present are routed through the oil removal system.

A National Pollutant Discharge Elimination System (NPDES) permit for SONGS 2 & 3 was issued on June 14, 1976, by the California Regional Water Quality Control Board, San Diego Region. The chemical effluent limitations for the combined discharges (cooling water, low-volume wastes, and storm drains) are: (1) the monthly average free available chlorine discharged shall not exceed 0.2 mg/liter (0.757 grains/gal), and the daily maximum shall not exceed 0.5 mg/liter (1.89 grains/gal); (2) discharge of free available chlorine or total residual chlorine from any plant unit for more than 2 hr in any one day or for more than one unit in the plant at any one time is prohibited; (3) the pH of the effluent shall be within the range of 6.0 to 9.0; and (4) after July 1, 1976, the discharge shall not exceed the limits given in Table 3.4. The permit prohibits the discharge of any chemicals or pollutants from the fish handling system. The low-volume waste discharge shall not exceed the following limits: (1) a monthly average of 30 mg/liter (113.6 grains/gal) and a daily maximum of 100 mg/liter (378.6 grains/gal) for total suspended solids and (2) a monthly average of 15 mg/liter (56.78 grains/gal) and a daily maximum of 20 mg/liter (75.7 grains/gal) for oil and grease. The discharge from the storm drains shall not exceed a monthly average of 10 mg/liter (38 grains/gal) and a daily maximum of 15 mg/liter (56.78 grains/gal) for oil and grease.

3.2.4.2 Sanitary and other waste effluents

Sanitary wastes from Units 2 and 3 will receive secondary level treatment in the sewage treatment plant located at Unit 1, which will serve all three units. The treated wastes will have the following water quality characteristics (average daily concentration): suspended solids, 30 mg/liter (113.6 grains/gal); biological oxygen demand, 30 mg/liter(413.6 grains/gal); coliform, mean probable number of 200 per 100 ml (59 per ounce); pH, 7.0 to 8.5; and total residual chlorine, 2.0 mg/liter (7.57 grains/gal) (ER, Table 5.4-1). The treated wastes will be discharged into the Unit 1 circulating water discharge at an average rate of about 0.02 m^3/min (5 gpm). Because the circulating water discharge at Unit 1 is about 1200 m^3/min (320,000 gpm), the sanitary waste effluents will be reduced to negligible concentrations at the point of discharge to the ocean. The sanitary waste effluents for all three units will be within the

Table 3.4. NPDES chemical effluent limitations

Constituent	Concentration (mg/liter) not to be exceeded more than	
	50% of time	10% of time
Arsenic	0.01	0.02
Cadmium	0.02	0.03
Total chromium	0.005	0.01
Copper	0.2	0.3
Lead	0.1	0.2
Mercury	0.001	0.002
Nickel	0.1	0.2
Silver	0.02	0.04
Zinc	0.3	0.5
Cyanide	0.1	0.2
Phenolic compounds	0.5	1.0
Total chlorine residual	1.0	2.0
Ammonia (as N)	40	60
Total identifiable chlorinated hydrocarbons	0.002	0.004
Toxicity concentration	1.5[a]	2.0[a]

[a]Toxicity units.
Source: ER, Appendix 12C.

(To convert mg/liter to grains/gal, multiply by 3.785.)

limitations established for Unit 1 by the California Regional Water Quality Board and the Environmental Protection Agency.

Some gaseous wastes from the operation of diesel generators and the auxiliary boiler will be discharged intermittently. Four diesel generators will serve Units 2 and 3, and it is anticipated that these will operate for about 2 hr once per month. The estimated hourly full-load emission in kilograms (pounds) from each generator is nitrogen oxides, 84 (185); sulfur dioxide, 11 (25); particulates, 0.9 (2); hydrocarbons, 3.9 (8.5); and carbon monoxide, 9.5 (21) (ER, Sect. 3.7.4.1). A single auxiliary boiler will be used for both Units 2 and 3. This boiler will be operated for varying time periods throughout the life of the plant (ER, Sect. 3.7.4.2). The maximum annual use is expected to be 1250 hr at full load and 3130 hr at half load. Under these conditions, the anticipated annual emissions in tonnes (tons) are nitrogen oxides, 44 (49); sulfur dioxide, 98 (108); and particulates, 34 (38).

Trash from screens for the circulating water system for Units 2 and 3 will be taken to the Bonsall Sanitary Landfill near the city of Vista, California. This landfill is used for the disposal of trash from Unit 1.

3.2.5 Transmission lines

Much of the description of the transmission lines presented in Sect. 3.7 of the FES-CP is no longer valid. Construction of SCE's transmission line from SONGS to Santiago Substation will be completed only up to Santiago Tap, thereby deleting that portion between Santiago Tap and Santiago Substation. SDG&E's line from Telega Substation to Escondido Substation has also been deleted. SCE will retrofit transmission lines from SONGS to Santiago Tap, Santiago Tap to Santiago Substation, and Santiago Tap to Black Star Canyon Tap. SDG&E will add a line from SONGS to Mission Substation. SDG&E's lines from SONGS to Telega Substation and SONGS to Encina Substation will still be constructed but the staff has received additional information with regard to these lines since issuance of the FES-CP. Therefore, these lines will be further discussed in Sect. 3.2.5.2. All transmission lines for operation of SONGS Units 2 and 3 are illustrated in Figs. 3.7 and 3.8. Generally, the lines are coastal, using existing rights-of-way traversing northward from SONGS to Talega Substation, Santiago Tap, Santiago Substation, and Black Star Canyon Tap, and southeast to Encina and Mission Substations. A total of about 159.1 km (98.9 miles) will be crossed by the transmission lines. No new rights-of-way, however, will be required.

The SCE and SDG&E transmission lines will each be supported by two steel horizontal portal structures (Fig. 3.9) for the initial 0.6 km (0.4 mile) of right-of-way northeast of the SONGS switchyard. These structures will replace the steel lattice towers now supporting the existing circuits in this area. No additional land for tower bases or access roads will be required.

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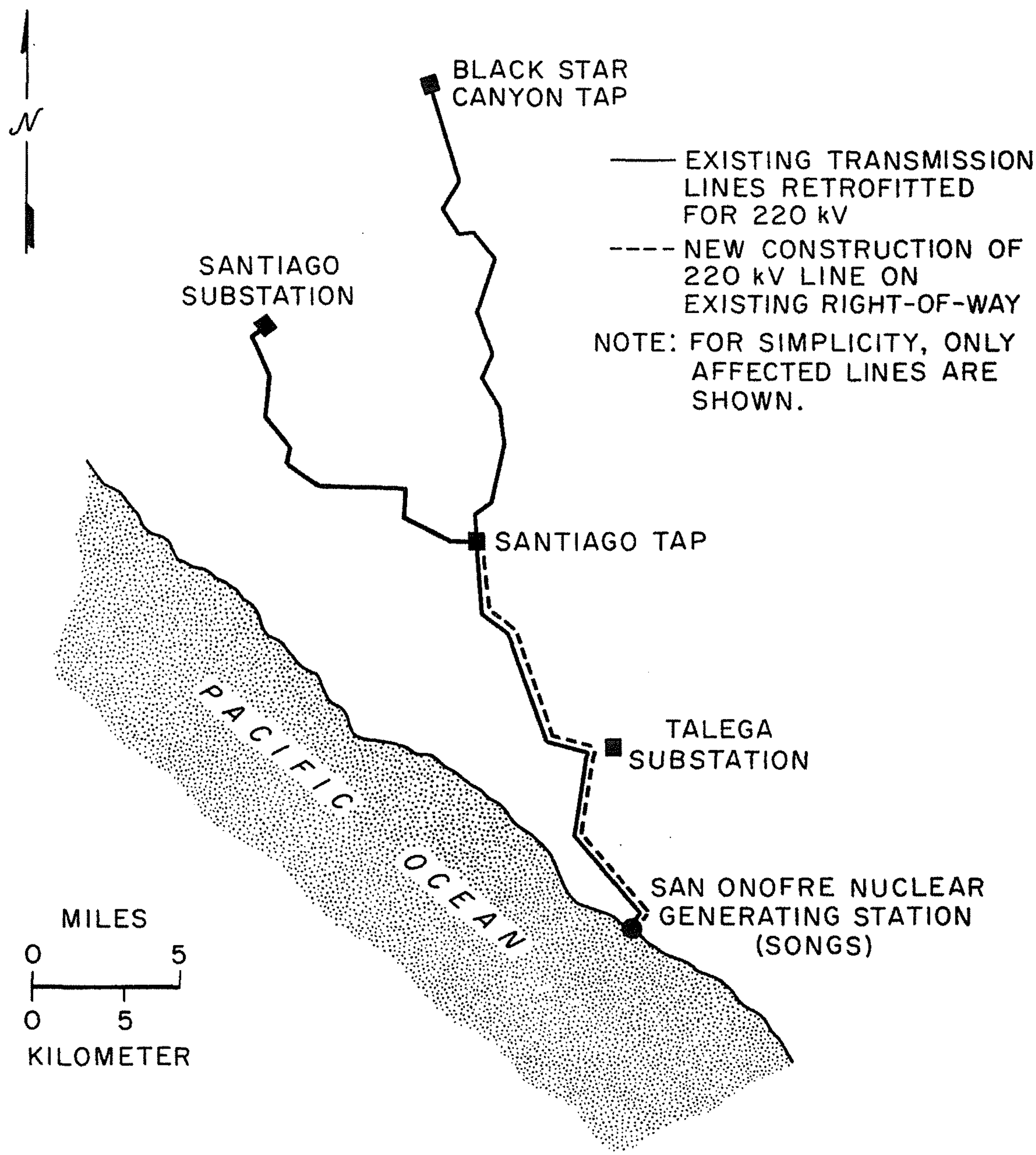

Fig. 3.7. Schematic diagram of proposed Southern California Edison Company transmission lines for SONGS 2 & 3.

3.2.5.1 SCE transmission lines

A double circuit 220-kV transmission line will be constructed between SONGS and Santiago Tap, an approximate distance of 24.3 km (15.1 miles) (Fig. 3.7). About 73 steel lattice towers (Fig. 3.10) will be required for this line, with an average span of about 335 m (1100 ft) between towers. The average tower height is estimated to be 39.6 m (130 ft). The new tower bases will require 2.44 ha (6.03 acres), and access road extensions are expected to require 1.32 ha (3.25 acres) of land (ER, Suppl. 2, Item 36). Additional transmission lines required by SCE that were not discussed in the FES-CP are those from SONGS to Santiago Tap, Santiago Tap to Santiago Substation, and Santiago Tap to Black Star Canyon Tap. These lines, totaling

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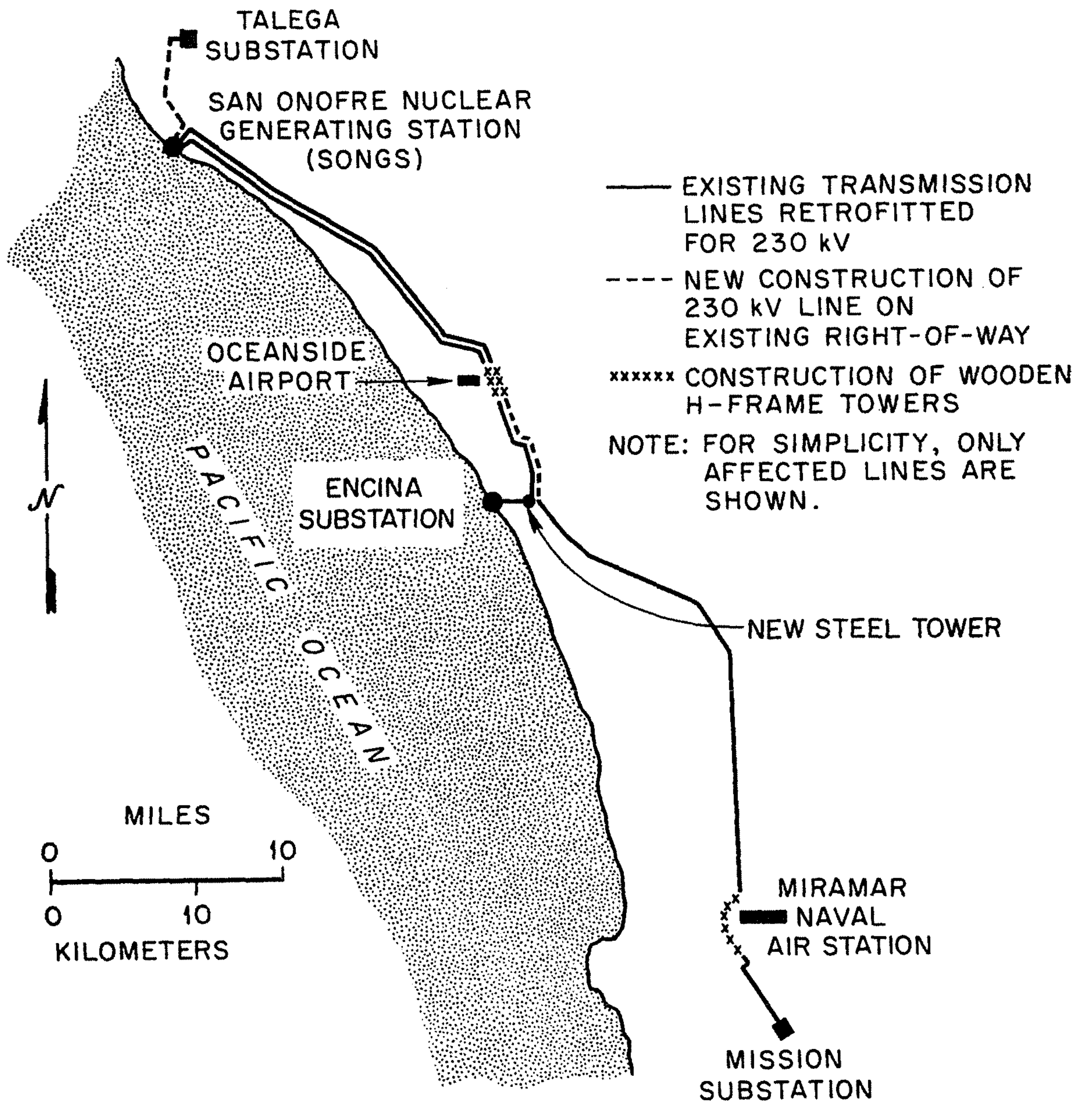

Fig. 3.8. Schematic diagram of proposed San Diego Gas and Electric Company transmission lines for SONGS 2 & 3.

71.7 km (44.2 miles) will be retrofitted to operate at 220 kV. Retrofitting will involve the replacement of existing conductors with larger ones (on existing towers) and the construction of four additional towers between Santiago Tap and Black Star Canyon Tap.[4] These towers are required to provide adequate ground clearance in some spans where the wire tension will have to be reduced from its present value (ER, Sect. 3.9.1.1). This additional construction is expected to require 0.13 ha (0.33 acres) of land for new tower bases and 0.52 ha (1.3 acres) for access road extensions (ER, Suppl. 2, Item 36).

The material storage yard for SCE transmission lines will be located about 1.6 km (1 mile) north of the San Onofre Nuclear Generating Station within Camp Pendleton Marine Base. The area involved will be about 2.2 ha (5.5 acres) and will not require any clearing or opening of new roads (ER, Suppl. 2, Item 30).

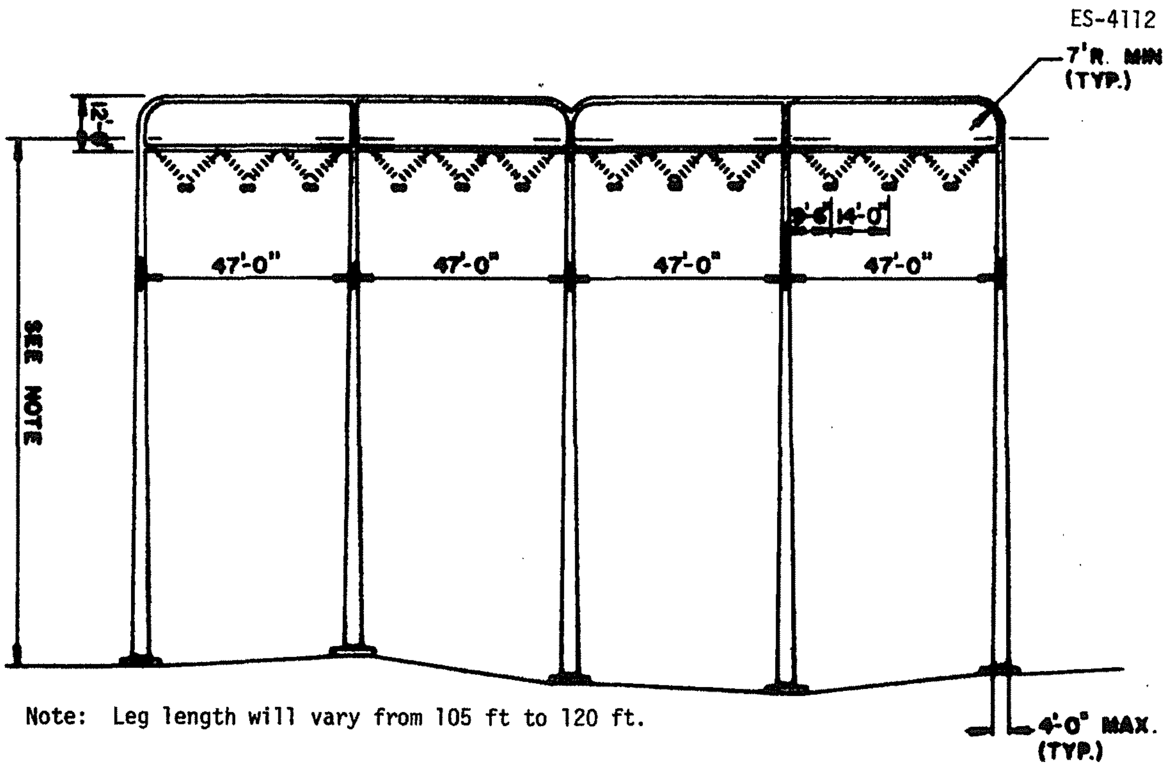

Fig. 3.9. Four-circuit steel horizontal portal structures used by Southern California Edison Company; San Diego Gas and Electric Company will use a similar structure with five circuits. Source: ER, Fig. 3.9-2.
(To convert ft to m, multiply by 0.3048.)

3.2.5.2 SDG&E transmission lines

The only transmission line required by SDG&E that was not discussed in the FES-CP will run between SONGS and Mission Substation, a distance of 85 km (53 miles) (Fig. 3.8). This line will be installed by adding a 230 kV circuit to the vacant position on existing double circuit towers;[1] some of the existing towers will be replaced. A total of about 36 wooden H-frame towers (Fig. 3.11) will be constructed along a 1.6-km (1-mile) segment east of Oceanside Airport and a 6.8-km (4.2-mile) segment opposite Miramar Naval Air Station to accommodate FAA regulations.[1] About 9 km (5.6 miles) of existing 138 kV wood structures south of the Oceanside Airport will be replaced by approximately 32 double circuit steel lattice towers (Fig. 3.12). The construction of the new towers for this line will not require any additional land for tower bases or access roads (ER, Suppl. 2, Item 36). Subsequent to issuance to the FES-CP, additional information was supplied by the applicant regarding the line from SONGS to Encina Substation and SONGS to Talega Substation. The line from SONGS to Encina Substation, 40 km (25 miles), will be formed by adding a 230 kV circuit to the vacant position on existing double circuit towers.[1] In addition, approximately four wooden H-frame towers (Fig. 3.11) will be constructed along a 1-km (0.6 mile) segment east of Oceanside Airport to accommodate FAA regulations. To facilitate arrangement of the new conductors, a single steel tower will also be installed east of Encina Substation. All new structures will be constructed within existing rights-of-way and will not require any additional land for tower bases or access roads (ER, Suppl. 2, Item 36). The line from SONGS to Talega Substation traverses about 11.3 km (7 miles) and will require construction of about 32 steel lattice towers (Fig. 3.12). The new tower bases will require about 0.23 ha (0.58 acre), and access road extensions are expected to require 0.53 ha (1.3 acres) of land (ER, Suppl. 2, Item 36). Because SDG&E's original plan assumed that the Talega Substation would be constructed and in operation prior to completion of SONGS 2 & 3 (ER, Suppl. 2, Item 25), this facility was discussed in the FES-CP as if it were already in existence. Construction, however, was delayed. The proposed Talega Substation is expected to cover 2 ha (5 acres) of land; an additional 2 ha (5 acres) around the substation will also require grading.

The material storage yard for SDG&E transmission lines will be located in existing substations with the following exceptions: (1) fencing a level area of about 0.09 ha (0.23 acre) adjacent

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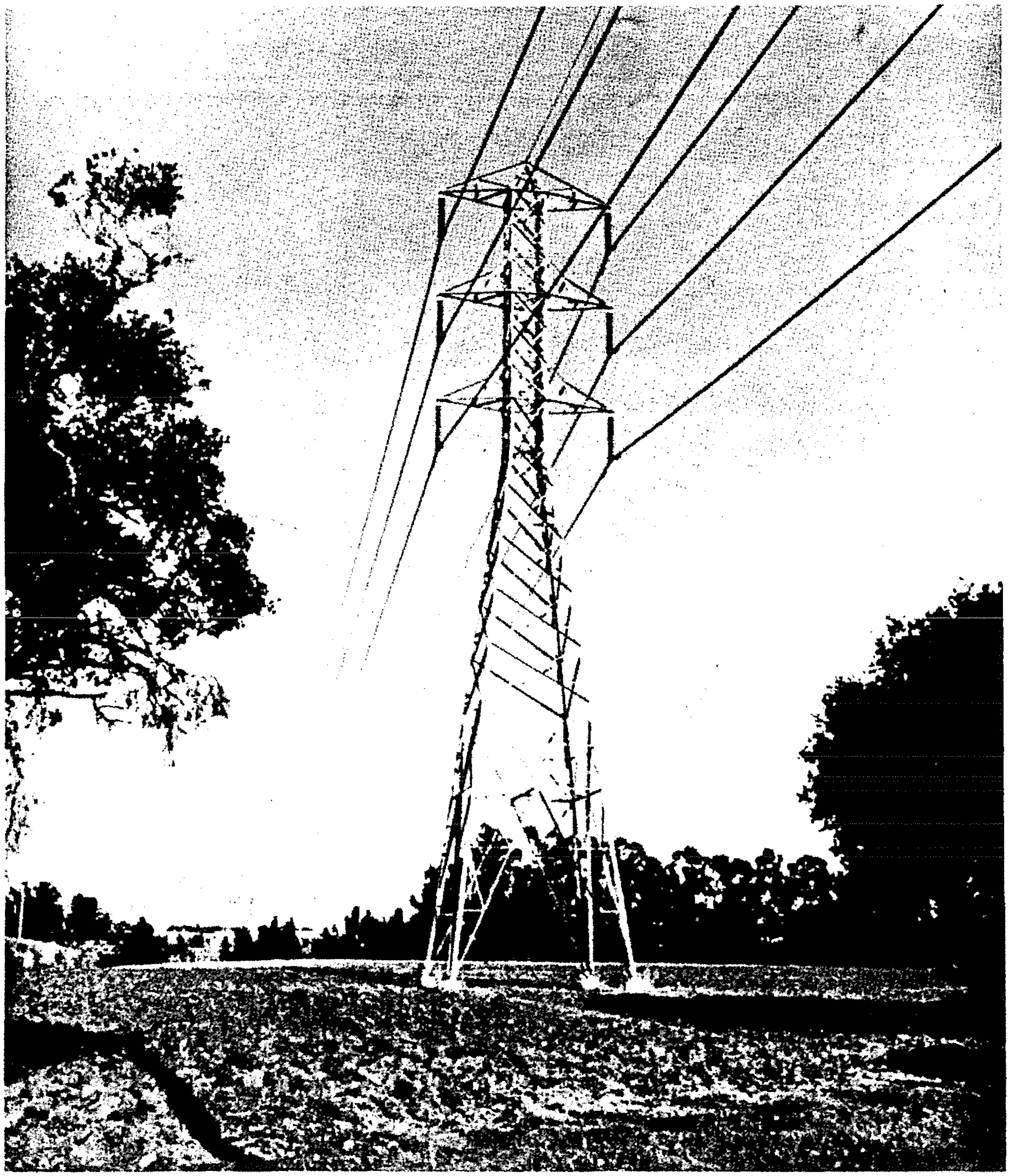

Fig. 3.10. Typical steel lattice tower design used by Southern California Edison Company. Source: ER, Fig. 3.9-3.

to the existing Pulgas Substation and (2) fencing a level area of about 0.09 ha (0.23 acre) adjacent to the Japanese Mesa Substation. No grading, clearing, or additional access roads are anticipated for this project (ER, Suppl. 2, Item 30).

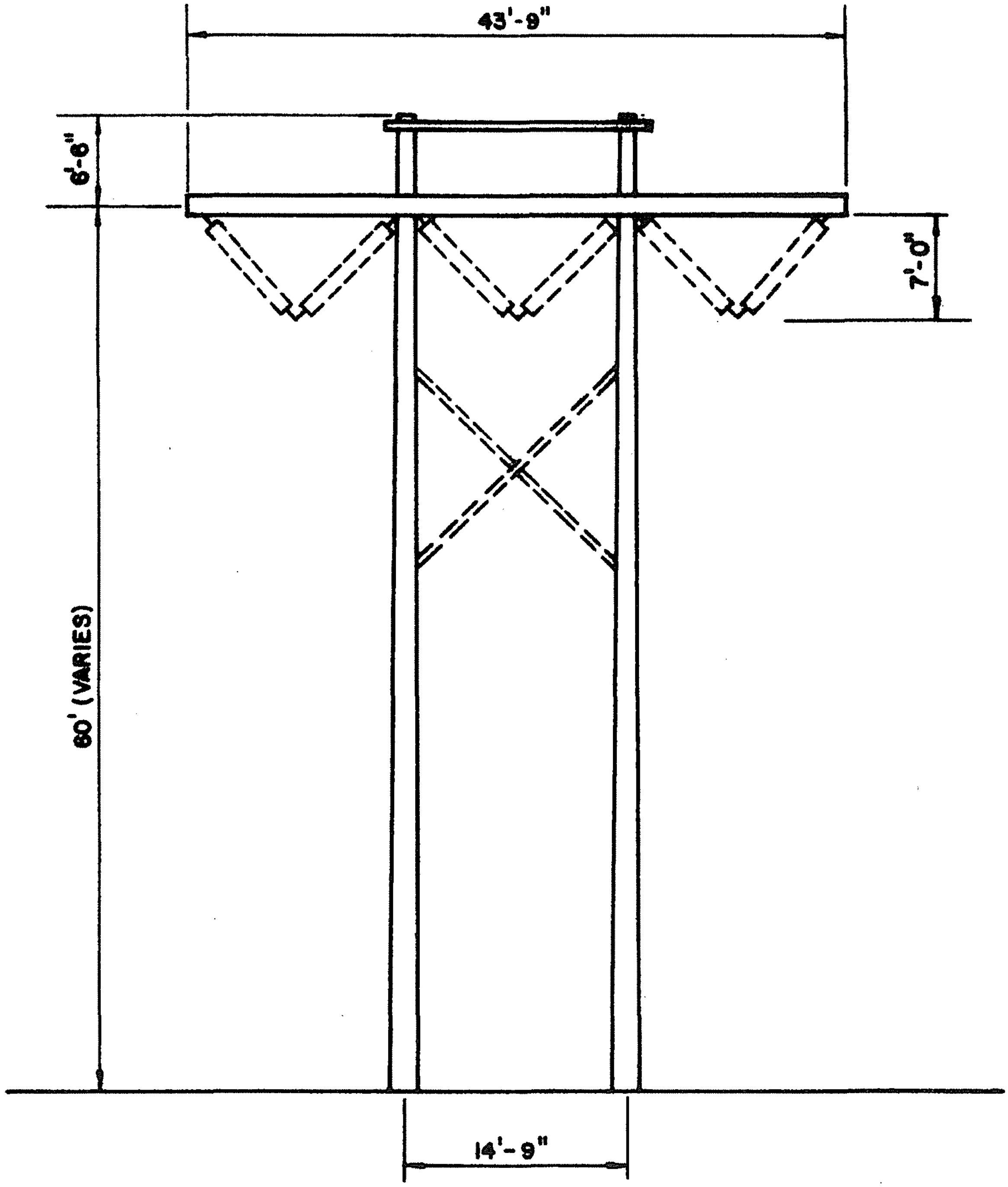

Fig. 3.11. Wooden H-frame tower used by San Diego Gas and Electric Company. Source: ER, Fig. 3.9-9.(To convert ft to m, multiply by 0.3048; to convert in. to mm, multiply by 25.4.)

3.2.6 Probable maximum flood berm

3.2.6.1 Description of structure and existing environment

Subsequent to issuance of the FES-CP the applicant was required to construct an earthern berm to protect the Station form the probable maximum flood (PMF). Construction of this structure

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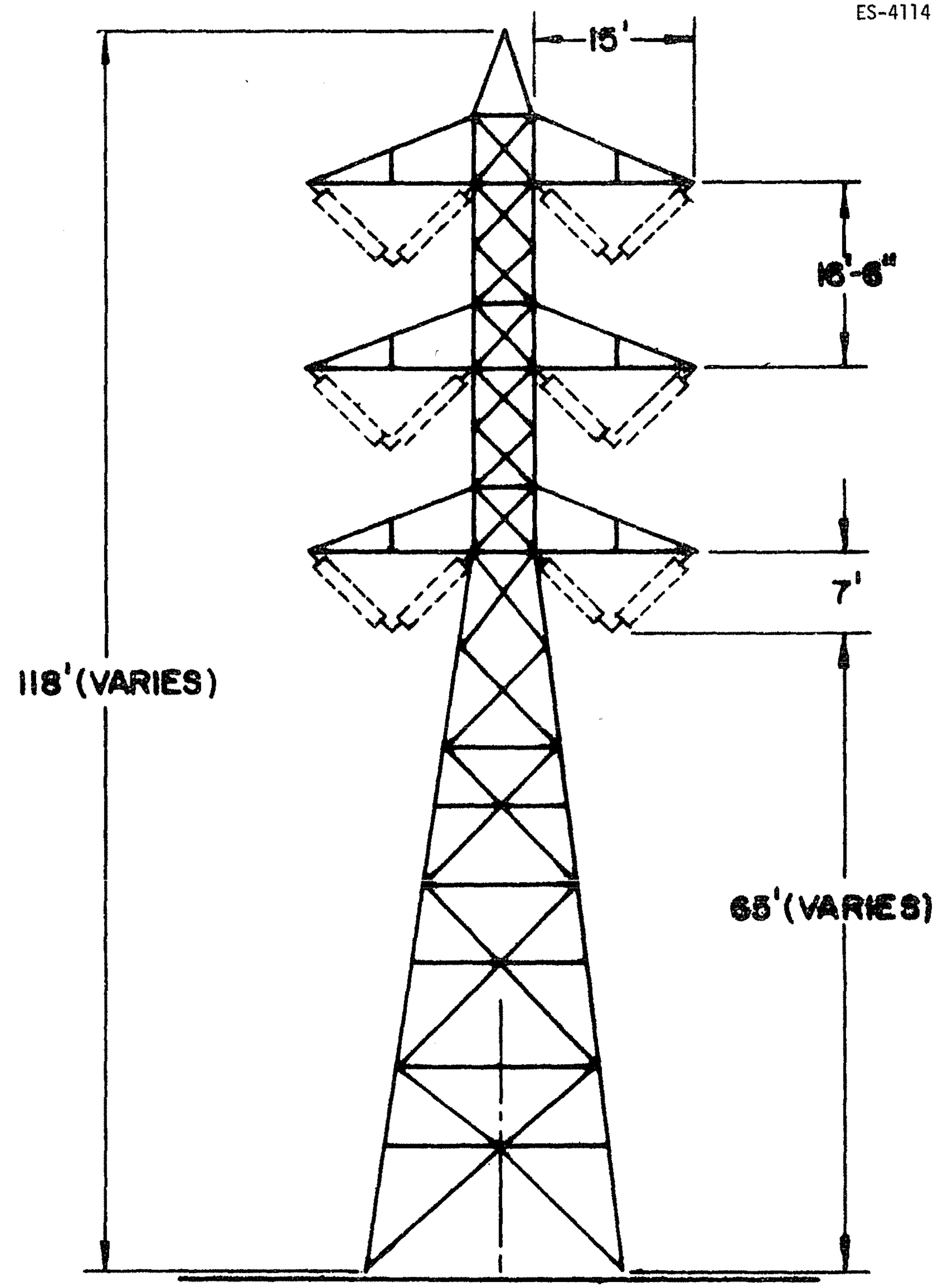

Fig. 3.12. Typical steel lattice tower design used by San Diego Gas and Electric Company. Source: ER, Fig. 3.9-8.(To change ft to m, multiply by 0.3048.)

and associated environmental impacts are presented by the applicant in a letter to the NRC[5] and in the applicant's final safety analysis report (FSAR).

The San Onofre site is located on a coastal plain at the base of the western foothills of the Santa Margarita Mountain Range. Elevation in this area rises sharply from sea level to a fairly level terrace formation 30 to 61 m (100 to 200 feet) above sea level. About 450 m (1500 feet) inland the foothills begin, rising with moderate slopes to an elevation of about 900 m (3000 ft) above sea level. Natural plant cover in the coastal plain typically consists of coastal chaparral and grassland, while in the foothills it is composed primarily of chaparral and open woodland.

There are no perennial streams in the general vicinity of the plant site. However, ephemeral streams and water courses do exist. The major streams are San Mateo Creek, located about 3.2 km (2 miles) to the northwest and San Onofre Creek located approximately 1.6 km (1 mile) to the northwest. The drainage divide separating San Mateo and San Onofre Creeks precludes the plant site from being influenced by San Mateo Creek. The applicant's results of the probable maximum flood (PMF) analysis concluded that the San Onofre Creek Basin exhibits no flooding potential to the site (FSAR, Sect. 2.4.2.2). Topographical features of the basin would contain the maximum flood stage and thereby preclude flooding of the site by this source. The foothill drainage basin, however, does contribute to the hydrologic factors influencing the plant site. The basin totals 2.2 km^2 (0.86 mi^2). There are no gaging stations located within the basin and, consequently, stream flow records are not available.

The entire watershed of the foothill drainage basin lies within the boundaries of the Marine Corps Base, Camp Pendleton. Elevation of the basin varies between 30 to 365 m (100 to 1200 feet) above sea level. Ground slope varies from 8 to 22%. Ground cover is moderate, consisting mainly of chaparral and grassland.

Water control structures at the foot of this basin consist of the 107- and 183-cm (42- and 72-in.) diameter concrete culverts under I-5. The capacity of these culverts is 5.1 and 14.7 m^3/sec (180 and 520 ft^3/sec), respectively. In addition to the two culverts, an earthern channel traverses the basin along the east side of I-5 diverting runoff to San Onofre Creek. The capacity of the channel is 52.4 m^3/sec (1850 ft^3/sec).

The applicant's analysis of the flooding potential of the foothill drainage area indicated that the plant site could be subjected to flooding during the occurrence of the PMF. In order to preclude flooding of the site by this source a diversion structure routes the surface runoff from the foothill drainage area to the San Onofre Creek Basin. This PMF structure will be an earthern berm, having an isoceles trapezoid cross section that is 2.4 m (8 feet) high and 12.8 m (42 feet) wide at its base, with 2:1 side slopes. The berm will parallel I-5 and will be 2.7 km (1.68 miles) long. The existing channel which parallels the proposed berm will be widened where necessary and will vary from 7.6 to 30.5 m (25 to 100 ft) in width. The berm will cover a portion of an existing road, El Camino Real Road, requiring the construction of a new road. The relocated road will run approximately parallel to and east of the proposed PMF berm.

Relocation of the road will require about 1.4 ha (3.5 acres) of land, the berm will cover approximately 3.5 ha (8.6 acres), and the channel (assuming a 30 m (96 ft) width) will require about 8.3 ha (20.6 acres) for a total land area requirement of 13.2 ha (32.7 acres). The existing channel and El Camino Real Road are included in this acreage.

A terrestrial biological survey of the site was conducted on October 25 and 31, 1977. Vegetation on the site is basically a southern coastal sage scrub community, being influenced by the coastal marine climatic conditions. However, nearly half of the site (northern portion) has been previously disturbed as evidenced by the presence of many non-native "weedy" species including saltbush (Atriplex semibaccata), Russian thistle (Salsola kali), mustard (Brassica geniculata) tree tobacco (Nicotiana glauca), and sow thistle (Sonchus oleraceus). Native species on this area include California sagebrush (Artemesia californica), California buckwheat (Eriogonum fascilculatum), and coyote brush (Baccharis pilularis). The southern half of the site is primarily vegetated with native species of the coastal sage scrub plant community including the native species listed above. The land on which the El Camino Real Road will be relocated contains many of the same species that occur at the berm site, but with a higher degree of cover.

Fauna surveys of the site and vicinity demonstrated that the majority of the species present were birds (24 species). Red-tailed hawks (Buteo jamaicensis) were prevalent in the vicinity using wooden posts, telephone and power poles as perches and a SCE lattice transmission tower for nesting. Although only 2 species of reptiles and 2 species of mammals were observed, others are likely to occur in the vicinity.

No threatened or endangered flora or fauna were observed on the proposed PMF Berm site, the area to be cut, or on the area where the El Camino Real Road is to be relocated.[5]

On November 14, 1977, an onsite inspection of the alignments of both the proposed berm and access road was conducted to determine the presence or absence of surficial paleontologic

values.[5] Although the survey did not result in locating any fossils, a review of the literature revealed that all sedimentary formations in the vicinity contain fossils. No localities in the immediate area have been placed on the National Registry of Natural Landmarks.

The site was surveyed for archaeological resources on December 8, 15, and 16, 1977 (ref. 5). The northern third of the berm was not surveyed because it had previously been studied; some portions of the berm also were not adequately surveyed because of dense vegetation.[5] In one area, eight pieces of marine shell were observed. The shells, however, were weathered and worn and gave the appearance of paleontological specimens, rather than archaeological remains.[5] An archaeological map and literature search revealed four recorded archaeological sites within 1.6 km (1 mile) of the proposed project, but none were located within the project area.[5]

3.2.6.2 Impacts of PMF berm

The berm will be built on top of an existing asphalt road. Consequently disruption of this area will have no significant biological impact. Widening the existing channel which parallels the proposed berm will require loss of about 8.5 ha (21 acres), and an additional 1.4 ha (3.5 acres) of habitat will be lost due to relocation of El Camino Real Road. Because these habitats do not represent unique communities, loss of this relatively small acreage should have no significant impact to biological resources of the area. To minimize the impact to raptors nesting in the vicinity the applicants will attempt to avoid construction activity during the period of March and April.[5]

The construction of the PMF berm might physically destroy fossils and/or relationships between fossils, or the environmental context of original deposition, that could provide significant paleontological data. In addition, the berm and new road may cover deposits containing significant paleontological data thereby making such data unreachable. To mitigate these potential impacts the applicants will conduct a paleontological survey prior to construction and monitor the excavation as it proceeds.[5] This will allow fossils to be salvaged as they are unearthed. Construction should be phased so that equipment could be shifted to other areas if fossils were located. Sufficient time should be allowed to uncover, record, and remove the fossils. If excavation were initiated in areas of highest paleontological potential, equipment could be moved to areas of low potential if paleontological values were encountered. This would provide a maximum amount of construction time and a maximum amount of time for paleontologic resource recovery.

Construction of the proposed PMF berm should not cause any direct or indirect adverse impact to known archaeological resources. However, the site would have been a favorable area for aboriginal habitation; i.e., an area of relatively flat topography with abundant fresh water and food resources.[5] The probability exists that buried resources may be in the area, especially where dense vegetation obscures the surface. Consequently, a trained archaeologist will monitor the construction activity and take appropriate conservation measures if necessary.[5]

No significant commitments of resources will result from construction and maintenance of the PMF Berm. The possibility exists that potential archaeological or palcontological resources would be destroyed during the excavation activity required for construction of the berm. However, if the proper mitigation measures are performed (monitoring, analysing, interpretating, preserving, and reporting), then these resources would not be irretrievable.

3.2.6.3 Floodplain management

The objective of Executive Order 11988, "Floodplain Management," is ". . . to avoid to the extent possible, the long- and short-term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct and indirect support of floodplain development whenever there is a practicable alternative." The Construction Permit was issued and the majority of construction completed prior to issuance of the Executive Order. Thus we conclude that no practicable alternative locations exist. The following is a discussion of floodplain conditions prior to construction of the plant and alterations made to these floodplains as a result of construction of San Onofre Units 2 and 3.

The San Onofre Units 2 and 3 are bounded on the east by Interstate Highway 5, the Atchison Topeka and Santa Fe Railroad and Highway 101. Interstate Highway 5 was constructed in 1968 prior to San Onofre Units 2 and 3. As part of the I-5 construction, a drainage channel designed for 100-year storm runoff was constructed parallel to and east of I-5. This channel intercepted tributary rainfall runoff from the foothills east of I-5 and transported it to the north away from the plant. The channel then merged with San Onofre Creek which in turn flowed to the Pacific Ocean.

The plant site which is bounded on the west by the Pacific Ocean was originally on a high coastal bench approximately 100 feet above sea level. Located at this elevation, the site was protected from severe flooding events and thus was not in the 100-year ocean floodplain.

The existing drainage channel which is west of and parallel to I-5, is being enlarged to contain floods and debris. The design capacity of the channel enlargement and extension is the Probable Maximum Flood, an event which is greater than the one-percent chance flood. The improvement will not induce higher flood stages.

The San Onofre plant grade is lower than the original coastal bench. However, construction of a seawall on the seaward side of the plant and east of the original bluff line provides protection from events larger than the one percent chance flood.

The plant, including the intake structure and seawall, is not built in the 100-year floodplain and will not be flooded by any 100-year flood levels. The intake crib and intake and discharge conduits are submerged on the ocean floor. The channel improvement east of Interstate Highway 5 will not increase flood levels. Therefore, the construction and operation of the San Onofre Unit 2 and 3 Nuclear Generating Station will comply with the intent of Executive Order 11988.

3.2.7 Emergency facilities

Emergency plans for San Onofre Units 2 and 3 call for an onsite Technical Support Center adjacent to the control room and an interim onsite Operational Support Center in the lunch room of the administration, warehouse, and shop building. Neither requires changes in the structural design or layout of the facility. An offsite Emergency Operations Facility is tentatively planned to be constructed on Japanese Mesa, east of Interstate 5, within the Camp Pendleton Reservation. This area was used for disposal of excavated material during construction. The structures must be designed to accommodate a minimum of 35 people.

REFERENCES

1. U.S. Nuclear Regulatory Commission, "Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion 'As Low as Practicable' for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents," May 5, 1975, and as amended Sept. 4, 1975, and Dec. 17, 1975, in Title 10, "Code of Federal Regulations," Part 50, Appendix I.

2. U.S. Nuclear Regulatory Commission, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors (PWR-GALE Code)," NUREG-0017, April 1976.**

3. U.S. Nuclear Regulatory Commission, "Cost-Benefit Analysis for Radwaste Systems for Light-Water-Cooled Nuclear Power Reactors," in Regulatory Guide 1.110, March 1976.**

4. Letter from Ira Thierer, Southern California Edison Co., to Dr. Knox Mellon, State Historic Preservation Officer, June 2, 1978.*

5. Letter from J. G. Haynes, Southern California Edison Co., to W. H. Regan, Jr., USNRC, undated, docketed on February 18, 1978.*

*Available for inspection and copying for a fee in the NRC Public Document Room, 1717 H St., N.W. Washington, DC 20555.

**Available from the NRC/GPO Sales Programs, Washington, DC 20555 and from the National Technical Information Service, Springfield, VA 22161.

4. STATUS OF SITE PREPARATION AND CONSTRUCTION

4.1 RESUME AND STATUS OF CONSTRUCTION

As of December 1980, the construction of SONGS Unit 2 was 97% complete, and SONGS Unit 3 was 68% complete. Figure 4.1 is a recent photograph of the site.

Impacts of construction have been identified in the FES-CP. The major terrestrial impact has been the excavation of about 16.4 ha (40.5 acres) of the San Onofre Bluffs, which resulted in the loss of a small amount of wildlife habitat. No rare or endangered animal species in the vicinity of the site have been or are expected to be adversely affected by construction activities.

The environmental impacts associated with changes in the routing of transmission lines subsequent to issuance of the FES-CP have been evaluated by the staff in its environmental impact appraisal regarding extension of the earliest and latest construction completion dates.

4.2 Offsite Emergency Operations Facility

An offsite Emergency Operations Facility is tentatively planned to be constructed on Japanese Mesa, east of Interstate 5, within the Camp Pendleton Reservation. This area was used for disposal of excavated material during construction. The structure must be designed to accommodate a minimum of 35 people. Construction of the Emergency Operations Facility on Japanese Mesa will not significantly disturb the area relative to previous disturbances.

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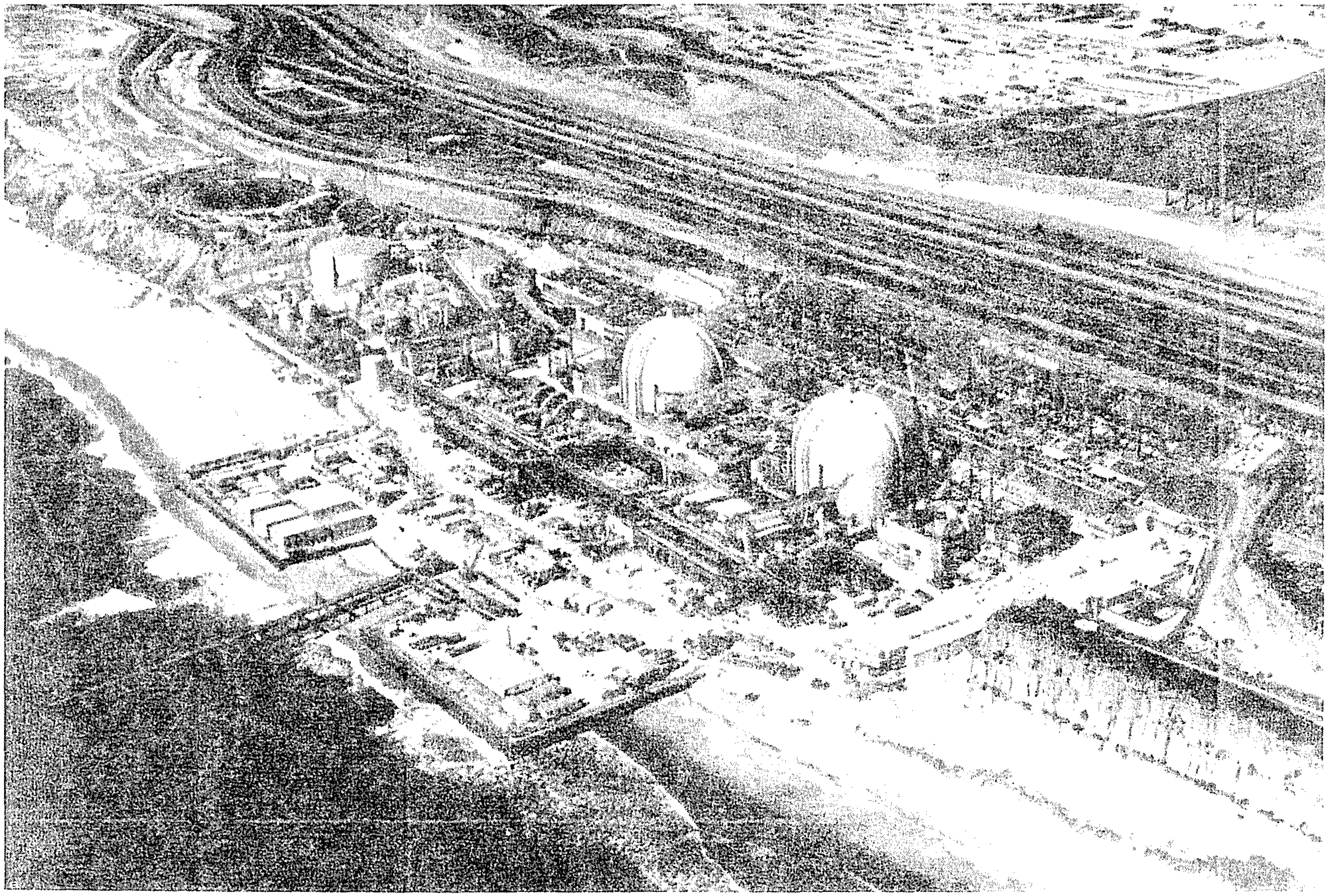

Fig. 4.1. Photograph of San Onofre Nuclear Generating Station taken in October 1980.

5. ENVIRONMENTAL EFFECTS OF STATION OPERATION

5.1 RESUME

The major design changes that have environmental effects involve the heat dissipation system. A more thorough analysis by the staff of the thermal plume is described in Sect. 5.3.1.2. The effects of the revised thermal-plume analysis on aquatic biota are discussed in Sect. 5.4.2.1. Changes in the effects of chemical effluents are discussed in Sects. 5.3.2 and 5.4.2.2. A revised discussion of radiological impacts is given in Sect. 5.5. Sect. 5.6 contains a revised assessment of the socioeconomic impacts.

5.2 IMPACTS ON LAND USE

Although the transmission line routes have been modified since the issuance of the construction permit (Sect. 3.2.5), the analysis of projected impacts as set forth in the FES-CP (Sect. 5.1) remains valid. All new transmission lines will be constructed on existing rights-of-way; a total of 5.2 ha (12.8 acres) of land will be required for access road extensions and for new tower bases.

The operation of SONGS 2 & 3 is not expected to affect any existing or proposed areas of the National Park System nor any existing or known potential sites to be listed as national landmarks.[1] In 1980, the applicant conducted a National Register assessment program of the 230 kV transmission right-of-way from San Onofre Nuclear Station to Black Star Canyon and Santiago Substation and to Encina and Mission Valley Substation and evaluated 41 previously identified archaeological sites. As a result of this effort, the NRC, in consultation with the State Historic Preservation officer, is seeking a determination of eligibility for inclusion in the National Register of Historic Places for 23 sites (see Appendix D, letter from Dr. Knox Mellon, State Historic Preservation officer, to D. C. Scaletti, USNRC, dated December 18, 1980). The staff agrees with the conclusions of the December 18, 1980, letter and will seek concurrence of determinations of effect from the Advisory Council on Historic Preservation.

5.3 IMPACTS ON WATER USE

5.3.1 Thermal discharges

5.3.1.1 Applicant's thermal analysis

The applicant retained the California Institute of Technology to perform a thermal analysis for the purpose of modifying the diffuser design in order to ensure compliance with state thermal standards. To accomplish this, a physical hydraulic model study was carried out at the W. M. Keck Laboratory of Hydraulics and Water Resources. The culmination of this effort was the diffuser design and configuration described in Section 3.2.2.

The physical model simulation was performed in a basin having horizontal dimensions of 11 m (36 ft) by 6 m (20 ft) which represents a prototype modeled region of about 8500 m (28,000 ft) by 4900 m (16,000 ft). The location and orientation of the Units 2 and 3 model intakes and diffusers within the basin are illustrated in Fig. 5.1. The bottom of the basin was filled with sand which was shaped to produce a simplified representation of the San Onofre bathymetry. The resulting bottom geometry was uniform in the longshore direction and varied as a composite of linear slopes in the offshore direction, as shown in Fig. 5.2. In order to satisfy scaling laws, the number of ports per laboratory diffuser was 16.

To perform simulations, the basin was filled with water at a constant temperature, then water at a temperature 16.67°C (30°F) higher was discharged through the diffusers. This excess temperature was required to maintain proper similitude and represents a 11.1°C (20°F) prototype excess temperature. Water was withdrawn from the basin through the intakes; however, this water was not recirculated. The model basin had the capability to simulate a variety of longshore current regimes, and among those investigated were no crossflow, crossflows of various amplitudes, reversing flows of various amplitudes, and special currents. The results of the simulations are summarized in the ER, Table 5.1-1. Among

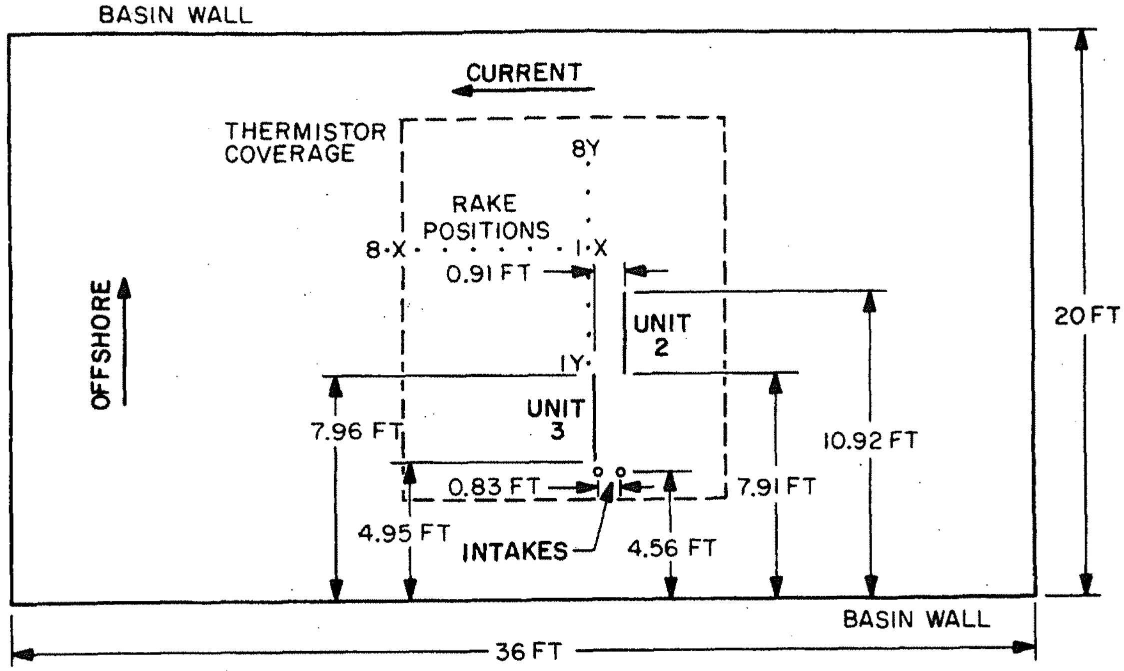

Fig. 5.1. Layout of basin used for the physical model study. Source: R. C. Y. Koh, N. H. Brooks, E. J. List, and E. J. Wolanski, *Hydraulic Modeling of Thermal Outfall Diffusers for the San Onofre Nuclear Power Plant*, W. M. Keck Laboratory of Hydraulics and Water Resources, California Institute of Technology, Report KH-R-30, January 1974, Fig. 6.1. (To change ft to m, multiply by 0.3048.)

these simulations, the worst case was that of zero crossflow. A plot of surface isotherms produced by the model for this case is given in Fig. 5.3. Further details of the physical-model study can be found in ref. 2. There are, however, certain physical conditions and mechanisms that could not be properly modeled in the laboratory. In an effort to account for this limitation on modeling, the modelers associated a probable temperature excess with each uncertainty. The total of these individual uncertainties was 0.83°C (1.5°F). It was therefore reasoned that state thermal standards should be met if the laboratory results satisfied these standards for 1.39°C (2.5°F), with the 0.83°C (1.5°F) margin of error, rather than 2.2°C (4.0°F).

It is evident from Fig. 5.3 that this case satisfies the state thermal standards. The applicant suggests that this is the worst case and, therefore, concludes that SONGS 2 and 3 will, under all conditions, comply with California State thermal standards.

The staff has reviewed the applicant's thermal analysis and believes that the physical model does not adequately represent certain hydrodynamic mechanisms and certain physical features of the prototype. The most significant of these is the duration of the physical model simulation. The staff believes that the physical model simulation, which yielded the result given in Fig. 5.3, has not reached thermal equilibrium. This is apparent in the applicant's results for surface excess temperature versus time given in Fig. 5.4. The upper curve represents the maximum surface temperature as a function of time anywhere in the basin, while the lower curve represents the maximum surface temperature as a function of time beyond 305 m (1000 ft) from the discharge point. The time scale for thermal equilibrium in the upper curve is a function of the time required for the heated water from the discharge to reach the surface and, therefore, should be relatively short. The staff has substantiated this by performing a least-squares curve fit on the data shown in the upper curve. The results show that the maximum surface excess temperature anywhere in the basin is increasing less than 0.028°C (0.05°F) per day. This is small compared with the standard deviation of the curve fit and, therefore, thermal equilibrium can justifiably be assumed. Beyond 305 m (1000 ft) from the discharge, the thermal equilibrium time scale will be a function of the rate of transport of heated water by densimetric effects and diffuser momentum away from the discharge point. This time scale should be longer than that for thermal equilibrium near the discharge. A similar curve fit performed on the lower plot reveals that the excess surface temperature beyond 305 m (1000 ft) from the discharge is increasing by approximately 0.16°C (0.29°F) per day. The staff believes that such a time-rate-of-change of temperature does not represent thermal equilibrium. Using a mathematic model, the staff has qualitatively reproduced the applicant's results. However, this mathematical simulation demonstrates that for increased

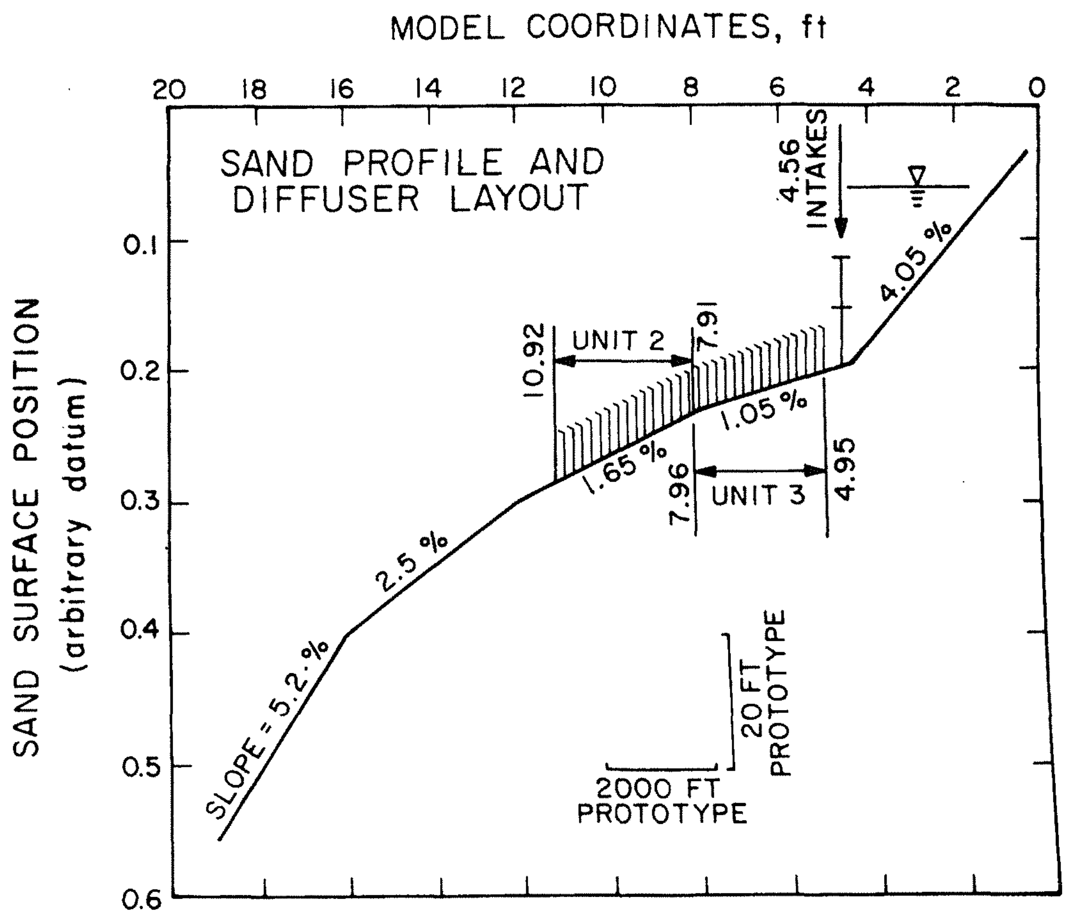

Fig. 5.2. Bottom profile used for the physical model study. Source: R. C. Y. Koh, N. H. Brooks, E. J. List, and E. J. Wolanski, "Hydraulic Modeling of Thermal Outfall Diffusers for the San Onofre Nuclear Power Plant," W. M. Keck Laboratory of Hydraulics and Water Resources, California Institute of Technology, Report KH-R-30, January 1974, Fig. 6.2. (To change ft to m, multiply by 0.3048)

duration of the simulation, there is a substantial increase in the predicted excess temperatures. In fact, for the conditions represented in Fig. 5.3, an increase in simulation time would likely have resulted in predicted excess temperatures that violate state thermal standards. However, such a prediction is unimportant because the particular simulation then represents conditions so unrealistic that the results become irrelevant.

Although the problem of underprediction is inherent in all the applicant's results, it is less significant for the realistic cases. For conditions more realistic than those in Fig. 5.3, the predicted excess temperatures are sufficiently low so that no violations of thermal standards would be expected as a result of increases of simulation duration in the physical model. This expectation is confirmed by the staff's mathematical model study.

5.3.1.2 Staff's thermal analysis

The staff has performed an independent thermal analysis for the proposed operation of the once-through cooling system. Depth-averaged numerical models from the Unified Transport Approach[3] were used to simulate plant-induced flows, natural flow, and water temperatures. Predictions have been made for conditions typical of mid-July, since this is the time of year when thermal impacts should be the most severe. The modeled region is a rectangle measuring approximately 24,000 m (80,000 ft) in the longshore direction and approximately 12,000 m (40,000 ft) in the offshore direction. This region with the numerical grid system superimposed is shown in Fig. 5.5.

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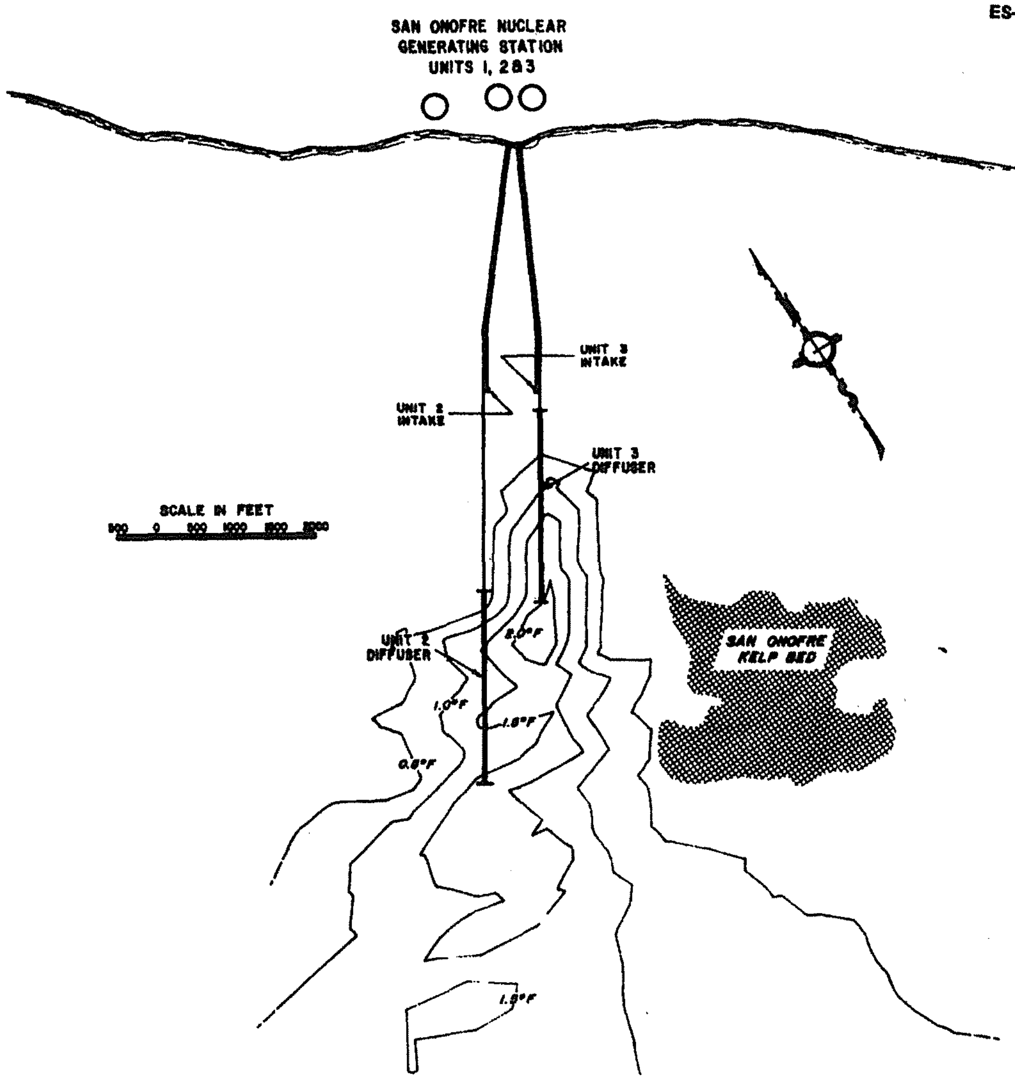

Fig. 5.3 Excess temperature at the surface predicted in the physical model study, for the case of no ambient flow. Source: ER Fig. 5.1-1. (To change ft to m, multiply by 0.3048; to change F° to C°, divide by 1.8.)

One numerical model was used to generate the induced flow from intakes and discharges from all three units. In this model, the intakes are represented as point sinks and the Unit 1 discharge is represented as a point source. The diffusers for Units 2 and 3 are each represented as a superposition of five jets. The hydrodynamics of each jet is modeled using a uniformly valid singular-perturbation theory, numerically corrected for bathymetry. The individual flows from the three intakes and discharges were summed to generate a total plant-induced flow field, as shown in Fig. 5.6.

A quasi-potential hydrodynamic model was used to generate the magnitude and direction of the natural currents and free surface displacement resulting from two tidal components and a net downcoast drift, at each grid element. The open-water boundary conditions were adjusted to produce flows which are consistent with observed data[4-7] from current meters and drogues. Three individual runs were executed, one for each of the two tidal harmonics (a 12.4 hr period and a 24.8 hr period), and a third to generate the drift current. These three flow components were combined, with the appropriate phase relationships, to produce a simulation of the natural flow field during mid-July conditions.

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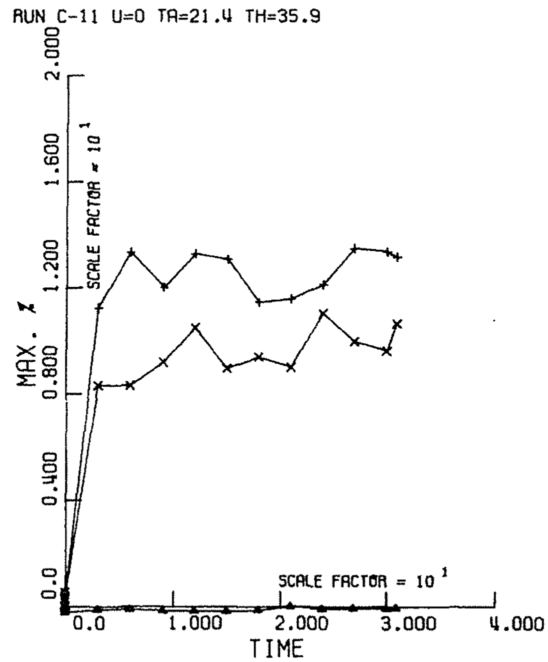

Fig. 5.4. *Summary of maximum temperature excesses (in percent of source temperature* excess) measured anywhere in basin (+), beyond 305 m (1000 ft) of diffusers (x), and ambient temperature (Δ) (Run C-11, u = 0.0 knot).

Water temperatures were computed using a depth-averaged thermal model. Inputs to this model were the calculated natural and plant-induced flows, along with meteorological parameters used for surface heat transfer calculations. The required meteorological variables are incoming solar radiation, cloud cover, air temperature, wind speed, and relative humidity. The incoming solar radiation is the mid-day value, which the code automatically adjusts for the time of day, from sunrise to sunset. The remaining parameters are taken to vary sinusoidally over one day and, therefore, require as input the daily average, the amplitude of the daily variation, and the time of maximum value. Typical values for these parameters during mid-July were used and are shown plotted as a function of time in Fig. 5.7.

This thermal model was first run without thermal output or flow from any of the units to produce a five-day simulation of ambient ocean temperatures. Subsequently, the calculation was repeated, with all three units operating at full capacity, to predict the total temperature field. These two results were then subtracted to generate excess temperature plots. Figures 5.8 through 5.15 show ambient flow and excess temperature plots at 6 hr intervals during the fifth day of the simulation at 2:00 am, 8:00 am, 2:00 pm, and 8:00 pm respectively. Isotherms are plotted in increments of 0.28°C (0.5°F) from 0.28°C (0.5°F) to 2.8°C (5.0°F). In general, the hottest spots occur directly above the discharge for each unit, with Unit 1 being consistently hotter than Unit 2 or 3. In addition, during the part of the tidal cycle when the natural flow is downcoast, there is a secondary warm spot approximately 3000 m (10,000 ft) downcoast of the discharges. This apparently is a result of the influence of the shape of the shoreline on the flow which, in turn, causes the plume from Units 2 and 3 to intersect the plume from Unit 1 at this point downcoast.

California thermal standards require that the 2.2°C (4°F) excess temperature isotherm never reach the shoreline or bottom, and that the 2.2°C (4°F) surface isotherm must be within 305 m (1000 ft) of the discharge point during at least one-half of the tidal cycle. Although the thermal model is depth averaged, it is still possible to address the state standards with the model results because the ambient crossflow has a destabilizing effect upon the discharge buoyancy. During portions of the tidal cycle, the ambient crossflow is of sufficient magnitude to dominate the stable stratification, resulting in mixing of the plume to the ocean bottom in the neighborhood of the diffuser. Recent work by Almquist[8] provides the basis for determination of conditions for vertical mixing. According to Almquist, the warm plume will mix to the bottom when the ratio of the ambient crossflow velocity to the cube root of the buoyancy flux per unit length of diffuser is greater than one. Figure 5.16 (a) is a plot of this stability parameter versus time for one tidal cycle based on the staff's ambient flow predictions. The shaded area shows the period during the tidal cycle when instability will occur and the water column will be vertically homogeneous.

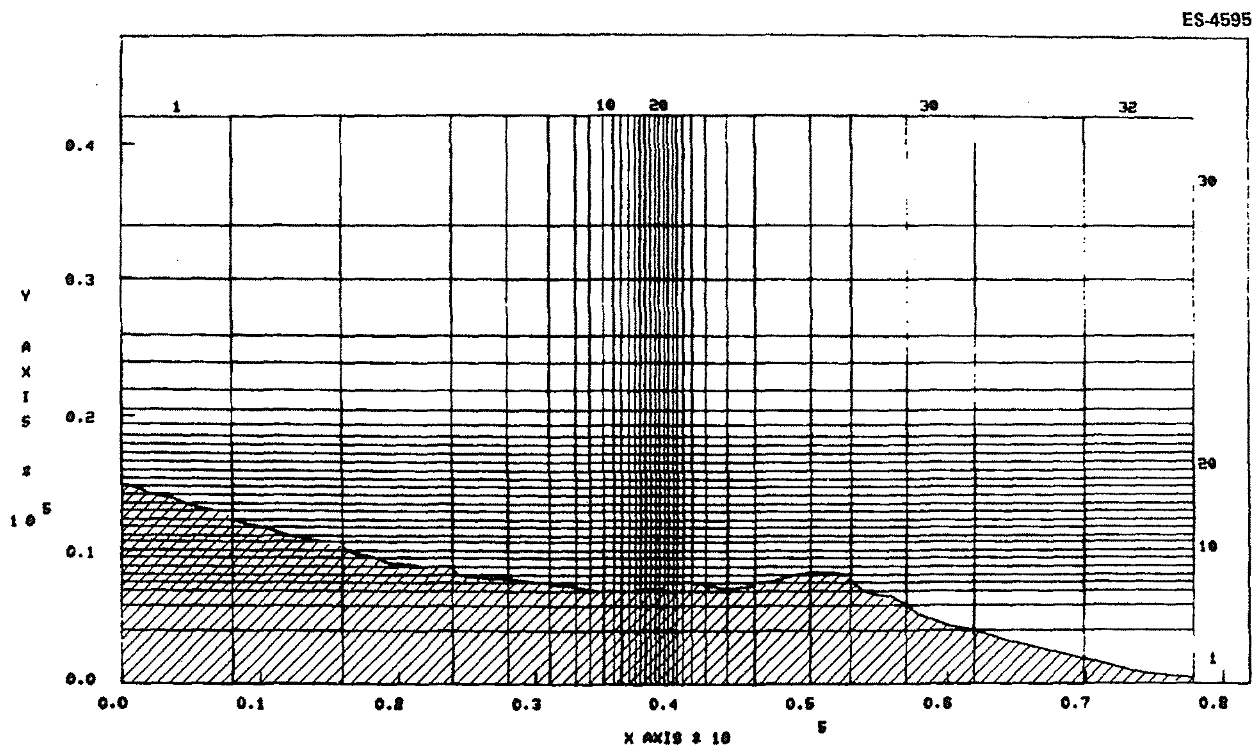

Fig. 5.5. Plot of region and grid system used for the mathematical model applications.

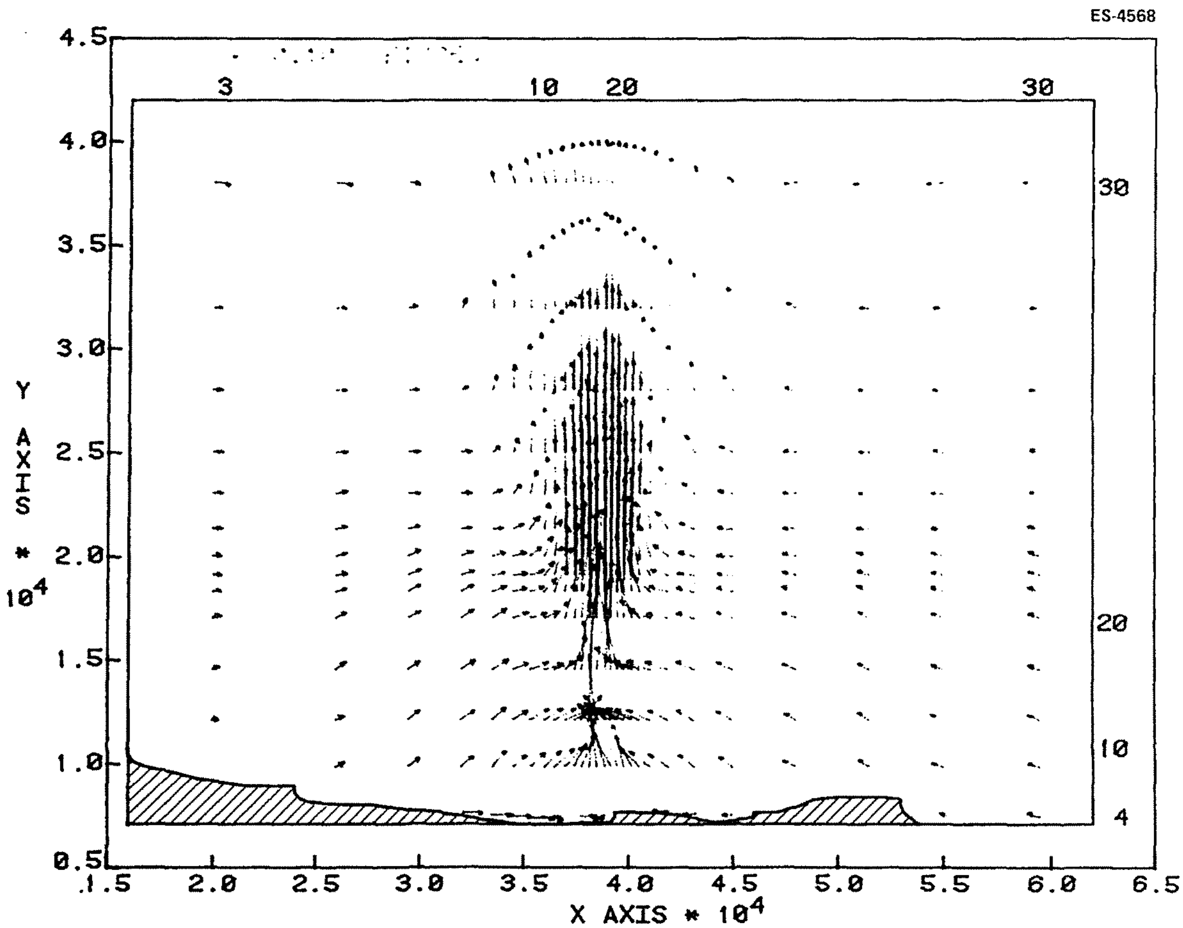

Fig. 5.6. Predicted, depth-averaged, plant-induced flow field for Units 1, 2, and 3.

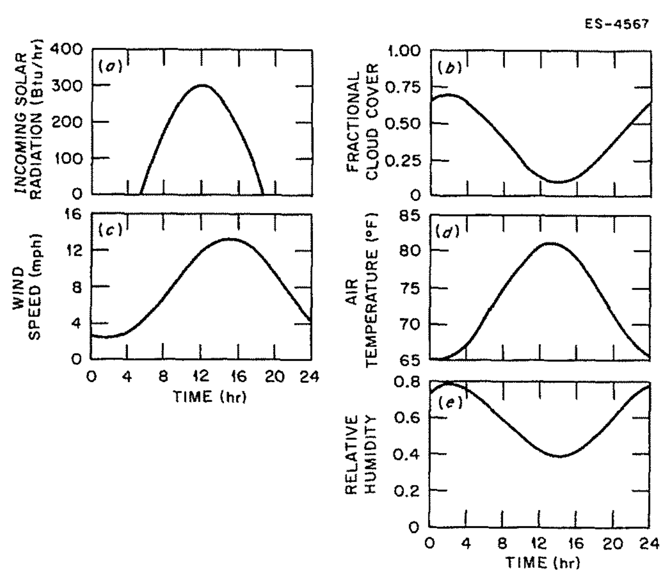

Fig. 5.7. Plots of meteorological variables as a function of time use in the thermal model. (To convert mi to km, multiply by 1.6; to convert °F to °C, subtract 32 and divide by 1.8.)

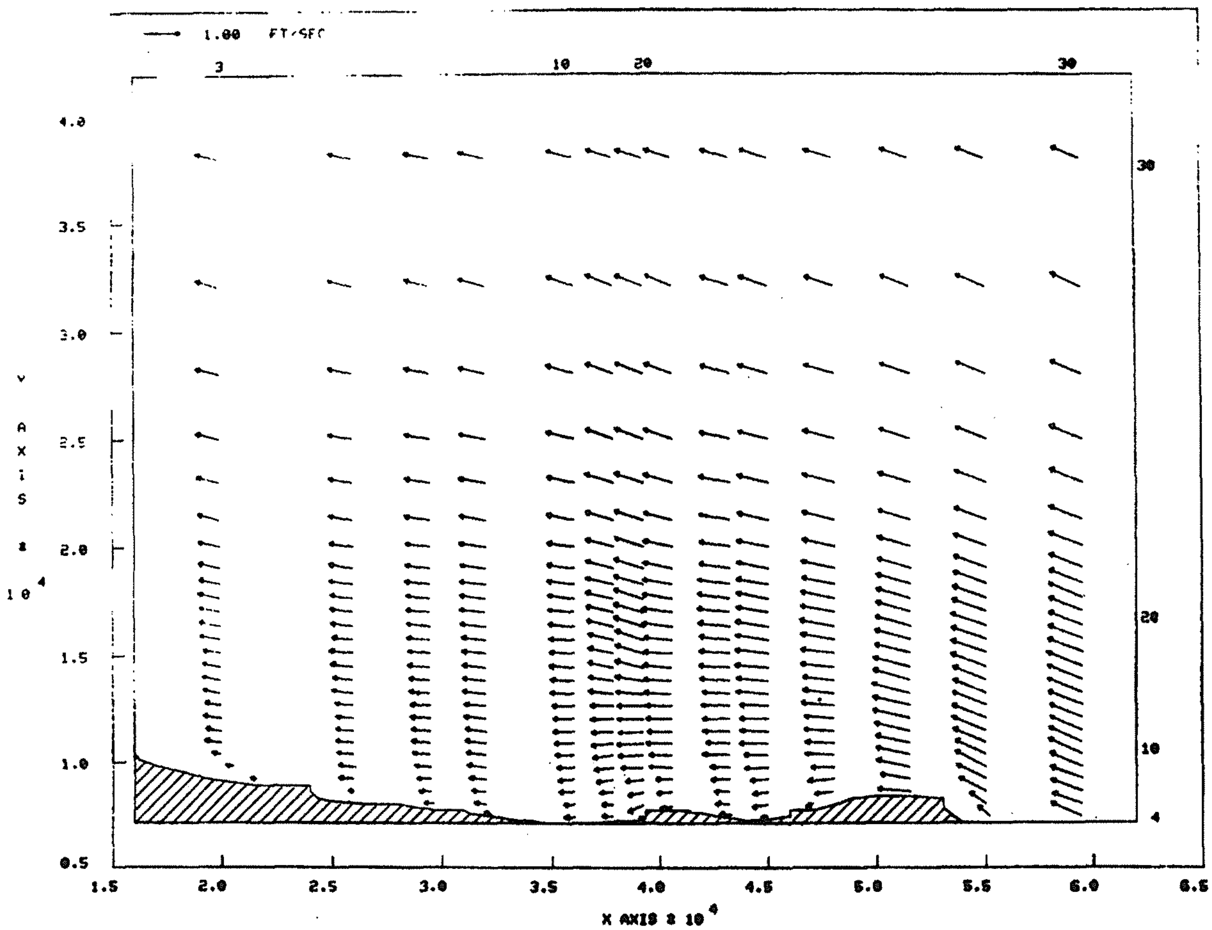

Fig. 5.8 Predicted natural flow field in the San Onofre region at 2:00 a.m. on the fifth day. (To change ft to m, multiply 0.3048; to change °F to °C, subtract 32 and divide by 1.8.)

Figure 5.16 (b) is a plot of the maximum excess temperature in the vicinity of the diffuser as a function of time for one tidal cycle. The shaded portion of this curve represents the period during the tidal cycle when the excess temperature is greater than or equal to 2.2°C (4.0°F) and the plume is vertically well mixed. In other words, the shaded area in this figure reflects the portion of the tidal cycle that will violate state thermal standards as applied to excess bottom temperature. It is clear from this figure that bottom excess temperatures greater than 2.2°C (4.0°F) are predicted to occur for two hours during the tidal cycle. Because, however, this prediction, based on a low ambient drift current, is conservative, excessive incremental bottom temperatures should not occur during each tidal cycle but rather during periods of worst case conditions.

With an assumed persistent drift, the data shown in Figs. 5.8 through 5.15 indicate that the constraints on the surface and shoreline excess temperature will be satisfied. The model is inadequate for addressing the issue of bottom temperature. However, at worst, the 2.2°C (4°F) excess temperature should only touch the bottom over a very limited area in the vicinity of the Unit 2 and 3 diffusers. On the basis of these results, the staff believes that violations of the state thermal standards are unlikely.

Heat treatment

Heat treatment will be necessary to control biological growth in the discharge conduits, intake conduits, and screenwells. Heat treatment consists of decreasing the flow rate through the heat-dissipation system while maintaining a constant waste-heat rejection rate. The result is an increased temperature rise across the condensers.

ES-4544

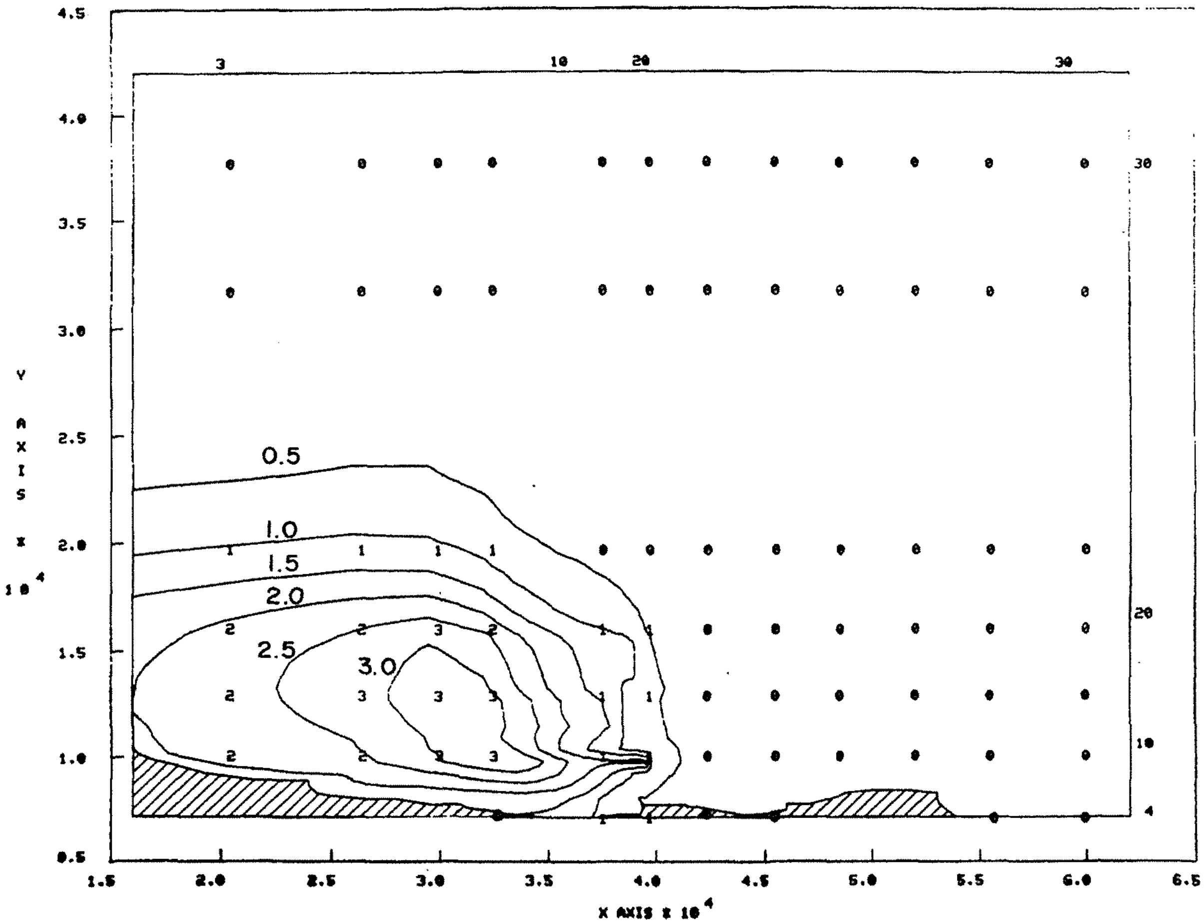

Fig. 5.9. Predicted excess temperatures in the San Onofre region at 2:00 a.m. on the fifth day. Isotherms are plotted in increments of 0.28°C (0.5°F) beginning with the 0.2°C (0.5°F) isotherm. (To change F° to C°, divide by 1.8.)

Discharge heat treatment will be required only when none of the following conditions are met:

1. discharge temperatures exceed 26.7°C (80°F) for a minimum of 1000 hrs,

2. discharge temperatures exceed 29.4°C (85°F) for 150 hrs, or

3. discharge temperatures exceed 32.2°C (90°F) for 31 hrs.

On the basis of these conditions it is expected that discharge heat treatment will be required only infrequently and usually during the winter. When discharge heat treatment is required, it will be performed at a discharge temperature of 40.6°C (105°F) for a duration of 1.1 hrs for Unit 2 and 0.9 hrs for Unit 3. During discharge heat treatment, discharge flow rates will be reduced and discharge temperatures will be increased. The discharge excess temperature will be the difference between the ambient water temperature and 40.6°C (105°F.) The reduction in the discharge flow rate will be proportional to the increase in the discharge excess temperature.

Although the exact nature of the thermal plume resulting from discharge heat treatment will be dependent upon the ambient conditions at the time of heat treatment, the thermal plume will be qualitatively similar to the plume resulting from normal operation as shown in Figs. 5.9, 5.11, 5.13, and 5.15. However, the flow is reduced and the temperature increased, so that the plume will be somewhat warmer and smaller in spatial extent than that from normal operation. The greatest plume temperatures will occur if Units 2 and 3 are heat treated simultaneously. A warmer plume will persist the longest when the heat treatment for these units are sequenced.

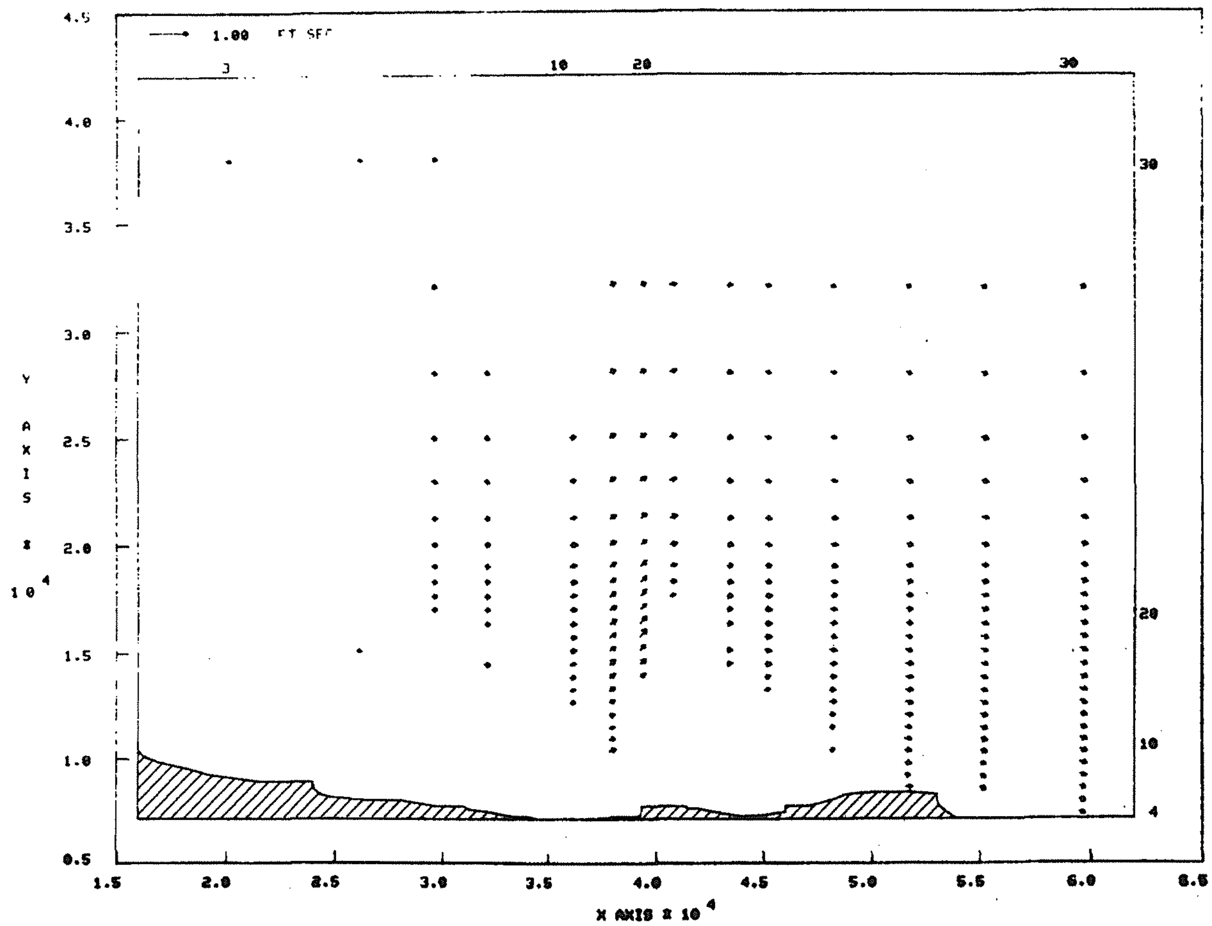

Fig. 5.10. Predicted natural flow field in the San Onofre region at 8:00 a.m. on the fifth day. (To change ft to m, multiply by 0.3048; to change F° to C°, divide by 1.8.)

During the summer months, discharge heat treatment should increase far-field plume temperatures by no more than 25% if both units are heat treated simultaneously (an unlikely event due to the increased probability of a reactor scram) and by no more than 15% if the units are heat treated sequentially. Plume temperatures at this extreme would persist for several hours, and plume temperatures would return to normal within several tidal cycles.

During the winter, the thermal plume should exhibit temperature distributions no greater that those predicted during the summer (Figs. 5.9, 5.11, 5.13, and 5.15). Excess temperatures during winter heat treatment will be greater than during the summer since a greater condenser temperature rise will be required to meet the design discharge temperature of 40.6°C (105°F). For an ambient water temperature of 10°C (50°F) (typical of winter) excess temperature at the San Onofre kelp bed would be approximately 4°C (7.2°F) if the Units 2 and 3 discharges are heat treated simultaneously and 2 to 3°C (3.6 to 4.8°F) if the discharges are heat treated sequentially.

Intake conduit and screenwell heat treatment will be performed by reducing the flow rate through the heat-dissipation system, thereby increasing the temperature rise across the condensers, and by reversing the flow direction so that ambient water is withdrawn through the diffuser and heated water is discharged from the velocity cap intake. The duration of this heat treatment will be 2.1 hr at an anticipated maximum temperature of 37.8°C (100°F). The plume produced by discharge through the velocity caps will resemble the thermal plume from Unit 1. Since this discharge does not induce the dilution produced by diffusers, the heat-treatment plume will be considerably hotter, though much smaller, than the plume resulting from normal plant operation. Plume temperatures will decrease approximately as the square of the distance from the intakes. Heat treatment on either the Unit 2 or the Unit 3 intake will have an indirect impact on the thermal plume of the unit operating normally. If, for example, the Unit 2 intake is heat treated while Unit 3 is operating normally, the Unit 2 heat treatment plume could be advected during certain times in the

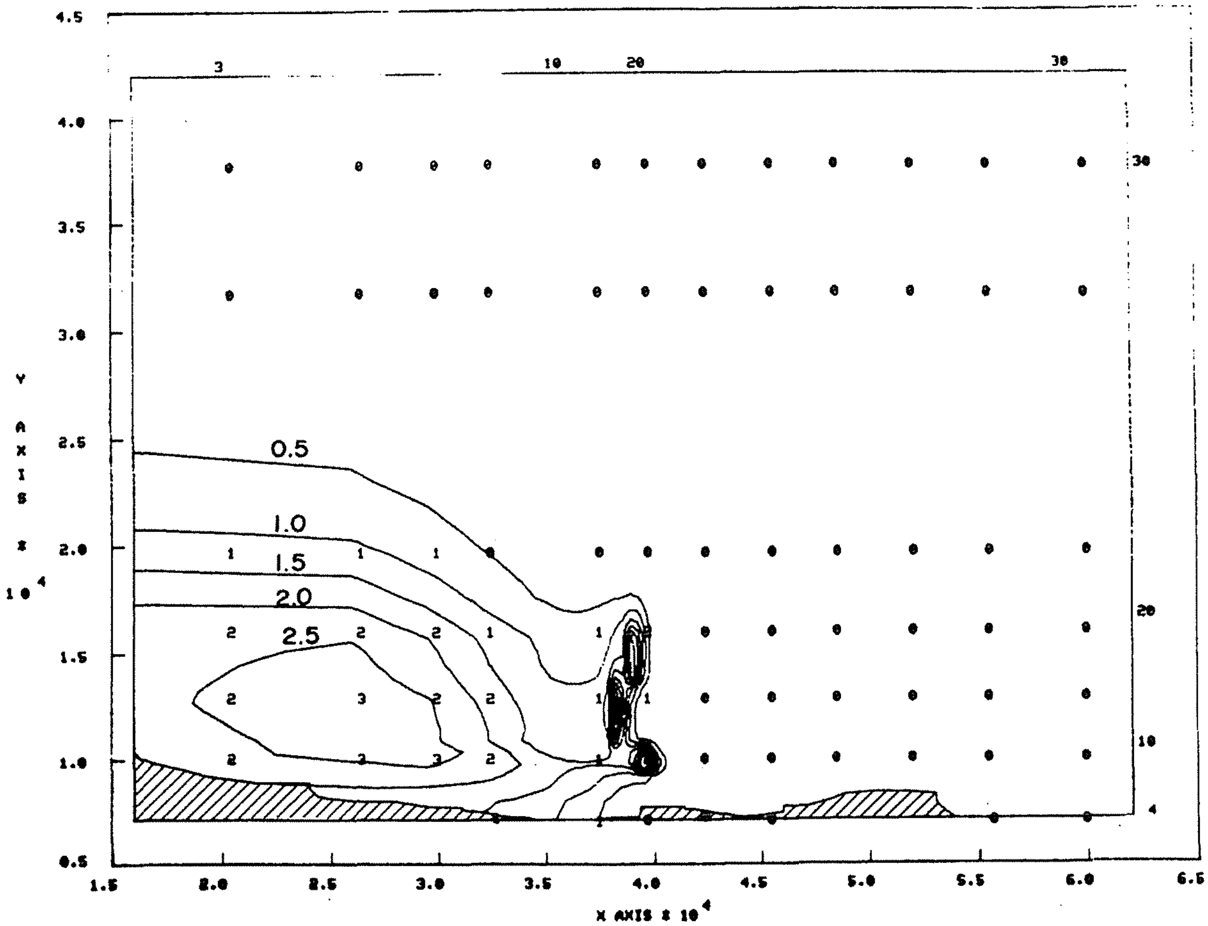

Fig. 5.11. Predicted excess temperatures in the San Onofre region at 8:00 a.m. on the fifth day. Iostherms are plotted in increments of 0.5°F beginning with the 0.5°F isotherm. (To change F° to C°, divide by 1.8.)

tidal cycle towards the Unit 3 intake. As a result, water at temperaures above the ambient could be drawn into the Unit 3 intake, resulting in a temperature rise in the Unit 3 discharge plume. Similarly, Unit 3 intake heat treatment could affect the plume from Unit 2. This recirculation phenomenon will be offset by virtue of the fact that only one unit will be discharging through the diffuser. Therefore, far-field diffuser plume temperatures will likely be less during intake heat treatment than during normal plant operations.

Both discharge and intake heat treatment will produce plumes showing temperatures greater than plume temperatures expected during normal operations. These increased temperatures will be greatest near the point of discharge, and will be of short duration returning to normal within several tidal cycles after completion of heat treatment.

Should it be determined that heat treatment results in significant excess temperatures at biologically sensitive areas, impacts could be mitigated by scheduling heat treatments during phases of the tidal cycle (such as periods when the tidal flow will transport the thermal plume away from areas of concern) that will minimize excess temperatures occurring in such areas.

5.3.2 Chemical discharges

The assessment of the effect of chemical discharges on water use contained in the FES-CP (5.2) is still, for the most part, valid. The discussion of the impacts of copper and nickel discharges has been altered by the change to titanium condenser tubes (3.2.4.1), and these discharges should not affect water use since the tubes no longer contain copper or nickel.

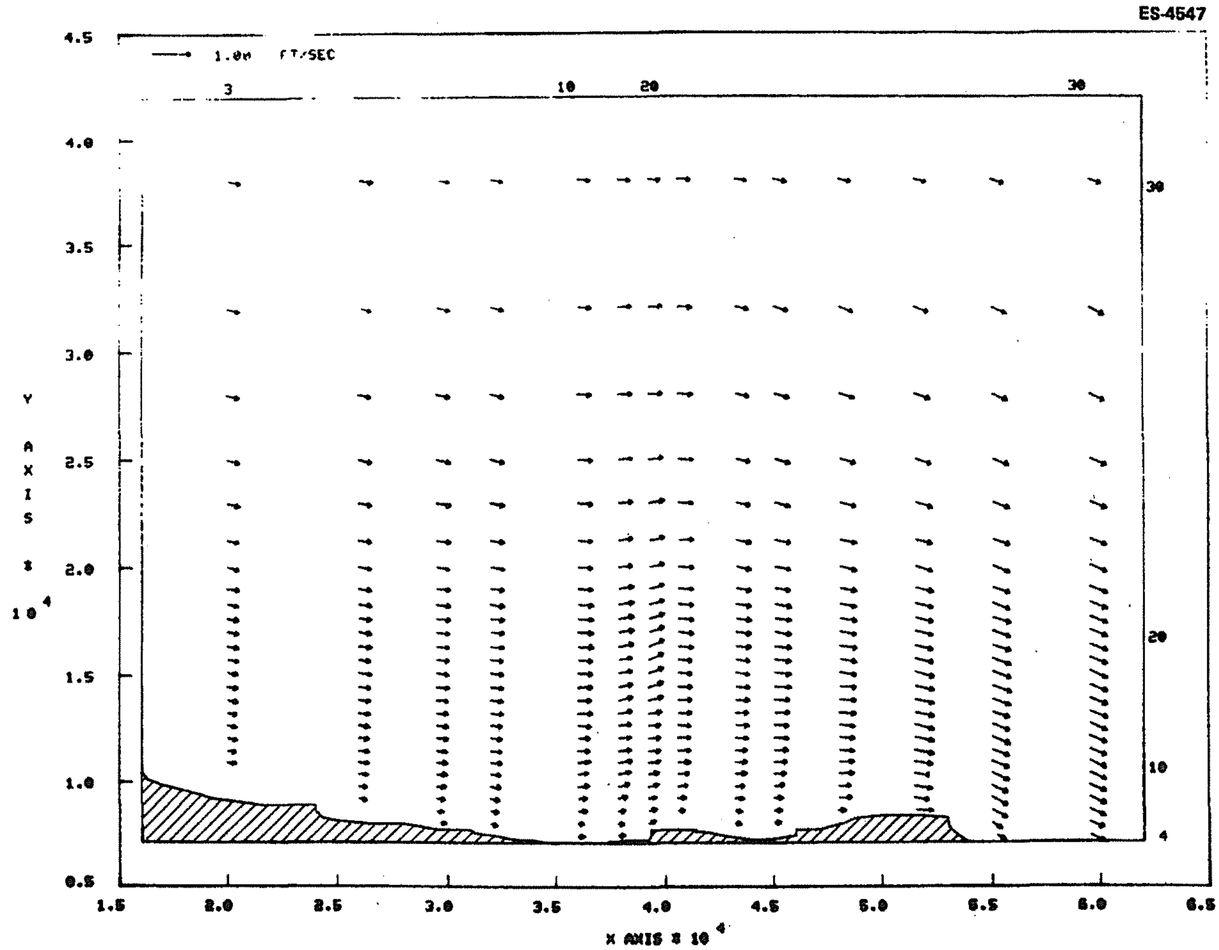

Fig. 5.12. Predicted natural flow field in the San Onofre region at 2:00 p.m. on the fifth day.

A National Pollutant Discharge Elimination System Permit for SONGS 2 & 3 was issued on June 4, 1976, by the California Regional Water Quality Control Board, San Diego Region. The chemical effluent limitations imposed by this permit are given in Sect. 3.2.4.1.

5.4 ENVIRONMENTAL IMPACTS

5.4.1 Terrestrial environment

Generally, operation of SONGS 2 and 3 and associated transmission lines should have no significant impact on the terrestrial ecological characteristics of the area. Although the transmission line routes have been modified since the issuance of the construction permit (3.2.5), the analysis of projected impacts as set forth in the FES-CP (5.3.1) remains the same. All new transmission lines will be constructed on existing rights-of-way; a total of 5.2 ha (12.8 acres) of land will be required for access road extensions and for new tower bases. The fire break which was bulldozed adjacent to the transmission line on Camp Pendleton Marine Base is expected to be maintained by periodic blading. Impacts associated with this operation should be minimal.

Other potential terrestrial impacts associated with operation of SONGS 2 and 3 which were not addressed in FES-CP are as follows. Some audible noise will be generated from the operation of the transmission lines. Noise levels, however, will be well within the urban evening levels accepted by the public (ER, Section 5.5.1). The transmission lines will be designed to minimize any affects on radio and television reception (ER, Section 5.5.1). Maintenance of the transmission lines (washing and repair work) requires that the access

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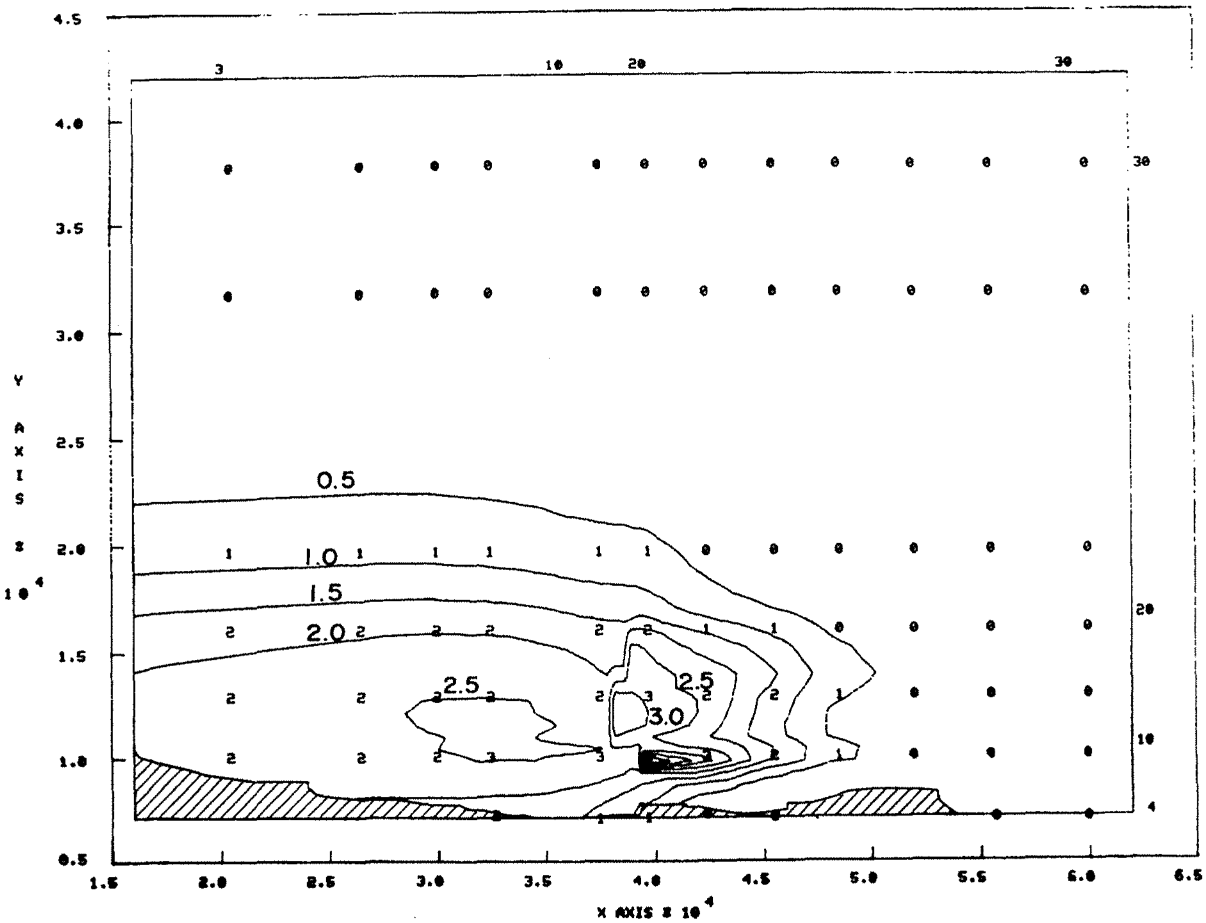

Fig. 5.13 Predicted excess temperatures in the San Onofre region at 2:00 p.m. on the fifth day. Isotherms are plotted in increments of 0.5°F beginning with the 0.5°F isotherm. (To change F° to C°, divide by 1.8.)

roads be kept in good condition by blading (ER, Suppl. 1, Item 21); associated impacts should be minimal. Maximum ground-level field gradients for all transmission lines will not exceed 7.5 kV/m (ER, Suppl. 1, Item 20). Generally, no harmful effects occur from the electrical fields associated with lines operating at 230 kV and below.[9]

5.4.2 Impacts on the aquatic environment

5.4.2.1 Effects of the heat dissipation system

A description of the heat dissipation system to be employed at SONGS 2 and 3 is found in Sect. 3.3 of the FES-CP. Design changes that have occurred since then are discussed in 3.2.2 of this statement. The only changes of potential significance for the assessment of biological effects involve the final specifications for the fish return system, the biocide use program, and the composition of the condenser tubing. Assessments of most major potential impacts also have been reevaluated in light of additional data obtained during technical specifications monitoring programs for SONGS 1 and from construction and preoperation monitoring programs for SONGS 2 and 3 (Section 2.5.2). Except as noted, the reassessments have resulted in the same conclusions that were reached in the FES-CP.

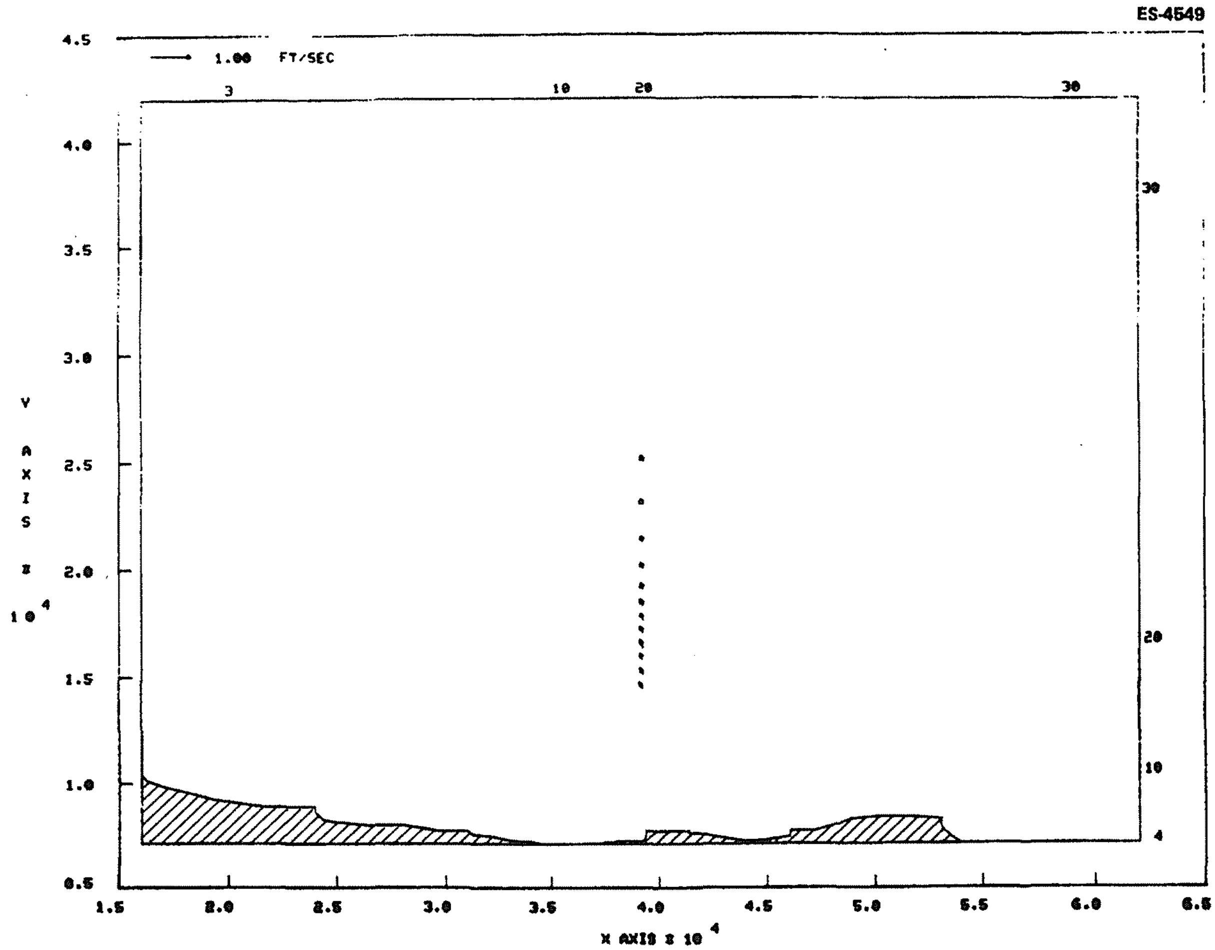

Fig. 5.14. Predicted natural flow field in the San Onofre region at 8:00 pm on the fifth day.

Thermal effects

The discharges from SONGS 2 & 3 must conform to regulations of the California State Water Resources Control Board, the Environmental Protection Agency (with regard to thermal discharges), and the California Regional Water Quality Board, San Diego Region, (under the auspices of the EPA) with regard to NPDES permit considerations (primarily chemical effluent limitations). The regulatory restrictions on thermal discharges are found in Sect. 5.1.1 of the ER; the NPDES permit, as amended, is found in Appendix 12C of the ER.

The results of thermal models used to evaluate temperature increases attributable to SONGS 2 & 3 (and incremental to SONGS 1) are discussed in Sect. 5.3.1. These data indicate that the thermal plume characteristics will be different from those estimated in the FES-CP and in the ER. Since the area to be affected by thermal discharges is now estimated to be greater than previously thought and since areas of substantial biological importance potentially will be affected (e.g., kelp beds), a reassessment is necessary.

Plankton. More planktonic organisms will be affected by thermal discharges than estimated in the FES-CP because the plume will cover greater area. The types of impact will, however, be the same (e.g., species compositon changes, greater respiration rates), and significant changes should be localized. The staff believes that changes which are produced in plankton communities will not threaten the ecological integrity of the near-shore region surrounding the facility (see pp. 5-26 to 5-32 of the FES-CP for a description of the anticipated effects).

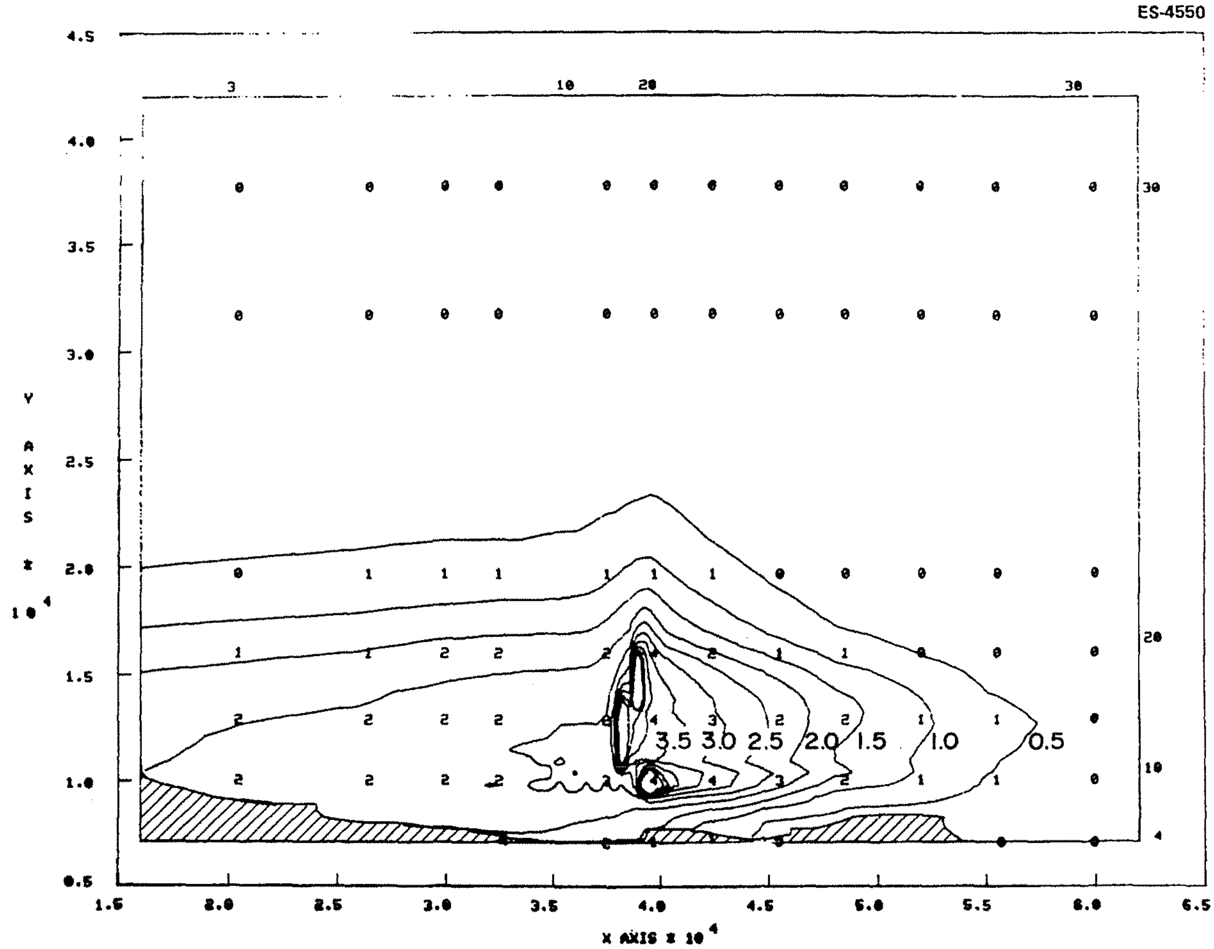

Fig. 5.15. Predicted excess temperatures in the San Onofre region at 8:00 p.m. on the fifth day. Isotherms are plotted in increments of 0.5°F beginning with the 0.5°F isotherm. (To change F° to C°, divide by 1.8)

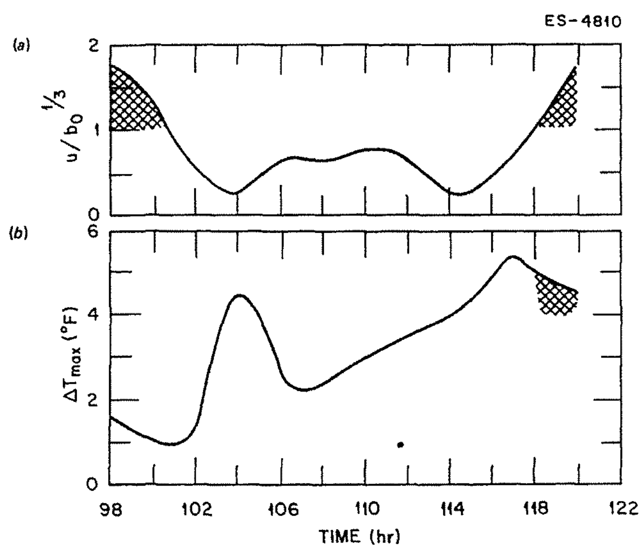

Fig. 5.16. (a) Plot of stability parameter versus time. The shaded area represents periods of vertical mixing. (b) Plot of maximum excess temperature versus time. The shaded area represents the period during which excess bottom temperatures are predicted to be greater than 4°F. (To change F° to C°, divide by 1.8.)

Fish. The types of impact on fish to be expected as the result of thermal discharges are the same as those discussed in the FES-CP. However, with more area to be influenced by the effluent, more fish potentially will be affected. The most observable change is likely to be shifts in the types of species (and their numbers) which inhabit the area; e.g., species which normally exhibit increased standing crops during naturally warm years will be more prevalent. Although the area of potential impact will be greater than estimated before, no fish populations are expected to be adversely impacted in the vicinity of the facility. Species composition changes, however, may affect commercial and recreational fishing within the thermal plume (in some cases adversely, and in others, beneficially; see FES-CP for details). However, because the plume will occupy a relatively small area of the available fishing space nearby, no significant changes in harvest rates for the various species are expected.

As stated in the FES-CP, cold kills of fish are not likely to occur to any large degree. The principal reasons are the relatively high ambient winter temperatures and the fact that all three units are not likely to be inoperative at any given time.

Benthic fauna. The major component of the ecosystem expected to receive the greatest impact from thermal discharges is the benthic community. Unlike free-swimming organisms, benthic individuals cannot easily avoid undesirable temperatures. And unlike planktonic organisms, they do not regenerate quickly to compensate for losses or experience continual, rapid recruitment from surrounding waters. Two major categories of the benthic community exist: animals, such as starfish and molluscs, and attached algae, the most conspicuous of which is kelp (discussed in the following section).

Among the benthic fauna recorded in the vicinity of SONGS during surveys conducted in 1977 in compliance with Environmental Technical Specifications criteria for SONGS Unit 1 were the gastropod molluscs Astraea undosa, Kelletia kelletii, and Roperia poulsoni, the asteroid echinoderm Pisaster giganteus, and the echinoid echinoderm Strongylocentrotus franciscanus.[10]

Although there have been only a limited number of detailed studies concerning the effects of temperature on marine species inhabiting the Pacific Coast, some recent laboratory simulation experiments of 12 to 14 weeks duration have examined the effects of thermal effluent on the survival, growth, and state of health of seven motile invertebrates from shallow rocky habitats along the southern California coast.[11] The treatment conditions simulated temperatures measured at distances of 84 and 335 m (276 and 1098 ft) from the cooling-water discharge structure of the Redondo Generating Station, located approximately 100 km (62 miles) upcoast of SONGS. Several of the species displayed low survival and impaired growth, especially among large adults, in response to the simulated thermal plume conditions at 84 m. Weekly mortality data for S. franciscanus, P. ochraceus, and R. poulsoni showed that individuals of all three species began to die when the temperature fluctuated over a range of 19° to 23°C (66° to 73°F), with a mean for the week of 21.4°C (70.5°F). No deaths had occurred the previous week when the same temperature range prevailed and the mean was slightly higher 22.8°C (73°F). The mortality observed during the second of these two weeks may, however, actually have been a delayed response to the higher average temperature of the previous week.

In the test involving R. poulsoni under a different thermal regime, deaths began occurring when the temperature flunctuated between 18° and 24°C (64° and 75°F) during the week, with a mean of 20.3°C (68.5°F). Although mortality began to appear at a lower mean temperature than in the previous experiment with this organism, the maximum temperature in this second experiment was 1°C (1.8°F) higher (24° vs 23°C) (75°F vs 73°F) and the temperature range was 2°C (3.6°F) wider (6° vs 4°C) (4.28° vs 39.2°F) than in the previous experiment. These results demonstrate the complicated nature of temperature effects; that is, adverse conditions can result from a critical high temperature of short duration, an extreme temperature fluctuation of short duration, or a prolonged period of a high but normally subcritical temperature.

The ambient depth-averaged temperatures predicted for the hottest time of the year (end of July) in the vicinity of SONGS are shown in 5.3.1. This section also contains data on the temperature expected during the operation of all three units. Temperatures potentially as high as 27.8°C (82°F) may occur naturally, and increases of 0.5° to 1.7°C (0.90° to 3.1°F) brought about by the operation of all three units can occur within an area of several square kilometers.

On the basis of the 1976 study,[11] the staff concludes that several components of the benthic fauna in the vicinity of SONGS would probably be adversely affected in areas where weekly mean temperatures of 22°C (71.6°F) prevail for one month or more or where daily temperatures reach or exceed 24°C (75°F). It is not, however, anticipated that temperatures averaging 22°C will occur for more than 2 to 3 weeks or that the area experiencing temperatures of 24°C or greater as a result of SONGS operation will be considerably larger than the area experiencing these temperatures under natural conditions.

The staff concludes that any impacts to the benthic fauna as a result of thermal discharges will be minimal and of an acceptable nature.

Kelp. Kelp beds off California occupy roughly 194 sq km (75 sq mi) of ocean bottom in water depths of 6-18 m (20-60 ft).[12] Although management efforts have possibly halted further severe decline, kelp bed coverage has decreased markedly since about 1920. Although this deterioration may have been partially a result of overharvesting, much of it is probably caused by the increased alteration of the near-shore environment by human activities. In particular, increased temperatures and increased turbidity have been shown to be inimical to kelp survival.[13]

Even without the influence of human perterbations, individual kelp beds experience long-term variations in stand density, productivity, areal extent, etc. Natural factors implicated in causing these variations include storm damage (causing detachment of plants), sand movement (burying holdfasts and causing detachment or prohibiting regeneration), introduction of turbid water masses, high natural temperatures, influx of grazing urchin masses, and fungal and bacterial diseases.[12] Thus, for example, in 1957-59, unusually warm temperatures off southern California caused an estimated loss of 90% of the regions' beds during this period (ER, pp. 2.2-28 and 2.2-29), as judged by surface examinations. Individual beds also commonly display changes in canopy extent during the year. For example, the three beds near the SONGS site showed marked variation in canopy area during 1975 and 1976 (Fig. 2.10). Typically, canopy tissue deteriorates during the warmest time of the year, leaving the basal portion of the plant (which is in cooler water) for regeneration when temperature and light conditions permit.[13] Reduced surface nutrients and higher bottom nutrient mixtures may also contribute to canopy deterioration and basal tissue regeneration respectively.[14]

Kelp beds represent a very important ecological community in California's near-shore waters. It has been estimated that kelp beds are at least three times more productive than the autotrophic components of other near-shore communities. Conservative estimates place the total standing crop of kelp in southern California at 1.8×10^9 kg (2 million tons) and new annual growth potential is on the order of 2-3 times this amount.[13] Kelp beds harbor numerous types of animals and plants, adding greatly to the diversity of an area. Invertebrates commonly found on the plants themselves include ostracods, copepods, amphipods, decapods, polychaetes, nematods, bryozoans, turbellaria and molluscs. Molluscs and echinoderms are kelp grazers prevalent on and around the plants. It is estimated that the larval, juvenile, and adult stages of 25 main sport fish use kelp beds for refuge and food gathering (eating the associated invertebrates, the kelp itself, or other algae), and the average standing crop of fish is estimated to be 300 kg/ha (300 lbs/acre).[13] Kelp not only enter the food chain via grazers, but they contribute large quantities of organic matter to the detritus-based food chains. For example, since several detritus feeders are intermediate in the grazing food chain of many of California's commercial fishes, kelp indirectly influences the populations of these fishes through the production of detritus.[13]

Kelp is an important commercial commodity as well. Although used extensively in the past for such diverse things as fertilizer, cattle feed, and for the production of potassium, acetone, and iodine, most kelp today is processed for the production of algin, a polysaccharide with numerous industrial uses.[12] It is estimated that roughly 15% of the annual kelp production is harvested yearly at a landed value (1964 dollars) of $2 million (market value is roughly 4 times this figure).[13] The kelp beds in the vicinity of SONGS are not now harvested.

Besides the necessity for a favorable physicochemical environment, kelp requires a solid substrate for attachment. Thus, the local distribution of kelp beds in an unperturbed area is largely substrate-dependent. Near the SONGS site, sandy bottoms are prevalent limiting the areas where beds can develop. Natural environmental fluctuations (e.g., higher-than-average temperatures) can virtually denude an area, but, since the casual phenomena are short-lived, kelp beds generally reestablish themselves quickly. However, anthropogenic disturbances frequently completely eliminate kelp beds in their sphere of influence because they generally are of long duration. Even chronic, low-level perturbations which only slightly decrease kelp production often cause the consumption by grazers to outpace new growth.[13]

The temperature tolerance of kelp is probably a reflection of a combination of factors, including physiological responses, susceptibility to disease, and susceptibility to grazing. It has been rather well established that temperatures above 18-20°C (64-68°F) cause deterioration of kelp, and the degree of degradation is directly related to the duration of the exposure to these temperatures. Increased surface temperatures caused by SONGS operation (all three units) would have the effect of extending the period of canopy absence. During the hottest time of the year, data in Section 5.3.1 suggest that the closest kelp bed (San Onofre bed) will experience an average surface temperature increase (over a 24-hr period) of 1.4°C (2.6°F); the range of temperature increase will be 0.6-2.2°C (1-4°F).

Although daily natural temperature variations of 1°C (2°F) are not uncommon in the area (ER, p. 2.2-28), they would not be continuous in nature and thus might not affect the bed

as severely as the continuous SONGS discharges would, where the thermal plume may impinge on the bed for a longer time. Prediction of the degree to which canopy disappearance would be prolonged is impossible. Regeneration would be quicker in years with naturally cooler ocean temperatures, assuming the regenerative tissues remained unaffected (see below).

The greatest threat of SONGS to the long-term survival of the San Onofre kelp bed is the possibility of injury to the basal tissues from which the canopy is regenerated each year as the waters cool. Estimates for bottom temperatures within the bed at the end of July (Section 5.3.1) indicate that temperatures could reach 23-25°C (74-76°F), with a 24-hr mean of 24°C (75°F). Such temperatures would represent a 1-1.5°C (2-3°F) increase above ambient conditions encountered during the hottest portion of the year (conditions which are likely to persist for up to approximately a one-week period) (Section 5.3.1). Although the ambient temperatures given above would in and of themselves be detrimental to the kelp, exposure to them for up to a week would not likely cause permanent degradation of the entire bed[13] because the mean exposure temperature does not quite exceed a recognized threshold temperature for rapid degradation (24°C) and deeper portions of the bed would be slightly cooler than the average and would have a greater probability of maintaining a viable population. However, adding 1-1.5°C to these ambient temperatures could place the bottom kelp tissues in a critical temperature environment subjecting the tissues of most of the plants to temperatures greater than their short-term tolerance, and prolonging the period of time in which the plants would experience temperatures greater than 20°C (68°F), which would cause them to be more susceptible to grazing pressure, diseases, etc., leading to their eventual demise.[13] Since ambient bottom temperature in the region from August – early September may typically range up to 19°C (66°F) (Section 5.3.1), a several week period could exist in which temperatures exceed 19°C.

The information above suggests that the thermal discharges from SONGS 1, 2 and 3 may result in the destruction of at least a portion of the San Onofre Kelp Bed during the summer months. Under average conditions, the result may not be detectable or it may be manifested in a noticeably earlier decline of the canopy. However, under extreme worst case conditions (e.g., several days with high ambient temperatures and slack currents, and with all three plants operating continuously), destruction of the basal regenerative tissues might result. Although recolonization of the area from outside sources could occur during the cooler months, the community, if destroyed frequently, could never achieve a stable state characteristic of other kelp beds in the area. Furthermore, constant temperature increases coupled with added turbidity would be inimical to interim reestablishment since these factors tend to increase the effects of grazing.[13] The perennial occurrence of worst case conditions seems highly unlikely (Section 5.3.1) and the staff thus concludes that the long-term thermal impacts from normal station operation are not likely to be severe. However, in view of (1) the potential additive of synergistic effects of turbidity and sediment with thermal discharges, (2) the ecological importance of kelp beds and their already diminished stature, and (3) the fact that the San Onofre bed represents about one-third of this resource along approximately 16 km (10 mi) of shoreline in the vicinity of SONGS, the staff recommends monitoring to ensure the bed's protection.

Heat treatment

In addition to the thermal discharge associated with the normal operation of the facility (see above), the applicant proposes to heat treat portions of the intake and discharge systems to remove biological growth (see Section 5.3.1.2). This antifouling procedure will result in periodic discharge temperatures higher than those normally encountered. As a result, the state required the applicant to perform a demonstration to determine if significant impacts will result from the procedure. This demonstration, in part provided for under part 316(a) of the Federal Water Pollution Control Act of 1972, was used to determine if the proposed process is acceptable to these government agencies. To date, approvals have been obtained from the California State Water Resources Control Board (Resolution No. 80-95 adopted December 18, 1980), thus removing any regulatory obstacles from the state for conducting the antifouling process.

As stated in Section 5.3.1.2, biofouling control will be needed primarily in the winter; ambient summer temperatures will normally be sufficiently high to obviate the need for the procedure at that time. Additionally, the state has imposed a five-week minimum treatment interval for each unit. Hence, the biological effects will be a manifestation of short-term intermittent stress. Localized mortality and chronic debilitation are inevitable, particularly for sessile organisms. However, only one community of organisms is judged to be significantly vulnerable ecologically – the San Onofre Kelp Bed.

The thermal effects of normal operation on kelp are discussed above along with more detailed information on thermal tolerances, etc. Since intake heat treatment should produce smaller far-field ΔT's than that produced by normal operation (Section 5.3.1.2), the effects on kelp will be less than or equal to the effects induced normally. Discharge heat treatment is

judged to produce potentially greater far-field thermal effects, however. Without dispersing currents (i.e., during a slack in the tidal cycle), kelp bed temperatures during the summer may increase by ca. 0.4°C (0.72°F) (above normal operations) (Section 5.3.1.2). This negligible increase would not be likely to affect the kelp, particularly since the canopy will be naturally reduced (see kelp discussion above) and the heated water is not likely to be near the bottom.

Discharge heat treatment during the winter may cause a temperature increase in the kelp bed of up to 4°C (7.2°F). The kelp are ordinarily tolerant of the absolute temperatures this would produce, but the rapid heat-up involved (e.g., 0.5 h) could be deleterious since the kelp would not be "hardened" for such a temperature regime. However, it is not possible to tell from the literature the severity of such an event. The plants could be only temporarily taxed physiologically and rebound without sequelae. Conversely, the stress could initiate an increased vulnerability to other, natural stresses such as predation, sloughing, and encrustation. Overt mortality is unlikely. In the absence of definitive data, it would be wise to (1) ensure continuation of the kelp monitoring program and (2) attempt to avoid heat treatment during unfavorable ocean current conditions. As pointed out in Section 5.3.1.2, effects can be mitigated by staggering heat treatment at Units 2 and 3 (thus allowing thermal dispersion from the first treated unit before treating the second) and by conducting the antifouling procedures when current and tidal cycles are known to move the adjacent water mass away from the kelp bed.

Turbidity and sediment transport effects

The FES-CP discusses the types of effects turbidity increases due to SONGS operation will have on the various biological communities, indicating that it is not possible to predict the areal extent of this impact.

The organisms likely to receive the greatest impact from increased turbidity are those which cannot readily avoid adverse conditions or do not regenerate quickly (or experience rapid recruitment from surrounding waters), namely, the benthos. Since the San Onofre Kelp Bed is estimated to be enveloped within the thermal plume, it is likely that it will also experience increased turbidity. The effect on the kelp would potentially be decreased photosynthesis, possibly causing many of the plants to die if the exposure is continuous (a 1% increase in the absorption coefficient has been found to result in a 20% loss in net photysynthesis at 15 m (49.2 ft)[13] and burial of the holdfasts in particles which settle out, inhibiting regeneration and recolonization. Regardless of the magnitude of these effects, their presence would add to the probability that the kelp bed would be adversely affected (see preceding section).

Some of the effects of increased sediment transport on benthic fauna are addressed in the FES-CP. The staff has further addressed the impact of the change in sediment size in areas near the SONGS site which would result from sediment redistribution. A study conducted during SONGS 1 operation, shutdown, and subsequent startup showed a significant reduction in the number of species and the total abundance of individual benthic fauna (primarily molluses and polychaete worms) within 200 m (656 ft) of the intake and discharge structure, probably because of the coarsening of the grain size of the sediments in this area.[15] Sediment coarsening appears to be mainly a result of the discharge of shells and shell fragments of fouling organisms (barnacles, molluscs) sloughed from the insides of the intake and discharge pipes during normal operation and especially during heat treatment.

The sediment-altered area associated with SONGS 1 (following 13 years of operation) is estimated to be approximately 125,600 m^2 (.048 mi^2), on the assumption of a circular pattern of effect with a radius of 200 m (656 ft).[15] Assuming sediment alteration associated with SONGS 2 and 3 forms a rectangular pattern approximately 200 m from the sides and ends of each diffuser, the area affected by SONGS 2 and 3 would be approximately 0.8 km^2 (0.31 mi^2). Adding this to the area affected by SONGS 1 (125,600 m^2 (0.48 mi^2)) plus an estimate of the area affected by heat-treatment backflushing of the SONGS 2 condenser (59,900 m^2 (0.023mi^2)) gives a total area affected by all three units, from both normal operation and heat treatments, of approximately 1.0 km^2 (.386 mi^2).

It is difficult, however, to extrapolate from the effects associated with the point source discharge of SONGS 1 to the 762-m (2500-ft) long dual, staggered diffusers of SONGS 2 and 3. SONGS 2 and 3 jointly are expected to have 5 times the cooling water flow rate, 3.3 times the intake pipe area per intake structure, and 12.5 times the total fouling surface area associated with the two outfall lines that SONGS 1 has.[15] None of these factors has been taken into consideration in calculating the area potentially affected by SONGS 2 and 3. The magnitude of the effect will also increase with duration of operation.

In contrast to the above prediction of benthic impoverishment, the staff concludes that a zone of enhanced species diversity and abundance is to be anticipated beyond the area of

sediment modification. This conclusion is also based on results of the Marine Review Committee study,[15] which indicates that within a zone of 200 to 800 m (656 to 2424 ft) from the intake and outfall of SONGS 1, diversity and abundance of benthic fauna show a positive correlation with proximity to these structures. It has been estimated that this area contains 2 times the diversity and 8 times the abundance of benthic fauna as the sediment-altered area within the 200-m (656-ft) radius of the outfall. This phenomenon is believed to be a result of organic enrichment from sinking plankton fragments and/or material continually resuspended by the localized turbulence of the discharged cooling water.[15]

Assuming an eliptical ring pattern for this area of enhancement, starting from a point 200 m (656 ft) on either side of the intake and outfall structures of SONGS 1, to 1200 m (3936 ft) upshore and downshore (the extent of enhancement appears to diminish between 800-1500 m (2624-4920 ft) downcoast) and extending for a distance of 400 m (1312 ft) beyond the 200-m (656-ft) point in the onshore and offshore directions (offshore/onshore effect is much less than longshore), the area of enhancement is estimated to be approximately 2.1 km^2 (0.81 mi^2).

Predicting the magnitude of an enhancement effect associated with SONGS 2 and 3 on the basis of SONGS 1 observations is complicated. The total volume of dead plankton dispersed might be approximately 5 times that of SONGS 1 as a result of the 5-fold increase in cooling water flow rate. However, the volume of discharge for each diffuser port is less than for the single outfall of SONGS 1 so that the distance the entrained plankton are dispersed would be expected to be less. There may also be considerable differences between the shallow current patterns where the SONGS 1 outfall is located and the current patterns in the deeper waters where the SONGS 2 and 3 diffusers will be located.

If it is assumed that the dispersal distances for dead plankton will extend approximately half the distance from the sediment-altered area surrounding the SONGS 2 and 3 diffusers as was found associated with the SONGS 1 discharge, and accounting for overlap, the area of enhancement would be approximately 2.4 km^2 (0.93 mi^2). Adding to this the area affected similarly by SONGS 1 gives a total of 4.5 km^2 (1.74 mi^2). This is an area approximately 5 times that estimated to show a reduction in benthic diversity and abundance. The staff concludes that the impacts likely to occur to the benthic fauna as a result of sediment transport effects are acceptable.

Entrainment

The staff's analysis of entrainment effects in the FES-CP remains valid (FES-CP, p. 5-7 to 5-12). A program on the mortality experienced by entrained ichthyoplankton is being planned currently at SONGS 1 and is expected to be submitted to the NRC staff in 1981. The results of this program should help to determine the significance of any impacts although the analysis presented in the FES-CP indicates that impacts should not be significant. The completion date for this study will be approximately one year after it is initiated.

The circulation of water from near-shore areas to offshore areas will cause some redistribution of species, particularly zooplankton, since species composition is not exactly the same for both areas (Section 2.5.2). Although this may result in long-term species composition changes, the areas affected should be small (FES-CP, Section 5.3.2) relative to the coastal areas as a whole around San Onofre. Because no other power plants or industrial facilities that could exert a similar influence exist within several miles, this impact is judged acceptable.

Impingement

The basic impingement analysis contained in the FES-CP remains valid. Some additional information is available, however, on the design and efficiency of the fish return system. The system is described in detail in Section 3.4 of the ER and in Section 3.2.2 of this document. Basically, the fish return system consists of a mechanism for shunting any fish entrained in the intake to a side holding area by means of an angled conduit design to avoid impinging them on the trash removal mechanisms in front of the final intake. Preliminary experimental results (ER, p. 5.1-20) indicate that perhaps 90% or more of the fish can be returned to the ocean unharmed. However, precise figures on the effectiveness of this system will not be available until the fish return system is in full-scale operation. The FES-CP analysis assumes a worst-case situation in which the fish return system is not at all effective. Under these conditions, 33 to 91 tonnes (36 to 100 tons) of fish per year would be removed from the San Onofre area. These figures are based on extrapolations from data obtained on SONGS 1 operation; new data do not indicate that these figures should be adjusted significantly. The majority of the fish impinged at SONGS 1 are queenfish, and, for reasons given in the FES-CP, losses from all three units should not have a significant impact on the population. Moreover, of the dominant recreational fish impinged at SONGS 1, losses were less than 0.8% of the amount taken by fishermen. Likewise, the primary

commercial fish of the area – jack mackerel, Pacific bonito, and white seabass – were seldom entrained at SONGS 1.

Offshore current induction

The analysis of the effects of induced circulation as given in the FES-CP (p. 5-16) remains valid, despite the design changes described in Section 3.2.2.

5.4.2.2 Effects of biocides and other chemical discharges

The FES-CP expressed concern about the potential long-term effects of copper being released into surrounding water by corrosion of the condenser tubing. Design changes have eliminated the plan to use a copper-nickel alloy for condenser tubing; titanium tubing will be used. Therefore, copper- or nickel-induced stresses to the receiving water from condenser tubing would not occur.

The FES-CP conclusion that the effects of chlorine will not be significant remains valid. However, new information is available on this subject. The applicant estimates that the effluent chlorine concentrations will be no greater than 1.5 ppm as total residual before discharge to the ocean (ER, p. 5.3-2). With a 10-to-1 mixing in the immediate vicinity of the diffuser ports (ER, p. 5.3-2), this value would be reduced to 0.15 ppm. The FES-CP required, and the applicant agreed, that the total residual concentration of chlorine and other halogens in the immediate vicinity of the discharge from each unit be limited to less than 0.1 ppm for no more than six 15-min periods each day [FES-CP, p. iv, item 7.a(2)]. Experience at SONGS 1 indicates that total residual chlorine concentrations quickly dissipate to undetectable quantities within a hundred or so meters of the outfall and, for any given 15-min dosing period, are only detectable over the outfall for 2 to 18 min (ER, p. 5.3-2). Even assuming a worst-case condition for SONGS 2 and 3 in which chlorine remains at levels around 0.15 ppm (total residual) in the vicinity of the outfall ports for as long as 30 min, any significant impacts are unlikely.[16] Thus, any chlorine effects are likely to be minimal and of an acceptable nature. Moreover, the difference in effect between discharges of 0.1 and 0.15 ppm are negligible. In view of this and in light of the provisions of the Federal Water Pollution Control Act Amendments of 1972, the staff does not believe that a more stringent limitation on chlorine discharges is necessary.

Miscellaneous chemicals will be discharged through the circulating water outfall system and will include laboratory wastes, ion exchange regeneration chemicals, and pH adjusters (Section 3.2.4 of this document and Section 3.5 of the FES-CP). The FES-CP analysis of the impact of these chemicals remains valid; that is, because of the small quantities involved, the great dilution factors present, and the relatively innocuous nature of most of these chemicals, impacts will not be detectable.

5.4.2.3 Effects of sanitary waste discharge

The effects of sanitary waste discharge are not discussed specifically in the FES-CP. However, any effects will be insignificant for the following reasons.

1. On the average, only about 26 m^3/day (7000 gpd) of secondary treated sewage will be discharged.

2. The discharge will be made into the circulatory water system at the rate of 0.02 m^3/min (5 gpm). The cooling water flow is about 1200 m^3/min (320,000 gpm). Thus, a 6400 dilution factor will result.

3. The resulting concentrations of suspended solids, BOD, N, P, coliform bacteria, and chlorine will not result in detectable incremental increases above ambient levels even before discharge into the ocean.

5.5 RADIOLOGICAL IMPACTS

5.5.1 Radiological impact on man

The impact on man associated with the routine release of radioactive effluents from SONGS 2 and 3 has been estimated. The quantities of radioactive material that may be released annually from the plant are estimated based on the description of the radwaste systems given in the applicant's ER and PSAR and using the calculational model and parameters described in NUREG-0017.[17] Using these quantities and site environs information, the dose commitments to individuals are estimated using models and considerations discussed in detail in Regulatory Guide 1.109. Additional assumptions and models described in Appendix B of this environmental statement were used to estimate integrated population doses.

5.5.1.1 Exposure pathways

The environmental pathways that were considered in calculating the radiological impact are shown in Fig. 5.17. Calculations of radiation doses to man at and beyond the site boundary were based on the radioactive material quantities shown in Tables 3.2 and 3.3, on site meteorological and hydrological considerations, and on exposure pathways at SONGS 2 & 3.

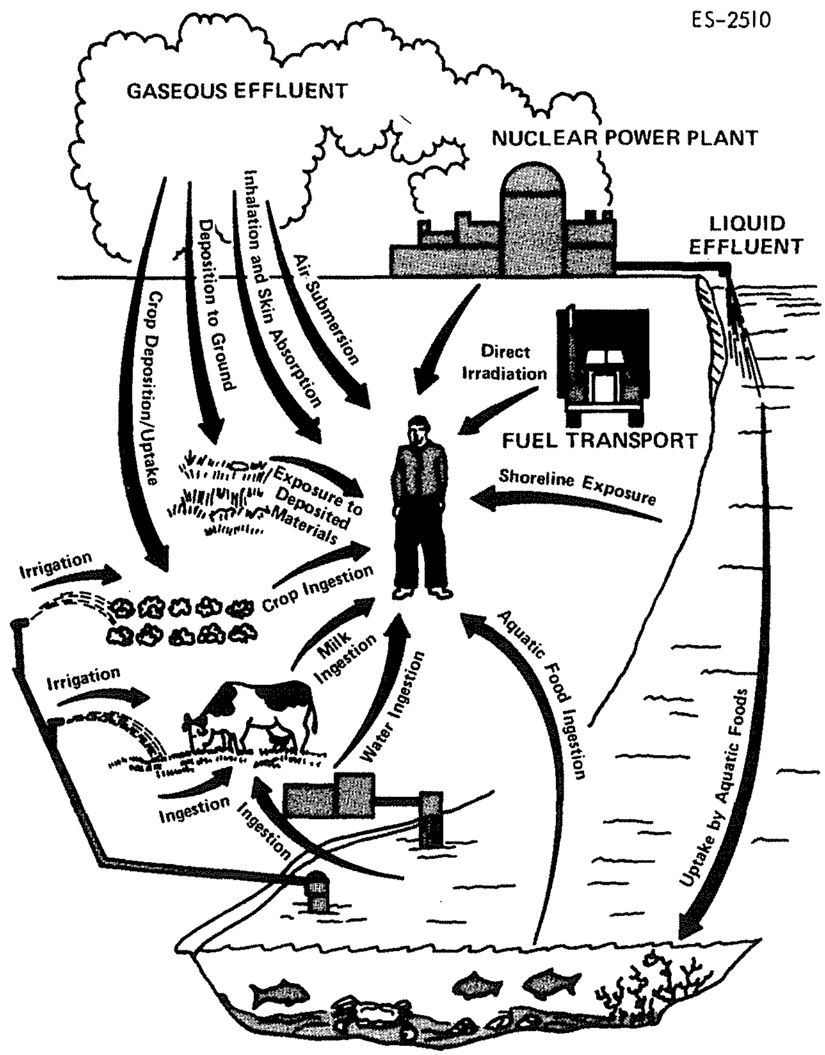

Fig. 5.17. Exposure pathways to man.

In the analysis of all effluent radionuclides released from the plant, tritium, carbon-14, radiocesium and radiocobalt inhaled with air and ingested with food and water were found to account for essentially all total-body dose commitments to individuals and the population within 80 km (50 miles) of the plant.

5.5.1.2 Dose commitments from radioactive releases to the atmosphere

Radioactive effluents released to the atmosphere from SONGS 2 & 3 will result in small radiation doses to the public. NRC staff estimates of the expected gaseous and particulate releases listed in Table 3.3 and the site meteorological considerations discussed in Sect. 2.4 of this statement and summarized in Table 5.1 were used to estimate radiation doses to individuals and populations.

Table 5.1. Summary of atmospheric dispersion factors and deposition values for selected locations near SONGS 2 & 3[a]

Location	Source[b]	X/Q (sec/m^3)	Relative deposition (m^{-2})
Nearest site land boundary (0.36 mile NNW)[c]			
	A	5.4 E–5	2.1 E–7
	B	2.4 E–5	9.3 E–8
Nearest residence and garden (1.3 mile NNW)[c]			
	A	4.8 E–6	2.0 E–8
	B	1.7 E–6	6.9 E–9

[a]The doses presented in the following tables are corrected for radioactive decay and cloud depletion from deposition, where appropriate, in accordance with Regulatory Guide 1.111, Rev. 1, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light Water Reactors," July 1977.

[b]Source A is gas decay tank, 48 purges per year, 12 hr per purge; source B is continuous release.

[c]"Nearest" refers to that type of location where the highest radiation dose is expected to occur from all appropriate pathways.

[d]Here E-x is used to indicate the factor 10^{-x}; i.e., 5.4 E–5 = 5.4×10^{-5}

(To change mi to km, multiply by 1.609.)

Dose commitments to individuals and the population can be estimated using different methodologies. The staff's assessment of dose is based on a 50-year commitment and is described in Regulatory Guide 1.109. The results of the calculations are discussed below.

Radiation dose commitments to individuals

The predicted dose commitments to the "maximum" individual from radioiodine and particulate releases are listed in Tables 5.2 and 5.3. The maximum individual has been estimated to receive the highest dose commitment from SONGS 2 & 3 and is assumed to consume well above average quantities of the foods considered (see Table A-2 in Regulatory Guide 1.109). The maximum annual air, total body, and skin doses from noble gas releases are presented in Tables 5.3 and 5.4.

Table 5.2. Maximum annual dose commitments to an individual near the SONGS 2 & 3 plant caused by particulate and liquid effluents

Location	Pathway	Dose (millirems per year per unit)		
		Total body	Thyroid	Other organs (if greater than 10% of dose)
	Iodine and particulate doses			
Nearest residence and garden (1.3 NNW)[a]	Ground deposit	0.66	0.66	NA
	Inhalation	0.07	0.48	
	Vegetation	0.40	2.5	
Totals		1.1	3.7	
	Liquid effluent doses			
Nearest fish	Fish ingestion	0.019	0.018	0.0016
	Invertebrate ingestion	0.0058	0.025	0.104
	Shoreline use	0.039	0.039	0.039
Totals		0.064	0.082	0.15

[a]"Nearest" refers to the location where the highest radiation dose to an individual from all applicable pathways has been estimated.

(To change mi to km, multiply by 1.609.)

Table 5.3. Maximum calculated dose commitments to an individual and the population from SONGS 2 & 3[a]

	Appendix I Design objectives	Calculated doses
	(Annual dose per reactor unit)	
Maximum individual doses		
Liquid effluents		
Dose to total body from all pathways, millirems	3	0.064
Dose to any organ from all pathways, millirems	10	0.15
Noble gas effluents (at site boundary)		
Gamma dose in air, millirads	10	4.6
Beta dose in air, millirads	20	14
Dose to total body of an individual, millirems	5	2.8
Dose to skin of an individual, millirems	15	8.5
Radioiodines and particulates[b]		
Dose to any organ from all pathways, millirems	15	3.7
Population doses within 80 km (50 miles)		
	Total body (man-rems)	Thyroid (man-rems)
Natural radiation background[c]	700,000	
Liquid effluents	0.17	0.14
Gaseous effluents	21	46

[a]Appendix I design objectives from Sects. II.A, II.B, II.C, and II.D of Appendix I, 10 CFR 50; considers maximum doses to individuals and population per reactor unit. Source: *Federal Regist.* 40, 19442, May 5, 1975.

[b]Carbon-14 and tritium have been added to this category.

[c]"Natural Radiation Exposure in the United States," U.S. Environmental Protection Agency, ORP-SID-72-1 (June 1972); using the average State of California background dose of 97 millirems per year and year 2000 projected population of 262 million.

Table 5.4. Annual total-body, skin, and air doses at the nearest site boundary of SONGS 2 & 3 caused by gaseous radioactive effluents[a]

Location	Dose (millirem per year per unit)			
	Total body	Skin	Gamma air dose	Beta air dose
Nearest site boundary (0.36 mile WNW)[a]	2.5	8.3	4.2	14

[a]"Nearest" refers to that site boundary location where the highest radiation doses caused by gaseous effluents have been estimated to occur.

(To convert mi to km, multiply by 1.6.)

Radiation dose commitments to populations

The calculated annual radiation dose commitments to the population within 80 km (50 mi) of SONGS 2 and 3 from gaseous and particulate releases are presented in Table 5.3. Estimated dose commitments to the U.S. population are presented in Table 5.5. Background radiation doses are provided for comparison.

Within 80 km of the plant site, specific meteorological, populational, and agricultural data for each of 16 compass sectors around the plant were used to evaluate the doses. Beyond 80 km, meteorological models were extrapolated by assuming uniform dispersion of noble gases and continued deposition of radioiodines and particulates until no suspended radionuclides remained. Doses were evaluated using average population densities and food production values discussed in Appendix B. The doses from atmospheric releases during normal operation represent an extremely small increase in the normal population dose from background radiation sources.

Table 5.5. Annual total-body population dose commitments in the year 2000

Category	U.S. population dose commitment for the site
Natural background radiation, man-rems per year[a]	27,000,000
SONGS 2 & 3 operation, man-rems per year per site	
Plant workers	2600
General public	
Gas and particulates	160
Liquid effluents	<1
Transportation of fuel and waste	14

[a]Using the average U.S. background dose of 102 man-rems per year and year 2000 projected U.S. population from "Population Estimates and Projections," Series II, U.S. Department of Commerce, Bureau of the Census, Series P-25, No. 541 (February 1975).

5.5.1.3 Dose commitments from radioactive liquid releases to the hydrosphere

Radioactive effluents released to the hydrosphere from SONGS 2 & 3 during normal operation will result in small radiation doses to individuals and populations. The staff estimates of the expected liquid releases listed in Table 3.2 and the site hydrological considerations discussed in Sect. 2.3 of this statement and summarized in Table 5.6 were used to estimate radiation dose commitments to individuals and populations. The results of the calculations are discussed below.

Table 5.6. Summary of hydrologic transport and dispersion for liquid releases from SONGS 2 & 3[a]

Location	Transit time (hr)	Dilution factor
Nearest sport fishing location (plant outfall)[b]	0.1	1
Nearest shoreline (plant boundary)	0.1	1

[a]See Regulatory Guide 1.112, "Analytical Models for Estimating Radioisotope Concentrations in Different Water Bodies," (1976).

[b]Assumed for purposes of an upper-limit estimate; detailed information not available.

Radiation dose commitments to individuals

The estimated dose commitments to individuals at selected offsite locations where exposures are expected to be largest are listed in Tables 5.2 and 5.3. The standard NRC models given in Regulatory Guide 1.109 were used for these analyses.

Radiation dose commitments to populations

The estimated population radiation dose commitments to 80 km for SONGS 2 & 3 from liquid releases, based on the use of water and biota from the Pacific Ocean, are shown in Table 5.3. Dose commitments beyond 80 km were based on the assumptions discussed in Appendix B.

Background radiation doses are provided for comparison. The dose commitments from liquid releases from SONGS 2 & 3 represent small increases in the population dose from background radiation sources.

5.5.1.4 Direct radiation

Radiation from the facility

Radiation fields are produced in nuclear plant environs as a result of radioactivity contained within the reactor and its associated components. Doses from sources within the plant are

primarily due to nitrogen-16, a radionuclide produced in the reactor core. Since the primary coolant of pressurized water reactors is contained in a heavily shielded area of the plant, dose rates in the vicinity of PWRs are generally undetectable (less than 5 millirems per year). Low-level radioactivity storage containers outside the plant are estimated to contribute less than 0.01 millirem per year at the site boundary.

Occupational radiation exposure

The dose to nuclear plant workers varies from reactor to reactor and can be projected for environmental impact purposes by using the experience to date with modern pressurized water reactors (PWRs). Most of the dose to nuclear plant workers is due to external exposure to radiation from radioactive materials outside of the body rather than from internal exposure from inhaled or ingested radioactive materials. Recently licensed 1000 MWe PWRs are designed and operated in a manner consistent with the new (post-1975) regulatory requirements and guidelines. These new requirements and guidelines place increased emphasis on maintaining occupational exposure at nuclear power plants as low as is reasonably achievable (ALARA), and are outlined in 10 CFR Part 20, Standard Review Plan Chapter 12, and Regulatory Guide 8.8. The applicant's proposed implementation of these requirements and guidelines are reviewed by the NRC staff at the construction permit licensing stage, the operating license licensing stage, and during actual operation. Approval of the proposed implementation of these requirements and guidelines is granted only after the review indicates that an ALARA program can actually be implemented. As a result of our review the staff has determined that the applicant is committed to design features and operating practices that will assure that individual occupational radiation doses can be maintained within the limits of 10 CFR Part 20 and that individual and population doses will be as low as is reasonably achievable.

On the basis of actual operating experience, it has been observed that this occupational dose has varied considerably from plant to plant, and from year to year. Average individual and collective dose information is available from over 190 reactor-years of operation between 1974 and 1979. These data indicate that the average reactor annual dose at PWRs has been about 410 man-rem, with particular plants experiencing an average annual dose as high as 1300 man-rem. These dose averages are based on widely varying yearly doses at PWRs. For example, annual collective doses for PWRs have ranged from 18 to 5262 man-rem per reactor. The average annual dose per nuclear plant worker has been about 0.8 rem.

The wide range of annual doses (18 to 5262 man-rems) experienced by U.S. PWRs is dependent on a number of factors, such as the amount of required routine and special maintenance, and the degree of reactor operations and inplant surveillance. Since these factors can vary in an unpredictable manner, it is impossible to determine in advance a specific year-to-year or average annual occupational radiation dose for a particular plant over its operating lifetime. It is necessary to recognize that high doses may occur, even at plants with radiation protection programs that have been developed to assure that occupational radiation doses will be kept at levels that are ALARA. Consequently, the NRC staff's occupational dose estimates for environmental impact purposes for SONGS 2 and 3 are based on the conservation assumption that the station may have an higher than average level of special maintenance work. On the basis of the staff's review of the applicant's Safety Analysis Report, as well as occupational dose data from over 190 PWR reactor operating years, the NRC staff projects that the occupational doses at SONGS 2 and 3 could average as much as 1300 man-rem/yr when averaged over the life of the plant. However, actual year to year doses may differ greatly from this average, depending on actual plant operating conditions.

Transportation of radioactive material

The transportation of cold fuel to a reactor, of irradiated fuel from the reactor to a fuel reprocessing plant, and of solid radioactive wastes from the reactor to burial grounds is within the scope of the NRC report entitled "Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants" [10 CFR 51.20(g)]. The estimated population dose commitments associated with transportation of fuels and wastes are listed in Tables 5.5 and 5.7.

5.5.1.5 Comparison of dose assessment models

The applicant's site and environmental data provided in the ER and in subsequent answers to staff questions were used extensively in the dose calculations. Any additional data received which could significantly affect the conclusions reached in this draft statement will be used in preparing the final statement.

Table 5.7. Environmental impact of transportation of fuel and waste to and from one light-water-cooled nuclear power reactor[a,b]

Exposed population	Estimated *number of* persons	Range of doses to exposed *individuals* (millirems per reactor year)[c]	Cumulative dose to exposed population (man-rems per reactor year)[d]
Transportation workers	200	0.01 to 300	4
General public			
Onlookers	1,100	0.003 to 1.3	
Along Route	600,000	0.001 to 0.06	3
Accidents in transport			
Radiological effects		Small[e]	
Common (nonradiological) causes		1 fatal injury in 100 reactor years; 1 nonfatal injury in 10 reactor years; $475 property damage per reactor year	

[a]*Data supporting this table are given in the Commission's Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants,* WASH-1238, December 1972, and Suppl. I, NUREG-75/038, April 1975.

[b]Normal conditions of transport: heat (per irradiated fuel cask in transit), 250,000 Btu/hr; weight (governed by Federal or State restrictions), 73,000 lb per truck; 100 tons per cask per rail car; traffic density, <1 per day; rail <3 per month.

[c]The Federal Radiation Council has recommended that radiation doses from all sources of radiation other than natural background and medical exposures should be limited to 5000 *milirems per year for individuals as a result of occupational exposure and should be* limited to 500 millirems per year for individuals in the general population. The dose to individuals as a result of average natural background radiation is about 102 millirems per year.

[d]Man-rem is an expression for the summation of whole body doses to individuals in a group. Thus, if each member of a population group of 1000 people were to receive a dose of 0.001 rem (1 millirem), or if 2 people were to receive a dose of 0.5 rem (500 millirems) each, the total man-rem in each case would be 1 man-rem.

[e]Although the environmental risk of radiological effects stemming from transportation accidents is currently incapable of being numerically quantified, the risk remains small regardless of whether it is being applied to a single reactor or a multireactor site.

(To convert lb to kg, multiply by 0.45; to convert tons to tonnes, multiply by 0.907.)

5.5.1.6 Evaluation of radiological impact

The actual radiological impact associated with the operation of SONGS 2 & 3 will depend, in part, on the manner in which the radioactive waste treatment system is operated. The staff concludes on the basis of their evaluation of the potential performance of the radwaste system that the system as proposed is capable of meeting the dose design objectives of 10 CFR Part 50, Appendix I. Table 5.3 compares the calculated maximum individual doses to the dose design objectives. However, because the facility's operation will be governed by operating license technical specifications and because the technical specifications will be based on the dose design objectives of 10 CFR Part 50, Appendix I, as shown in the first column of Table 5.3, the actual radiological impact of plant operation may result in doses close to the dose design objectives. Even if this situation exists, however, the individual doses will still be very small when compared to natural background doses (∿100 millirems per year) or of the dose limits specified in 10 CFR Part 20. As a result the staff concludes that there will be no measurable radiological impact on man from routine operation of SONGS 2 & 3.

5.5.2 Radiological impacts to biota other than man

Depending on the pathway and the radiation source, terrestrial and aquatic biota will receive doses approximately the same or somewhat higher than man receives. Although guidelines have not been established for acceptable limits for radiation exposure to species other than man, it is generally agreed that the limits established for humans are also conservative for other species. Experience has shown that it is the maintenance of population stability that is crucial to the survival of a species, and species in most ecosystems suffer rather high mortality rates from natural causes. Although the existence of extremely sensitive biota is possible and increased radiosensitivity in organisms may result from environmental interactions with other stresses (e.g., heat, biocides, etc.), no biota have yet been discovered that show a sensitivity (in terms

of increased morbidity or mortality) to radiation exposures as low as those expected in the area surrounding SONGS 2 & 3. Furthermore, in all the plants for which an analysis of radiation exposure to biota other than man has been made, there have been no cases of exposures that can be considered significant in terms of harm to the species, or that approach the exposure limits to members of the public permitted by 10 CFR Part 20.[19] Since the BEIR Report[20] concluded that the evidence to date indicates that no other living organisms are very much more radiosensitive than man, no measurable radiological impact on populations of biota is expected as a result of the routine operation of this plant.

5.5.3 Environmental effects of the uranium fuel cycle

On March 14, 1977, the Commission presented in the *Federal Register* (42 FR 13803) an interim rule regarding the environmental considerations of the uranium fuel cycle. It was effective (by Amendment of September 12, 1978) through March 14, 1979 and revised Table S-3 of Paragraph (e) of 10 CFR Part 51.20.* In a subsequent announcement on April 14, 1978, (43 FR 15613), the Commission further amended Table S-3 to delete the numerical entry for the estimate of radon releases and to clarify that the table does not cover health effects. On July 27, 1979, the Commission approved a final rule setting out revised environmental impact values for the uranium fuel cycle to be included in environmental reports and environmental statements for reactors (44 FR 45362). The final rule reflects new and updated information relative to reprocessing of spent fuel and radioactive waste management as discussed in NUREG-0116, *Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle*,[21] and NUREG-0216,[22] which presents staff responses to comments on NUREG-0116. The rule also considers other environmental factors of the uranium fuel cycle, including aspects of mining and milling, isotopic enrichment, fuel fabrication, and management of low-and high-level wastes. These are described in the AEC report WASH-1248, *Environmental Survey of the Uranium Fuel Cycle*.[23]

Specific categories of natural resource use are included in Table S-3 of the final rule, which is reproduced in this statement as Table 5.8.† These categories relate to land use, water consumption and thermal effluents, radioactive releases, burial of transuranic and high- and low-level wastes, and radiation doses from transportation and occupational exposures. The contributions in Table 5.8 for reprocessing, waste management, and transportation of wastes are maximized for either of the two fuel cycles (uranium only and no recycle); that is, the cycle that results in the greater impact is used.

The following assessment of the environmental impacts of the fuel cycle as related to the operation of SONGS 2 & 3 is based on the values given in Table 5.8 and the staff's analysis of the radiological impact from radon releases. For the sake of consistency, the analysis of fuel-cycle impacts has been cast in terms of a model 1000 MWe LWR operating at an annual capacity factor of 80%. In the following review and evaluation of the environmental impacts of the fuel cycle, the staff conclusions would not be altered if the analysis were to be based on the net electrical power output of SONGS 2 & 3.

The total annual land requirement for the fuel cycle supporting a model 1000 MWe LWR is about 46 ha (114 acres). Approximately 5 ha (13 acres) per year are permanently committed land, and 40 ha (100 acres) per year are temporarily committed. (A "temporary" land commitment is a commitment for the life of the specific fuel-cycle plant, e.g., mill, enrichment plant, or succeeding plants. On abandonment or decommissioning, such land can be used for any purpose. "Permanent" commitments represent land that may not be released for use after plant shutdown and/or decommissioning.) Of the 40 ha per year of temporarily committed land, 32 ha (79 acres) are undisturbed and 9 ha (22 acres) are disturbed. Considering common classes of land use in the U.S.,‡ fuel-cycle land-use requirements to support the model 1000 MWe LWR do not represent a significant impact.

The principal water-use requirement for the fuel cycle supporting a model 1000 MWe LWR is that required to remove waste heat from the power stations supplying electrical energy to the enrichment step of this cycle. Of the total annual requirement of 43×10^6 m^3 ($11{,}000 \times 10^6$ gal), about 42×10^6 m^3 are required for this purpose, assuming that these plants use once-through cooling. Other water uses involve the discharge to air (e.g., evaporation losses in process cooling) of about 0.6×10^6 m^3 per year and water discharged to ground (e.g., mine drainage) of about 0.5×10^6 m^3 per year.

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*A notice of final rulemaking proceedings was given in the *Federal Register* of May 26, 1977 (42 FR 26987) that calls for additional public comment before adoption or final modification of the interim rule.

†A narrative explanation of Table 5.8 (Table S-3) was published in the *Federal Register* (46 FR 15154-75) on March 4, 1981.

‡A coal-fired power plant of 1000 MWe capacity using strip-mined coal requires the disturbance of about 81 ha (200 acres) per year for fuel alone.

Table 5.8. Summary of environmental considerations for uranium fuel cycle[a]

Normalized to model LWR annual fuel requirement (WASH-1248) or reference reactor year (NUREG-0116)

Natural resource use	Total	Maximum effect per annual fuel requirement or reference reactor year of model 1000-MWe LWR
Land, acres		
Temporarily committed[b]	100	
Undisturbed area	79	
Disturbed area	22	Equivalent to 110-MWe coal-fired power plant
Permanently committed	7.1	
Overburden moved, millions of metric tons	2.8	Equivalent to 95-MWe coal-fired power plant
Water, millions of gallons		
Discharged to air	160	Equals 2% of model 1000-MWe LWR with cooling tower
Discharged to water bodies	11,090	
Discharged to ground	127	
Total	11,377	Less than 4% of model 1000-MWe LWR with once-through cooling
Fossil fuel		
Electrical energy, thousands of megawatt hours	321	Less than 5% of model 1000-MWe LWR output
Equivalent coal, thousands of metric tons	117	Equivalent to the consumption of a 45-MWe coal-fired power plant
Natural gas, millions of standard cubic feet	135	Less than 0.3% of model 1000-MWe energy output
Effluents – chemical, metric tons		
Gases (including entrainment)[c]		
SO_x	4,400	
NO_x[d]	1,190	Equivalent to emissions from 45-MWe coal-fired power plant for a year
Hydrocarbons	14	
CO	29.6	
Particulates	1,154	
Other gases		
F^-	0.67	Principally from UF_6 production, enrichment, and reprocessing. Concentration within range of state standards – below level that has effects on human health
HCl	0.014	
Liquids		
SO_4^{2-}	9.9	From enrichment, fuel fabrication, and reprocessing steps. Components that constitute a potential for adverse environmental effect are present in dilute concentrations and receive additional dilution by receiving bodies of water to levels below permissible standards. The constituents that require dilution and the flow of dilution water are:
NO_3^-	25.8	NH_3 – 600 cfs
Fluoride	12.9	NO_3 – 20 cfs
Ca^{2+}	5.4	*Fluoride – 70 cfs*
Cl^-	8.5	
Na^+	12.1	
NH_3	10.0	
Fe	0.4	
Tailings solutions, thousands of metric tons	240	From mills only – no significant effluents to environment
Solids	91,000	Principally from mills – no significant effluents to environment
Effluents – radiological, curies		
Gases (including entrainment)		
Rn-222		Presently under reconsideration by the Commission
Ra-226	0.02	
Th-230	0.02	
Uranium	0.034	
Tritium, thousands	18.1	
C-14	24	
Kr-85, thousands	400	
Ru-106	0.14	Principally from fuel reprocessing plants
I-129	1.3	
I-131	0.83	
Tc-99	0.203	Presently under consideration by the Commission
Fission products and transuranics		
Liquids		
Uranium and daughters	2.1	Principally from milling – included in tailings liquor and returned to ground – no effluents; therefore, no effect on environment
Ra-226	0.0034	From UF_6 production
Th-230	0.0015	
Th-234	0.01	From fuel fabrication plants – concentration 10% of 10 CFR Part 20 for total processing 26 annual fuel requirements for model LWR
Fission and activation products	5.9×10^{-6}	
Solids (buried on site)		
Other than high level (shallow)	11,300	9100 Ci come from low-level reactor wastes and 1500 Ci come from reactor decontamination and decommissioning – buried at land burial facilities. Mills produce 600 Ci – included in tailings returned to ground; about 60 Ci come from conversion and spent-fuel storage. No significant effluent to the environment
TRU and HLW (deep)	1.1×10^7	Buried at Federal repository
Effluents – thermal, billions of British thermal units	4,063	Less than 4% of model 1000-MWe LWR
Transportation, person-rems	2.5	
Exposure of workers and general public		
Occupational exposure, person-rems	22.6	From reprocessing and waste management

[a]In some cases where no entry appears, it is clear from the background documents that the matter was addressed and that, in effect, this table should be read as if a specific zero entry had been made. However, there are other areas that are not addressed at al in this table. Table S-3 of WASH-1248 does not include health effects from the effluents described in this table or estimates of releases of Radon-222 from the uranium fuel cycle. These issues which are not addressed at all by this table may be the subject of litigation in individual licensing proceedings. Data supporting this table are given in the *Environmental Survey of the Uranium Fuel Cycle*, WASH-1248, April 1974; the *Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle*, NUREG-0116 (Suppl. 1 to WASH-1248); and the *Discussion of Comments Regarding the Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle*, NUREG-0216 (Suppl. 2 to WASH-1248). The contributions from reprocessing, waste management, and transportation of wastes are maximized for either of the two fuel cycles (uranium only and no-recyle). The contribution from transportation excludes transportation of coal fuel to a reactor and of irradiated fuel and radioactive wastes from a reactor which are considered in Table S-4 of Sect. 51.20(g). The contributions from the other steps of the fuel cycle are given in columns A – E of Table S-3A of WASH-1248.

[b]The contributions to temporarily committed land from reprocessing are not prorated over 30 years, because the complete temporary impact accrues regardless of whether the plant services 1 reactor for 1 year or 57 reactors for 30 years.

[c]Estimated effluents based on combustion of equivalent coal for power generation.

[d]1.2% from natural gas use and process.

On a thermal effluent basis, annual discharges from the nuclear fuel cycle are about 4% of those from the model 1000 MWe LWR using once-through cooling. The consumptive water use of 0.6 x 10^6 m^3 per year is about 2% of that of the model 1000 MWe LWR using cooling towers. The maximum consumptive water use (assuming that all plants supplying electrical energy to the nuclear fuel cycle used cooling towers) would be about 6% of that of the model 1000 MWe LWR using cooling towers. Under this condition, thermal effluents would be negligible. The staff finds that these combinations of thermal loadings and water consumption are acceptable relative to the water use and thermal discharges of the proposed project.

Electrical energy and process heat are required during various phases of the fuel-cycle process. The electrical energy is usually produced by the combustion of fossil fuel at conventional power plants. Electrical energy associated with the fuel cycle represents about 5% of the annual electrical power production of the model 1000 MWe LWR. Process heat is primarily generated by the combustion of natural gas. This gas consumption, if used to generate electricity, would be less than 0.3% of the electrical output from a 1000 MWe plant. The staff finds that the direct and indirect consumption of electrical energy for fuel-cycle operations are small and acceptable relative to the net power production of the proposed project.

The quantities of chemical, gaseous, and particulate effluents with fuel-cycle processes are given in Table 5.8. The principal species are SO_x, NO_x, and particulates. The staff finds, on the basis of data in a Council on Environmental Quality report,[24] that these emissions constitute an extremely small additional atmospheric loading in comparison with these emissions from the stationary fuel-combustion and transportation sectors in the U.S., i.e., about 0.02% of the annual national releases for each of these species. The staff believes such small increases in releases of these pollutants are acceptable.

Liquid chemical effluents produced in fuel-cycle processes are related to fuel-enrichment, -fabrication, and -reprocessing operations and may be released to receiving waters. These effluents are usually present in such dilute concentrations that only small amounts of dilution water are required to reach levels of concentration that are within established standards. Table 5.8 specifies the flow of dilution water required for specific constituents. Additionally, all liquid discharges into the navigable waters of the United States from plants associated with the fuel-cycle operations will be subject to requirements and limitations set forth in an NPDES permit issued by an appropriate state or Federal regulatory agency.

Tailings solutions and solids are generated during the milling process. These solutions and solids are not released in quantities sufficient to have a significant impact on the environment.

Radioactive effluents estimated to be released to the environment from reprocessing and waste management activities and certain other phases of the fuel-cycle process are set forth in Table 5.8. Using these data, the staff has calculated the 100-year involuntary environmental dose commitment* to the U.S. population. These calculations estimate that the overall involuntary total body gaseous dose commitment to the U.S. population from the fuel cycle (excluding reactor releases and the dose commitment due to radon-222) would be approximately 400 man-rems per year of operation of the model 1000 MWe LWR. The additional involuntary total body dose commitment to the U.S. population from radioactive liquid effluents due to all fuel-cycle operations other than reactor operation, estimated on the basis of the values given in Table 5.8, would be approximately 100 man-rems per year of operation. Thus, the estimated involuntary 100-year environmental dose commitment to the U.S. population from radioactive gaseous and liquid releases due to these portions of the fuel cycle is approximately 500 man-rems (whole body) per year of operation of the model 1000 MWe LWR.

At this time Table 5.8 does not address the radiological impacts associated with radon-222 releases. Principal radon releases occur during mining and milling operations and, following completion of mining and milling, as emissions from stabilized mill tailings and from unreclaimed open-pit mines. The staff has determined that releases from these operations for each year of operation of the model 1000 MWe LWR are as follows:

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*The environmental dose commitment (EDC) is the integrated population dose for 100 years; i.e., it represents the sum of the annual population doses for a total of 100 years. The population dose varies with time, and it is not practical to calculate this dose for every year.

Mining: (during active mining)[25]	4060 Ci
Mining: (unreclaimed open-pit mines)[26]	30 to 40 Ci/year
Milling and Tailings:[27] (during active milling)	780 Ci
Inactive Tailings:[27] (prior to stabilization)	350 Ci
Stabilized Tailings:[27] (several hundred years)	1 to 10 Ci/year
Stabilized Tailings:[27] (after several hundred years)	110 Ci/year

The staff has calculated population dose commitments for these sources of radon-222 using the RABGAD computer code described in Section IV.J of Appendix A of NUREG-0002.[28] The results of these calculations for mining and milling activities prior to tailings stabilization are shown in Table 5.9.

Table 5.9. Estimated 100-year environmental dose commitment per year of operation of the model 1000 MWe LWR

Radon-222 releases		Dose commitments (man-rems)		
Source	Amount (Ci)	Total body	Bone	Lung (bronchial epithelium)
Mining	4100	110	2800	2300
Milling and active tailings	1100	29	750	620
Total		140	3600	2900

When added to the 500 man-rem total body dose commitment for the balance of the fuel cycle, the overall estimated total body involuntary 100-year environmental dose commitment to the U.S. population from the fuel cycle for the model 1000 MWe LWR is approximately 600 man-rems. Over this period of time, this dose is equivalent to 0.00002% of the natural background dose of about 3,000,000,000 man-rems to the U.S. population.*

The staff has considered health effects associated with the releases of radon-222, including both the short-term effects of mining, milling, and active tailings and the potential long-term effects from unreclaimed open-pit mines and stabilized tailings. After completion of active mining, the staff has assumed that underground mines will be sealed, with the result that releases of radon-222 from them will return to background levels. For purposes of providing an upper-bound impact assessment, the staff has assumed that open-pit mines will be unreclaimed and has calculated that if all ore were produced from open-pit mines, releases from them would be 110 Ci/year of operation of the model 1000 MWe LWR. However, since the distribution of uranium ore reserves available by conventional mining methods is 66.8% underground and 33.2% open pit,[29] the staff has further assumed that uranium to fuel LWRs will be produced by conventional mining methods in these proportions. This means that long-term releases from unreclaimed open-pit mines will be 0.332 x 110 or 37 Ci/year of operation of the model LWR.

On the basis of these assumptions, the radon released from unreclaimed open-pit mines over 100- and 1000-year periods can be calculated to be about 3700 Ci and 37000 Ci/year of operation of the model reactor, respectively. The total dose commitments for a 100-1000-year period would be as follows:

*Based on an annual average natural background individual dose commitment of 100 mrem and a stabilized U.S. population of 300 million.

Time span	Total release	Population dose commitments (man-rems)		
		Total body	Bone	Lung (brochial epithelium)
100 years	3,700	96	2,500	2,000
500 years	19,000	480	13,000	11,000
1,000 years	37,000	960	25,000	20,000

The above dose commitments represent a worst-case situation since no mitigation circumstances are assumed. However, state and Federal laws currently require reclamation of strip and open-pit coal mines, and it is very probable that similar reclamation will be required for uranium open-pit mines. If so, long-term releases from such mines should approach background levels.

For long-term radon releases from stabilized tailings piles, the staff has assumed that these tailings would emit, per year of operation of the model 1000 MWe LWR, 1 Ci/year for 100 years, 10 Ci/year for the next 400 years, and 100 Ci/year for periods beyond 500 years. With these assumptions, the cumulative radon-222 release from stabilized tailings piles per operating year of the model reactor will be 100 Ci in 100 years, 4,090 Ci in 500 years, and 53,800 Ci in 1000 years[30]. The total body, bone, and bronchial epithelium dose commitments for these periods are as follows:

Time span	Total release	Population dose commitments (man-rems)		
		Total body	Bone	Lung (brochial epithelium)
100 years	100	2.6	68	56
500 years	4,090	110	2,800	2,300
1,000 years	53,800	1,400	37,000	30,000

Using risk estimators of 135, 6.9, and 22.2 cancer deaths per million man-rems for total body, bone, and lung exposures, respectively, the estimated risk of cancer mortality due to mining, milling, and active tailings emissions of radon-222 would be about 0.11 cancer fatalities per operating year of the model 1000 MWe LWR. When the risk due to radon-222 emissions from stabilized tailings over a 100-year release period is added, the estimated risk of cancer mortality over a 100-year period is unchanged. Similarly, a risk of about 1.2 cancer fatalities is estimated over a 1000-year release period per operating year of the model 1000 MWe LWR. When potential radon releases from reclaimed and unreclaimed open-pit mines are included, the overall risks of radon induced cancer fatalities per operating year of the model 1000 MWe LWR would range as follows:

0.11-0.19 fatalities for a 100-year period

0.19-0.57 fatalities for a 500-year period

1.2-2.0 fatalities for a 1000-year period

To illustrate: A single model 1000 MWe LWR operating at an 80% capacity factor for 30 years would be predicted to induce between 3.3 and 5.7 cancer fatalities in 100 years, 5.7 and 17 in 500 years, and 36 and 60 in 1000 years as a result of releases of radon-222.

These doses and predicted health effects have been compared with those that can be expected from natural-background emissions of radon-222. Using data from the National Council on Radiation Protection[31], the average radon 222 concentration in air in the contiguous United States is about 150 pCi/m^3, which the NCRP estimates will result in an annual dose to the bronchial epithelium of 450 mrem. For a stabilized future U.S. population of 300 million, this represents a total lung dose commitment of 135 million man-rems per year. Using the same risk estimator of 22.2 lung cancer fatalities per million man-lung-rems used to predict cancer fatalities for the model 1000 MWe LWR, estimated lung cancer fatalities alone from background radon-222 in the air can be calculated to be about 3000 per year or 300,000 to 3,000,000 lung cancer deaths over periods of 100 and 1,000 years respectively.

Other nuclides produced in the cycle, such as carbon-14, will contribute to population exposures in addition to the radon-related potential health effects from the fuel cycle. It is estimated that 0.08 to 0.12 additional cancer deaths may occur per operating year of the model 1000 MWe LWR (assuming that no cure or prevention of cancer is ever developed) over the next 100 to 1000 years, respectively, from exposures to these other nuclides.

These latter exposures can also be compared with those from naturally-occurring terrestrial and cosmic-ray sources, which average about 100 mrem. Therefore, for a stable future population of 300 million persons, the whole-body dose commitment would be about 30 million man-rems per year, or 3 billion man-rems and 30 billion man-rems for periods of 100 and 1000 years respectively. These dose commitments could produce about 400,000 and 4,000,000 cancer deaths during the same time periods. From the above analysis, the staff concludes that both the dose commitments and health effects of the uranium fuel cycle are insignificant when compared to dose commitments and potential health effects to the U.S. population resulting from all natural background sources.

5.6 SOCIOECONOMIC IMPACTS

5.6.1 Introduction

A 96-km (60-mile) radius of the San Onofre site circumscribes most of the metropolitan areas of Los Angeles and San Diego, the third and fourteenth largest cities, respectively, in the United States. Between 1970 and 1980, San Diego County had a 37.1% increase in population, reaching a total of 1,861,846 in 1980 and a density of about 170/km^2 (438/m^2).

Continued growth within 96 km (60 miles) of the San Onofre site is expected for the next three decades. The central portion of Orange County and the city of San Diego and its immediate environs are projected to be the major growth areas (ER, Sect. 2.1.3.2.2). The population growth rates within 16 km (10 miles) of the site are expected to fluctuate over the operating life of SONGS 2 and 3. The annual growth rate between 1976 and 1980 is expected to be 4.2%, decreasing to 0.3% between 1990 and 2000, and rising to 1.1% between 2010 and 2020 (ER, Sect. 2.1.3.1.1).

5.6.2 Impact of the construction labor force

A peak labor force of about 3000 workers was employed at SONGS 2 and 3 in late 1979. Of this number, the applicant has estimated that about 600 workers (20% of the peak labor force) have relocated to the southern California area (Sect. 2.2.3). Although the staff could not determine the exact location of these workers, current growth projections for the area indicate that the addition of 600 workers represents an insignificant impact. Between 1976 and 1980 the population in the area that is 16 to 80 km (10 to 50 miles) from the site was projected to increase 2.2% (ER, Sect. 2.1.3.2.1). The addition of 600 workers accounts for less than 0.1% of the growth expected during that time period.

Staff interviews with local and regional officials indicated that construction of SONGS 2 and 3 has had no impact on cities within 24 km (15 mi) of the site. Representatives of Southern California Association of Governments stated that it was doubtful that any significant impact attributable to plant construction could be identified in Orange County. The facts that (1) the majority of the work force commuted to site, (2) there was widespread busing to and from Orange County, Oceanside, Vista, Escondido, and San Diego, and (3) the region is currently experiencing rapid population growth support the staff's judgment that no significant social impact has occurred or is likely to occur due to in-migration of construction workers.

Cessation of large construction projects can result in varying degrees of economic dislocation to an area, especially if a previously underdeveloped commercial and service structure is expanded to meet the requirements of a large, short-term population influx. The southern California area has a well-developed infrastructure; thus, ending the construction phase of SONGS 2 and 3 is not expected to produce significant economic dislocation.

5.6.3 Impact of the operating labor force

The operation of SONGS 2 and 3 will employ about 200 workers. Table 5.10 provides an estimate for typical operating personnel requirements and types of employment positions at a two-unit pressurized-water reactor (PWR). The operations positions will be filled first by current members of I.B.E.W. Local No. 246. Positions unfilled will be offered to all Southern California Edison (SCE) employees, and if the position remains unfilled, SCE will advertise in local and regional newspapers (ER, p. S.2-175). Because of the diversified labor markets of Los Angeles and San Diego, the staff believes that at least 75% of these workers can be hired from within a 96-km (60-mile) radius of the site.

The applicant conducted surveys in March 1976 to determine the residential location of SONGS 1 workers. Seventy-five percent of these workers lived within 40 km (25 miles) of the San Onofre site, and 65% resided in Orange County, 30% in San Diego County, and 5% in Los Angeles and Riverside counties (ER, Appendix 8A, p. 10). The surveys further indicated that the cities of Carlsbad, Oceanside, San Clemente, San Juan Capistrano, and Vista were the major

Table 5.10. Operating personnel for a two-unit PWR

1 Plant superintendent
1 Assistant plant superintendent
2 Safety engineers

Quality assurance staff
- 1 Superintendent
- 4 Engineers
- 6 Engineering aides

Administrative services
- 1 Superintendent
- 1 Assistant superintendent
- 3 Payroll clerks
- 9 Stenographers and file clerks
- 7 Janitors

1 Industrial engineer
1 Nurse

Health physics staff
- 1 Superintendent
- 2 Technicians
- 1 Clerk

Security staff
- 1 Superintendent
- 1 Assistant superintendent
- 9 Security officers

Operations
- Control room staff
  - 1 Superintendent
  - 1 Assistant superintendent
  - 1 Training coordinator
  - 5 Clerks
  - 6 Shift engineers
  - 10 Assistant shift engineers
  - 15 Unit operators
  - 18 Assistant unit operators
- Communications engineering staff
  - 2 Engineers
  - 3 Engineering aides

Warehouse staff
- 1 Superintendent
- 1 Assistant superintendent
- 5 Clerks
- 1 Truck driver

Engineering section
- 1 Superintendent
- 3 Instrument engineers
- 3 Instrument engineering aides
- 2 Senior instrument mechanic foremen
- 20 Mechanics
- 2 Mechanical engineers
- 3 Mechanical engineering aides
- 1 Reactor engineer
- 1 Reactor engineering aide
- 2 Nuclear engineers
- 1 Chemical engineer
- 9 Chemical engineering aides

Maintenance staff
- 1 Superintendent
- 1 Assistant superintendent (electrical)
- 1 Assistant superintendent (mechanical)
- 2 Mechanical maintenance engineers
- 1 Electrical maintenance engineer
- 3 Engineering aides

Trades and labor staff
- 1 Machinist foreman
- 11 Machinists
- 1 Boiler-maker foreman
- 5 Boiler makers
- 1 Steam-fitter foreman
- 12 Steam fitters
- 1 Electrician foreman
- 10 Electricians
- 1 Labor foreman
- 10 Laborers
- 2 Truck drivers
- 2 Carpenters
- 2 Sheet metal workers
- 2 Painters
- 2 Insulators
- 1 Structural iron worker

Source: Tennessee Valley Authority, Department of Planning, Chattanooga, Tenn., 1977.

communities of worker residence. The staff estimates that approximately the same pattern of location will occur with SONGS 2 and 3 workers as occurred with SONGS 1 workers.

Between 1973 and 1980, northern San Diego County was expected to have a population increase of about 22,000. From 1975 to 1980 southern Orange County was projected to grow by about 21,000 persons. Assuming that all operations workers relocated to the area, the staff concludes that the addition of 200 workers and their households represents a negligible effect.

The staff cannot determine precisely the number of workers who will (1) relocate from outside the area or (2) choose to move from within the 96-km (60-mile) radius to a residence closer to the plant. In order to predict the maximum possible impact on housing in the area, the staff assumes that all of the workers will relocate and thus require housing. A relocating operations force will likely demand permanent housing. From Table 5.11, it appears that housing availability in Orange and San Diego counties is sufficient to provide diversity in location for all operations workers' households. The table further indicates that, based on the number of vacant units in 1976, a surplus of housing exists in each of the communities expected to house workers.

Estimates on the location of SONGS 1 worker indicate SONGS 2 and 3 households will likely contribute to increased enrollments in the school districts of Carlsbad, Capistrano, Oceanside, Saddleback Valley, and Vista. The total additional enrollment at all five school districts

Table 5.11. Housing availability in Orange and San Diego counties

Communities	Residential distribution of households SONGS 2 & 3	Number of existing dwelling units as of Jan. 1, 1976	Number of vacant units as indicated by number of idle electric meters for Jan. 1, 1976
Orange County *total*	127	592,932	10,080
San Clemente	32	10,636	170
San Juan Capistrano	41	4,561	73
Saddleback (Irvine)	22	11,102	178
Other unincorporated areas	32	76,260	1,220
San Diego County total	61	547,708	8,763
Carlsbad	11	9,111	200
Oceanside	25	20,835	458
Vista	20	12,539	276
Other unincorporated areas	5	108,841	2,395

Source: ER, Suppl. 2, Table 89-A, p. S.2-178.

will be about 105 students (ER, Appendix A, p. 20). The community college districts of Oceanside-Carlsbad, Palomar, and Saddleback will likely increase their enrollments by approximately 20 to 25 students (ER, Appendix 8A, p. 20). The staff concludes that this estimated increased enrollment represents a negligible impact on the school districts.

Operations employment at SONGS 2 and 3 will be relatively high-paying, stable work. About 87% of the total work force will have gross incomes in excess of $15,000 per year (ER, Appendix 8A, p. 15). The annual average income in 1976 dollars for a SONGS 2 and 3 household will be about $20,800. This compares to a median family income in 1980 for San Diego and Orange counties of $21,500 and $26,200 respectively. SONGS 2 and 3 households are expected to contribute to the economic activity of the area. Total taxable retail expenditures by households of operations employees are estimated to be about $855,000 per year (ER, p. S.2-176). In addition, those workers who build homes will contribute further to the economic activity of the area.

5.6.4 Economic impacts

The staff believes that the major economic impact associated with the operation of SONGS 2 and 3 will be a result of tax revenues generated by the plant. These taxes include property tax, state income tax, utility users tax, franchise tax payments, and sales and use taxes. The analysis presented here differs from that presented earlier in the DES by taking into account the impacts of the Jarvis-Gann Amendment (Proposition 13). The following discussion is based on two important assumptions. (1) The method of determining the value of state-regulated utility systems, currently before the State Court of Appeals, will be decided in accordance with the decision of the State Board of Equalization. Accordingly, SONGS 2 and 3 will be assessed on current market value, based on historical methods of valuation rather than on the 1975-76 base year as prescribed in Proposition 13. (2) The allocation of tax revenues among the various funds and districts within the county will remain roughly the same as at present.[32] Changes in either of the above conditions in the future may result in significant variation from the situation described here.

Under Proposition 13, neither the assessed value of the SONGS 2 and 3 units nor their annual tax liability differs greatly from the figures presented in the DES. Earlier projections were for an assessed valuation of $348 million in 1976 dollars (ER, Appendix 8-A, p. 4) and an annual property tax payment of $13.1 million (DES, Sect. 5.6.4). Current calculations show an eventual assessed value of $326 million in 1979 dollars and an annual tax of approximately $13 million (Table 5.12). At present, current construction at SONGS 2 and 3 is already assessed at roughly $100 million and is generating $4 million yearly in property tax revenues. The remaining $9 million in property taxes will be added as construction is completed.[32]

While the total tax burden is not significantly different under the terms of Proposition 13, the distribution of the resulting revenues is. Previously, it was projected that nearly all of the $13 million in property taxes generated by SONGS 2 and 3 would go to the County General Fund, the County Library Fund, and three local school districts in the immediate vicinity of the plant – Fallbrook Union Elementary, Fallbrook Union High, and Palomar Community College (DES,

Table 5.12. Projected impacts of SONGS 2 & 3 on San Diego County property tax revenues

	San Diego County	SONGS 2 & 3	Total: County plus SONGS 2 & 3	SONGS 2 & 3 as % of total
Assessed value	$7,775.5 million[1]	$326 million[3]	$8,101.5 million	4.0%
Annual taxes	$311 million[2]	$13 million[3]	$324 million	4.0%

[1]For FY 1978-79, not counting $100 million of SONGS 2 & 3 construction currently on tax rolls.
[2]For FY 1978-79, not counting $4 million currently received for SONGS 2 & 3 construction.
[3]As of project completion, in 1979 dollars.
Source: Letter from J. H. Drake, Southern California Edison Co., to W. H. Regan, Jr., U.S. NRC, dated April 17, 1979.

Sect. 5.6.4). Now, however, the new revenues will be distributed throughout the county on the basis of the historical property tax revenue relationships between all the various funds and districts. Accordingly, the five entities named above will receive roughly one-fourth of the plant-induced taxes, or $3.4 million, because this is the proportion of all county funds they have traditionally received. The remaining $9.6 million will go to other recipients county-wide. Because of this widespread distribution, the property taxes paid by SONGS 2 and 3 will not bring a large windfall to any single district but, rather, a modest 4.0% increase to all county funds and districts over pre-construction receipts (2.9% over the present situation where $100 million of plant construction is already on the tax rolls). The debt service rate of the three previously named school districts will be reduced as a result of plant induced revenues but this represents a very small part of the total property tax.[32]

Sales and use taxes payable to the State of California are levied at 6% of the retail or use value of fixtures, equipment, machinery, and materials purchased either in or outside of the State of California and placed in use within the state. For every 6 cents collected, 1.25 cents is allocated to counties and cities. The state tax on nuclear fuel for SONGS 2 and 3 is expected to be about $2.5 million per year. In addition, $415,000 in sales tax for materials will be paid in 1981, the first year of operation (ER, Appendix 8A, p. 8).

Over the operating life of SONGS 2 & 3, about $66 million in California state corporate income taxes will be paid by the applicant. California also has a City Utility Users Tax that, although it is difficult to determine the proportion for which SONGS 2 & 3 are directly responsible, is estimated to increase by $1.6 million per year (ER, Appendix 8A, p. 8). This tax varies for each city, and the revenues are not earmarked for any particular purposes.

The California Energy Resources Surcharge is included in the retail customer's bill and is collected by the utility. The current surcharge is $0.00015 per kilowatt-hour. The revenues collected are placed in the State Energy Resources Conservation and Development Special Account in the General Fund in the State Treasury by the State Board of Equalization. All funds in the account are to be expended for the purpose of carrying out the provisions of the Warren-Alquist State Energy Resources Conservation and Development Act.

5.6.5 Impact on recreational resources

In the early 1960s the applicant secured a leasehold from the U.S. Marine Corps at Camp Pendleton. During construction of SONGS 1, the Marine Corps released about 5.6 km (3.5 miles) of beach front to the State of California to be maintained as San Onofre State Beach. When this park opened in 1971, an additional 2440 m (8000 ft) of beach front had gained public access. Of this, 1370 m (4500 ft) are on the applicant's leasehold and the remaining 1070 m (3500 ft) are immediately north of the plant site, comprising another section of the state beach.

In order to comply with NRC regulations regarding the siting of nuclear power plants set forth in 10 CFR Part 100, the applicant proposes to control recreational activities on the beach for a distance of about 1.4 km (0.85 mile) adjacent to the station (ER, Sect. 2.1.2). Access to this area will be permitted for the purpose of viewing the barrancas and bluffs south of the station and for pedestrian passage between the public beach areas north and south of the station. Recreational activities, such as sunbathing or picnicking, will not be permitted within the landward portion of this restricted area. To facilitate passage between the beaches, a walkway will be constructed through the restricted area adjacent to the seawall. This walkway will be 4.6 m (15 ft) wide, will be bounded by a 2.4-m (8-ft) chain link fence, and will be used only for passage through the restricted area. It is the judgment of the staff that the fence proposed by the applicant is inappropriate in light of the scenic nature of the area and that a less aesthetically objectionable way should be

sought to restrict access to the beach. Therefore, it is recommended that the applicant consider alternate methods of beach enclosure that will safely restrict access in a manner compatible with the scenic nature of this area.

In the Final Environmental Statement required for the construction permit of SONGS 2 and 3, the staff stated, "Use of the beach will not be restricted after construction is complete" (FES-CP, p. 2-11). The current plan to restrict use of approximately 1.4 km (0.85 mile) of the beach front for the 30-year operating life of the plant is a significant loss of valuable recreational and scenic space and represents a substantial change in action between issuance of the FES-CP and application for an operating license. The staff further stated, "The beach in the vicinity of the Station (5639 m (18,500 ft) south and 1036 m (3400 ft) north) is considered to be a unique and scarce recreational resource," (FES-CP, p. 2-11) and "Closure for even a brief period is objectionable" (FES-CP, p. 8-1). The loss of this resource precludes recreational benefits to significant numbers of beach users in the vicinity of San Onofre Beach. The staff reiterates those judgments and concludes that the current plan to restrict the public's use of this beach is a significant cost of the project, unanticipated at issuance of the construction permit. This impact is not sufficiently adverse, however, to warrant denying an operating license.

While all state beaches in the Pendleton coast area experienced increased usage in recent years, the attendance at San Onofre State Beach has risen significantly faster than at the other facilities. Between 1972 and 1978, the annual number of visits to the San Onofre State Beach rose by 98% while San Clemente and Doheny State Beaches showed increases of 46% and 25%, respectively (ER, Appendix 8A, Table 24, and Reference 32). As demand on available recreational resources increases, the significance of removing the beach in front of SONGS 2 & 3 from unrestricted public use will increase.

5.6.6 Emergency planning impacts

The applicants are currently revising the Emergency Plan, San Onofre Nuclear Generating Station Units 2 and 3 in accordance with 10 CFR Part 50, as amended July 23, 1980, as well as the recommended criteria contained in NUREG-0654. The staff believes the only noteworthy potential source of impact on the public from emergency planning would be associated with the siren alert system. The system will be designed to provide a minimum 10db dissonant differential from the ambient noise levels. The maximum sound level received by any member of the public should be lower than 123db. A complete cycle test will be required annually. The test requirements and alarm noise levels are consistant with those used for existing alert systems; therefore the staff concludes that the noise impacts associated with the siren alert system will be infrequent and insignificant.

5.6.7 Summary and conclusion

The staff concludes that, with the significant exception of restricting public use of 1.4 km (0.85 mi) of the San Onofre beach, the social and economic impact of operating SONGS 2 & 3 will be moderate. The large population within 96 km (60 miles) of the site and the projected population growth in the area is such that the addition of all 200 workers and their families would represent negligible impact to the area. Under the terms of Proposition 13, the property tax revenues received by the various funds and districts in San Diego County will be relatively small in proportion to existing revenues.

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* Available for inspection and copying for a fee in the NRC Public Document Room, 1717 H St., NW., Washington, DC 20555.
** Available from the NRC/GPO Sales Program, Washington, DC 20555, or the National Technical Information Service, Springfield, VA 22161.
***Available from NTIS only.

6. ENVIRONMENTAL MONITORING

6.1 SUMMARY

The applicant has expanded its San Onofre Unit 1 environmental monitoring program (biological, chemical, physical, and thermal) to determine environmental effects which may occur as a result of site preparation and construction of Units 2 and 3 and to establish an adequate preoperational baseline by which the operational effects of Units 2 and 3 may be judged.

The aquatic preoperational environmental monitoring program for SONGS 2 and 3 was approved by NRC and implemented by the applicant in April 1978. The NRC-approved program terminated in September 1980. However, all NPDES permit monitoring program requirements will continue to be met until an approved operational monitoring program is implemented. Results of the preoperational monitoring program will be used in formulating the operational monitoring program, which the applicant will submit for approval by the California Regional Water Quality Control Board to be incorporated in the NPDES permit monitoring program.

The environmental monitoring programs presented here differ somewhat from the description in the FES-CP. More detailed information is given here than in the FES-CP. Two state agencies, the California Regional Water Quality Control Board and the California Coastal Commission, have imposed environmental monitoring requirements in the vicinity of the San Onofre Station. NRC has discussed the results of its environmental review with the State agencies and has provided the State with recommendations for monitoring. The sections which follow include NRC staff recommendations based on its environmental review. However, requirements for non-radiological monitoring of the aquatic environment will be the responsibility of the State.

6.2 PREOPERATIONAL ENVIRONMENTAL PROGRAMS

The results from the preoperational monitoring program for Units 2 and 3 will be submitted with the Annual Operating Report for Unit 1.

6.2.1 Aquatic biological monitoring program

The applicant's preoperational aquatic biological monitoring program was designed to determine the species composition, abundance, and the temporal and spatial distribution of phytoplankton, zooplankton, ichthyoplankton, nekton, benthos, kelp beds, and intertidal organisms. The data obtained will be used to provide a basis for comparison with future operational monitoring data to determine if plant operation has caused observable perturbations in the ecosystem.

The possible operational impacts identified in this document and the FES-CP include: changes in local plankton populations due to entrainment; changes in the abundance of fish eggs, larvae, juveniles, and adults due to entrainment; adult fish population shifts due to fish impingement; alterations in some of the benthic and fish communities from thermal discharges; and changes in benthic and planktonic communities from increased turbidity. Thus, results from the preoperational and operational monitoring programs will be used to determine the extent to which the above effects occur.

6.2.1.1 Phytoplankton and zooplankton

Phytoplankton and zooplankton were sampled bimonthly. Samples were collected from at least four fixed stations, one each in zones 0B, 1B, 2B and 6 (Figure 6.1). A pump system is used to sample the water column and a 202 μm mesh-size screen is used to collect the zooplankton. Zooplankton biomass is determined and predominant species are enumerated. Chlorophyll analyses are performed on whole-water samples. Collections are coordinated, as much as possible, with the collection of pertinent physical data such as temperature, transparency, and current velocity and direction.

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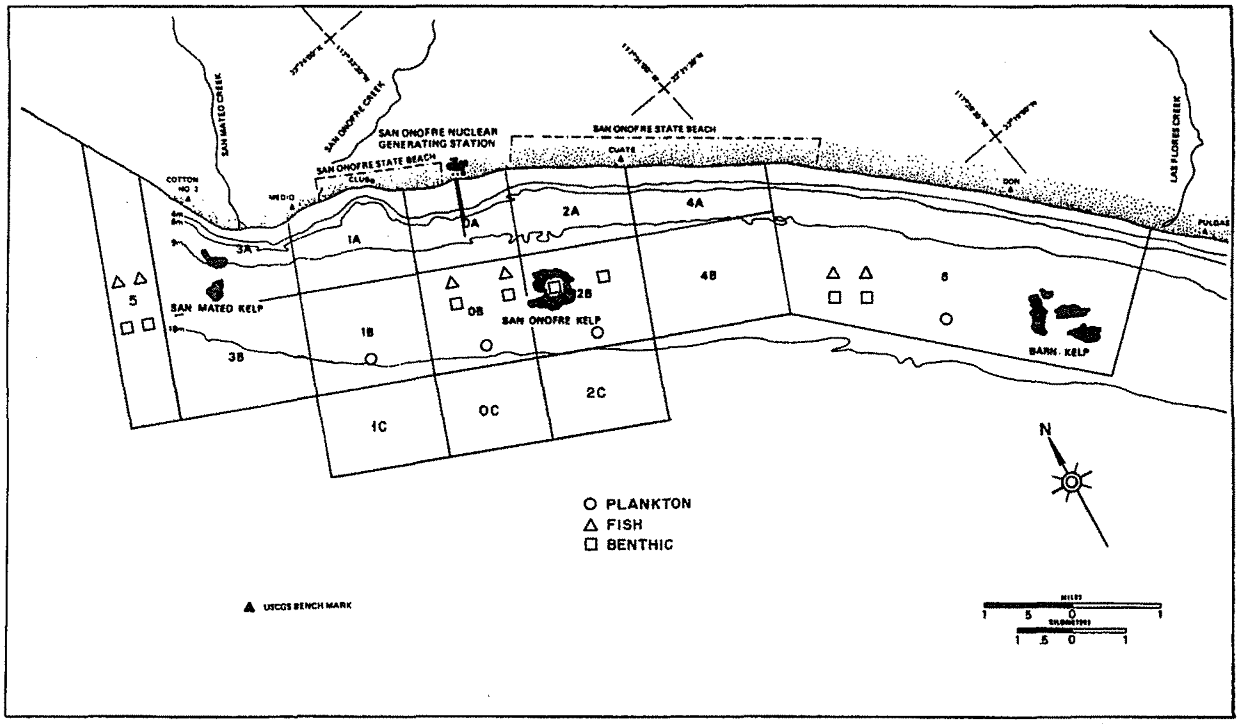

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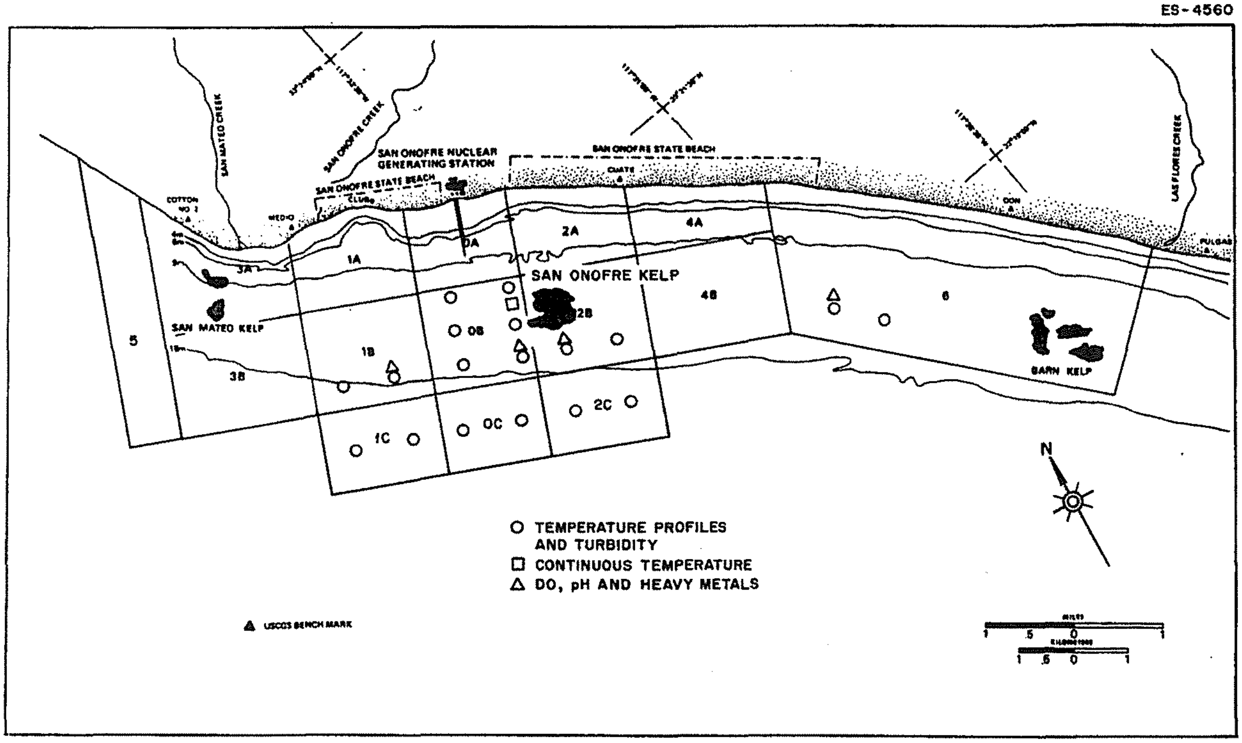

Fig. 6.1. Environmental monitoring stations for SONGS 2 and 3 preoperational monitoring program. Source: ER, Apendix 6A, Figs. 1 and 2.

The staff recommends that predominant phytoplankton genera also be enumerated to provide baseline conditions for this group. This would enable, for example, the determination of whether operation of the facility promotes red tide development (see Sect. 5.3.2, FES-CP).

6.2.1.2 Ichthyoplankton

Ichthyoplankton will be collected monthly at two stations in the Units 2 and 3 discharge area, zone OB, and at two stations in the reference area, either zone 5 or 6. Additionally, the Unit 1 intake area will be sampled. The study began approximately two years prior to initial operation of Unit 2 and lasted one year. Sampling was conducted during the day, at night, at dawn, and at dusk at the intake; night sampling was employed at the other locations. The water surface, water column, and epibenthos was sampled at each station. Fish larvae were identified to the lowest taxon possible and enumerated. Fish eggs were sorted and enumerated.

A study by the Marine Review Committee (MRC) was initiated in July 1976 (see Section 6.4.2) to assess the distribution, abundance, and entrainment of ichthyoplankton at SONGS 1. It is expected that data acquired from this work will also help characterize the SONGS 2 and 3 environment.

6.2.1.3 Nekton

Replicate fish samples were collected on a quarterly basis from at least two stations in zone OB, two in zone 5, two in the control zone, zone 6 (Figure 6.1). The gill nets used were 2- by 46-m (6- by 150-ft) full size, containing six 7.5-m (25-ft) panels of 19.05-, 25.4-, 31.75-, 38.1-, 44.5-, and 63.5-mm (3/4-, 1-, 1-1/4-, 1-1/2-, 1-3/4-, and 2-1/2-in.) bar mesh. The fish were measured, their state of health was assessed, and sexual maturation was determined on subsamples. Synoptic measurements of temperature and transmissivity were taken at each station.

6.2.1.4 Benthos

Benthic samples were collected quarterly at at least two stations within each of zones OB, 2B, 6 and 5 (or zones 3A and/or 3B) (Fig. 6.1). Permanent sampling stations exist in which a 6-m^2 (64.56-ft^2) sampling area has been established. Each sampling area contains 300 evenly spaced contact points which are used to estimate the distribution and relative abundance of sessile invertebrates, large motile invertebrates and macrophytes. Species enumeration and substrate type are recorded for each contact point. Additionally, four 0.125 m^2 (1.35-ft^2) quadrants are randomly placed within the sampling area to evaluate the distribution and abundance of small, clumped, or patchily distributed organisms. General observations to be recorded during sampling include: quantity and composition of drift algae, conspicuous or sparsely distributed biota not sampled with the point contact method, and substrate alteration (e.g., increased sedimentation). Selected species which are enumerated will be measured, and their general condition recorded. Procurement of some of the physical data, such as temperature and turbidity, will be coordinated with the benthic sampling program.

6.2.1.5 Intertidal organisms

Although not a required component of the preoperational monitoring program, quarterly observations were made along cobble intertidal transects at four monitoring stations and one control station. Predominant macroscopic species and substrate composition were identified and enumerated within three permanent 0.25-m^2 (2.69-ft^2) quadrats along a line perpendicular to the beach. Photographs were also taken of each quadrat for a permanent record of any possible ecological changes.

The staff believes that it is unnecessary to begin the intertidal sampling program until the time of removal of the construction apron from SONGS 2 and 3 (See FES-CP, Sect. 4.3.2, p. 4-9). At that time the intertidal monitoring program should be reinstated to assess the effect of the added sand movement in the intertidal zone. Provided the data show no significant effects, this program may be terminated after all translocation of sand has occurred or after two years. Until the time of apron removal, visual inspection of the intertidal zone will be sufficient, with biological sampling and laboratory analysis initiated only if needed. Deletion of the intertidal program may be reasonable during operational monitoring because of the extensive impact sustained by the intertidal area from activities unassociated with SONGS (Sect. 2.5.2.4) and because of the unlikely potential for any significant impact resulting from SONGS operation.

6.2.1.6 Kelp beds

The three kelp beds, San Mateo, San Onofre, and Barn, located near SONGS (Fig. 6.1) are being studied. A brief outline of the scope of effort at the three kelp beds is as follows:

1. Three benthic stations are located in and about the San Onofre kelp bed and one each at Barn kelp and San Mateo kelp. Stations are quantitatively assessed quarterly.

2. Kelp canopies and rock substrate are mapped for areal extent on a quarterly basis.

3. Water nutrient analysis for ammonia, nitrates, nitrites, and phosphate are taken monthly at all three beds. Water samples are taken from the surface and bottom from within each bed and offshore of each bed. An additional offshore station serves as a monitoring area for upwelling.

4. Kelp tissue analysis for nutrient content is conducted on a monthly basis at all three kelp beds. Each leaf is analyzed for nitrogen content.

5. An assessment of the health of the kelp plants in the three beds is made on a quarterly basis. Parameters assessed include: success of juvenile recruitment, density of kelp plants, amount of encrusting organisms and grazing by herbivores and abundance of senile and diseased plants.

6. Aerial infra-red photographs of the three kelp bed canopies will be taken on a monthly basis.

6.2.2 Water quality monitoring program

The preoperational water quality monitoring program is an expansion of the existing program required by the Environmental Technical Specifications for SONGS 1. This program is designed to establish baseline characteristics of selected oceanographic parameters for comparison with data obtained during the operation of SONGS. This comparison will allow determination of the extent to which SONGS operation alters water quality. Those parameters identified in the FES-CP and in this document which might be altered include: pH, temperature, turbidity, certain heavy metals, and dissolved oxygen.

Sea water temperature-depth profiles are measured bimonthly at stations in the area of the Units 2 and 3 diffusers and at a reference station outside of the area of predicted thermal influence. Stations are as follows: two within each of zones 1B, 2B, 1C, OC, 2C, and 6, six stations within zone OB (Fig. 6.1). Additionally, sea water temperatures are continuously monitored near the surface, at mid-depth, and near the bottom at a permanent station in zone OB. Temperatures from each depth are recorded hourly. The accuracy of the system is ±0.5 degrees centigrade, ±30 minutes per month.

Turbidity is monitored bimonthly at two stations within each of zones 1B, 2B, 1C, OC, 2C, and 6, and at six stations within zone OB (Fig. 6.1). The pH is monitored bimonthly at four sampling stations — one in each of zones OB, 1B, 2B, and 6. Dissolved oxygen is measured bimonthly at four stations — one in each of zones OB, 1B, 2B, and 6.

Mid-depth ocean water samples and grab samples of ocean bottom sediments are collected quarterly in the area of the Units 2 and 3 diffusers and an appropriate control area for analysis of heavy metals. One station in each of zones 1B, 2B, OB, and 6 is sampled. Samples will be analyzed for chromium, iron, and titanium. Copper will not be monitored as the applicant has indicated that SONGS 2 and 3 will have titanium condenser tubing.

The staff considers this program adequate with the following additions: (1) the water quality data should be collected within a two-day period at maximum to permit station-by-station comparisons and the investigation of possible cause and effect relationships, and (2) all control samples should be collected from an area predicted to be unaffected by any discharge effect.

6.2.3 Terrestrial monitoring program

The baseline terrestrial environmental monitoring program for the FES-CP was very nominal. As a condition of the construction permit, the applicant expanded its terrestrial monitoring program to establish an adequate preoperational baseline by which the operational effects of SONGS 2 and 3 may be judged. Biological data were collected seasonally in order to document changes in the biotic communities over a one-year time span. Methods utilized included

small mammal trapping; bird censusing; observations of reptiles, amphibians, and large mammals; plant species lists; and vegetation analyses using the line intercept and quadrat methods. Results of this expanded monitoring program are presented in Sect. 2.5.1.

The applicant has proposed and is currently monitoring areas of cut and fill associated with construction of the plant and transmission lines to detect areas of erosion (ER, Appendix 6A, Special Studies I). Visual inspections are conducted and documented biweekly; any erosion resulting from the applicant's construction activities will receive appropriate corrective action.

6.2.4 Radiological monitoring program

Radiological environmental monitoring programs are established to provide data on measurable levels of radiation and radioactive materials in the site environs. Appendix I to 10 CFR Part 50 requires that the relationship between quantities of radioactive material released in effluents during normal operation, including anticipated operational occurrences, and resultant radioactive doses to individuals from principal pathways of exposure be evaluated. Monitoring programs are conducted to verify the effectiveness of in-plant controls used for reducing the release of radioactive materials and to provide public reassurance that undetected radioactivity will not build up in the environment. A surveillance program is established to identify changes in the use of unrestricted areas to provide a basis for modifications of the monitoring programs.

The preoperational phase of the monitoring program provides for the measurement of background levels and their variations along the anticipated important pathways in the area surrounding the plant; the training of personnel; and the evaluation of procedures, equipment, and techniques.

This is discussed in greater detail in NRC Regulatory Guide 4.1, Rev. 1, "Programs for Monitoring Radioactivity in the Environs of Nuclear Power Plants," and the Radiological Assessment Branch Technical Position, August 1977, "Standard Technical Specification for Radiological Environmental Monitoring Program."

The applicant has proposed a radiological environmental monitoring program to meet the objectives discussed above. The applicant's proposed preoperational radiological environmental monitoring program is presented in Sect. 6.1.5 of the applicant's Environmental Report.

The applicant proposes to initiate parts of the program two years prior to operation of the facility, with the remaining portions beginning either six months or one year prior to operation.

The staff concludes that the radiological preoperational monitoring program proposed by the applicant is acceptable.

6.2.5 Onsite meteorological monitoring program[1,2,3]

The original onsite meteorological program began in late 1964 with wind measurements at the top of a 19.5-m (64-ft) mast. In December 1970, the current meteorological monitoring program began with the installation of a 36.6-m (120-ft) tower atop the coastal bluff about 100 m (330 ft) west-northwest from the Unit 1 containment and 420 m (1380 ft) west-northwest of the Unit 2 containment. In October 1975 the tower was extended to a height of about 43 m (140 ft). Table 6.1 describes the kinds of measurements and their elevations on the tower between 1970 and the present.

Southern California Edison Company also conducted an onshore tracer test program at the San Onofre site. Among the objectives of the program were (1) to evaluate the appropriateness of using data measured on the existing site meteorological tower located on the coastal bluff for making dispersion estimates for onshore flows, and (2) to characterize dispersion representative of meteorological conditions during routine plant releases. NUS-1927[3] describes the test program and data.

On the basis of our analysis of the test data, we conclude that the wind and vertical temperature data measured on the San Onofre onsite (bluff) tower are acceptable for use in calculating atmospheric dispersion estimates for the site vicinity using the staff's model, described in Sect. 2.4.4.

Table 6.1. SONGS onsite meteorological instrumentation

Period	Measured parameter	Elevation above ground Meters	Feet
December 1970–January 1973	Wind direction, speed and standard deviation	36.6	120
	Dry bulb vertical temperature gradient	36.6–6.1	120–20
January 1973–October 1975	Wind direction and speed	10, 36.6	33, 120
	Wind direction standard deviation	36.6	120
	Dry bulb temperature[a]	6.1	20
	Wet bulb temperature[b]	6.1	20
	Dry bulb vertical gradient	36.6–6.1	120–20
October 1975–present	Wind direction and speed	10, 20,[c] 40	33, 66, 131
	Wind direction standard deviation	10	33
	Dry bulb temperature	10	33,
	Dry bulb vertical gradient	40–10[d]	131–33
		36.6–6.1[c]	120–20

[a] Installed January 1974.
[b] Installed January 1974, removed January 1975.
[c] Temporary.
[d] Two sets of instruments.

6.3 OPERATIONAL MONITORING PROGRAMS

6.3.1 Aquatic biological monitoring program

The aquatic biological operational monitoring program will contain sampling programs which are extensions of the baseline and preoperational programs so that analyses can readily be made of the changes, if any, that occur in the aquatic environment due to plant operation. Thus, the ichthyoplankton study now being conducted and the required kelp preoperational program should be continued during operation of the facility until such time as it is possible to state credibly that no significant impacts result from the facility.

The new fish return system (Sect. 3.2.2) is expected to be about 90% effective according to laboratory models (ER, p. 5.1-20). Precise figures on its effectiveness will not be available until it is operated in conjunction with the heat dissipation system. The staff recommends that the applicant include a program for optimizing the effectiveness of the fish return system. This should include consideration of the delayed mortality of the fish successfully diverted by the fish return system by holding them for 48 to 96 hours before returning them to the ocean.

Consideration of deletion of the intertidal sampling program from the operational monitoring program for SONGS 2 and 3 is discussed in Sect. 6.2.1.5.

6.3.2 Water quality monitoring program

The water quality operational monitoring program is a continuation of the existing preoperational water quality monitoring program (Sect. 6.2.2). This continuity will allow for confirmatory monitoring to assess any possible changes to water quality due to operation of San Onofre Units 2 and 3.

The NRC and the California Regional Water Quality Control Board, San Diego Region (CRWQCB) have worked in a cooperative manner in order to develop the preoperational monitoring program for SONGS 2 and 3. NRC and CRWQCB have agreed to continue to work together to establish an operational phase NPDES permit which will incorporate the aquatic concerns from each regulatory group.

6.3.3 Terrestrial monitoring program

The applicant does not have an operational terrestrial monitoring program. The staff does not recommend any operational monitoring of floral or faunal species because no significant

effects have been identified between the operation of SONGS 2 & 3 and the terrestrial environment. The California Coastal Commission, however, requires the applicant to protect the bluffs 0.5 km (0.31 mile) south of the plant site for the duration of the site easement (expiration date, May 1, 2023) (ER, Appendix 12B).

6.3.4 Radiological monitoring program

The operational offsite radiological monitoring program is conducted to measure radiation levels and radioactivity in the plant environs. It assists and provides backup support to the detailed effluent monitoring (as recommended in NRC Regulatory Guide 1.21, "Measuring, Evaluating, and Reporting Radioactivity in Solid Wastes and Release of Radioactive Materials in Liquid and Gaseous Effluents from Light-Water Cooled Nuclear Power Plants") which is needed to evaluate individual and population exposures and to verify projected or anticipated radioactivity concentrations.

The applicant plans essentially to continued the proposed preoperational program during the operating period. However, refinements may be made in the program to reflect changes in land use or preoperational monitoring experience.

6.3.5 Meteorological monitoring program

The applicant plans to continue the program begun for the construction permit evaluation. The onsite meteorological tower provides data in accordance with the recommendations of Regulatory Guide 1.23, "Onsite Meteorological Programs." Furthermore, operating technical specifications require meteorological monitoring as a condition of operation.

6.4 RELATED ENVIRONMENTAL RESOURCE DATA

6.4.1 Thermal exception studies

As a condition of the exception to the State Thermal Plan granted by the California Regional Water Quality Control Board, San Diego, the applicants are required to perform studies to determine the optimum mode of heat treatment to control fouling organisms while minimizing adverse effects on marine life and to permit the Regional Board to set precise limits on the frequency, degree, and duration of heat treatment. These studies were submitted to the State Water Resources Control Board on January 31, 1979. On December 18, 1980, the Board determined that the studies fulfilled the conditions set earlier and further determined that the heat treatment operating conditions proposed by the applicant will assure the protection and propagation of a balanced, indigenous population of shellfish, fish, and wildlife within the meaning of Section 316(a) of the Clean Water Act.

6.4.2 Marine Review Committee studies

The California Coastal Commission specified in the Coastal Zone Permit issued in 1974 for SONGS 2 and 3 that an extensive study be conducted at San Onofre. The study program is funded by the utility and is being administered by a three-member Marine Review Committee (MRC) appointed by the Coastal Commission. The intent of the program is to provide an independent assessment of the marine environment and a prediction of the potential impact of SONGS 2 and 3. The MRC has identified the following areas for study: physical, oceanographic, and ecological monitoring and modeling; plankton – far field effects and entrainment; fish populations, impingement, and diversion; and benthic communities, intertidal zone organisms, and kelp beds.

MRC has conducted studies at SONGS 2 and 3 in some of the above mentioned areas since August 1976. In November 1980 the MRC issued a report containing its recommendations, predictions, and rationale. The conclusions of the MRC are essentially consistent with those of the staff as described in Section 5 of this statement. Although noting uncertainties, the MRC has concluded that it does not predict at this time that substantial adverse effects on the marine environment are likely to occur from the operations of the SONGS cooling system. Accordingly, the report recommends no design changes but does recommend continued monitoring of the aquatic community to ensure that there is no serious ecological damage, especially to the kelp beds, as a result of plant operation. (See Appendix E for the options and recommendations of the Marine Review Committee.)

6.5 CONCLUSIONS

The preoperational and operational monitoring programs as described above give adequate attention to impacts discussed in this environmental impact statement.

REFERENCES

These documents are available for inspection and copying for a fee in the NRC Public Document room 1717 H Street, N.W., Washington, D.C. 20555

1. Southern California Edison Company, "San Onofre Nuclear Generating Station Units 2 and 3, Environmental Report - Operating License Stage," Docket No. 50-361/362, 1977.

2. Southern California Edison Company, "San Onofre Generating Station Units 2 and 3, Final Safety Analysis Report," Docket No. 50-361/362, 1977.

3. M. Septoff, A. E. Mitchell, and L. H. Teuscher, "Final Report of the Onshore Tracer Tests Conducted December 1976 through March 1977 at the San Onofre Nuclear Generating Station," Report NUS-1927, NUS Corporation, Rockville, Md., 1977.

7. ENVIRONMENTAL IMPACT OF POSTULATED ACCIDENTS

7.1 PLANT ACCIDENTS

The staff has considered the potential radiological impacts on the environment of possible accidents at the San Onofre Nuclear Generating Station Units 2 and 3 in accordance with a Statement of Interim Policy published by the Nuclear Regulatory Commission on June 13, 1980.[1] The following discussion reflects these considerations and conclusions.

The first section deals with general characteristics of nuclear power plant accidents including a brief summary of safety measures to minimize the probability of their occurrence and to mitigate their consequences if they should occur. Also described are the important properties of radioactive materials and the pathways by which they could be transported to become environmental hazards. Potential adverse health effects and impacts on society associated with actions to avoid such health effects are also identified.

Next, actual experience with nuclear power plant accidents and their observed health effects and other societal impacts are then described. This is followed by a summary review of safety features of the San Onofre Units 2 and 3 facilities and of the site that act to mitigate the consequences of accidents.

The results of calculations of the potential consequences of accidents that have been postulated in the design basis are then given. Also described are the results of calculations for the San Onofre site using probabilistic methods to estimate the possible impacts and the risks associated with severe accident sequences of exceedingly low probability of occurrence.

7.1.1 General characteristics of accidents

The term accident, as used in this section, refers to any unintentional event not addressed in Section 5.5 that results in a release of radioactive materials into the environment. The predominant focus, therefore, is on events that can lead to releases substantially in excess of permissible limits for normal operation. Such limits are specified in the Commission's regulations at 10 CFR Part 20 and 10 CFR Part 50, Appendix I.

There are several features which combine to reduce the risk associated with accidents at nuclear power plants. Safety features in the design, construction, and operation comprising the first line of defense are to a very large extent devoted to the prevention of the release of these radioactive materials from their normal places of confinement within the plant. There are also a number of additional lines of defenses that are designed to mitigate the consequences of failures in the first line. Descriptions of these features for the San Onofre Units 2 and 3 plant may be found in the applicant's Final Safety Analysis Report,[2] and in the staff's Safety Evaluation Report.[3] The most important mitigative features are described in Section 7.1.3.1 below.

These safety features are designed taking into consideration the specific locations of radioactive materials within the plant, their amounts, their nuclear, physical, and chemical properties, and their relative tendency to be transported into and for creating biological hazards in the environment.

7.1.1.1 Fission product characteristics

By far the largest inventory of radioactive material in a nuclear power plant is produced as a byproduct of the fission process and is located in the uranium oxide fuel pellets in the form of fission products. These pellets are contained in the fuel rods which make up the fuel assemblies. During periodic refueling shutdowns, the assemblies containing these fuel pellets are transferred to a spent fuel storage pool so that the second largest inventory of radioactive material is located in this storage area. Much smaller inventories of radioactive materials are also normally present in the water that circulates in the primary coolant system and in the systems used to process gaseous and liquid radioactive wastes in the plant.

These radioactive materials exist in a variety of physical and chemical forms. Their potential for dispersion into the environment is dependent not only on mechanical forces that might physically transport them, but also upon their inherent properties, particularly their volatility. The majority of these materials exist as nonvolatile solids over a wide range of temperatures. Some, however, are relatively volatile solids and a few are gaseous in nature. These characteristics have a significant bearing upon the assessment of the environmental radiological impact of accidents.

The gaseous materials include radioactive forms of the chemcially inert noble gases krypton and xenon. These have the highest potential for release into the atmosphere. If a reactor accident were to occur involving degradation of the fuel cladding, the release of substantial quantities of these radioactive gases from the fuel is a virtual certainty. Such accidents are very low frequency but credible events (see Section 7.1.2). It is for this reason that the safety analysis of each nuclear power plant analyzes a hypothetical design basis accident that postulates the release of the entire contained inventory of radioactive noble gases from the fuel into the containment structure. If further released to the environment as a possible result of failure of safety features, the hazard to individuals from these noble gases would arise predominantly through the external gamma radiation from the airborne plume. The reactor containment structure is designed to minimize this type of release.

Radioactive forms of iodine are formed in substantial quantities in the fuel by the fission process and in some chemical forms may be quite volatile. For this reason, they have traditionally been regarded as having a relatively high potential for release from the fuel. The chemical forms in which the fission product radioiodines are found are generally solid materials at room temperature, however, so that they have a strong tendency to condense (or "plate out") upon cooler surfaces. In addition, most of the iodine compounds are quite soluble in, or chemically reactive with, water. Although these properties do not inhibit the release of radioiodines from degraded fuel, they do act to mitigate the release from containment structures that have large internal surface areas and that contain large quantities of water as a result of an accident. The same properties affect the behavior of radioiodines that may "escape" into the atmosphere. Thus, if rainfall occurs during a release, or if there is moisture on exposed surfaces, e.g., dew, the radioiodines will show a strong tendency to be absorbed by the moisture. Because of radioiodine's relatively high solubility and distinct radiological hazard, its potential for release to the atmosphere has also been reduced by the use of special containment spray systems. If released to the environment, the principal radiological hazard associated with the radioiodines is ingestion into the human body and subsequent concentration in the thyroid gland.

Other radioactive materials formed during the operation of a nuclear power plant have lower volatilities and therefore, by comparison with the noble gases and iodine, a much smaller tendency to escape from degraded fuel unless the temperature of the fuel becomes quite high. By the same token, such materials, if they escape by volatilization from the fuel, tend to condense quite rapidly to solid form again when transported to a lower temperature region and/or dissolve in water when present. The former mechanism can have the result of producing some solid particles of sufficiently small size to be carried some distance by a moving stream of gas or air. If such particulate materials are dispersed into the atmosphere as a result of failure of the containment barrier, they will tend to be carried downwind and deposit on surface features by gravitational settling or by precipitation (fallout), where they will become "contamination" hazards in the environment.

All of these radioactive materials exhibit the property of radioactive decay with characteristic half-lives ranging from fractions of a second to many days or years (see Table 7.1). Many of them decay through a sequence or chain of decay processes and all eventually become stable (nonradioactive) materials. The radiation emitted during these decay processes is the reason that they are hazardous materials.

7.1.1.2 Exposure pathways

The radiation exposure (hazard) to individuals is determined by their proximity to the radioactive material, the duration of exposure, and factors that act to shield the individual from the radiation. Pathways for the transport of radiation and radioactive materials that lead to radiation exposure hazards to humans are generally the same for accidental as for "normal" releases. These are depicted in Section 5, Figure 5.17. There are two additional possible pathways that could be significant for accident releases that are not shown in Figure 5.17. One of these is the fallout onto open bodies of water of radioactivity initially carried in the air. The second would be unique to an accident that results in temperatures inside the reactor core sufficiently high to cause melting and subsequent penetration of the basemat underlying the reactor by the molten core debris. This creates the potential for the release of radioactive material into the hydrosphere through contact with ground water. These pathways may lead to external exposure to radiation, and to internal exposures if radioactivity is inhaled, or ingested from contaminated food or water.

Table 7.1 Activity of Radionuclides in a San Onofre Reactor Core at 3560 MWt

Group/Radionuclide	Radioactive Inventory (millions of curies)	Half-life (days)
A. NOBLE GASES		
Krypton-85	0.63	3,950
Krypton-85m	27	0.183
Krypton-87	52	0.0528
Krypton-88	76	0.117
Xenon-133	190	5.28
Xenon-135	38	0.384
B. IODINES		
Iodine-131	95	8.05
Iodine-132	130	0.0958
Iodine-133	190	0.875
Iodine-134	210	0.0366
Iodine-135	170	0.280
C. ALKALI METALS		
Rubidium-86	0.029	18.7
Cesium-134	8.3	750
Cesium-136	3.3	13.0
Cesium-137	5.2	11,000
D. TELLURIUM-ANTIMONY		
Tellurium-127	0.029	18.7
Tellurium-127m	1.2	109
Tellurium-129	34	0.048
Tellurium-129m	5.9	34.0
Tellurium-131m	14	1.25
Tellurium-132	130	3.25
Antimony-127	6.8	3.88
Antimony-129	37	0.179
E. AKALINE EARTHS		
Strontium-89	100	52.1
Strontium-90	4.1	11,030
Strontium-91	120	0.403
Barium-140	180	12.8
F. COBALT AND NOBLE METALS		
Cobalt-58	0.87	71.0
Cobalt-60	0.32	1,920
Molybdenum-99	180	2.8
Technetium-99m	160	0.25
Ruthenium-103	120	39.5
Ruthenium-105	80	0.185
Ruthenium-106	28	366
Rhodium-105	55	1.50
G. RARE EARTHS, REFRACTORY OXIDES AND TRANSURANICS		
Yttrium-99	4.3	2.67
Yttrium-91	130	59.0
Zirconium-95	170	65.2
Zirconium-97	170	0.71
Niobium-95	170	35.0
Lanthanum-140	180	1.67
Cerium-141	170	32.3
Cerium-143	150	1.38
Cerium-144	95	284

Table 7.1 (Continued)

Group/Radionuclide	Radioactive Inventory (millions of curies)	Half-life (days)
G. RARE EARTHS, REFRACTORY OXIDES AND TRANSURANICS (Continued)		
Praseodymium-143	150	13.7
Neodymium-147	67	11.1
Neptunium-239	1800	2.35
Plutonium-238	0.063	32,500
Plutonium-239	0.023	8.9×10^6
Plutonium-240	0.023	2.4×10^6
Plutonium-241	3.8	5,350
Americium-241	0.0019	1.5×10^5
Curium-242	0.56	163
Curium-244	0.026	6,630

NOTE: The above grouping of radionuclides corresponds to that in Table 7.3.

It is characteristic of these pathways that during the transport of radioactive material by wind or by water, the material tends to spread and disperse, like a plume of smoke from a smokestack, becoming less concentrated in larger volumes of air or water. The result of these natural processes is to lessen the intensity of exposure to individuals downwind or downstream of the point of release, but they also tend to increase the number who may be exposed. For a release into the atmosphere, the degree to which dispersion reduces the concentration in the plume at any downwind point is governed by the turbulence characteristics of the atmosphere which vary considerably with time and from place to place. This fact, taken in conjunction with the variability of wind direction and the presence or absence of precipitation, means that accident consequences are very much dependent upon the weather conditions existing at the time.

7.1.1.3 Health effects

The cause and effect relationships between radiation exposure and adverse health effects are quite complex[4] but they have been more exhaustively studied than any other environmental contaminant.

Whole-body radiation exposure resulting in a dose greater than about 10 rem for a few persons and about 25 rem for nearly all people over a short period of time (hours) is necessary before any physiological effects to an individual are clinically detectable. Doses about to 10 to 20 times larger than the latter dose, also received over a relatively short period of time (hours to a few days), can be expected to cause some fatal injuries. At the severe, but extremely low probability end of the accident spectrum, exposures of these magnitudes are theoretically possible for persons in the close proximity of such accidents if measures are not or cannot be taken to provide protection, e.g., by sheltering or evacuation.

Lower levels of exposures may also constitute a health risk, but the ability to define a direct cause and effect relationship between any given health effect and a known exposure to radiation is difficult given the backdrop of the many other possible reasons why a particular effect is observed in a specific individual. For this reason, it is necessary to assess such effects on a statistical basis. Such effects include cancer and genetic changes in future generations after exposure of a prospective parent. Cancer in the exposed population may begin to develop only after a lapse of 2 to 15 years (latent period) from the time of exposure and then continue over a period of about 30 years (plateau period). However, in the case of exposure of fetuses (in utero), cancer may begin to develop at birth (no latent period) and end at age 10 (i.e., the plateau period is 10 years). The health consequences model currently being used is based on the 1972 BEIR Report of the National Academy of Sciences.[5]

Most authorities are in agreement that a reasonable and probably conservative estimate of the statistical relationship between low levels of radiation exposure to a large number of people is within the range of about 10 to 500 potential cancer deaths (although zero

is not excluded by the data) per million man-rem. The range comes from the latest NAS BEIR III Report (1980)[6] which also indicates a probable value of about 150. This value is virtually identical to the value of about 140 used in the current NRC health effects models. In addition, approximately 220 genetic changes per million person-rem would be projected by BEIR III over succeeding generations. That also compares well with the value of about 260 per million man-rem currently used by the NRC staff.

7.1.1.4 Health effects avoidance

Radiation hazards in the environment tend to disappear by the natural process of radioactive decay. Where the decay process is a slow one, however, and where the material becomes relatively fixed in its location as an environmental contaminant (e.g., in soil), the hazard can continue to exist for a relatively long period of time--months, years, or even decades. Thus, a possible consequential environmental societal impact of severe accidents is the avoidance of the health hazard rather than the health hazard itself, by restrictions on the use of the contaminated property or contaminated foodstuffs, milk, and drinking water. The potential economic impacts that this can cause are discussed below.

7.1.2 Accident experience and observed impacts

The evidence of accident frequency and impacts in the past is a useful indicator of future probabilities and impacts. As of mid-1980, there were 69 commercial nuclear power reactor units licensed for operation in the United States at 48 sites with power generating capacities ranging from 50 to 1130 megawatts electric (MWe). (The San Onofre Units 2 and 3 are designed for 1140 MWe each.) The combined experience with these units represents approximately 500 reactor years of operation over an elapsed time of about 20 years. Accidents have occurred at several of these facilities.[7] Some of these have resulted in releases of radioactive material to the environment, ranging from very small fractions of a curie to a few million curies. None is known to have caused any radiation injury or fatality to any member of the public, nor any significant individual or collective public radiation exposure, nor any significant contamination of the environment. This experience base is not large enough to permit a reliable quantitative statistical inference. It does, however, suggest that significant environmental impacts due to accidents are very unlikely to occur over time periods of a few decades.

Melting or severe degradation of reactor fuel has occurred in only one of these 69 operating units, during the accident at Three Mile Island - Unit 2 (TMI-2) on March 28, 1979. In addition to the release of a few million curies of xenon-133, it has been estimated that approximately 15 curies of radioiodine was also released to the environment at TMI-2.[8] This amount represents an extremely minute fraction of the total radioiodine inventory present in the reactor at the time of the accident. No other radioactive fission products were released in measurable quantity.

It has been estimated that the maximum cumulative offsite radiation dose to an individual was less than 100 millirem.[8,9] The total population exposure has been estimated to be in the range from about 1000 to 3000 man-rem. This exposure could produce between none and one additional fatal cancer over the lifetime of the population. The same population receives each year from natural background radiation about 240,000 man-rem and approximately a half-million cancers are expected to develop in this group over its lifetime,[8,9] primarily from causes other than radiation. Trace quantities (barely above the limit of detectability) of radioiodine were found in a few samples of milk produced in the area. No other food or water supplies were impacted.

Accidents at nuclear power plants have also caused occupational injuries and a few fatalities but none attributed to radiation exposure. Individual worker exposures have ranged up to about 4 rems as a direct consequence of accidents, but the collective worker exposure levels (man-rem) are a small fraction of the exposures experienced during normal routine operations that average about 500 man-rem per reactor year.

Accidents have also occurred at other nuclear reactor facilities in the United States and in other countries.[7] Due to inherent differences in design, construction, operation, and purpose of most of these other facilities, their accident record has only indirect relevance to current nuclear power plants. Melting of reactor fuel occurred in at least seven of these accidents, including the one in 1966 at the Enrico Fermi Atomic Power Plant Unit 1. This was a sodium-cooled fast breeder demonstration reactor designed to generate 61 MWe. The damages were repaired and the reactor reached full power four years following the accident. It operated successfully and completed its mission in 1973. This accident did not release any radioactivity to the environment.

A reactor accident in 1957 at Windscale, England released a significant quantity of radioiodine, approximately 20,000 curies, to the environment. This reactor, which was not operated to generate electricity, used air rather than water to cool the uranium fuel. During a special operation to heat the large amount of graphite in this reactor, the fuel overheated and radioiodine and noble gases were released directly to the atmosphere from a 123-m (405-ft) stack. Milk produced in a 512-km^2 (200-mi^2) area around the facility was impounded for up to 44 days. This kind of accident cannot occur in a reactor like San Onofre, however, because of its water-cooled design.

7.1.3 Mitigation of accident consequences

The Nuclear Regulatory Commission is conducting a safety evaluation of the application to operate San Onofre Units 2 and 3. Although this evaluation will contain more detailed information on plant design, the principal design features are presented in the following section.

7.1.3.1 Design features

San Onofre Units 2 and 3 are essentially identical units. Each contains features designed to prevent accidental release of radioactive fission products from the fuel and to lessen the consequences should such a release occur. Many of the design and operating specifications of these features are derived from the analysis of postulated events known as design basis accidents. These accident preventive and mitigative features are collectively referred to as engineered safety features (ESF). The possibilities or probabilities of failure of these systems are incorporated in the assessments discussed in section 7.1.4.

Each steel-lined concrete containment building is a passive mitigating system which is designed to minimize accidental radioactivity releases to the environment. Safety injection systems are incorporated to provide cooling water to the reactor core during an accident to prevent or minimize fuel damage. The containment atmosphere cooling system provides heat removal capability inside the containment following steam release accidents and helps to prevent containment failure due to overpressure. Similarly, the containment spray system is designed to spray cool water into the containment atmosphere. The spray water also contains an additive (sodium hydroxide) which will chemically react with any airborne radioiodine to remove it from the containment atmosphere and prevent its release to the environment.

The mechanical systems mentioned above are supplied with emergency power from onsite diesel generators in the event that normal offsite station power is interrupted.

The fuel handling area of each unit is located in a fuel building, a low leakage structure with a safety-grade ventilation system for accident mitigation. The safety-grade ventilation system is an internal recirculation system and contains both charcoal and high efficiency particulate filters. If radioactivity were to be released into the building, it would be drawn through the ventilation system, and radioactive iodine and particulate fission products would be removed from the flow stream, reducing the concentration within the building and hence the amount that might leak to the atmosphere.

There are features of each unit that are necessary for its power generation function that can also play a role in mitigating certain accident consequences. For example, the main condenser, although not classified as an ESF, can act to mitigate the consequences of accidents involving leakage from the primary to the secondary side of the steam generators (such as steam generator-tube ruptures).

If normal offsite power is maintained, the ability of the plant to send contaminated steam to the condenser instead of releasing it through the safety valves or atmospheric dump valves can significantly reduce the amount of radioactivity released to the environment. In this case, the fission product removal capability of the normally operating off-gas treatment system would come into play.

Much more extensive discussions of the safety features and characteristics of San Onofre Units 2 and 3 may be found in the applicant's Final Safety Analysis Report.[2] The staff evaluation of these features is addressed in the Safety Evaluation Report. In addition, the implementation of the lessons learned from the TMI-2 accident, in the form of improvements in design and procedures, and operator training, will significantly reduce the likelihood of a degraded core accident which could result in large releases of fission products to the containment. Specifically, the applicant will be required to meet those TMI-related requirements specified in NUREG-0737. As noted in Section 7.1.4.7, no credit has been taken for these actions and improvements in discussing the radiological risk of accidents in this supplement.

7.1.3.2 Site features

In the process of considering the suitability of the site of San Onofre Units 2 and 3, pursuant to NRC's Reactor Site Criteria in 10 CFR Part 100, consideration was given to certain factors that tend to minimize the risk and the potential impact of accidents. First, the site has an exclusion area as required in 10 CFR Part 100. The exclusion area of the (33.8 hectare (83.6-acre)) site has a minimum exclusion distance of (1968 ft) 600 meters from the containment centerlines to the closest site boundary. The applicant's authority to control all activities within the exclusion area was acquired by a grant of easement from the United States of America made by the Secretary of the Navy. The exclusion area is traversed by old U.S. Highway 101, the San Diego Freeway (Interstate 5), and the Atchison, Topeka and Santa Fe Railroad. The exclusion area on the ocean side extends over a narrow strip of beach and into the Pacific Ocean.

The applicant's control of the landward portion of the exclusion area extends to the mean high tide line but does not include the strip of beach lying between high and low tide that is occasionally uncovered. This strip of "tidal beach" is owned by the State of California and is used primarily as a passageway for individuals walking along the beach. The applicant's lack of control of this strip of tidal beach has been adjudicated in a Commission proceeding (see ALAB-432) and has been determined to be de minimis on the basis of its occasional use, together with the high probability that any radiation exposure to individuals in this zone will be within the guideline values of 10 CFR Part 100 in the event of an emergency.

Activities within the exclusion area which are unrelated to plant operation include a gas pipeline, railroad traffic, through traffic on the San Diego Freeway, and local recreational traffic on old U.S. Highway 101. Recreational activities in the plant vicinity include swimming, camping, and surfing. Recreational activities, such as sunbathing or picnicking, are discouraged within the landward portion of the exclusion area (the area landward of the contour of mean high tide). The seaward portion of the exclusion area (the area seaward of the contour of mean high tide) may be occupied by small numbers of people for passageway transit between the public beach areas upcoast and downcoast from the plant. Additional small numbers of people may be anticipated to occasionally be in the water within the exclusion area.

Transient access to an approximate 2.02-hectare (5-acre) at the southwest corner of the site for the purposes of viewing the scenic bluffs and barrancas will be on an unimproved walkway. The applicant has estimated that at any one time a maximum of 100 persons will be in the walkway and a 2.02-hectare (5-acre) viewing area, and on the beach and water below the mean high tide. The improved walkway affords landward passage between the two beach areas.

In case of a radiological emergency, the applicants have made arrangements with agencies of the State and local governments to control all traffic on the railroad, roadways, and waterways.

Second, beyond and surrounding the exclusion area is a low population zone (LPZ), also required by Part 100. This is a circular area of 3.14 km (1.95 mi) outer radius. Within this zone the applicant must assure that there is reasonable probability that appropriate measures could be taken on behalf of the residents in the event of a serious accident.

The San Onofre State Beach northwest and southwest of the San Onofre exclusion areas represents a public waterfront recreation area within an 8-km (5-mi) radius of the plant. The beach south of the nuclear facility is used for swimming, hiking, and vehicle parking. The 1036 m (3,400-ft) stretch of beach north of the site is used primarily for surfing.

The largest communities in the vicinity of the site are San Clemente, located about 4.8 km (3 mi) away, which had a 1976 estimated population of 23,000, and the U.S. Marine Corp base Camp Pendleton, with a total estimated population of about 33,000. The Marine Corp base consists of several population clusters or camps located at distances from 2.4 km to 19.31 km (1.5 mi to 12 mi) away.

The applicant has estimated a peak transient population in major tourist and recreational activities along Interstate 5 in a 16-km (10-mi) radius of the plant to be 56,600 persons. This occurs during the summer months and is due to persons engaged in water sport recreation on the Pacific Ocean beach and coastal waters.

The Mexican border lies about 121 km (75 mi) from San Onofre, toward the southeast. The cities of Tijuana, Mexicali, and Ensenada are within 241 km (150 mi) of the site.

The safety evaluation of the San Onofre site has also included a review of potential external hazards, i.e., activities offsite that might adversely affect the operation of the plant and cause an accident. This review encompassed nearby industrial, transportation, and military facilities that might create explosive, missile, toxic gas, or similar hazards. The staff concluded at the construction permit stage that the hazards from the nearby military facility are negligibly small. However, the hazards from the nearby interstate highway, the railroad right of way, and natural gas pipelines, are still under review by the staff. Reevaluation of these hazards has been requested by the staff, and the results will be reported in a supplement to the staff's Safety Evaluation Report. It is anticipated that the review will show that either the risks are acceptably small or may be acceptably small.

7.1.3.3 Emergency preparedness

Emergency preparedness plans including protective action measures for the San Onofre facility and environs are in an advanced, but not yet fully completed stage. In accordance with the provisions of 10 CFR Section 50.47, effective November 3, 1980, no operating license will be issued to the applicant unless a finding is made by the NRC that the state of onsite and offsite emergency preparedness provides reasonable assurance that adequate protective measures can and will be taken in the event of a radiological emergency. Among the standards that must be met by these plans are provisions for two Emergency Planning Zones (EPZ). A plume exposure pathway EPZ of about 16 km (10 mi) in radius and an ingestion exposure pathway EPZ of about 80 km (50 mi) in radius are required. Other standards include appropriate ranges of protective actions for each of these zones, provisions for dissemination to the public of basic emergency planning information, provisions for rapid notification of the public during a serious reactor emergency, and methods, systems, and equipment for assessing and monitoring actual or potential offsite consequences in the EPZs of a radiological emergency condition.

NRC findings will be based upon a review of the Federal Emergency Management Agency (FEMA) findings and determinations as to whether State and local government emergency plans are adequate and capable of being implemented, and on the NRC assessment as to whether the applicant's onsite plans are adequate and capable of being implemented. NRC staff findings will be reported in a supplement to the staff's Safety Evaluation Report. Although the presence of adequate and tested emergency plans cannot prevent the occurrence of an accident, it is the judgment of the staff that they can and will substantially mitigate the consequences to the public if one should occur.

7.1.4 Accident risk and impact assessment

7.1.4.1 Design basis accidents

As a means of assuring that certain features of the San Onofre Units 2 and 3 plants meet acceptable design and performance criteria, both the applicant and the staff have analyzed the potential consequences of a number of postulated accidents. Some of these could lead to significant releases of radioactive materials to the environment, and calculations have been performed to estimate the potential radiological consequences to persons offsite. For each postulated initiating event, the potential radiological consequences cover a considerable range of values depending upon the particular course taken by the accident and the conditions, including wind direction and weather, prevalent during the accident.

In the safety analysis of the San Onofre Units 2 and 3 plants, three categories of accidents have been considered. These categories are based upon their probability of occurrence and include (a) incidents of moderate frequency, i.e., events that can reasonably be expected to occur during any year of operation, (b) infrequent accidents, i.e., events that might occur once during the lifetime of the plant, and (c) limiting faults, i.e., accidents not expected to occur but that have the potential for significant releases of radioactivity. The radiological consequences of incidents in the first category, also called anticipated operational occurrences, are discussed in Section 5. Initiating events postulated in the second and third categories for the San Onofre Units 2 and 3 are shown in Table 7.2. These are collectively designated design basis accidents in that specific design and operating features as described above in Section 7.1.3.1 are provided to limit their potential radiological consequences. Approximate radiation doses that might be received by a person at the nearest site boundary (600 meters from the plant) are also shown in the table, along with a characterization of the time duration of the releases.

Table 7.2 Approximate Radiation Doses from Design Basis Accidents, Conservative Calculational Model

	Duration of Release	Dose (rem at 600 m[1])	
		Whole Body	Thyroid
Infrequent Accidents:			
Waste Gas Tank Failure	< 2 hr	< 3	< 30
Steam Generator Tube[2] Rupture	< 2 hr	< 3	2
Fuel Handling Accident	< 2 hr	7	40
Limiting Faults:			
Main Steam Line Break	< 2 hr	6	10
Control Rod Ejection	hrs-days	< 6	60
Large-Break LOCA	hrs-days	3	100

[1]The nearest site boundary.
[2]See NUREG-0651[6] for descriptions of three steam generator tube rupture accidents that have occurred in the United States.

The calculational model used is a conservative one in that it is expected to provide a reasonable estimate of the potential upper bound for individual exposures. The results are used to implement the provisions of 10 CFR 100 and to establish performance requirements for certain engineered safety features. The conservative assumptions used in these analyses include: (1) large (upper bound) amounts of radioactive material released by the initiating event, (2) single failures in important equipment, including operating the engineered safety features in a degraded mode,* (3) very adverse meteorological conditions, and (4) no reduction in exposure due to possible protective actions.

The results of these calculations show that, for these events, the limiting whole-body exposures are not expected to exceed 7 rem. They also show that radioiodine releases have the potential for offsite exposures ranging up to about 100 rem to the thyroid. For such an exposure to occur, an individual would have to be located at a point on the site boundary where the radioiodine concentration in the plume has its highest value and inhale at a breathing rate characteristic of a person jogging, for a period of two hours. The health risk to an individual receiving such a thyroid exposure is the potential appearance of benign or malignant thyroid nodules in about 4 out of 100 cases, and the development of a fatal cancer in about 2 out of 1000 cases.

The realistically expected consequences, were one of these initiating events actually to occur, would be very substantially less. Therefore, the risk is judged to be extremely small for these design basis accidents. The subject of risk is more fully discussed in Section 7.1.4.6 below.

7.1.4.2 Probabilistic assessment of severe accidents

In this and the following three sections, there is a discussion of the probabilities and consequences of accidents of greater severity than the design basis accidents identified in the previous section. As a class, they are considered less likely to occur, but their consequences could be more severe, both for the plant itself and for the environment. These severe accidents, heretofore frequently called Class 9 accidents, can be distinguished from design basis accidents in two primary respects: they involve substantial physical deterioration of the fuel in the reactor core, including overheating to the point of melting, and they involve deterioration of the capability of the containment structure to perform its intended function of limiting the release of radioactive materials to the environment.

*The containment structure, however, is assumed to prevent leakage in excess of that which can be demonstrated by testing, as provided in 10 CFR Section 100.11(a).

The assessment methodology employed is that described in the Reactor Safety Study (RSS) which was published in 1975.[10*] The San Onofre Units 2 and 3 are Combustion Engineering-designed pressurized water reactors (PWR) having similar design and operating characteristics to the Surry Unit 1 facility used in the RSS as a prototype for PWRs. This assessment has used as its starting point, therefore, the same set of accident sequences that were found in the RSS to be dominant contributors to risk in the prototype PWR. The same set of nine release categories, designated PWR 1 through 9, have also been used to represent the spectrum of severe accident releases that are hypothesized for the San Onofre Units 2 and 3. Characteristics of these categories are shown in Table 7.3. Sequences initiated by natural phenomena such as tornadoes, floods, or seismic events and those that could be initiated by deliberate acts of sabotage are not included in these events sequences. The radiological consequences of such events would not be different in kind from those which have been treated. Moreover, it is the staff's judgment, based upon design requirements of 10 CFR Part 50, Appendix A, relating to effects of natural phenomena, and safeguards requirements of 10 CFR Part 73, that these events do not contribute significantly to risk. The facts upon which the staff based its Safe Shutdown Earthquake and its conclusions regarding the effects of natural phenomena on the plant are given in the Safety Evaluation Report.

A calculated probability per reactor year associated with each release category is also shown in the second column in Table 7.3. These probabilities are the result of a detailed engineering analysis of the prototype PWR in the Reactor Safety Study. There are substantial uncertainties in these probabilities. This is due, in part, to difficulties associated with the quantification of human error and to inadequacies in the data base on failure rates of individual plant components that were used to calculate the probabilities[11] (see Section 7.1.4.7 below). Also, the detailed engineering analysis represents a plant designed by a different nuclear steam supply system designer (CE versus Westinghouse) with different detailed designs. The probability of accident sequences from the Surry plant were used to give a perspective of the societal risk at San Onofre Units 2 and 3 because, although the probabilities of particular accident sequences may be substantially different, the overall effect of all sequences taken together is likely to be within the uncertainties. Except as indicated in the footnotes in Table 7.3, the staff has no present basis for judging whether the probabilities may be too high or too low. The error band for the probabilities of some of the event sequences could be as great as a factor of 100. The event sequences in categories PWR 1-7 lead to partial or complete melting of the reactor core while those in the last two categories do not involve melting of the core. In release categories 1 to 3, the event sequences include containment failure by steam explosion, hydrogen burning, or overpressure. In release categories 6 and 7, the dominant containment failure mode is by melt-through of the containment base mat. The other release categories contain event sequences in which the systems intended to isolate the containment fail to act properly.

The magnitudes (curies) of radioactivity releases for each category are obtained by multiplying the release fractions shown in Table 7.3 by the amounts that would be present in the core at the time of the hypothetical accident. These are shown in Table 7.1 for a San Onofre plant at a core thermal power level of 3560 megawatts.

The potential radiological consequences of these releases have been calculated by the consequence model used in the RSS[12] and adapted to apply to a specific site. The essential elements are shown in schematic form in Figure 7.1. Environmental parameters specific to the San Onofre site have been used and include the following:

(1) Meteorological data for the site representing a full year of consecutive hourly measurements and seasonal variations.

(2) Projected population in the United States and Mexico for the year 2000 extending throughout regions of 80 and 560 km (50 and 350 mi) radius from the site.

(3) The habitable land fraction within the 560-km (350-mi) radius.

(4) Land use statistics, on a state-wide basis, including farm land values, farm product values including dairy production, and growing season information, for the State of California and each surrounding State within the 560-km (350-mi) region.

(5) Land use statistics for Mexico on a country-wide basis. Farm land values, growing season information, and comparison between agriculture and dairy products are based on comparison with U.S. values for nearby States. Farm product values are based on Mexico-average Gross National Product and "agriculture" percentage.

*Because this report has been the subject of considerable controversy, a discussion of the uncertainties surrounding it is provided in Section 7.1.4-7.

Table 7.3

Summary of Atmospheric Release Categories Representing Hypothetical Accidents in a PWR

Release Category	Probability (reactor-yr^{-1})	Fraction of Core Inventory Released[a]						
		Xe-Kr	I	Cs-Rb	Te-Sb	Ba-Sr	Ru[b]	La[c]
PWR 1	5.1×10^{-8}[d]	0.9	0.7	0.4	0.4	0.05	0.4	3×10^{-3}
PWR 2	7×10^{-6}	0.9	0.7	0.5	0.3	0.06	0.02	4×10^{-3}
PWR 3	2.3×10^{-6}	0.8	0.2	0.2	0.3	0.02	0.03	3×10^{-3}
PWR 4	2.1×10^{-11}	0.6	0.09	0.04	0.03	5×10^{-3}	3×10^{-3}	4×10^{-4}
PWR 5	5×10^{-8}	0.3	0.03	9×10^{-3}	5×10^{-3}	1×10^{-3}	6×10^{-4}	7×10^{-5}
PWR 6	6×10^{-7}	0.3	3×10^{-3}	8×10^{-4}	1×10^{-3}	9×10^{-5}	7×10^{-5}	1×10^{-5}
PWR 7	4×10^{-5}	6×10^{-3}	4×10^{-5}	1×10^{-5}	2×10^{-5}	1×10^{-6}	1×10^{-6}	2×10^{-7}
PWR 8	4×10^{-5}	2×10^{-3}	1×10^{-4}	5×10^{-4}	1×10^{-6}	1×10^{-8}	0	0
PWR 9	4×10^{-4}	3×10^{-6}	1×10^{-7}	6×10^{-7}	1×10^{-9}	1×10^{-11}	0	0

(a) Background on the isotope groups and release mechanisms is presented in Appendix VII, WASH-1400 (Ref. 9).

(b) Includes Ru, Rh, Co, Mo, Tc.

(c) Includes, Y, La, Zr, Nb, Ce, Pr, Nd, Np, Pu, Am, Cm.

(d) Current understanding of the phenomenon of containment failure by steam explosion embodied in this release category indicates the probability should be lower than stated.

NOTE: Refer to Section 7.1.4.6 for a discussion of uncertainties in risk estimates.

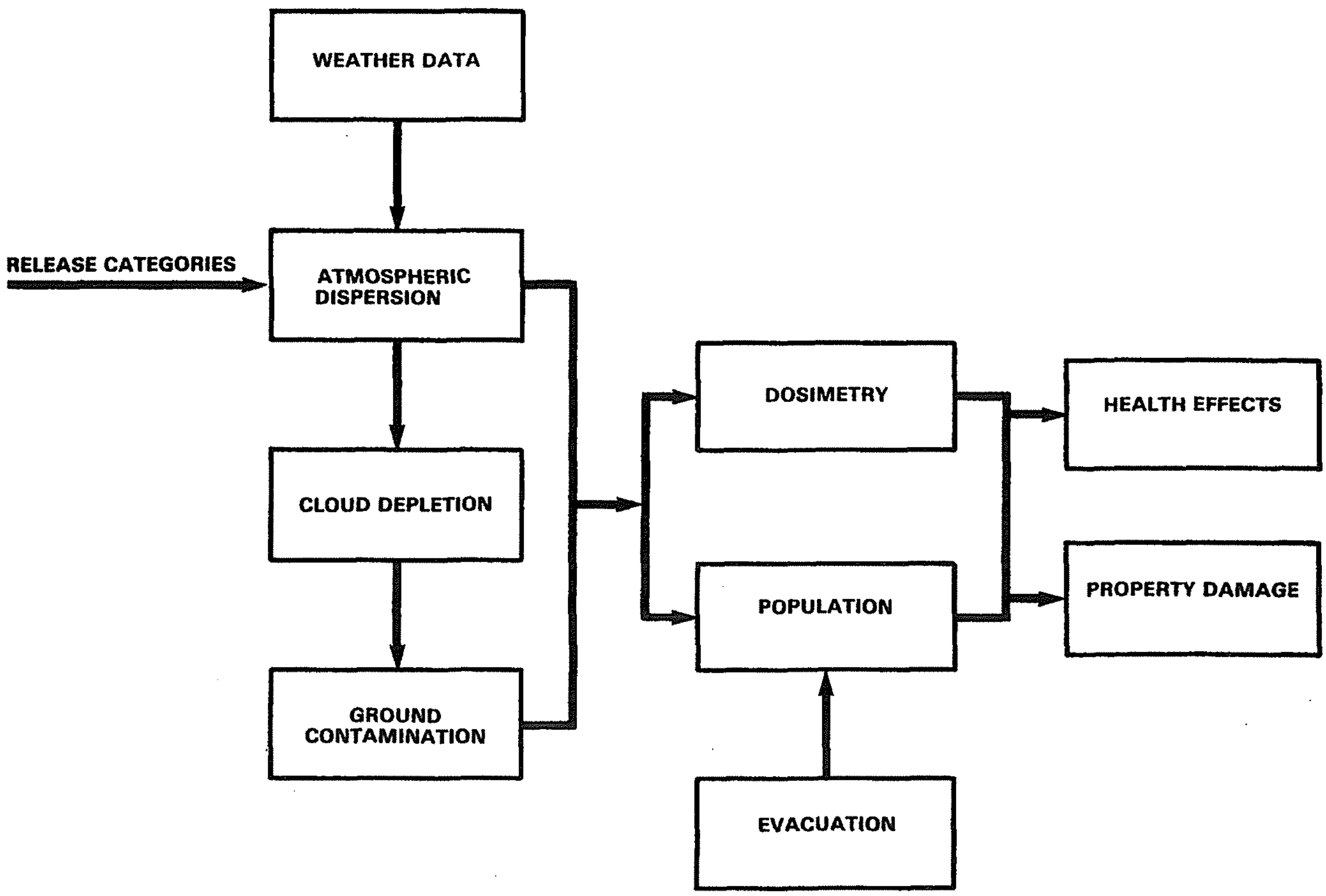

Figure 7.1 Schematic outline of consequence model

To obtain a probability distribution of consequences the calculations are performed assuming the occurrence of each accident release sequence at each of 91 different "start" times throughout a one-year period. Each calculation utilizes the site specific hourly meteorological data and seasonal information for the time period following each "start" time. The consequence model also contains provisions for incorporating the consequence reduction benefits of evacuation and other protective actions. Early evacuation of people would considerably reduce the exposure from the radioactive cloud and the contaminated ground in the wake of the cloud passage. The evacuation model used (see Appendix F) has been revised from that used in the RSS for better site-specific application. The quantitative characteristics of the evacuation model used for the San Onofre site are best estimate values made by the staff and based upon evacuation time estimates prepared by the applicant. Actual evacuation effectiveness could be greater or less than that characterized but would not be expected to be much less, even under adverse conditions.

The other protective actions include: (a) either complete denial of use (interdiction), or permitting use only at a sufficiently later time after appropriate decontamination of food stuffs such as crops and milk, (b) decontamination of severely contaminated environment (land and property) when it is considered to be economically feasible to lower the levels of contamination to protective action guide (PAG) levels, and (c) denial of use (interdiction) of severely contaminated land and property for varying periods of time until the contamination levels reduce to such values by radioactive decay and weathering so that land and property can be economically decontaminated as in (b) above. These actions would reduce the radiological exposure to the people from immediate and/or subsequent use of or living in the contaminated environment.

Early evaucation and other protective actions as mentioned above are considered as essential sequels to serious nuclear reactor accidents involving significant release of radioactivity to the atmosphere. Therefore, the results shown for San Onofre reactor include the benefits of these protective actions.

There are also uncertainties in the estimates of consequences, and the error bounds may be as large as they are for the probabilities. It is the judgment of the staff, however, that it is more likely that the calculated results are overestimates of consequences rather than underestimates.

The results of the calculations using this consequence model are radiological doses to individuals and to populations, health effects that might result from these exposures, costs of implementing protective actions, and costs associated with property damage by radioactive contamination.

7.1.4.3 Dose and health impacts of atmospheric releases

The results of the calculations of dose and health impacts performed for the San Onofre facility and site are presented in the form of probability distributions in Figures 7.2 through 7.5 and are included in the impact Summary Table 7.4. All of the nine release categories shown in Table 7.3 contribute to the results, the consequences from each being weighted by its associated probability.

Figure 7.2 shows the probability distribution for the number of persons who might receive whole body doses equal to or greater than 200 rem and 25 rem, and thyroid doses equal to or greater than 300 rem from early exposure,* all on a per-reactor-year basis. The 200 rem whole body dose figure corresponds approximately to a threshold value for which hospitalization would be indicated for the treatment of radiation injury. The 25 rem whole body (which has been identified earlier as the lower limit for clinically obervable physiological effects in nearly all people) and 300 rem thyroid figures correspond to the Commission's guidelines values for reactor siting in 10 CFR Part 100.

The figure shows in the left-hand portion that there is less than 1 chance in 100,000 per year (i.e. 10^{-5}) that one or more persons may receive doses equal to or greater than any of the doses specified. The fact that the three curves run almost parallel in horizontal lines initially shows that if one person were to receive such doses, the chances are about the same that several tens to hundreds would be so exposed. The chances of larger numbers of persons being exposed at those levels are seen to be considerably smaller. For example, the chances are about 1 in 100,000,000 (i.e. 10^{-8}) that 100,000 or more people might receive doses of 200 rem or greater. A majority of the exposures reflected in this figure would be expected to occur to persons within a 80-km (50-mi) radius of the plant. Virtually all would occur with a 160-km (100-mi) radius.

*The containment structure, however, is assumed to prevent leakage in excess of that which can be demonstrated by testing, as provided in 10 CFR Section 100.11(a).

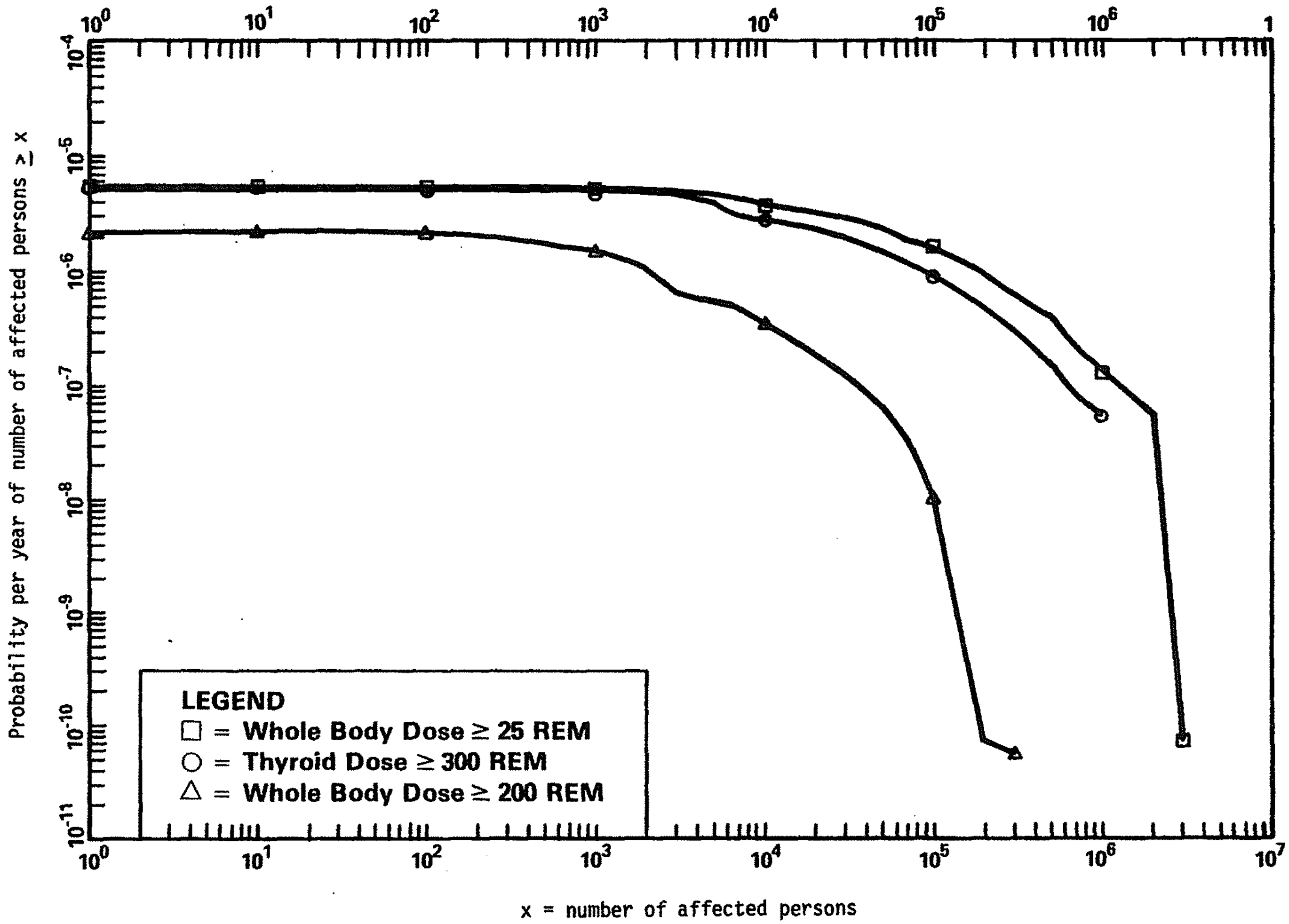

Figure 7.2 Probability distribution of individual dose impacts
(See Section 7.1.4.6 for a discussion of uncertainties in risk estimates.)

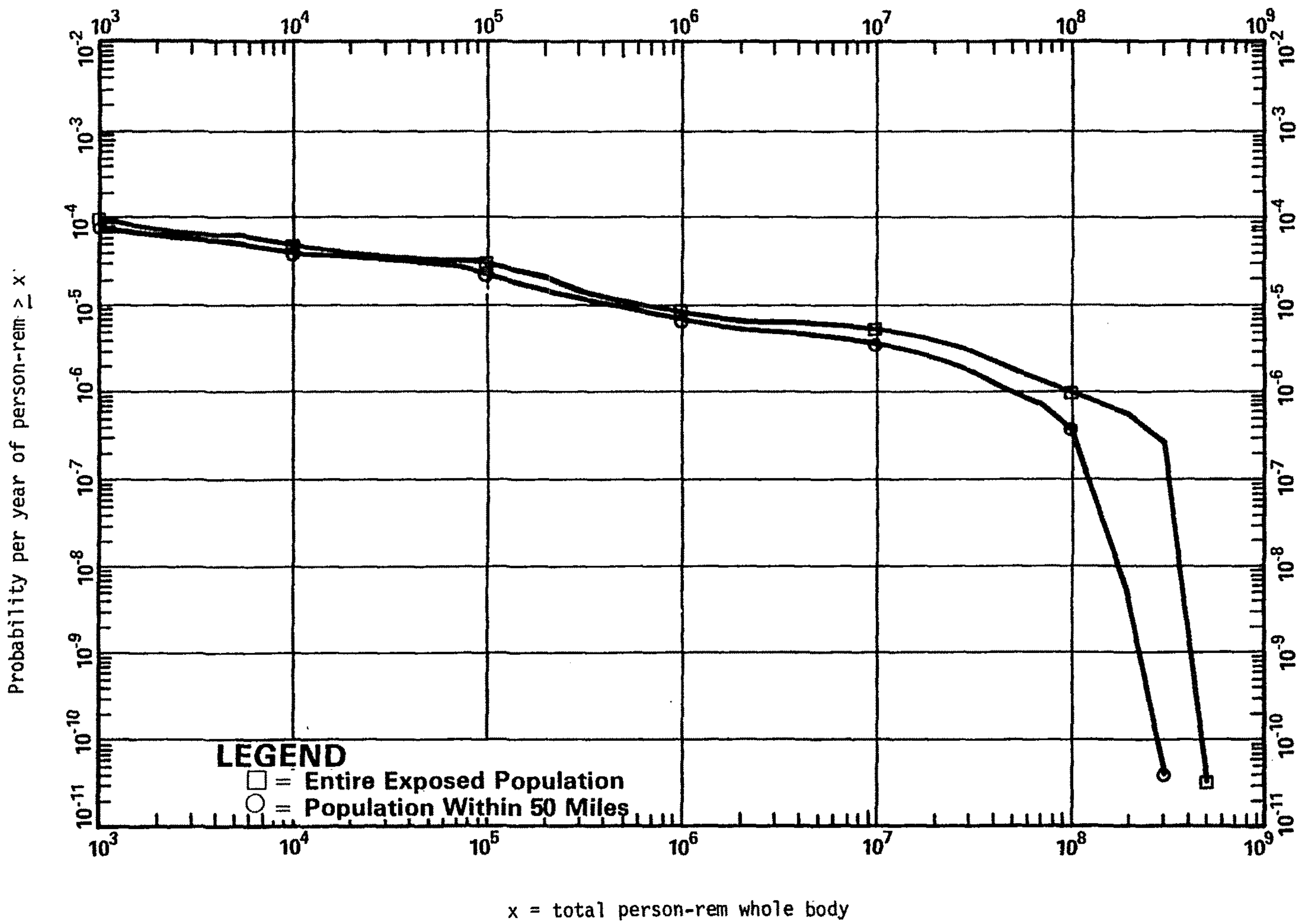

Figure 7.3 Probability distribution of population exposures. (See Section 7.1.4.6 for discussion of uncertainties in risk estimates.) (To convert miles to kilometers, multiply by 1.6.)

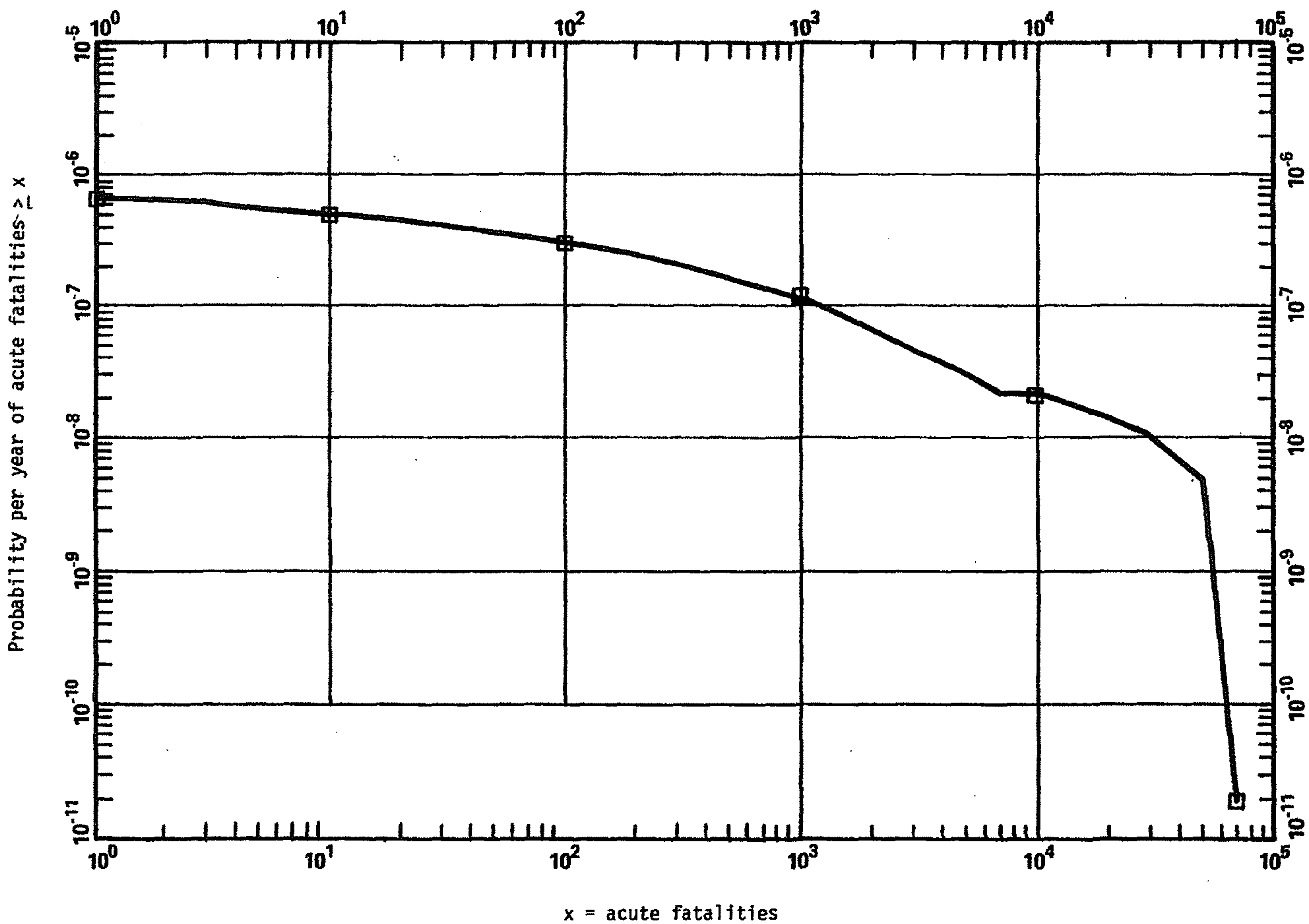

Figure 7.4 Probability distribution of acute fatalities. (See Section 7.1.4.6 for discussion of uncertainties in risk estimates.)

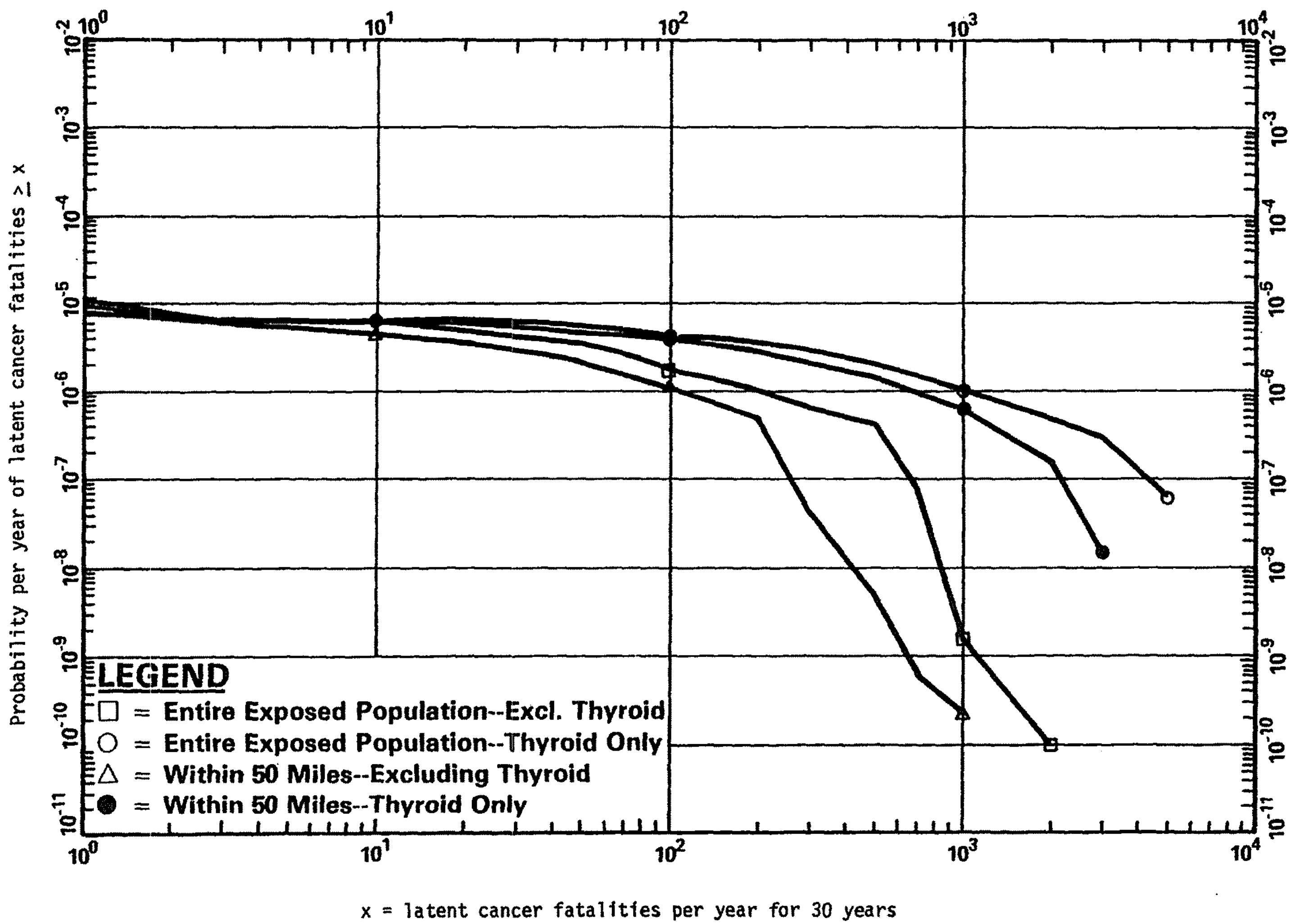

Figure 7.5 Probability distribution of cancer fatalities. (See Section 7.1.4.6 for discussion of uncertainties in risk estimates.) (To convert miles to kilometers, multiply by 1.6.)

Table 7.4 Summary of Environmental Impacts and Probabilities

Probability of impact per year	Persons exposed over 200 rem	Persons exposed over 25 rem	Acute fatalities	Population exposure, millions of man-rem 80 km/total	Latent* cancers, 80 km/total	Cost of offsite mitigating actions, $ millions
10^{-4}	< 1	< 1	< 1	< 0.001	< 60	< 0.001
10^{-5}	< 1	< 1	< 1	0.4/0.6	< 60	12
5×10^{-6}	< 1	160	< 1	2/10	1,400/2,500	400
10^{-6}	2,000	190,000	< 1	45/100	23,000/36,000	5,000
10^{-7}	31,000	1,100,000	1,100	110/300	71,000/143,000	15,000
10^{-8}	100,000	2,000,000	30,000	170/340	12,000/24,000	35,000
Related Figure	7.2	7.2	7.4	7.3	7.5	7.6

*Genetic effects would be approximately twice the number of latent cancers. Thirty times the values shown in the Figure 7.5 are shown in this column reflecting the 30-year period over which they might occur.

NOTE: Refer to Section 7.1.4.6 for a discussion of uncertainties in risk estimates.

Figure 7.3 shows the probability distribution for the total population exposure in person-rem, i.e., the probability per reactor-year that the total population exposure will equal or exceed the values given. A substantial fraction of the population exposure would occur within 80 km (50 mi) but the more severe releases (PWR 1-6) would result in exposure to persons beyond the 80-km (50-mi) range as shown.

For perspective, population doses shown in Figure 7.3 may be compared with the annual average dose to the population within 80 km (50 mi) of the San Onofre site due to natural background radiation of 700,000 man-rem, and to the anticipated annual population dose to the general public from normal station operation of 460 man-rem (excluding plant workers) (Section 5, Table 5.3 and 5.5).

Figure 7.4 shows the probability distribution for acute fatalities, representing radiation injuries that would produce fatalities within about one year after exposure. Virtually all of the acute fatalities would be expected to occur within a 64-km (40-mi) radius. The results of the calculations shown in this figure and in Table 7.4 reflect the effect of evacuation within the 16-km (10-mi) plume exposure pathway EPZ only. For the very low probability accidents having the potential for causing radiation exposure above the threshold for acute fatality at distances beyond 16 km (10 mi), it would be realistic to expect that authorities would evacuate persons at all distances at which such exposures might occur. Acute fatality consequences would therefore reasonably be expected to be very much less than the numbers shown.

Figure 7.5 represents the statistical relationship between population exposure and the induction of fatal cancers that might appear over a period of many years following exposure. The impacts on the total population and the population within 80 km (50 mi) are shown separately. Further, the fatal, latent cancers have been subdivided into those attributable to exposures of the thyroid and all other organs.

7.1.4.4 Economic and societal impacts

As noted in Section 7.1.1, the various measures for avoidance of adverse health effects including those due to residual radioactive contamination in the environment are possible consequential impacts of severe accidents. Calculations of the probabilities and magnitudes of such impacts for the San Onofre facility and environs have also been made. Unlike the radiation exposure and adverse health effect impacts discussed above, impacts associated with adverse health effects avoidance are more readily transformed into economic impacts.

The results are shown as the probability distribution for costs of offsite mitigating actions in Figure 7.6 and are included in the impact Summary Table 7.4. The factors contributing to these estimated costs include the following:

- o Evacuation costs
- o Value of crops contaminated and condemned
- o Value of milk contaminated and condemned
- o Costs of decontamination of property where practical
- o Indirect costs due to loss of use of property and incomes derived therefrom.

The last named costs would derive from the necessity for interdiction to prevent the use of property until it is either free of contamination or can be economically decontaminated.

Figure 7.6 shows that at the extreme end of the accident spectrum these costs could exceed tens of billions of dollars but that the probability that this would occur is exceedingly small, less than one chance in a hundred million per year.

Additional economic impacts that can be monetized include costs of decontamination of the facility itself and the costs of replacement power. Probability distributions for these impacts have not been calculated, but they are included in the discussion of risk considerations in Section 7.1.4.6 below.

7.1.4.5 Releases to groundwater

A pathway for public radiation exposure and environmental contamination that could be associated with severe reactor accidents was identified in Section 7.1.1.2 above. Consideration has been given to the potential environmental impact of this pathway for the San Onofre plant. The principal contributors to the risk are the core melt accidents associated with the PWR-1 through 7 release categories. The penetration of the basemat of the

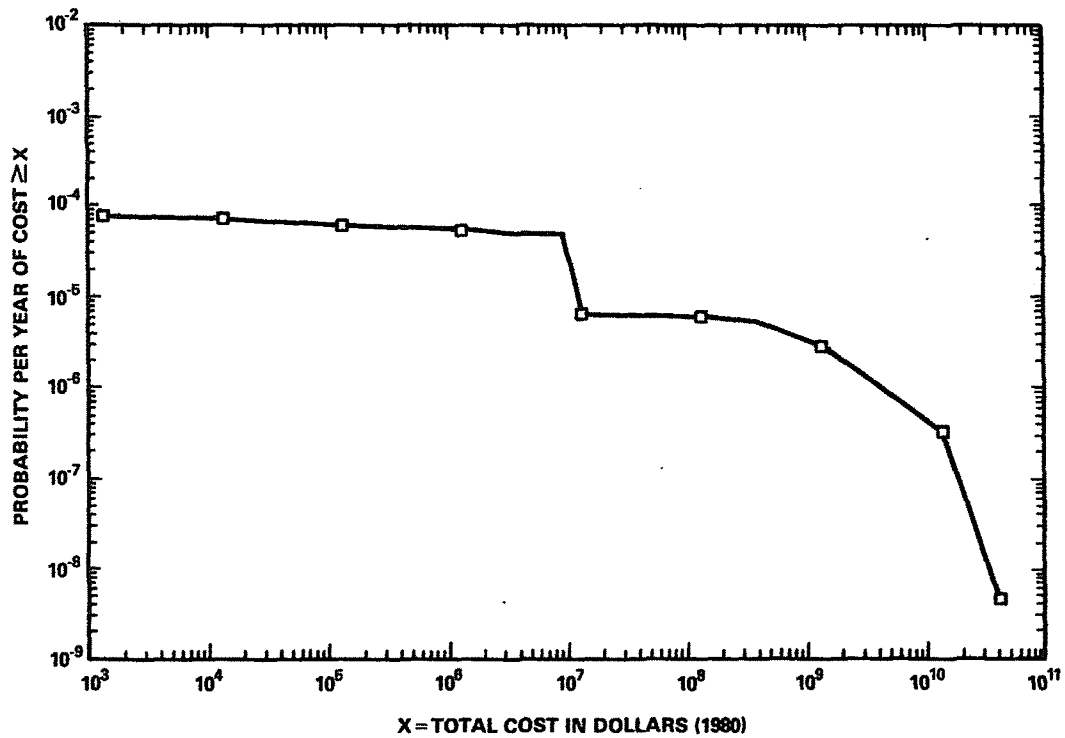

Figure 7.6 Probability distribution of cost of offsite mitigative measures

containment building can release molten core debris to the strata beneath the plant. Soluble radionuclides in this debris can be leached and transported with groundwater to downgradient domestic wells used for drinking or to surface water bodies used for drinking water, aquatic food and recreation. In pressurized water reactors, such as the San Onofre unit, there is an additional opportunity for groundwater contamination due to the release of contaminated sump water to the ground through a breach in the containment.

An analysis of the potential consequences of a liquid pathway release of radioactivity for generic sites was presented in the "Liquid Pathway Generic Study" (LPGS).[13] The LPGS compared the risk of accidents involving the liquid pathway (drinking water, irrigation, aquatic food, swimming and shoreline usage) for four conventional, generic land-based nuclear plants and a floating nuclear plant, for which the nuclear reactors would be mounted on a barge and moored in a water body. Parameters for the land-based sites were chosen to represent averages for a wide range of real sites and are thus "typical," but represented no real site in particular.

The discussion in this section is an analysis to determine whether or not the San Onofre site liquid pathway consequences would be unique when compared to land-based sites considered in the LPGS. The method consists of a direct scaling of the LPGS population doses based on the relative values of key parameters characterizing the LPGS "ocean" site and the San Onofre site. The parameters which were evaluated included amounts of radioactive materials entering the ground, groundwater travel time, sorption on geological media, surface water transport, aquatic food consumption, and shoreline usage.

Doses to individuals and populations were calculated in the LPGS without consideration of interdiction methods such as isolating the contaminated groundwater or denying use of the water. In the event of surface water contamination, commercial and sports fishing, as well as many other water-related activities would be restricted. The consequences would therefore be largely economic or social, rather than radiological. In any event, the individual and population doses for the liquid pathway range from fractions to very small fractions of those that can arise from the airborne pathways.

The San Onofre reactors are situated above the San Mateo Formation, which is about 274-m (876.8-ft) thick and consists of medium to coarse-grained sandstone.[2] Groundwater at the site occurs between elevation 0 and 1.5 m (4.8 ft) Mean Low-Low Water, under water table conditions. The basemat of the reactors would be beneath the water table.

The groundwater gradient is clearly toward the ocean. There are no wells between the site and the ocean, so no groundwater users could be affected by an accidental contamination from the plant. There is virtually no possibility of a reversal of the groundwater gradient due to heavy pumping inland, particularly because such a reversal would at the same time cause an unacceptable intrusion of saltwater into the aquifer. Therefore, liquid radioactivity released from a core melt accident could only cause contamination by being transported through the groundwater and subsequently released to the Pacific Ocean.

The staff's most conservative estimate of the groundwater travel time would be 215 days. For groundwater travel times of this magnitude, it is clear that the most important radionuclide contributors to the liquid pathway population dose would be Sr-90 and Cs-137. Conservative values of the retardation factors, which reflect the effects of sorption of the radionuclides on geologic materials, were estimated on media similar to the granular materials under the site[14] to be 31 for Sr-90 and 2204 for Cs-137. The mean transport time from the reactor building to the Pacific Ocean is therefore conservatively estimated to be about 16 years for Sr-90 and 1080 years for Cs-137. When these travel times are compared to 5.7 years for Sr-90 and 51 years for Cs-137 in the LPGS land-based ocean site case, the relatively larger travel times for the San Onofre site would allow a smaller portion of the radioactivity to enter the surface water. This reduces the Sr-90 release to about 78% of the LPGS value. Virtually all of the Cs-137 would have decayed before reaching surface water.

Contaminants released from the shoreline would disperse in the oceanic turbulence. The LPGS made no distinction between the turbulence which would be found in the east, gulf, or west coasts of the United States. The only assumption which can be made without site-specific data is that the mixing at the San Onofre and LPGS sites are similar.

The two major liquid pathway exposure pathways for an ocean site are aquatic food consumption and direct shoreline exposure.

The commercial and recreational finfish harvest for a rectangular block 80 km along shore and stretching 40 km offshore has been estimated by the staff from data provided in the

Environmental Report[15] to be about 13.1×10^6 kg. For comparison, the same size block using the LPGS ocean site fish catch densities would yield 5.8×10^6 kg of finfish.

Approximately 62% of population dose due to finfish consumption calculated in the LPGS was due to Cs-137 and approximately 38% was due to Sr-90. The only significant radionuclide which could reach the ocean in the San Onofre case would be Sr-90. The staff has conservatively estimated that the uninterdicted population dose in the San Onofre case would be about 69% of the LPGS land-based ocean case population dose for seafood consumption.

Nearly all of the direct shoreline exposure in the LPGS ocean-based site case was determined to emanate from Cs-137. Since virtually all of the Cs-137 would decay before reaching the ocean, the shoreline direct exposure can be eliminated from further consideration.

The San Onofre liquid pathway contribution to population dose has, therefore, been demonstrated to be smaller than that predicted for the LPGS land-based ocean site, which represents a "typical" ocean site. Thus, the San Onofre site is not unique in its liquid pathway contribution to risk.

There are measures which could be taken to minimize the impact of the liquid pathway. The staff estimated that the minimum groundwater travel time from the San Onofre site to the Pacific Ocean would be hundreds of days. In addition, the holdup of important radionuclides would provide additional time to utilize engineering measures such as slurry walls and well-point dewatering to isolate the radioactive contaminants at the source.

7.1.4.6 Risk considerations

The foregoing discussions have dealt with both the frequency (or likelihood of occurrence) of accidents and their impacts (or consequences). Since the ranges of both factors are quite broad, it is useful to combine them to obtain average measures of environmental risk. Such averages can be particularly instructive as an aid to the comparison of radiological risks associated with accident releases and with normal operational releases.

A common way in which this combination of factors is used to estimate risk is to multiply the probabilities by the consequences. The resultant risk is then expressed as a number of consequences expected per unit of time. Such a quantification of risk does not at all mean that there is universal agreement that people's attitudes about risk, or what constitutes an acceptable risk, can or should be governed solely by such a measure. At best, it can be a contributing factor to a risk judgment, but not necessarily a decisive factor.

In Table 7.5 are shown average values of risk associated with population dose, acute fatalities, latent fatalities, and costs for evacuation and other protective actions. These average values are obtained by summing the probabilities multiplied by the consequences over the entire range of the distributions. Since the probabilities are on a per-year basis, the averages shown are also on a per-year basis.

Table 7.5 Annual Average Values of Environmental Risks Due to Accidents

Population exposure	
man-rem within 80 km	170
man-rem total	380
Acute fatalities	
permanent residents	0.001
beach visitors	0.00002
Latent cancer fatalities	
all organs excluding thyroid	0.022
thyroid only	0.011
Cost of protective actions and decontamination	$19,000

NOTE: See Section 7.1.4.6 for discussions of uncertainties in risk estimates.

The population exposure risk due to accidents may be compared with that for normal operational releases. These are shown in Section 5, Tables 5.3 and 5.5, for San Onofre Units 2 and 3 operating concurrently. The radiological dose to the population from normal operational releases may result in:

(1) late somatic effects in the form of fatal and nonfatal cancer in various body organs--following age and organ-specific latency periods--of the exposed population, and

(2) fatal and nonfatal genetic disorders in the future generations of the exposed population.

Because of the randomness of these effects, calculations of these effects are made from the population dose (man-rem). Absolute risk estimators of 140 deaths from expression of latent cancer in various body organs per 10^6 total-body man-rem in the exposed population and 260 cases of all forms of genetic disorders per 10^6 total-body man-rem in the future generations of the exposed population were derived from the 1972 BEIR report.[5] This derivation assumes a linear and nonthreshold dose-effect relationship at all sublethal dose levels. Using these risk estimators and 228 man-rem as the annual population dose (Table 5.5, adjusted for one reactor), the staff calculated that there may occur 0.03 cancer deaths in the exposed population and 0.06 genetic disorders in all future generatons of the exposed population from each year of operation of one reactor.

The comparison of 0.03 cancer deaths given above with about the same value for latent cancer deaths from Table 7.1.4-5 shows that the accident risks are comparable to those for normal operational releases.

There are no acute fatality nor economic risks associated with protective actions and decontamination for normal releases; therefore, these risks are unique for accidents. For perspective and understanding of the meaning of the acute fatality risk of 0.001 per year, however, the staff notes that to a good approximation the population at risk is that within about 16 km (10 mi) of the plant, about 92,000 persons in the year 2000. Accidental fatalities per year for a population of this size, based upon overall averages for the United States, are approximately 20 for motor vehicle accidents, 7 from falls, 3 from drowning, 3 from burns, and 1 from firearms (ref. 5, p. 577).

As a separate item under acute fatalities in Table 7.5 is an entry of 0.00002 for "Beach visitors." As discussed in Section 7.1.3.2, the beaches near the site are heavily used for recreation. The average number of visitors has been estimated, based on seasonal and daily variation. The effects on the visitors are tallied separately because in actuality they are likely to be permanent residents from other nearby locations.

Figure 7.7 shows the calculated risk expressed as whole-body dose to an individual from early exposure as a function of the distance from the plant within the plume exposure pathway EPZ. The values are on a per-reactor-year basis and all accident sequences and release categories in Table 7.3 contributed to the dose, weighted by their associated probabilities. Calculated risk to an individual living within the plume exposure pathway EPZ of San Onofre of acute death due to potential accidents in the reactor is shown in Figure 7.8 as curves of constant risk per year to an individual as a function of distance due to potential reactor accidents. Figure 7.9 shows the same type of isopleths for death from latent cancer. Directional variation of these curves reflect the variation in the average fraction of the year the wind would be blowing into different directions from the plant. For comparison the following risk of fatality per year to an individual living in the U.S. may be noted (ref. 4, p. 577); automobile accident 2.2×10^{-4}, falls 7.7×10^{-5}, drowning 3.1×10^{-5}, burning 2.9×10^{-5}, and firearms 1.2×10^{-5}.

The economic risk associated with protective actions and decontamination could be compared with property damage costs associated with alternative energy generation technologies. The use of fossil fuels, coal or oil, for example, would emit substantial quantities of sulfur dioxide and nitrogen oxides into the atmosphere, and, among other things, lead to environmental and ecological damage through the phenomenon of acid rain (Ref. 4, 559-560). This effect has not, however, been sufficiently quantified to draw a useful comparison at this time.

There are other economic impacts and risks that can be monetized that are not included in the cost calculations discussed in Section 7.1.4.4. These are accident impacts on the facility itself that result in added costs to the public, i.e., ratepayers, taxpayers, and/or shareholders. These are costs associated with decontamination of the facility itself and costs for replacement power.

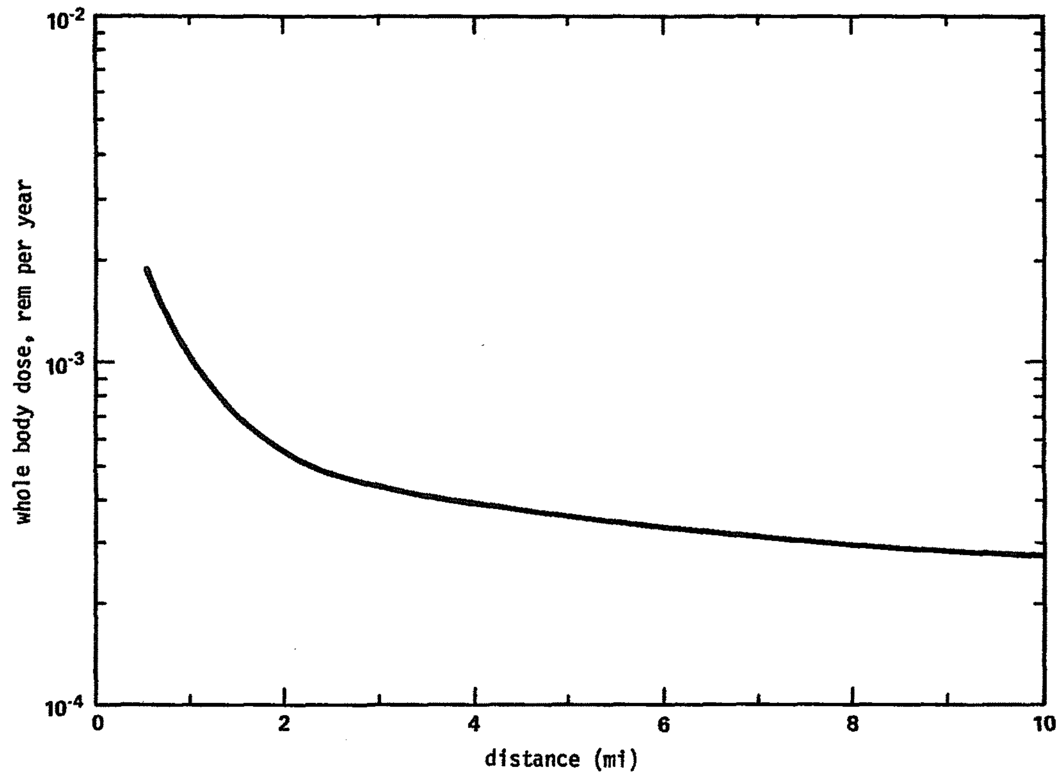

Figure 7.7 Individual risk of dose as a function of distance. (To convert mi to km, multiply by 1.6.)

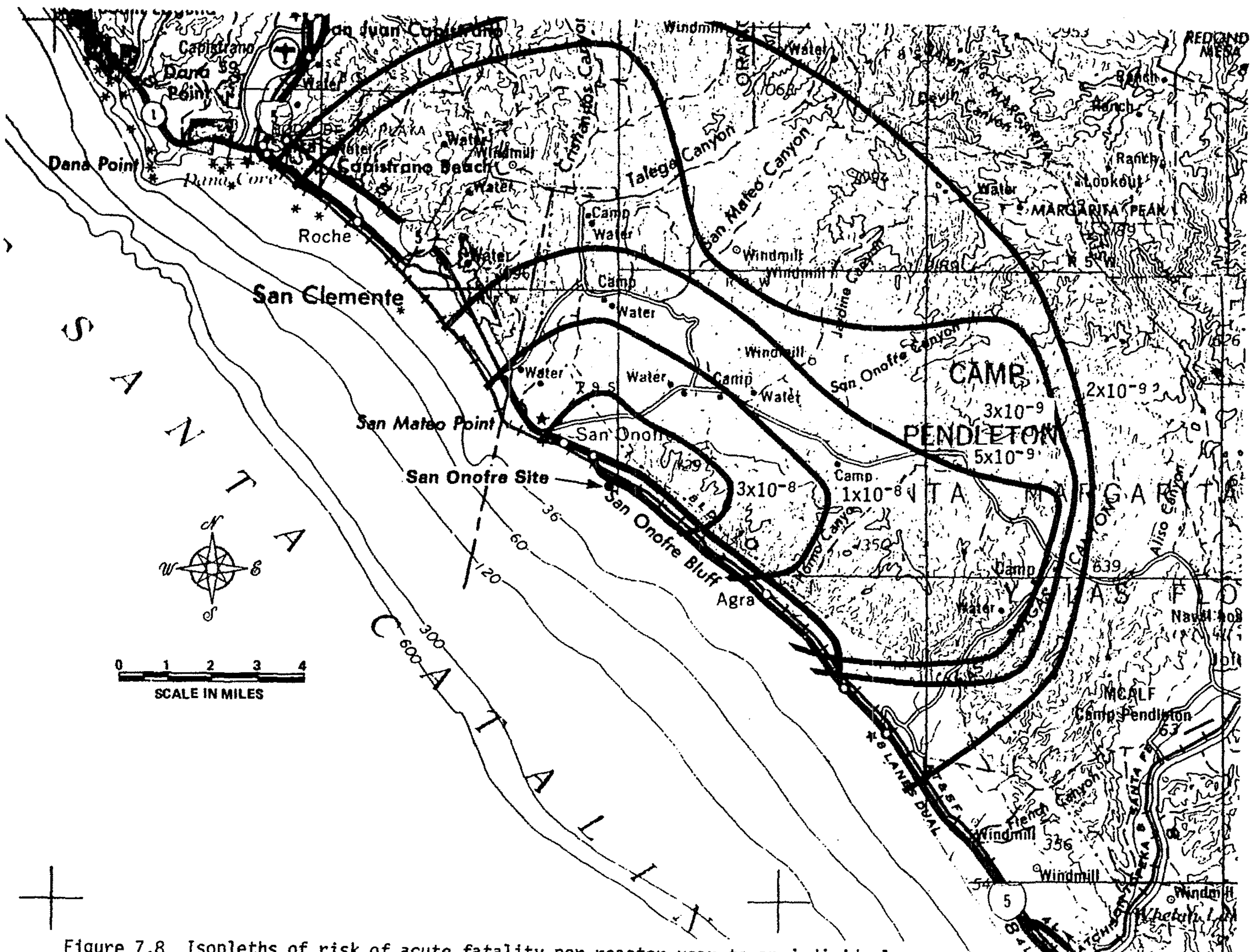

Figure 7.8 Isopleths of risk of acute fatality per reactor year to an individual. (See Section 7.1.4.6 for a discussion of uncertainties in risks estimates.) (To convert miles to kilometers, multiply by 1.6.)

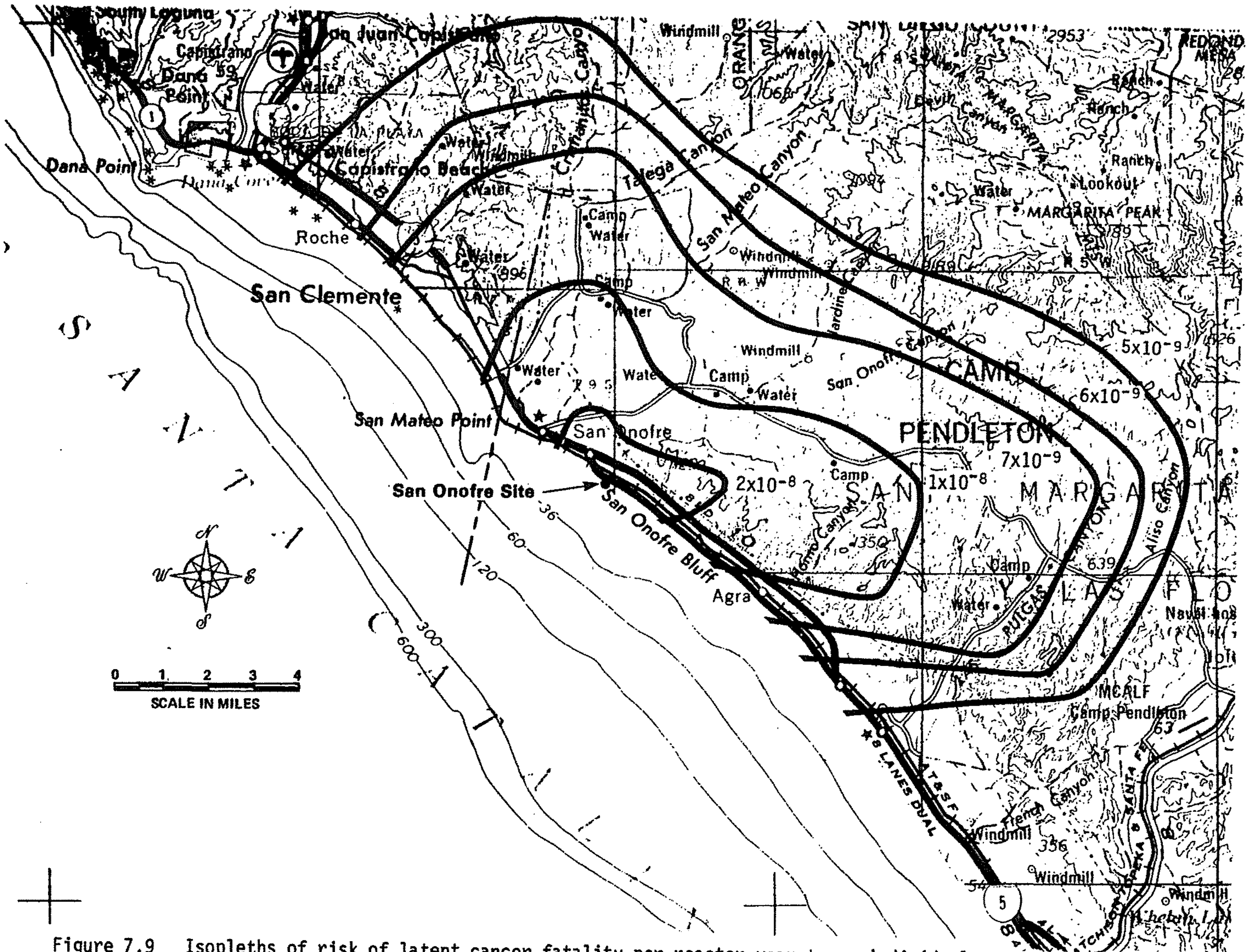

Figure 7.9 Isopleths of risk of latent cancer fatality per reactor year to an individual. (See Section 7.1.4.6 for a discussion of uncertainties in risks estimate.) (To convert miles to kilometers, multiply by 1.6.)

No detailed methodology has been developed for estimating the contribution to economic risk associated with cleanup and decontamination of a nuclear power plant that has undergone a serious accident toward either a decommissioning or a resumption of operation. Experience with such costs is currently being accumulated as a result of the Three Mile Island accident. It is already clear, however, that such costs can approach or even exceed the original capital cost of such a facility. As an illustration of the possible contribution to the economic risk, if the probability of an accident serious enough to require extensive cleanup and decontamination is taken as the sum of the nine categories in Table 7.3, i.e., about 5 chances in 10,000 per year, and if the "average" decontamination cost for these nine categories is assumed to be one billion dollars, then the estimated economic risk would be about $500,000 per year.

Other costs, besides damage to or loss of the facility, result from accidents. The major additional costs are replacement power and replacement of the capacity. These costs are affected by the point in the lifetime of the plant at which an accident might occur. The present worth cost is highest for an accident occurring at the beginning of the plant operating life and decreases over the plant life. It is assumed for these calculations that one unit of San Onofre 2 or 3 is permanently lost and replaced by new capacity after eight years and the undamaged unit is shut down for three years before restart. For illustrative purposes, the costs and economic risk have been estimated for a "worst case" situation for the approximately 2200-megawatt (electric) San Onofre Units 2 and 3 complex by postulating a total loss of one of the units in the first year of a projected 30-year operating life. Net replacement power cost of 45 mills/kWh is assumed (nearly all fossil units in southern California are oil-fired). Using a 60% capacity factor, the annual cost of replacement power would be $520 million for the two units in 1980 dollars. The additional capital costs as a result of having to construct a new facility are $60 million per year, again in 1980 dollars.

If the probability of sustaining a total loss of the original facility is taken as the probability of the occurrence of a core melt accident (approximately by the sum of probabilities for the categories PWR-1 through 7 in Table 7.3, i.e., about 5 chances in 100,000 per year), then the average contribution to economic risk that would result from a loss early in the operating life of a San Onofre unit is about $29,000 for each of the first three years until the undamaged plant is returned to service, then $16,000 per year until the damaged unit is replaced, and $3000 per year additional capital costs for the assumed remaining 22 years of plant service.

7.1.4.7 <u>Uncertainties</u>

The foregoing probabilistic and risk assessment discussion has been based upon the methodology presented in the Reactor Safety Study (RSS),[10] which was published in 1975.

In July 1977, the NRC organized an Independent Risk Assessment Review Group to (1) clarify the achievements and limitations of the Reactor Safety Study Group, (2) assess the peer comments thereon and the responses to the comments, (3) study the current state of such risk assessment methodology, and (4) recommend to the Commission how and whether such methodology can be used in the regulatory and licensing process. The results of this study were issued September 1978.[11] This report, called the Lewis Report, contains several findings and recommendations concerning the RSS. Some of the more significant findings are summarized below.

(1) A number of sources of both conservatism and nonconservatism in the probability calculations in RSS were found, which were very difficult to balance. The Review Group was unable to determine whether the overall probability of a core melt given in the RSS was high or low, but they did conclude that the error bands were understated.

(2) The methodology, which was an important advance over earlier methodologies that had been applied to reactor risk, was sound.

(3) It is very difficult to follow the detailed thread of calculations through the RSS. In particular, the Executive Summary is a poor description of the contents of the report, should not be used as such, and has lent itself to misuse in the discussion of reactor risk.

On January 19, 1979, the Commission issued a statement of policy concerning the RSS and the Review Group Report. The Commission accepted the findings of the Review Group.

The accident at Three Mile Island occurred in March 1979 at a time when the accumulated experience record was about 400 reactor years. It is of interest to note that this was within the range of frequencies estimated by the RSS for an accident of this severity (ref. 4, p. 533). It should also be noted that the Three Mile Island accident has resulted in a very comprehensive evaluation of reactor accidents like that one, by a significant number of investigative groups both within NRC and outside of it. Actions to improve the safety of nuclear power plants have come out of these investigations, including those from the President's Commission on the Accident at Three Mile Island, and NRC staff investigations and task forces. A comprehensive "NRC Action Plan Developed as a Result of the TMI-2 Accident," NUREG-0660, Vol. I, May 1980 collects the various recommendations of these groups and describes them under the subject areas of: Operational Safety; Siting and Design; Emergency Preparedness and Radiation Effects; Practices and Procedures; and NRC Policy, Organization and Management. The action plan presents a sequence of actions, some already taken, that will result in a gradually increasing improvement in safety as individual actions are completed. The San Onofre plant is receiving and will receive the benefit of these actions on the schedule indicated in NUREG-0660. The improvement in safety from these actions has not been quantified, however, and the radiological risk of accidents discussed in this chapter does not reflect these improvements.

7.1.5 Conclusions

The foregoing sections consider the potential environmental impacts from accidents at the San Onofre facility. These have covered a broad spectrum of possible accidental releases of radioactive materials into the environment by atmospheric and groundwater pathways. Included in the considerations are postulated design basis accidents and more severe accident sequences that lead to a severely damaged reactor core or core melt.

The environmental impacts that have been considered include potential radiation exposures to individuals and to the population as a whole, the risk of near- and long-term adverse health effects that such exposures could entail, and the potential economic and societal consequences of accidental contamination of the environment. These impacts could be severe, but the likelihood of their occurrence is judged to be small. This conclusion is based on (a) the fact that considerable experience has been gained with the operation of similar facilities without significant degradation of the environment; and (b) a probabilistic assessment of the risk based upon the methodology developed in the Reactor Safety Study. The overall assessment of environmental risk of accidents, assuming protective action, shows that it is roughly comparable to the risk for normal operational releases although accidents have a potential for acute fatalities and economic costs that cannot arise from normal operations. The risk of acute fatalities from potential accidents at the site are small in comparison with the risk of acute fatalities from other human activities in a comparably-sized population.

The staff has concluded that there are no special or unique features about the San Onofre site and environs that would warrant special or additional engineered safety features for the San Onofre plants.

REFERENCES

1. Statement of Interim Policy, "Nuclear Power Plant Accident Considerations Under the National Environmental Policy Act of 1969," 45 Federal Register 40101-40104, June 13, 1980.*

2. "Final Safety Analysis Report (FSAR), San Onofre Nuclear Generating Station Units 2 and 3, Docket Numbers 50-361 and 50-362," Southern California Edison Company and San Diego Gas and Electric Company, December 1, 1976, as amended.*

3. "Safety Evaluation Report related to the operation of San Onofre Nuclear Generating Station, Units 2 and 3 Docket Numbers 50-361 and 50-362," NUREG-0712, February 1981, as supplemented.**

4. "Energy in Transition 1985 - 2010," Final Report of the Committee on Nuclear and Alternative Energy Systems (CONAES), Chapter 9, pp. 517-534, National Research Council, 1979 (available in public technical libraries) (also C.E. Land, Science 209, 1197, September 12, 1980).

5. "The Effects on Populations of Exposure to Low Levels of Ionizing Radiation," Advisory Committee on the Biological Effects of Ionizing Radiations (BEIR), National Academy of Sciences/National Research Council November 1972.***

6. "The Effects on Populations of Exposure to Low Levels of Ionizing Radiation," Committee on the Biological Effects of Ionizing Radiations (BEIR), National Academy of Sciences/National Research Council, July 1980.***

7. H.W. Bertini and others, "Descriptions of Selected Accidents that Have Occurred at Nuclear Reactor Facilities," Nuclear Safety Information Center, Oak Ridge National Laboratory, ORNL/NSIC-176, April 1980;*** also, "Evaluation of Steam Generator Tube Rupture Accidents," L.B. Marsh, USNRC Report NUREG-0651, March 1980.**

8. "Three Mile Island - A Report to the Commissioners and the Public," Vol. I, Mitchell Rogovin, Director, Nuclear Regulatory Commission Special Inquiry Group, January 1980, Summary Section 9.*

9. "Report of the President's Commission on the Accident at Three Mile Island," October 1979, Commission Findings B, Health Effects.*

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11. H. W. Lewis and others, "Risk Assessment Review Group Report to the U.S. Nuclear Regulatory Commission," NUREG-CR-0400, September 1978.**

12. "Overview of the Reactor Safety Study Consequences Model," USNRC Report NUREG-0340, October 1977.**

13. "Liquid Pathway Generic Study," USNRC Report NUREG-0440, February 1978.**

14. Dana Isherwood, "Preliminary Report on Retardation Factors and Radionuclides Migration," Lawrence Livermore Laboratories, UCID-A3.44, August 5, 1977 (available in public technical libaries).

15. San Onofre Nuclear Generating Station Units 2 and 3, Applicant's Environmental Report, Operating License Stage, Volume 2, November 1976.*

*Available for inspection and copying for a fee in the NRC Public Document Room, 1717 H St. N. W., Washington, DC 20555.
**Available from the NRC/GPO Sales Program, Washington, D. C. 20555 and the National Technical Information Service, Springfield, VA, 22161.
***Available from NTIS only.

8. NEED FOR THE STATION

8.1 RESUME

The ownership of Units 2 and 3 of the San Onofre Nuclear Generating Station is divided among Southern California Edison Company (SCE), 76.55%; San Diego Gas & Electric Company (SDG&E) 20%; the City of Riverdale, California, 1.79%; and the City of Anaheim, California, 1.66%. This section presents an analysis of the need for the station based on the energy demands of the applicant's service areas, the potential for production cost savings, and the potential for increasing the reliability of the applicant's systems.

8.2 APPLICANT'S SERVICE AREAS AND REGIONAL RELATIONSHIPS

8.2.1 Applicant's service areas

Southern California Edison Company's service area extends over a 15-county area of southern and central California, covering about 130,000 km^2 (50,000 mi^2) and containing a population in excess of 7.5 million. In 1978, SCE served 2.95 million customers, over 88% of which were residential. San Diego Gas & Electric Company supplies electricity to about 700,000 customers in San Diego County and in portions of Orange and Imperial counties. The boundaries of the service area enclose a 10,630-km^2 (4105-mi^2) area. The cities of Anaheim and Riverside serve their respective municipalities. A map of the applicant's service area is presented in Figure 8.1.

8.2.2 Regional relationships

SCE and SDG&E are members of the Western Systems Coordinating Council (WSCC) and the California Power Pool (CPP). The WSCC is the regional reliability council for the interconnected power network that serves the states west of the Rockies and parts of British Columbia. Established in 1967, the WSCC's primary function is to facilitate coordinated planning among its member systems and to provide technical support. In relation to these duties, the WSCC compiles load and resource data for the region, performs reliability studies, and recommends minimum reserve criteria. The California Power Pool, whose members are Pacific Gas & Electric Company (PG&E), SCE, and SDG&E, was formed in 1964 to provide for the continuous interconnected operation of the member utilities' power supply systems. This interconnected operation allows the utilities to make more efficient, and therefore more economical use of their generation resources and increases the overall reliability of electric service.

8.3 BENEFITS OF STATION OPERATION

8.3.1 Minimization of production costs

To minimize energy production costs, it is necessary to use the most economical mix of generation resources. The impact of the operation of SONGS 2 & 3 on the applicant's total cost of generation will be a major factor in determining the desirability of such operation. In assessing this impact, it is important to note that the fixed costs of each facility, such as the sunken capital investment and the fixed portion of the operating and maintenance costs, are irrelevant to the choice of which generation resources will be used to meet a given load, precisely because these costs are fixed and will not vary with an altered mode of system operation.

To assess the impact of station operation on the applicant's overall production costs, the staff first reviewed the latest production costs reported by the applicants for their electric generation stations. These data, presented in Tables 8.1 and 8.2, show that all oil/gas- and oil-fired facilities that are listed as base and/or intermediate units had production costs ranging from \$29.2 to \$56.7 per MWh, whereas Unit 1 of the San Onofre Nuclear Generating Station had a production cost of \$9.0/MWhr. In determining how the additional units of the San Onofre Station would compare with these figures, the staff estimated the 1983 fuel cost for these units to be \$10.8/MWhr.[1] Because SCE's and SDG&E's installed capacity is predominately oil- and oil/gas-fired, the staff concludes

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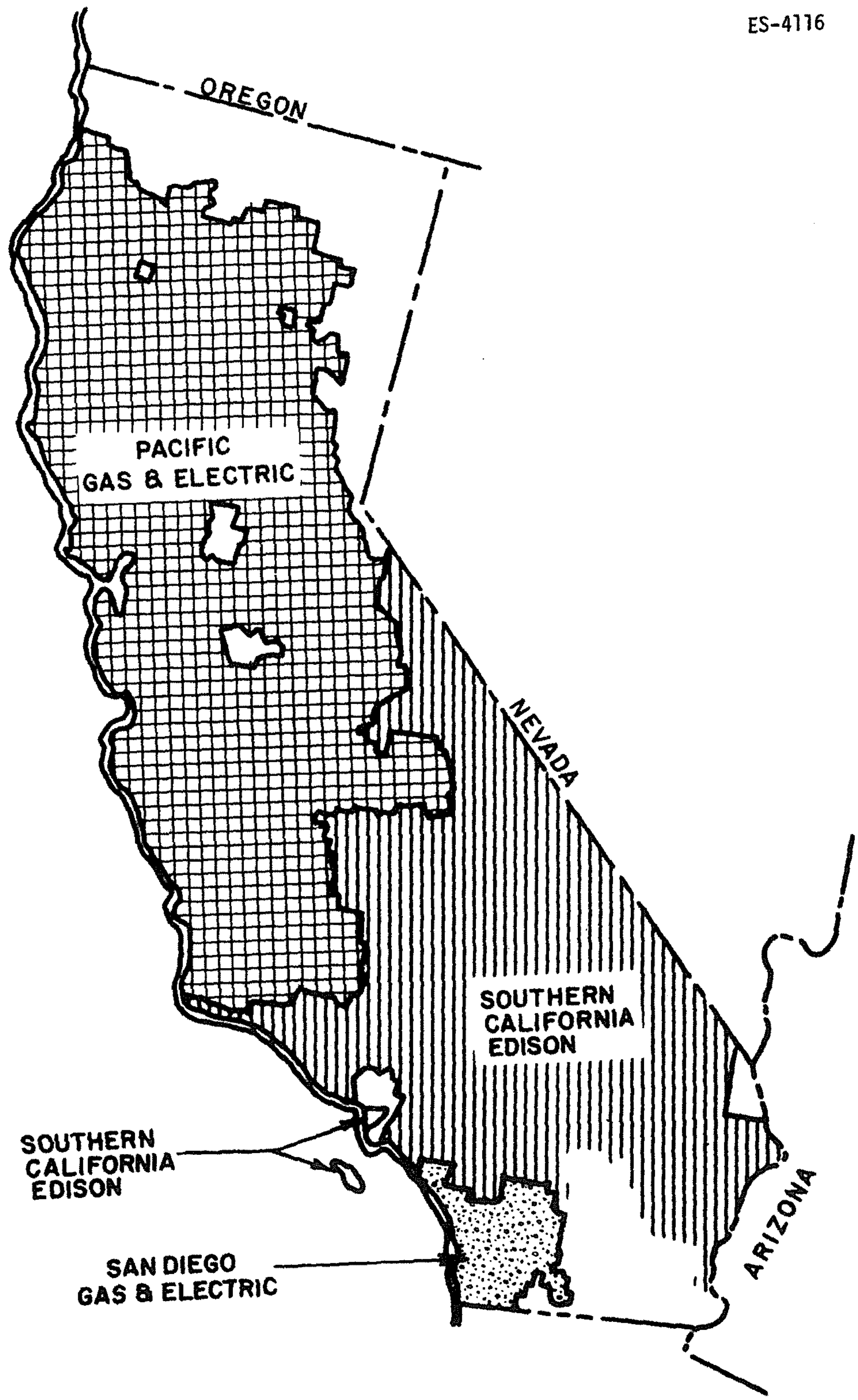

Fig. 8.1. Service areas of the member utilities of the California Power Pool. Source: ER, p. S.2-193.

Table 8.1. Southern California Edison Co. thermal-electric generating stations and production costs

Station Name	On-line dates for first and last unit	Function	Fuel type	Total station capacity (MW)	1980 Production cost (dollars/MWh)*
Long Beach	1928-1977	P	Oil/gas	156 530	77.9 38.1
Redondo Beach	1948-1967	B, I	Oil/gas	642	41.5 31.8
Huntington Beach	1958-1969	I, P	Oil/gas	870 114	39.3 49.2
Mandalay	1959-1970	I, P	Oil/gas	430 117	44.0 94.7
Ormond Beach	1971-1973	I	Oil/gas	1,500	50.6
Alamitos	1956-1969	B, I, P	Oil/gas	990 960 114	41.6 45.5 80.7
El Segundo	1955-1965	I	Oil/gas	1,020	41.8
Etiwanda	1953-1969	I, P	Oil/gas	904 108	42.2 71.8
Mohave	1971	B	Coal	885	11.8
Four Corners	1969-1970	B	Coal	768	4.6
San Onofre Unit 1	1967	B	Nuclear	349	9.0
Coolwater	1961-1978	I	Oil/gas	146 482	29.2 56.7
Highgrove	1952-1955	P	Oil/gas	154	50.5
San Bernardino	1957-1958	P	Oil/gas	126	35.0
Garden State	1967	P	Oil/gas	12	67.0
Ellwood	1974	P	Oil/gas	48	61.6

Note: B = base, I = intermediate, and P = peaking.
*Fuel only.
Source: Letter from K. P. Baskin, Southern California Edison Co., to Frank Miraglia, USNRC, undated; received by USNRC on February 25, 1981.

Table 8.2. San Diego Gas & Electric Co. thermal-electric generating stations and production costs

Station Name	On-line dates for first and last unit	Function	Fuel type	Total station capacity (MW)	1979 Production cost (dollars/MWh)
Station "B"	1923-1941	P	Oil/gas	90	188.8
Silver Gate	1943-1952	I	Oil/gas	230	48.9
Encina	1954-1978	B	Oil/gas*	917	33.7
Encina GT	1968	P	Oil/gas	16	98.6
South Bay	1960-1971	B	Oil/gas	706	33.7
South Bay GT	1966	P	Jet Fuel	18	233.4
San Onofre Unit 1	1967	B	Nuclear	87**	9.3
El Cajon	1968	P	Oil/gas	17	62.2
Kearny	1969	P	Oil/gas	147	77.5
Division	1968	P	Oil	16	97.6
Naval Training Center	1968	C	Oil/gas	16	46.0
Miramar	1972	P	Oil/gas	38	53.1
North Island	1972	P/C	Oil	41	43.7
Naval Station	1976	C	Oil/gas	26	41.0
Rohr	1979	C	Oil	1	75.8

Note: P = peaking, I = intermediate, B = base, and C = Cogeneration.
*Encina Unit 5 (320 MW) oil only.
**SDG&E's 20% share.
Source: Letter from K. P. Baskin, Southern California Edison Co., to V. A. Moore, USNRC, dated April 11, 1980.

that the operation of SONGS Units 2 and 3 would tend to reduce reliance on these facilities with corresponding savings in production costs.

To quantify the magnitude of the production cost savings, the staff made a comparison between the fuel cost that would be incurred in 1983 (the first full year in which both units are scheduled for full operation) if the two nuclear units were operated at a combined capacity factor of 50%, and the fuel cost that would be incurred if an oil-fired facility produced the same amount of electricity. In this comparison, the staff assumed a nuclear fuel cost of $10.8/MWhr in 1983, an oil cost of $4.4 per million Btu in 1983, and an oil-fired plant conversion ratio of 9,000 Btu/kWhr. These assumptions lead to an oil cost of $39.6/MWhr. All costs have been adjusted by the Producers Price Index to reflect costs in 1980 dollars. The results show that operating the nuclear units will save $270 million in fuel costs during 1983. Lowering the assumed plant capacity factor to 40% resulted in a fuel cost savings of $210 million, and raising the capacity factor to 60% gave a cost savings of $320 million. The cost of nuclear fuels would have to rise by a factor of about 3-1/2, and the price of oil would have to remain the same for the fuel savings of operating the nuclear units to disappear. These results, coupled with the information presented in Tables 8.1 and 8.2, clearly indicate that the applicant's production costs will be reduced significantly by the operation of SONGS 2 & 3.

8.3.2 Energy demand

Table 8.3 presents SCE's forecasts of peak demand, energy requirements, installed generating capacity, and reserve margins through 1985. These projections indicate that without SONGS 2 & 3 reserve margins fall below 13% from 1982-84 and dip to 7.1% in 1985. From 1980-85 SCE forecasts peak demand to grow at an average annual rate of 2.8%. A comparison with the State Level Electricity Demand[2] (SLED) forecasting model developed at Oak Ridge National Laboratory indicates that over the same period the electrical energy demand in California is forecasted to grow at an average annual rate of 4.5%. SCE's projected reserve margins without SONGS 2 & 3 clearly indicates a need for this capacity to maintain system reliability. The comparison of the applicant's forecasts of demand with the SLED forecasts reinforces the need for the additional capacity and reserve margins provided by SONGS 2 & 3.

Table 8.3. Southern California Edison Co. forecasts of peak demand, energy requirements, installed generating capacity, and reserve margins through 1985[a]

Year	Area peak demand (MW)	Growth[b] (%)	Total energy requirements kWh × 10^6	Growth[b] (%)	Installed Capacity (MW)		Reserve Margin (%)	
					With SONGS 2 & 3	Without SONGS 2 & 3	With SONGS 2 & 3	Without SONGS 2 & 3
1976	11292		59428		14071	14071	24.6	24.6
1977	11564	2.4	63345	6.6	14278	14278	23.5	23.5
1978	12159	2.9	63877	0.8	14966	14966	23.1	23.1
1979	12662	4.1	66217	3.7	15071	15071	19.0	19.0
1980	12841	1.4	65459	−1.1	15504	15504	20.7	20.7
1981	13274	3.4	67120	2.5	15471	15471	16.6	16.6
1982	13647	2.1	67910	1.2	16184	15304	18.6	12.1
1983	13895	1.8	70220	3.4	17446	15686	25.6	12.9
1984	14305	3.0	72590	3.4	17837	16077	24.7	12.4
1985	14735	3.0	75130	3.5	17535	15775	19.0	7.1

[a]Per November 18, 1980 Resource Plan.
[b]Percentage increase over previous year. 1976 through 1980 is recorded.
Source: Letter from K. P. Baskin, Southern California Edison Co., to Frank Miraglia, USNRC, undated, received by USNRC on February 25, 1981.

Table 8.4 provides analogous projections of electricity demand, installed capacity, and reserve margins for SDG&E. Without SONGS 2 & 3 reserve margins drop below 15% in 1984 and below 10% in 1985. The average annual growth in peak demand has been forecast at 1.3% which is significantly below the 4.5% rate forecast by SLED[2] for electrical energy demand in the State of California. Reserve margins forecast by SDG&E indicate a need for

Table 8.4. San Diego Gas & Electric Co. forecasts of peak demand, energy requirements, installed generating capacity, and reserve margins through 1987

Year	Area peak demand[a] (MW)	Growth[b] (%)	Energy requirements kWh × 10^6	Growth[b] (%)	Installed Capacity (MW)[c]		Reserve Margin (%)[c]	
					With SONGS 2 & 3	Without SONGS 2 & 3	With SONGS 2 & 3	Without SONGS 2 & 3
1978[d]	1981	13.5	10053	7.8	2030	2030	2.5	2.5
1979[d]	2019	1.9	10548	4.9	2363	2363	17.0	17.0
1980[d]	2050	3.7	10403	-1.4	2401[e]	2401[e]	17.1	17.1
1981	1975	-3.7	10738	3.2	2366	2366	19.8	19.8
1982	2004	1.5	10824	0.8	2586	2366	29.0	18.1
1983	2033	1.4	11108	2.6	2806	2366	38.0	16.4
1984	2077	2.2	11407	2.7	2806	2366	35.1	13.9
1985	2184	5.2	11762	3.1	2806	2366	28.5	8.3
1986	2272	4.0	12244	4.1	2806	2366	23.5	4.1
1987	2361	3.9	12763	4.2	2806	2366	18.8	0.0

[a] 1981–1987 SDG&E CFM III Forecast adopted by California Energy Commission in December 1980.
[b] Percentage increase over previous year.
[c] Excludes purchased capacity.
[d] 1978 through 1980 are recorded.
[e] July net rating.
Source: Letter from K. P. Baskin, Southern California Edison Co., to Frank Miraglia, USNRC, undated, received by USNRC on February 25, 1981.

SONGS 2 & 3 to maintain system reliability. Once again comparing the applicant's forecasts to the SLED forecasts reinforces the need for the additional capacity and reserve margins provided by SONGS 2 & 3.

The staff concludes on the basis of the analysis of the applicant's projected reserve margins that operation of SONGS 2 & 3 will be needed to ensure reliability within the time frame that operation is anticipated to begin. Furthermore, the analysis of cost savings due to a shift from oil-fired to nuclear generation (Sect. 8.3.1) makes operation of SONGS 2 & 3 economically desirable independent of load forecasts.

REFERENCES

The documents references below are available from the NRC/GPO Sales Program, Washington, DC 20555 and the National Technical Information Service, Springfield, VA 22161.

1. J. O. Roberts, S. M. Davis, and D. A. Nash, "Coal and Nuclear: A Comparison of the Cost of Generating Baseload Electricity by Region," U.S. Nuclear Regulatory Commission Report NUREG-0480, December 1978.

2. W. S. Chern, J. W. Dick, C. A. Gallagher, B. D. Holcomb, R. E. Just, and H. D. Nguyen, "The ORNL State-Level Electricity Demand Forecasting Model," Oak Ridge National Laboratory Report ORNL/NUREG-63, July 1980.

9. CONSEQUENCES OF THE PROPOSED ACTION

9.1 ADVERSE EFFECTS THAT CANNOT BE AVOIDED

The staff has reassessed the physical, social, and economic impacts that can be attributed to SONGS 2 & 3. The identification of adverse effects that cannot be avoided, given in Chap. 8 of the FES-CP, remains valid. The major effects identified were the destruction of a small amount of wildlife habitat in the area occupied by the plant buildings and the loss of fish and other marine organisms that will be entrained in the circulating cooling water system. In addition, construction has resulted in the excavation of about 16.4 ha (40.5 acres) of the San Onofre Bluffs, and operation of the plant will result in the removal of approximately 1.4 km (0.85 mile) of beach from unrestricted public use.

9.2 SHORT-TERM USES AND LONG-TERM PRODUCTIVITY

The assessment of the short-term uses and long-term productivity contained in Chap. 9 of the FES-CP remains valid. About 21 ha (52 acres) of the total of 36 ha (90 acres) comprising all three units will be devoted to the production of electrical energy for the next 30 to 40 years. If, at the end of this period, the site is no longer needed for the production of electrical energy, it could be used for other purposes (see Sect. 9.4, below).

9.3 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

There has been no change in the staff's assessment of these commitments since the earlier review (FES-CP, Chap. 10) except that the continuing escalation of costs has increased the dollar values of the materials used for construction and for fueling the plant. The staff has, however, expanded and updated the discussion on uranium fuel availability. This updated discussion is presented below.

9.3.1 Replaceable components and consumable materials

Uranium is the principal natural resource irretrievably consumed in facility operation. Other materials consumed, for practical purposes, are fuel-cladding materials, reactor-control elements, other replaceable reactor core components, chemicals used in processes such as water treatment and ion-exchanger regeneration, ion-exchange resins, and minor quantities of materials used in maintenance and operation. Except for the uranium isotopes U-235 and U-238, the consumed resource materials have widespread use; therefore, their use in the proposed operation must be reasonable with respect to needs in other industries. The major use of the natural isotopes of uranium is for production of useful energy.[1]

The reactor will be fueled with uranium enriched in the isotope U-235. After use in the plant, the fuel elements will still contain U-235 slightly above the natural fraction. This slightly enriched uranium, if separated from plutonium and other radioactive materials (separation would take place in a chemical reprocessing plant), would be available for recycling through the gaseous diffusion plant if required. Scrap material containing valuable quantities of uranium may also be recycled through appropriate steps in the fuel production process. Should chemical reprocessing of spent fuel be effected in the future, the fissionable plutonium recovered is potentially valuable for fuel in power reactors.

In view of the quantities of materials in natural reserves, resources, and stockpile and the quantities produced yearly, the expenditure of such material for the power facility is justified by the benefits from the electrical energy produced. A detailed discussion of uranium supply and demand follows.

9.3.2 Uranium resource availability

This section reviews information available from the Department of Energy (DOE) on the domestic uranium resource situation and the outlook for development of additional domestic supplies, availability of foreign uranium, and the relationship of uranium supply to planned nuclear generating capacity.

Analysis of uranium resources and their availability has been carried out by the government since the late 1940's. The work was carried out for many years by the Atomic Energy Commission (AEC). The activity was made part of the Energy Research and Development Administration (ERDA) when the agency was created in early 1975[1] and was subsequently transferred to the DOE when it was formed October 1, 1977.

9.3.2.1 U.S. resource position

To establish some basic terminology, a review of resource concepts and nomenclature would be worthwhile. Figure 9.1 defines resource categories based on varying geologic knowledge. Resources designated as ore reserves have the highest assurance regarding their magnitude and economic availability. Estimates of reserves are based on detailed sampling data, primarily from gamma ray logs of drill holes. DOE obtains basic data from industry from its exploration effort and estimates the reserves in individual deposits. In estimating ore reserves, detailed studies of feasible mining, transportation, and milling techniques and costs are made. Consistent engineering, geologic and economic criteria are employed. The methods used are the result of over 30 years of effort in uranium resource evaluation.

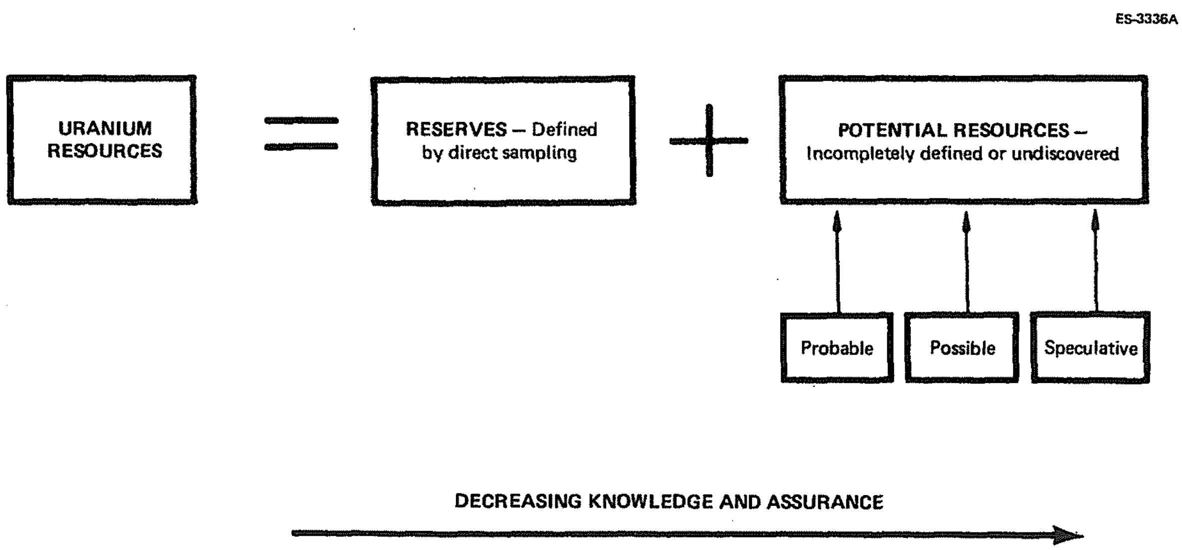

Fig. 9.1. DOE uranium resource categories.

Resources that do not meet the stringent requirements of reserves are classed as potential resources. For its study of resources, DOE subdivides potential resources into three categories: probable, possible, and speculative.[2] Probable potential resources are those contained within favorable trends, largely delineated by drilling, within productive uranium districts, i.e., those having more than 10 tons of U_3O_8 production and reserves. Quantitative estimates of potential resources are made by considering the extent of the identified favorable areas and by comparing certain geologic characteristics with those associated with known ore deposits.

Possible potential resources are outside of identified mineral trends but are in geologic provinces and formations that have been productive. Speculative resources are those estimated to occur in formations or geologic provinces which have not been productive but which, based on the evaluation of available geologic data, are considered to be favorable for the occurrence of uranium deposits.

Because any evaluation of resources is dependent upon the availability of information, the estimates themselves are, to a large degree, a scorecard on the state of development of information. Thus, appraisal of U.S. uranium resources is heavily dependent on the completeness of exploration efforts and the availability of subsurface geologic data. Since the geology of the United States as it relates to mineral deposits can never be completely known in detail, it will not be possible to produce a truly complete appraisal of domestic uranium resources. It is likely that the total resource picture will eventually prove larger than currently estimated given the nature and status of estimation methodology. The key factor may be the timeliness with which resources are identified, developed, and produced.

Conceptually, a resource, whether uranium or other mineral commodity, would initially be in the potential category. Development of additional data and clarification of production techniques and economics would be required to delineate and understand specific ore deposits to a degree that they could be categorized as reserves.

We can expect a dynamic balance between anticipated markets and prices and the extent to which exploration and reserve delineation will be done. There is no economic incentive for industry to expand reserves if the additional uranium will not be needed for many years ahead, and especially if the long-term market outlook is uncertain. This has been true for uranium. The mining companies are concentrating on markets for the next 5 to 15 years. The utilities and government are concerned with the outlook for the next 30 to 40 years.

Conversion of the currently estimated potential resources into ore reserves will take many years and will cost several billion dollars. It would be difficult to economically justify accelerating such an effort to delineate ore reserve levels equal to lifetime requirements of all planned reactors covering some 30 to 40 years in the future simply to satisfy planners. Supply assurance through continued timely additions to reserves and maintenance of a resource base adequate to support production demands, coupled with carefully developed information on potential resources, is considered to be adequate and a more realistic and economic approach. The conversion of potential resources to ore reserves and expansion of production facilities can be accomplished when needed as markets expand and production is needed.

All uranium resource estimates made by DOE and its predecessor agencies before 1979 were single estimates of tons of ore and grade for various cost categories. The estimtes were made by experienced geologists and engineers according to standard procedures, and represented a reasonable measure of resources. The current procedures for estimating uranium resources provide both mean values and distributions to characterize the reliability of the estimates at specific confidence levels. All available geologic information and the expertise of the estimators are fully utilized. These procedures are standardized and documented to minimize personal biases and to facilitate reviews and revisions as new information is acquired.

The estimates of resources in the United States are developed from a data base accumulated during the past three decades of Government and industry activities and enhanced by National Uranium Resource Evaluation program investigations of the past five years. Data acquired to support resource assessment have been extensive and varied. The assessment includes the evaluation of several hundred thousand industry-drilled holes; aerial radiometric surveys; sampling and geochemical analyses of groundwater, stream water, and stream sediment; selective drilling to fill voids in subsurface information; and extensive geologic field examinations. These data have been evaluated to determine those areas favorable for uranium occurrences. Evaluation criteria have been developed from studies of uranium deposits throughout the world. In favorable areas, the uranium endowment, material greater than 0.01 percent U_3O_8, is estimated, and subsequently economic factors are applied to assess the potential resources available at selected costs.

The costs used to calculate uranium resources are forward costs which consider both operating and capital costs, in current dollars, that would be incurred in producing the uranium. These costs include power, labor, materials, royalties, payroll, severance and ad valorem taxes, insurance, and applicable general and administrative costs. All previous expenditures (before the time of the estimate) for such items as property acquisition, exploration, mine development, and mill construction are excluded. Also excluded are income taxes, profit, and the cost of money. The resources assigned to the various cost categories are independent of the market price at which the uranium might be sold.

There are two major methodologies in uranium assessment; one is used for the estimation of reserves based on sample results from drill holes on specific properties; the second involves the use of a variety of geologic information to subjectively estimate potential resources. Reserves are calculated individually for properties throughout the United States using data voluntarily provided by the uranium companies to DOE. The data consist primarily of radiometric drill hole logs and maps. Parameters evaluated include thickness and tenor of mineralized rock; depth and spatial relationships, mining methods, ore dilution, and recovery; and amenability of ores to processing. The amounts of uranium that could be exploited at the forward cost levels are calculated according to conventional engineering practices utilizing available engineering, geologic, and economic data.

A regional reserves distribution estimate is obtained by mathematically combining the estimates of individual distributions for each property. These regional distributions are then combined to provide a total for the United States. Estimates include all material over a selected minimum thickness with a uranium content above 0.01% U_3O_8. A recovery factor is applied, after rate procedures are used for properties on which solution mining is in progress or is planned.

Potential resource estimates are based on geologic analogy. Geologic characteristics related to uranium potential in the area being investigated are compared with those in an area with similar characteristics, that is, a control area that contains uranium deposits for which the frequency distribution of grades and tonnages in the deposits has been developed. The analogy-based methodology is made feasible by DOE's extensive data base from which detailed characterizations of the distribution of uranium have been developed. From systematic comparison with an appropriate control area, an estimate is developed of the total amount of uranium, above 0.01% U_3O_8, that might be present in an area being evaluated. Uranium endowment factors, such as surface area, fraction underlain by endowment, grade, and tonnage are estimated at three confidence levels, i.e., a modal value which is considered as most likely, and a low and high estimate corresponding respectively to a 95 and 5% probability that the factor is at least that large. The endowment estimate is analyzed to determine the portions that are producible at various cost categories within stated confidence levels.

Table 9.1 provides the mean reserve and potential resource estimates for each cost category, as well as estimates at the 95th and 5th percentile. The 95th percentile value provides an estimate for which there is a 95% confidence that at least that amount exists. The 5th percentile provides an estimate for which there is a 5% probability that it will be exceeded. Due to the correlation of the individual estimates that are aggregated to generate the regional and national totals, the estimates at the 95th and 5th percentile are not directly additive; however, the mean values are additive.

Table 9.1. Uranium resources of the United States[a]

Reserves as of January 1, 1980
Other Resources as of October 1, 1980
Tons U_3O_8
Probability distribution values

Forward-cost category	Mean	95th percentile	5th percentile
At \$15 per pound of U_3O_8 [c]			
Reserves	225,000	190,000	260,000
Probable	295,000	185,000	448,000
Possible	87,000	42,000	156,000
Speculative	74,000	30,000	162,000
Totals	681,000	447,000	1,026,000
At \$30 per pound of U_3O_8 [b,d]			
Reserves	645,000	567,000	729,000
Probable	885,000	659,000	1,161,000
Possible	346,000	194,000	530,000
Speculative	311,000	155,000	600,000
Totals	2,187,000	1,731,000	2,748,000
At \$50 per pound of U_3O_8 [b,e]			
Reserves	936,000	821,000	1,060,000
Probable	1,426,000	1,102,000	1,802,000
Possible	641,000	346,000	973,000
Speculative	482,000	251,000	890,000
Totals	3,485,000	2,771,000	4,313,000
At \$100 per pound of U_3O_8 [b,f]			
Reserves	1,122,000	971,000	1,291,000
Probable	2,080,000	1,646,000	2,573,000
Possible	1,005,000	521,000	1,526,000
Speculative	696,000	378,000	1,225,000
Totals	4,903,000	3,875,000	6,056,000

[a]Uranium resources are estimated quantities recoverable by mining.
[b]Includes lower cost resource categories.
[c]\$6.80 per kilogram.
[d]\$13.60 per kilogram.
[e]\$22.65 per kilogram.
[f]\$45.30 per kilogram.
(To convert pounds to kilograms, multiply by 0.454; to convert tons to tonnes, multiply by 0.907.)

Most of the uranium resources are located in a few areas in the Colorado Plateau of New Mexico, Arizona, Colorado, and Utah, in the Wyoming Basins, and in the Texas Gulf Coastal Plain, Figs. 9.2 and 9.3. It should be noted that the reserve estimates in Table 9.1 were as of January 1, 1980, and the lower cost reserves have undoubtedly decreased since that date because of continuing rising costs.

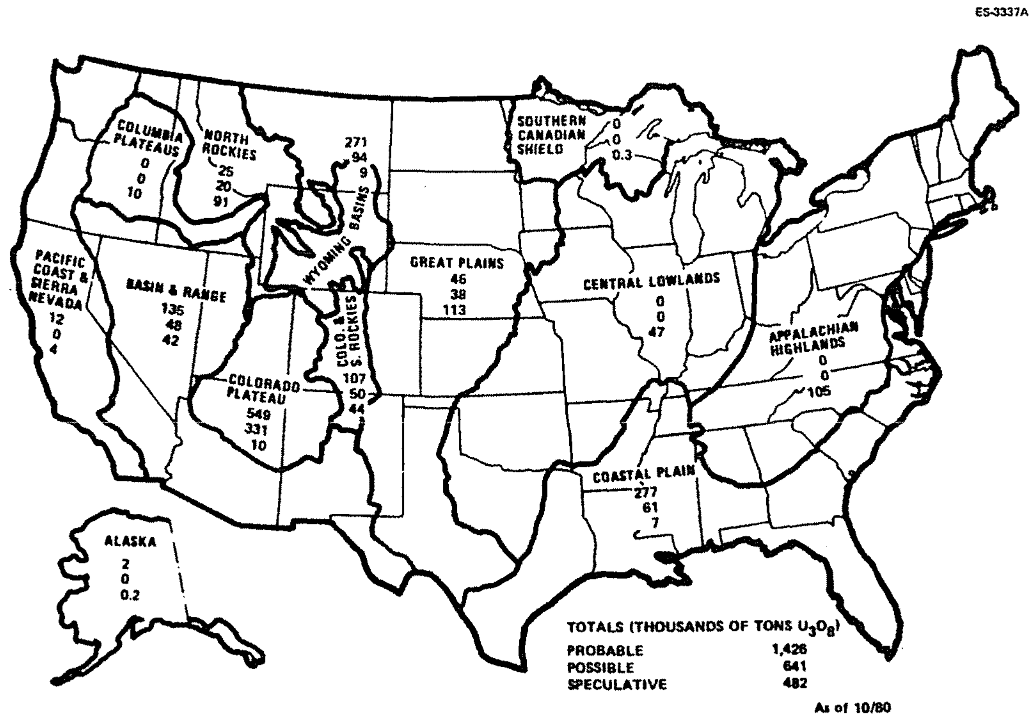

Fig. 9.2. Potential uranium resources by region ($22.65 per kilogram ($50 per pound) of U_3O_8).

9.3.2.2 Uranium exploration activities

Uranium exploration in the United States reached its all time high in 1978 as measured by the principal exploration indicator, surface drilling. Data provided to DOE by the exploration companies indicated a total of 14.6 million meters (48 million feet) of drilling in 1978. In 1979, however, drilling declined to 12.5 million meters (41 million feet), and during 1980 the downward trend steepened with drilling estimated to be approximately 8.5 million meters (28 million feet) for the year (see Figure 9.4).

Annual gross additions to reserves, a measure of exploration success, have been at high levels for the higher cost, i.e., $13.60 to $22.65 per kilogram ($30 and $50 per pound) U_3O_8 categories, but have been decreasing for lower cost levels. Costs have increased significantly in recent years raising the quality of resources needed to produce at a given cost level and reducing the quantities available at that level. For example, in 1979 only 907 tonnes (1000 tons) were added to $6.80 ($15) cost revenues, but 47,164 tonnes (52,000 tons) were removed, largely because of inflation, and an additional 12,698 tonnes (14,000 tons) were depleted by production. Hence, in 1979, $6.80 ($15) reserves decreased from 263,030 to 204,075 tonnes (290,000 to 225,000 tons). This trend continued in 1980. On the other hand, in 1979 some 84,351 tonnes (93,000 tons) were added to $22.65 ($50) reserves and 69,839 tonnes (77,000 tons) removed for a net increase of 14,512 tonnes (16,000 tons) U_3O_8. Thus, while exploration has been successful, the costs of producing the resources found are high in comparison with current prices and concurrently the cost of producing previously found resources has also increased.

The sharp rise in exploration resulted from the increase in prices in the 1974 to 1976 period, the active procurement activity of utilities, and the optimistic projections of future growth in uranium demand. Many new companies became active in exploration. Over 150 companies were involved in exploration in 1979. Considering the drop in requirement projections the level of activity reached probably was in excess of real needs. Therefore, some reduction of effort more in line with future needs is not detrimental.

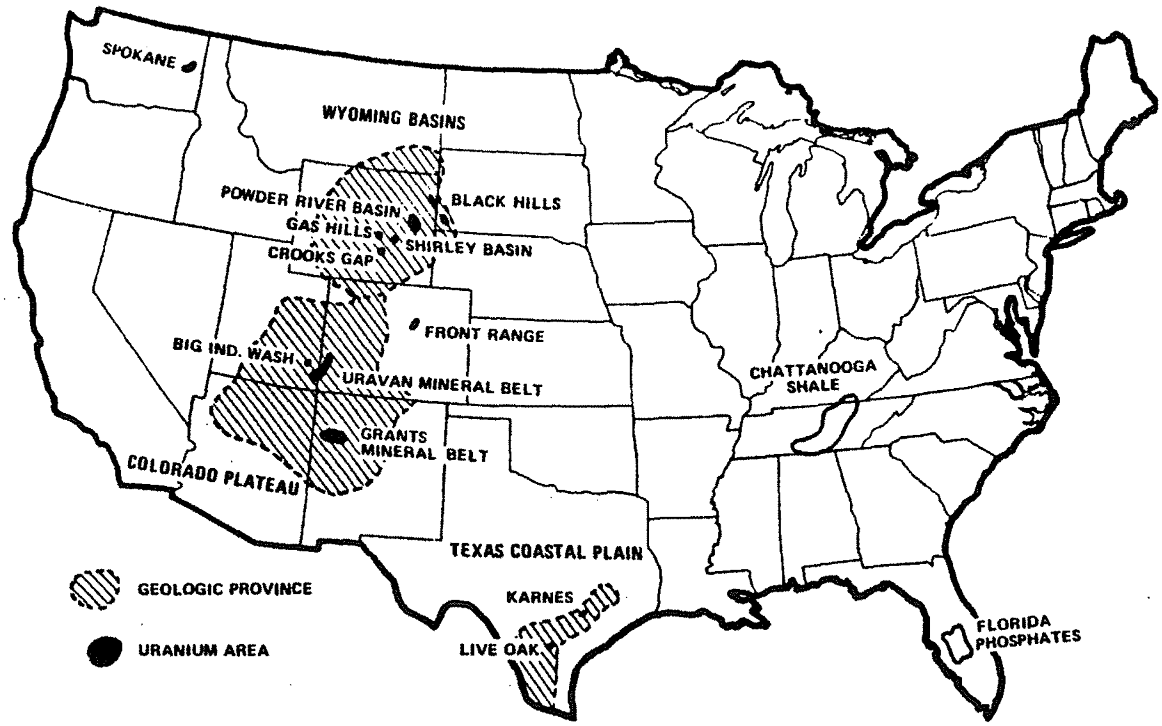

Fig. 9.3. Uranium areas of the United States.

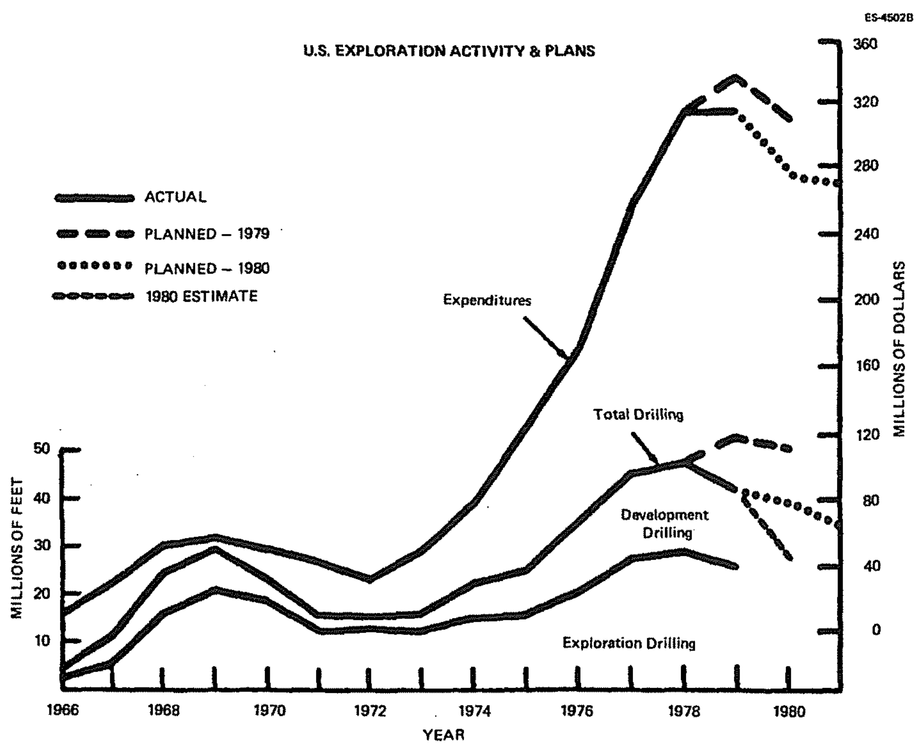

Fig. 9.4. U.S. exploration activity and plans. (To convert feet to meters, multiply by 0.3048.)

9.3.2.3 Domestic uranium production and capability

Domestic uranium production in 1980 was 19,573 tonnes (21,850 tons) U_3O_8 in concentrate. This represents a 15% increase over 1979 and is the highest U.S. production level for any single year. Production in recent months has been at record rates; the equivalent of over 19,954 tonnes (22,000 tons) U_3O_8 per year. This production comes from conventional mine-mill operations as well as nonconventional sources such as solution mining and byproduct recovery from processing of other minerals. The high production levels are in response to prior sales contracts. Buyers are actually receiving uranium in excess of their currently scheduled needs.

Several new uranium processing facilities are under construction or planned which could bring the total national capacity to around 27,000 tonnes (30,000 tons) per year by the mid-1980s.

Despite the increases in ore throughput and uranium production in 1980, a widespread curtailment of uranium mining and milling activities is underway. Production at some operating mines has been reduced and some planned mill expansions and construction are being postponed. The reduction in mine output will not be reflected in decreased uranium production until mine and mill ore stockpiles are reduced.

Studies have been conducted on attainable uranium production levels from uranium reserves in the United States and related costs. The uranium production capability projections should not be construed as being estimates of actual future supply, but simply as potential production which may be available to meet whatever demand eventually exists.

Using the "production center" concept, U.S. uranium production capability has been projected from ore reserves estimated as of January 1980, to be available at forward costs of $13.60 to $22.65 per kilogram ($30 and $50 per pound) U_3O_8 or less. The production centers consist of operating (Class 1), committed (Class 2), planned (Class 3) uranium extraction and processing facilities, and projected (Class 4) facilities based on probable potential resources. The study included conventional mills supplied by open pit and/or underground mines; solution mining and heap-leach operations; and operations where uranium is recovered as a byproduct of phosphate, copper, or beryllium mining and processing activities.

Projections are based primarily on operating conditions – average ore grades, mill recoveries, and operating and capital costs – similar to those currently prevalent in the uranium mining and milling industry. Specific information on company plans, costs, and operating methods has been considered.

Figure 9.5 shows the total projected production capability for $13.60 ($30) resources by resource category. Figure 9.6 shows the capability for $22.65 ($50) resources. Projected uranium demand and current sales commitments are also shown. Domestic demand is based on the DOE's Office of Uranium Resources and Enrichment 1980 nuclear power growth projections, assuming no reprocessing and a 0.20% U-235 enrichment tails assay.

9.3.2.4 Domestic reactor requirements

The outlook for uranium requirements is closely related to the growth of nuclear power. On December 1, 1980, there were 75 nuclear power reactors licensed to operate in the U.S., concentrated mostly in the East and Midwest. These plants have an electrical generating capacity of 55 Gigawatts (GWe). In addition to operating plants, there are under construction 86 plants with a total rated capacity of 95 GWe. Some of the plants are at such an early construction stage that they may be deferred or cancelled completely. An additional 17 reactors with 20 GWe capacity are on order. Together the group aggregates 170 GWe of capacity. However, the future for some of the ordered reactors is questionable.

Latest projections of nuclear power growth by the DOE's Office of Uranium Resources and Enrichment (URE) and the Energy Information Administration (EIA), Table 9.2, show an increase in nuclear power licensed to operate from 55 GWe at the end of 1980 to 96 GWe in 1985, 129 GWe in 1990, 155 GWe in 1995, and 180 GWe in 2000. EIA also projected a low case of 160 GWe and a high case of 200 GWe in 2000.

There are alternative views on U.S. power growth. The DOE's Office of Planning and Analysis has projected nuclear growth to the year 1990 at 125 GWe and to the year 2000 at 150 GWe, based on historic delays to nuclear power growth. The DOE Office of the Assistant Secretary of Nuclear Energy has projected 400 GWe, based on energy demand, growth, nuclear competitiveness, and industry construction capability. All of these values are sharply reduced from the projected growth of the nuclear industry of just a few years ago. For example, in 1976 U.S. nuclear capacity in the year 2000 had been projected to be 500 GWe, and in 1978 it had been projected to be 320 GWe.

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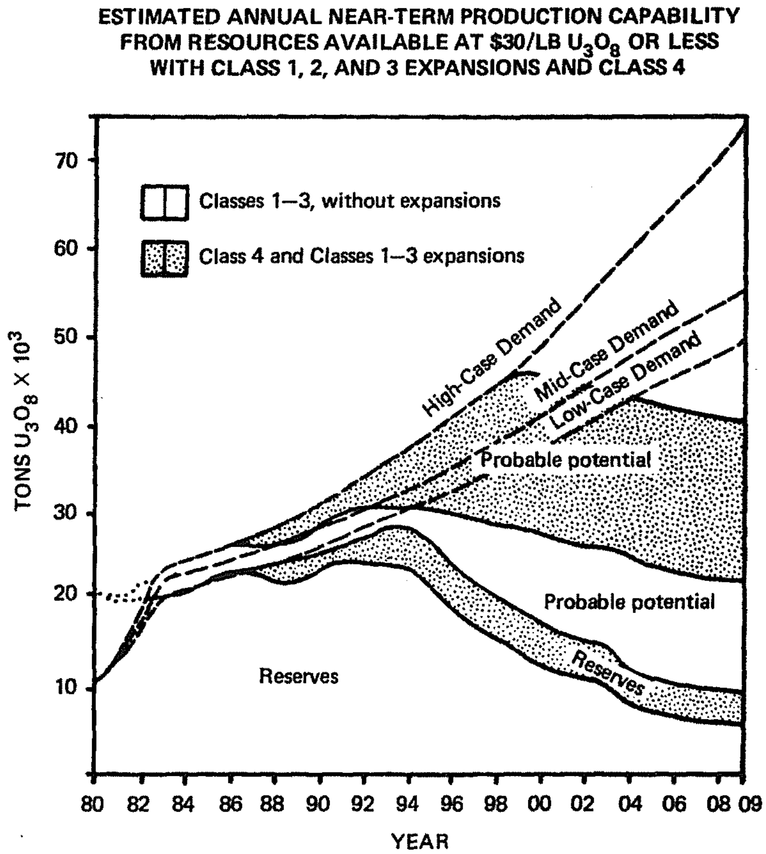

Fig. 9.5. Estimated annual near-term production capability from resources available at \$13.60 per kilogram (\$30 per pound) of U_3O_8 or less with Class 1, 2, and 3 expansions and Class 4. (To convert tons to tonnes, multiply by 0.907.)

Even at the more conservative estimates, nuclear capacity still is expected to expand substantially and to provide a significant portion of future domestic electric capacity. Current methods of projecting nuclear growth and uranium requirements are based on estimates of reactor startup dates considering construction and licensing times, and systems power requirements. Accurate forecasts have proven to be difficult.

The uranium needed to be delivered by uranium concentrate-producing plants as fuel for the nuclear plants will also increase over time; for the URE mid-case, from 12,063 tonnes (13,300 tons) U_3O_8 in 1981 to 21,405 (23,600) in 1985, 26,212 (28,900) in 1990, 31,745 tonnes (35,000 tons) in 1995, and 36,280 tonnes (40,000 tons) in 2000, if the enrichment plants are operated at 0.20% U-235 tails assay. Cumulative uranium requirements through the year 2000 range from 462,570 to 562,340 tonnes (510,000 to 620,000) tons U_3O_8 with 516,990 tonnes (570,000 tons) U_3O_8 for the mid-case.

Uranium requirements are based on normal lead times for fuel cycle steps and current technology for enrichment and for reactor design and operation. There are possible improvements in enrichment which would allow use of lower tails assays which would reduce uranium requirements. There are also possible improvements to reactor design and operation that could reduce uranium requirements. These factors are not likely to have a significant impact on uranium demands until at least well into the 1990s.

9.3.2.5 Uranium inventories

Buyers' inventories of uranium have been increasing for several years as actual deliveries have been in excess of needs. Inventories at the beginning of 1980 totalled 32,742 tonnes (36,100 tons) of natural uranium (Table 9.3), with 25,033 tonnes (27,600 tons) held by utilities. In 1980, U.S. utilities sent an

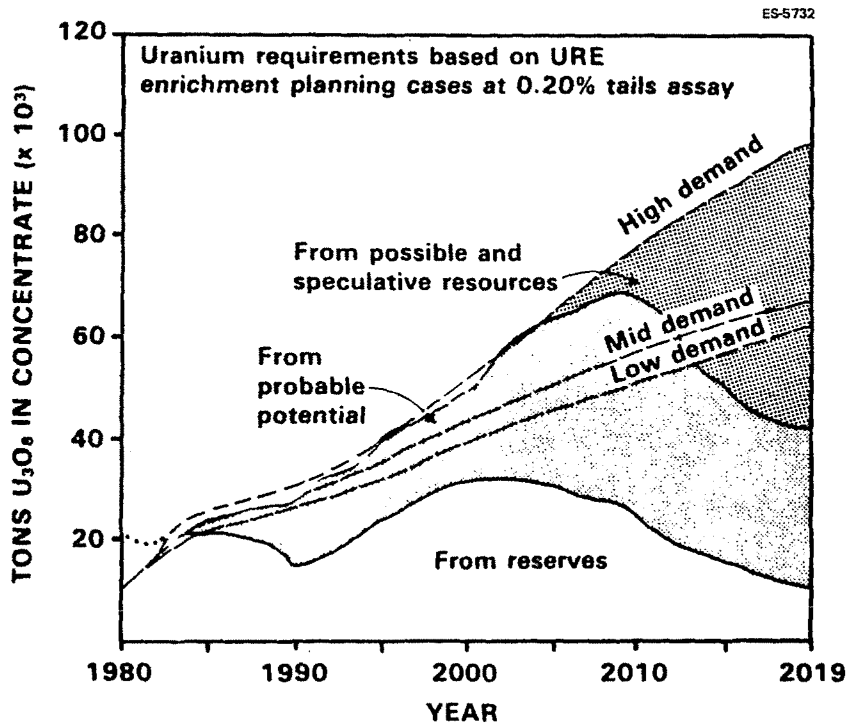

Fig. 9.6. Annual production capability from resources available at $22.65 per kilogram ($50 per pound) of U_3O_8 or less projected to meet nuclear power growth demand. (To convert tons to tonnes, multiply by 0.907.)

Table 9.2. U.S. nuclear power growth projections (June 1980)

End of year	Power Range [GW(e)] Low	Mid	High
1985	85	96	105
1990	125	129	140
1995	142	155	165
2000	160	180	200

Table 9.3. Buyers' inventories of natural uranium (Tons U_3O_8)

Beginning of year	Domestic origin	Foreign origin	Total
1976	22,600	1,100	23,700
1977	25,800	3,500	29,300
1978	25,100	3,600	28,700
1979	28,000	5,200	33,200
1980	30,800	5,300	36,100

(To convert tons to tonnes, multiply by 0.907.)

equivalent of 15,691 tonnes (17,300 tons) U_3O_8 to the DOE gaseous diffusion plants for enrichment. Thus, the 25,033 tonnes (27,600 tons) inventory level amounted to 1.6 years of U.S. utilities' needs. Of those U.S. utilities who have responded to questions on inventory levels, most have indicated that they desire a level amounting to about one year's needs, although some have reported inventory levels as small as three month's needs, while others desire inventories as great as two year's needs. Producers also had inventories of about 2,177 tonnes (2,400 tons) U_3O_8 at the beginning of 1980, which is about a normal working inventory. The outlook is for a continuing buildup of buyers' inventories, as current contracted deliveries are in excess of actual needs.

9.3.2.6 Analysis of production capability and reactor capacity

Study of attainable production capability from currently estimated $13.60 ($30) U.S. ore reserves and probable potential resource, previously referenced, indicates that production levels of 40,815 tonnes (45,000 tons) U_3O_8 per year can be achieved with aggressive resource development and exploitation including both mining and milling. Although the level may be achieved by use of domestic $13.60 ($30) ore reserves and probable resources alone, development and utilization of $30 possible and speculative categories and use of $22.65 ($50) ore reserves and potential resources would provide added assurance that the levels could be attained and sustained. Considering the use of $22.65 ($50) resource, a level of 54,240 tonnes (60,000-tons)/year supply is achievable from currently estimated resources. Such a level could be reached by the early 1990s. Imported uranium and inventories would add to the supply from these projections.

The level of nuclear generating capacity supportable with 54,240 tonnes (60,000 tons)/year of uranium, will vary with enrichment tails assay and recycle assumptions. Without recycle of uranium or plutonium and with a 0.30% U-235 enrichment tails assay, about 260,000 MWe could be supported. Without recycle and at 0.20% tails assay, about 310,000 MWe could be supported. With recycle of uranium and plutonium and a 0.20% tails assay, about 520,000 MWe could be supported. All the levels of supportable capacity are above the 170,000 MWe of capacity in operation (55,000 MWe), under construction (95,000 MWe), and on order (20,000 MWe), as of late 1980. Thus, currently estimated resources can provide adequate uranium supplies for a sizable expansion to U.S. nuclear generating capacity.

The cumulative lifetime (30 years) uranium requirements for all of the above reactors (170,000 MWe) would be about .907 million tonnes (1.0 million tons) U_3O_8 at 0.20% enrichment tails with no recycle, compared to the 1.45 million tonnes (1.6 million tons) mean value in $13.60 (($30) or the 2.27 million tonnes at $22.65 (2.5 million tons at $50)) ore reserves, by-product, and probable potential resources. Evaluation of long-term fuel commitments on the basis of ore reserves and probable potential resources is considered a prudent course for planning. The lifetime commitment would be less than one-third of currently estimated $22.65 ($50) domestic resources, including the possible and speculative categories (see Table 9.1).

9.3.2.7 Uranium resource recovery

In regard to the availability of estimated uranium resources considering recoveries in mining and ore processing, estimates of U.S. uranium resources represent the quantity of uranium estimated to be minable expressed as tons of U_3O_8 of ore in the ground. These estimates are a reflection of the information available to DOE at the time of the estimate and thus are dependent on the extent of exploration. In view of the considerations involved in preparing the resource estimates and the uranium resource outlook, no adjustment for losses is warranted.

U.S. mining practice results in recovery of high percentages of the uranium contained in a deposit. DOE resource estimation procedures consider the capabilities and requirements of mining systems currently in use so that the estimates are a realistic appraisal of what is minable. Because deposits frequently are not fully delineated before they are developed, it is not unusual for more uranium to be recovered from deposits than was included in ore reserves before such deposits were put into production. Mining company practice seeks to recover as much of the contained mineral content as possible before abandoning a mine. A strong incentive for such practice is the increase in financial returns. In the processing of uranium ores, recoveries generally are over 90%. In 1980, mill recovery averaged about 93%. Higher recoveries are usually possible if economically justified.

9.3.2.8 High cost resources

An alternative to identification of additional low-cost resources is the utilization of higher cost resources. The highest cutoff cost category included in DOE resources in Table 9.1, is $45.30 per kilogram ($100 per pound) of U_3O_8. This level is an upper range of what might be of interest for utilization in light water reactors over the next few decades.

The increased price of oil and coal in the last few years has been a contributing factor to the increased price of uranium economically acceptable in light water reactors. This impact results from the relative insensitivity of nuclear electric power costs to increases in uranium prices. The cost of fuel is a very small fraction of the cost of power from a nuclear plant. In turn, the cost of natural uranium is only a small fraction of the fuel cost; enrichment, fabrication, reprocessing, and carrying charges make up the balance. As a result, large increases in uranium prices result in comparatively small increases in power costs. As pointed out in Section 9.3.2.6, nuclear capacity currently in operation, under construction, and on order, is expected to have adequate supplies of U_3O_8 at prices much lower than $45.30 per kilogram ($100 per pound) in 1980 dollars.

Knowledge of U.S. resources in the above $22.65 ($50) category is meager, largely because of the lack of past economic interest. There has been virtually no industry activity to search for or to develop such resources. Prospects for discovery of higher cost resources in the United States are considered promising at this stage of U.S. exploration. The principal large, very low-grade deposits that have been studied in some detail in the past are the shales and phosphates. The Chattanooga shale in Tennessee is of particular interest because of its large size. This deposit was extensively drilled, sampled, and studied in the 1950s. The higher grade part of the Chattanooga shale has an average uranium content of about 60 to 80 ppm compared to 1500 ppm in present-day ores. It contains in excess of 4.5 million tonnes (5 million tons) of U_3O_8 that may be producible at a cost of $45.30 or more per kilogram ($100 or more per pound) of U_3O_8. Additional work to develop production technology will be needed.

If Chattanooga shale were mined to fuel an 1150-MWe reactor, assuming recycle of uranium (but not of plutonium) and a 0.3% enrichment tail, about 11,428 tonnes (12,600 tons) of shale would have to be processed each day; with uranium and plutonium recycle (should that be practiced) and 0.20% enrichment tails, about 7,710 tonnes (8500 tons) per day would have to be processed. An average of about 10,250 tonnes (11,300 tons) of coal would have to be burned each day if 20 MJ/kg (8700 Btu/lb) of coal were used to produce power equivalent to that produced by a 1150-MWe reactor.

Utilization of the very low-grade resources such as Chattanooga shale would, of course, involve mining and processing very much larger quantities of ore than is currently mined to produce the same amount of uranium. From an environmental as well as from an economic point of view, identification and utilization of additional higher grade ores would be preferable. However, the shales are available if their use should become necessary.

9.3.2.9 Prices

During the period 1973-1979, the average delivery price per kilogram (pound) of U_3O_8 for sales from domestic producers to domestic buyers, in year-of-delivery dollars, increased from $3.22 to $10.80 ($7.10 to $23.85), as shown in Table 9.4.

Table 9.4. Historical trend of average uranium prices

(Dollars[a] per pound of U_3O_8)

Year	Final Price
1973	$ 7.10
1974	7.90
1975	10.50
1976	16.10
1977	19.75
1978	21.60
1979	23.85

[a] Year-of-delivery dollars.

(To convert dollars per pound to dollars per kilogram, multiply by 0.453.)

Future prices for material under contract as of July 1, 1980, as reported to DOE, is shown in Table 9.5. Also shown are the percentages of material under contract price arrangements covering the price data presented. The remainder is in market price contracts or in captive production.

9.3.2.10 Foreign uranium resource position

The most reliable source of information on world uranium resources is that compiled by the Working Party on Uranium Resources sponsored jointly by the Nuclear Energy Agency (NEA) and the International Atomic

Table 9.5. Average contract prices and settled market price contracts for uranium July 1, 1980

(Dollars[a] per pound of U_3O_8)

Year	Price	Percentages of procurement under contract price contracts
1980	26.00[b]	66
1981	28.70[b]	55
1982	34.80	47
1983	41.40	43
1984	43.45	35
1985	43.45	32
1986	46.85	16
1987	43.55	18
1988	42.70	22
1989	51.85	23
1990	53.25	16

[a] Year-of-delivery dollars.
[b] These years include settled market price contracts. Market price contract prices are determined sometime before delivery, based on prevailing market prices.

(To convert dollars per pound to dollars per kilogram, multiply by 0.453.)

Energy Agency (IAEA). This group has been gathering and publishing uranium resource estimates since 1965 and includes most of the significant uranium resource countries. In compiling its estimates this group classifies resources as Reasonably Assured resources (roughly comparable to ore reserves in the usual mining industry sense) and Estimated Additional resources (roughly comparable to DOE's probable potential resources). Resources in the world outside of the centrally planned economies area (WOCA) are tabulated by continents and major countries in Table 9.6.

Almost 80% of these resources are concentrated in three continents: North America, Africa, and Australia. Six countries within those continents - U.S., Canada, South Africa, Namibia, Niger, and Australia - have about three-quarters of the Reasonably Assured resources. This geographic concentration is a reflection of the geologic favorability of these areas as well as the extent of exploration and resource appraisal efforts to date.

9.3.2.11 Foreign production capacity and plans

Studies by the NEA and the IAEA have also provided reliable information on world production capacity. The current production capacity of existing non-U.S. plants (Class 1) is about 34,466 tonnes (38,000 tons) U_3O_8 annually, as shown in Table 9.7. This production is primarily in Canada, France, Namibia, Niger, and South Africa.

Construction of new plants (Class 2) with a capacity of about 7,256 additional tonnes (8,000 tons) is taking place, primarily in Australia and Canada. Plants that are planned (Class 3), could increase total annual production by another 32,652 tonnes (36,000 tons) U_3O_8 for a total of 76,188 tonnes (84,000 tons) U_3O_8 by 1990. Since needs for uranium are well below attainable production capacity levels, and prices would not justify all operations, it is likely that many of the projected plants will be built on a deferred schedule. It is also possible that some new plants will replace existing operations. Countries of particular significance in future production expansion are Australia and Canada, which have 82% of capacity under construction and 70% of the planned additional capacity.

9.3.2.12 Foreign reactor requirements

The uranium requirements in non-Communists foreign countries have been projected by the Energy Information Administration based on the reactors planned and timing of construction. Table 9.8 shows three cases of power plant growth which, by the year 2000, range from 300 GWe to 400 GWe of nuclear power in operation. The mid-case is taken as the most likely one. However, nuclear power growth projections have been subject to continual downward revision in the last several years.

Table 9.6. World uranium resources by continent[a]

(World outside centrally planned economies area)
(thousand tons U_3O_8)

	Reasonably assured		Estimated additional	
	$30/lb	$50/lb[b]	$30/lb	$50/lb[b]
North America				
U.S.	645	940	885	1,430
Canada	280	305	480	945
Other	9	44	44	65
Total	930	1,290	1,410	2,440
Africa				
South Africa	320	508	70	180
Niger	210	210	69	69
Namibia	152	173	39	69
Other	109	115	2	22
Total	790	1,000	180	340
Australia				
Total	380	390	165	180
Europe				
France	51	72	34	60
Spain	13	13	11	11
Sweden	1	390	0	4
Other	22	31	19	53
Total	90	510	60	130
Asia				
India	39	39	1	31
Other	13	21	0	0
Total	50	60	0	30
South America				
Brazil	96	96	117	117
Argentina	30	36	5	12
Other	0	0	7	8
Total	130	130	130	140
Worldwide total (rounded)	2,400	3,400	1,900	3,300

[a]Modified from "Uranium Resources, Production and Demand" OECD, Nuclear Energy Agency (NEA), and the International Atomic Energy Agency (IAEA), December 1979.

[b]Includes resources at $30 per pound of U_3O_8.

(To convert tons to tonnes, multiply by 0.907; to convert $ per pound to $ per kilogram, multiply by 0.453.)

In order to supply these nuclear plants, EIA has estimated the amount of uranium required assuming 0.20% U-235 enrichment plant tails and no recycle of uranium or plutonium. Table 9.8 gives the annual tons U_3O_8 from 1980 to 2000 for high-, mid-, and low-cases.

For the mid-case, foreign requirements increase from 16,689 tonnes (18,400 tons) U_3O_8 in 1980, to 23,763 tonnes (26,200 tons) U_3O_8 in 1985, and to 49,069 tonnes (54,100 tons) U_3O_8 in the year 2000. Cumulative requirements through the year 2000 total 650,319 tonnes (717,000 tons) U_3O_8.

If all the planned foreign mine-mill production came on-stream as currently projected, there would be considerable excess capacity. If only operating mills or those under construction were available by the late 1980s, production capacity would cover annual demands through the late 1990s.

Table 9.7. Foreign uranium production capability

(Thousand tons U_3O_8)

Year	Australia			Canada			France			Namibia			Niger			S. Africa			Other[b]			Foreign Total		
	1[a]	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
1980	1.3	0	0	9.8	0	0	4.5	0	0	5.3	0	0	5.2	0	0	8.3	0	0	4.1	0	0	38.5	0	0
1981	1.8	1.1	0	9.8	1.4	0	4.5	0.2	0	5.3	0	0	5.2	0	0	8.3	0	1.2	4.1	0	0.8	39.0	2.7	2.0
1982	1.8	3.3	0	9.8	1.9	0	4.5	0.5	0	5.3	0	0	5.2	0	0	8.3	0	2.9	4.1	0	3.0	39.0	5.7	5.9
1983	1.8	3.3	0	10.5	1.9	2.0	4.5	0.7	0	5.3	0	1.2	5.2	0	0	8.3	0	4.6	4.1	0	4.1	39.7	5.9	11.9
1984	1.8	3.3	0	11.0	2.9	4.0	4.5	0.7	0	5.3	0	1.2	5.2	0	0.7	8.3	0	5.2	4.1	0	4.4	40.2	6.9	15.5
1985	1.8	3.3	6.5	12.0	2.9	5.0	4.5	0.7	0	5.3	0	1.2	5.2	0	2.5	8.3	0	5.5	4.1	0	5.1	41.2	6.9	25.8
1986	1.2	3.3	11.5	12.0	2.9	7.2	4.5	1.4	0	5.3	0	1.2	5.2	0	5.2	8.3	0	5.6	4.1	0	5.1	40.6	7.6	35.8
1987	1.2	3.3	11.5	12.0	2.9	7.2	4.5	1.4	0	5.3	0	1.2	5.2	0	5.2	8.3	0	5.6	4.1	0	5.2	40.6	7.6	35.9
1988	1.2	3.3	11.5	12.0	2.9	7.2	4.5	1.4	0	5.3	0	1.2	5.2	0	5.2	8.3	0	5.5	4.1	0	5.3	40.6	7.6	35.9
1989	1.2	3.3	11.5	12.0	2.9	7.2	4.5	1.4	0	5.3	0	1.2	5.2	0	5.2	8.3	0	5.5	4.1	0	5.4	40.6	7.6	36.0
1990	1.2	3.3	11.5	12.0	2.9	7.2	4.5	1.4	0	5.3	0	1.2	5.2	0	5.2	8.3	0	5.2	4.1	0	5.5	40.6	7.6	35.8
Total																							84.0	

[a]Class: 1. Currently operating plants
2. Plants under construction
3. Planned plants

[b]Includes: Argentina, Brazil, CAR, Gabon, India, Italy, Mexico, Portugal, Spain, Yugoslavia. Based on "Uranium Resources, Production and Demand," December 1979.

(To convert tons to tonnes, multiply by 0.907.)

Table 9.8. Foreign nuclear capacity and uranium requirements

	Capacity [GW(e)]			Requirements (tons U_3O_8)[a]		
	Low	Mid	High	Low	Mid	High
1980	66	68	77	17,300	18,400	19,800
1985	117	124	128	24,000	26,200	29,200
1990	165	181	201	27,500	31,600	32,700
1995	229	252	280	34,600	41,500	47,800
2000	300	350	400	42,700	54,100	64,300

[a]0.20% U-235 tails assay.

(To convert tons to tonnes, multiply by 0.907.)

Additional projections of WOCA nuclear growth and uranium requirements were developed during the International Nuclear Fuel Cycle Evaluation (INFCE). While the projections are now considered as high by many, they do provide an additional, more optimistic, viewpoint on future nuclear growth. The INFCE low case — modified to exclude the U.S. - indicated a growth in foreign (WOCA) nuclear capacity from 82 GWe at the end of 1980 to 217 GWe in 1990 and 580 GWe in the year 2000. Corresponding foreign uranium requirements would be 19,047 tonnes (21,000 tons) in 1980, 45,350 tonnes (50,000 tons) in 1990 and 108,840 tonnes (120,000 tons) in 2000. Such projections indicate a much larger possible growth in future uranium demands

9.3.2.13 Foreign competition and the domestic industry

The concentration of world uranium resources and production has, in past periods of low prices and ore production, fostered attempts to form cartel-like organizations seeking to restrict the free movement of uranium and influence pricing. The concentration of uranium production in a few countries will continue for some time, though there is an increasing diversity of supply sources. The opportunity for future foregin cartel-like activities will continue, particularly if uranium producer country governments are involved, which has been the case in the past. However, the severe criticism of such practice and the legal actions that have resulted in the United States might operate to discourage such activities in the future. Since the U.S. has the capability of producing a large portion - or all - of its uranium needs, and since the U.S. uranium buyers historically have shown a strong preference for domestic uranium, the U.S. is not expected to develop a large dependence on foreign uranium. These factors would tend to reduce the susceptibility of the U.S. to direct impacts of any cartel-like activity.

9.3.2.14 Conclusions

In conclusion, DOE assessment of uranium resources indicates that currently estimated ore reserves and probable potential resources at forward costs up to $13.60 per kilogram ($30 per pound) U_3O_8 total over 1.36 million tonnes (1.5 million tons), and at forward costs up to $22.65 per kilogram ($50 per pound) U_3O_8 total almost 2.17 million tonnes (2.4 million tons). The 2.17 million tonnes (2.4 million tons) U_3O_8 will support 390 GWe of nuclear power generating capacity, assuming a 30-year life for the reactors, no spent fuel reprocessing and an enrichment plant tails assay of 0.20% U-235. Under the latest DOE forecast for nuclear generating capacity in the post-2000 period, these resources should support U.S. nuclear power growth, including SONGS 2 and 3, well into the next century. However, meeting the uranium requirements for an expanding U.S. nuclear power industry will require extensive industry efforts to sustain exploration, and success in discovering and developing the potential uranium resources.

Foreign uranium resources are substantial and have been growing. Some of the more recently discovered deposits, especially in Canada and Australia, will have comparatively low-cost uranium production. The staff, therefore, concludes that there will be sufficient nuclear fuel available for SONGS 2 and 3.

9.4 DECOMMISSIONING

A license to operate a nuclear power plant is issued for a period of 40 years, beginning with the issuance of the construction permit. At the end of the 40-year period the operator of a nuclear power plant must renew the license for another time period or apply for termination of the license and for authority to dismantle the facility and dispose of its components.[8] If prior to the expiration of the operating license, technical, economic, or other factors are unfavorable to continued operation of the plant, the operator may elect to apply for license termination and dismantle authority at that time. In addition, at the time of applying for a license to operate a nuclear power plant, the applicant must show that he possesses "or has reasonable assurance of obtaining the funds necessary to cover the estimated costs of permanently shutting the facility down and maintaining it in a safe condition."[9] These activities, termination of operation and plant dismantling, are generally referred to as "decommissioning."

NRC regulations do not require the applicant to submit decommissioning plans at the time the construction permit and operating license are obtained; consequently, no definite plan for the decommissioning of the station has been developed. At the end of the station's useful lifetime, the applicant will prepare a proposed decommissioning plan for review by the Nuclear Regulatory Commission. The plan will comply with NRC rules and regulations then in effect.

The decommissioning of reactors is not new. Since 1960, five licensed nuclear plants, four demonstration nuclear power plants, six licensed test reactors, 28 licensed research, and 22 licensed critical facilities have been or are in the process of being decommissioned.[10] The primary methods of decommissioning consist of mothballing, entombing, dismantling, or a combination of these three alternatives. The primary methods are defined below in terms of the definitions provided in Regulatory Guide 1.86.[11]

Mothballing is the process of placing a facility in a nonoperating status. The reactor may be left intact except that all reactor fuel, radioactive fluids, and nonfixed radioactive wastes such as ion exchange resins, contaminated scrap materials, and contaminated chemicals are removed. The existing license is amended to a "possession only" status and continues in effect until residual radioactivity decays to levels acceptable for release to unrestricted access or until residual radioactivity is removed. The "possession only" license is a reactor facility license that permits a licensee to possess the facility but prohibits operation of the facility as a nuclear reactor.

Entombment consists of removing all fuel assemblies, radioactive fluids, and wastes followed by the sealing of remaining radioactive material within a structure integral with the biological shield or by some other method to prevent unauthorized access into radiation areas. A program of inspection, facility radiation surveys, and environmental sampling is required for a licensed facility that has been entombed.

Dismantling is defined as removal of all fuel, radioactive fluids and waste, and all radioactive structures. Surface contamination levels, established in Table 1 of Regulatory Guide 1.86, must be met prior to termination of the facility license. In addition to meeting the surface contamination levels, the acceptability of the presence of materials which have been made radioactive by neutron activation would be evaluated on a case-by-case basis prior to termination of the license. If the facility owner so desires, the remainder of the reactor facility may be dismantled and all vestiges removed and disposed of.

For a single nuclear reactor, the mothballing alternative costs about $2.45 million initially plus an annual maintenance and surveillance cost of $167,000. If a 24-hr manned security force is not required (e.g., a site with continuing operations), the annual cost could be reduced to $88,000. Translating these costs into unit cost of generating electricity, the 30-year levelized unit cost* would be about 0.04 mills/kWhr and if a manned security force is not required about 0.03 mills/kWhr.[12]

The entombing alternative costs about $7.58 million initially for a single unit facility plus an annual maintenance and surveillance cost of $58,000 for the duration of the entombment period.[13] These costs, when translated to a 30-year levelized unit cost* basis, amount to about 0.06 mills/kWhr.

The dismantling alternative for a single nuclear power reactor costs about $33.3 million to remove the radioactive structures associated with NRC requirements for terminating a possession only license.[12] An additional $4.8 million would be needed to remove the nonradioactive structures (cooling towers, administration buildings, etc.) to below grade.[13] There are no annual costs associated with this alternative. When the dismantling costs are translated to a 30-year levelized unit cost* basis, this amounts to about 0.17 mills/kWhr.

Combinations of mothballing and delayed (about 100 years) dismantling have 30-year levelized unit costs that are about the same as the mothballing alternative costs. Likewise, the costs for the entombing delayed dismantling combinations are about the same as the entombing cost. In both instances the annual maintenance cost for mothballing and entombing alternatives, on a present value basis, is sufficient to cover all the delayed dismantling cost for the mothballing alternative and about 80% for the entombing alternative.

Although the above costs are for a one-unit station, the savings associated with multiunit stations are small; thus, the unit cost (mills/kWhr) is essentially the same for a single unit station or multiunit station. For the San Onofre Nuclear Generating Station Units 2 and 3 the decommissioning costs would be about double that indicated for all of the decommissioning one-unit alternatives.

Studies of social and environmental effects of decommissioning large commercial power generating units have not identified any significant impacts.[13]

Also, studies indicate that occupational radiation doses can be controlled to levels comparable to occupational doses experienced with operating reactors through the use of appropriate work procedures, shielding, and remotely controlled equipment.[13]

The applicant may retain the site for power generation purposes indefinitely after the useful life of the station. The degree of dismantlement would be determined by an economic and environmental study involving the value of the land and crop value versus the complete demolition and removal of the complex. In any event, the operation will be controlled by rules and regulations in effect at the time to protect the health and safety of the public.

SONGS 2 and 3 are designed to operate for about 30 years, and the end of their useful life will occur approximately in the year 2011. The applicant has made no firm plans for decommissioning, but assumes that the following steps would be taken as minimum precautions for maintaining a safe condition:

1. All fuel would be removed from the facility and shipped offsite for disposition.

2. All radioactive wastes – solid, liquid, and gas – would be packaged and removed from the site insofar as practical.

A decision as to whether the station would be further dismantled would require an economic study involving the value of the land and scrap value versus the cost of complete demolition and removal of the complex. However, no additional work would be done unless it is in accordance with rules and regulations in effect at the time.

In addition to personnel required to guard and secure the station, concrete and steel would be used to prevent ingress into any building, particularly the radioactive areas.

Since the San Onofre site is located on U.S. Marine Corps property, the applicant must, if desired by the government, remove all of the improvements installed on the site at the end of the applicant's lease arrangement. This requirement could potentially entail complete removal and dismantling of the plant (ER, Section 5.8).

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*Based on a 1200-MWe generating unit beginning operation in 1958, a capacity factor of 60%, an escalation rate of 5%, and a discount rate of 10%. A more complete analysis of decommissioning costs can be found in Appendix B of NUREG-0480.[6]

REFERENCES

Unless otherwise noted, documents are available in public technical libraries.

1. U.S. Department of the Interior, Bureau of Mines, "Mineral Facts and Problems," 1970, p. 230.

2. U.S. Atomic Energy Commission, "Uranium Industry Seminar," Grand Junction, Colorado, Office, Report GJO-108(74), October 1974.***

3. Energy Research and Development Administration, "Survey of U.S. Uranium Marketing Activity," Report ERDA 77-46, May 1977.***

4. U.S. Atomic Energy Commission, "Survey of U.S. Uranium Marketing Activity," Report WASH-1196(74), April 1974.***

5. U.S. Nuclear Regulatory Commission, "Final Generic Environmental Statement on the Use of Recycle Plutonium in Mixed Oxide Fuel in Light Water Cooled Reactors," Report NUREG-0002, vol. 4, U.S. Government Printing Office, Washington, D.C., August, 1976, Table XI-32, Section 4.**

6. U.S. Nuclear Regulatory Commission "Coal Vs. Nuclear: A Comparison of the Cost of Generating Baseload Electricity by Region," NUREG-0480, December 1978.**

7. U.S. Atomic Energy Commission, Press Release, No. T-517, Oct. 25, 1974.*

8. Title 10, "Rules and Regulations," Code of Federal Regulations, Part 50, "Licensing of Production and Utilization Facilities," Section 50.51, "Applications for Termination of Licenses."

9. Title 10, "Rules and Regulations," Code of Federal Regulations, Part 50, "Licensing of Production and Utilization Facilities, Section 50.33, "Content of Applications; General Information."

10. P. B. Erickson and G. Lear, "Decommissioning and Decontamination of Licensed Reactor Facilities and Demonstration Nuclear Power Plants," presented at Conference on Decontamination and Decommissioning in Idaho Falls, Idaho, Aug. 19-21, 1975.*

11. U.S. Nuclear Regulatory Commission, Regulatory Guide 1.86, "Termination of Operating Licenses for Nuclear Reactors."

12. U.S. Nuclear Regulatory Commission, "Draft Generic Environmental Statement on Decommissioning of Nuclear Facilities," USNRC Report NUREG-0586, January 1981.

13. Atomic Industrial Forum, Inc., "An Engineering Evaluation of Nuclear Power Reactor Decommissioning Alternatives," Report AIF/NESP-009.

* Available for inspection and copying for a fee in the NRC Public Document Room, 1717 H Street, N.W. Washington, D.C. 20555.

** Available from NRC/GPO Sales Program, Washington, D.C. 20555, and the National Technical Information Service, Springfield, VA 22161.

*** Available from NTIS only.

10. BENEFIT-COST SUMMARY

10.1 RÉSUMÉ

There have been minor changes in the benefit-cost analysis of station operation since the issuance of the FES-CP in March 1973. The most significant changes are that the staff has revised the economic cost estimates upwards to reflect the rapid escalation seen during the last few years and has included among the benefits of station operation the fuel oil savings that will be made possible by having additional non-oil-fired, base-load capacity available in the California Power Pool. There have been essentially no significant changes in the staff's assessment of the environmental costs of operating SONGS 2 & 3; however, a broadening of the review process has occurred and is reflected in Table 10.1.

10.2 BENEFITS

The primary benefits of station operation will be the 9.3 to 13.0 billion kWhr of electricity produced by the two additional units each year (assuming a range of capacity factors of 50 to 70%), the increase in the reliability of electric service resulting from the addition of 2114 MWe of generating capacity, and an estimated regional decrease in the consumption of fuel oil of 13.2 million to 18.5 million barrels of oil per year (again assuming a range of capacity factors of 50 to 70%).

The staff also notes that operation of SONGS 2 & 3 will result in the generation of local revenues through property taxes and state sales and use taxes (annual property taxes will be approximately $13 million while state sales and use taxes resulting from station operation are estimated to be $3 million per year) and will increase local employment (over 300 new jobs will be directly created, with the average income of station workers being approximately $30,000 per year in 1980 dollars). However, these considerations are not included in the staff's benefit-cost analysis because from a societal viewpoint these local benefits are in actuality transfer payments from those using the electricity generated by the station to the recipients of the tax and employment benefits.

10.3 ECONOMIC COSTS

Since the issuance of the FES-CP the fuel, operating, and maintenance costs of nuclear plant operation have escalated more rapidly than anticipated by the staff in 1973. Based on more recent information, the staff now estimates the 1983 costs of station operation to be as follows: fuel costs — $120 million per year; operating and maintenance costs — $45 million per year; and decommissioning costs — $2.7 million per year.

10.4 ENVIRONMENTAL COSTS

Since the issuance of the FES-CP the applicants have accumulated additional environmental data and have made modifications in the station design. The staff, on making a reassessment of the environmental costs of station operation based on this new information, has found that the conclusions reached in the FES-CP are still valid. Table 10.1 summarizes the staff's assessment of the environmental impacts of station operation.

10.5 SOCIAL COSTS

The restriction in public use of 1.4 km (0.85 mile) of the San Onofre Beach is a significant cost of operation of the station. The number of personnel needed to operate SONGS 2 & 3 is a small fraction of the expected population growth in the communities near the station. As a result, the extra cost of providing public services to station personnel who relocate in the area is not likely to be discernible in these communities.

Table 10.1. Benefit-cost summary for the operation of SONGS 2 & 3[a]

Primary impact and population or resource affected	Unit of measure	Magnitude of impact
DIRECT BENEFITS		
ENERGY (50–70% capacity factor)	kWhr/yr X 10^6	9,300–13,000
CAPACITY	kW X 10^3	2,114
REDUCED FUEL OIL CONSUMPTION (50–70% capacity factor)	bbl/yr X 10^6	13.2–18.5
ECONOMIC COSTS		
OPERATING (1980 dollars, 60% capacity factor)		
Fuel	$/year	120,000,000
Operation and maintenance	$/year	45,000,000
DECOMMISSIONING (annualized value)	$/year	1,100,000
ENVIRONMENTAL COSTS		
IMPACT ON LAND		
Land use		Insignificant
Terrestrial ecology		Negligible
IMPACT ON WATER		
Fresh water consumption	gal/day	1,066,000
Salt water consumption		Insignificant
Heat discharge to natural water body		
Aquatic biota		Insignificant
Migratory fish		Insignificant
Chemical discharge to natural water body		
People		Not discernible
Aquatic biota		Not discernible
Water quality		Not discernible
Radionuclide contamination of natural surface water body		
All except tritium	Ci/year/unit	1.1
Tritium	Ci/year/unit	300
Chemical contamination of groundwater		
People		Not discernible
Plants		Not discernible
Radionuclide contamination of groundwater		
People		Not discernible
Plants and animals		Not discernible
Effects on natural water body of condenser cooling system operation		
Primary producers and consumers		Small
Fisheries		Small
Natural water drainage		
Flood control		No damage
Erosion control		Insignificant
IMPACT ON AIR		
Chemical discharge to ambient air		
Air quality, chemical		Negligible
Air quality, odor		Negligible
Radionuclides discharged to ambient air		
Noble gases	Ci/year/unit	8,800
Radioiodines	Ci/year/unit	0.195
Carbon-14	Ci/year/unit	8
Argon-41	Ci/year/unit	25
Tritium	Ci/year/unit	1,100
Particulates	Ci/year/unit	0.34
Fogging and icing		None
TOTAL BODY DOSES TO U.S. POPULATION		
General public, unrestricted area	Man-rem/year	442
SOCIETAL COSTS		
OPERATIONAL FUEL DISPOSITION		
Fuel transport (new)	Trucks per year	11
Fuel storage		In-building storage
Waste products (spent fuel)	Trucks per year	200
PLANT LABOR FORCE		Insignificant

[a]See Appendix C for calculations and explanations of table entries.

(To convert gal to liters, multiply by 3.7.)

10.6 ENVIRONMENTAL COSTS OF THE URANIUM FUEL CYCLE AND TRANSPORTATION

The staff has evaluated the environmental impacts of the uranium fuel cycle as presented in Table 5.8 and has found these impacts to be sufficiently small so that when superimposed upon the other environmental impacts assessed against the operation of the station, they do not alter the overall benefit-cost balance.

10.7 SUMMARY OF BENEFIT-COST

As the result of this second review of potential environmental, economic, and social impacts, the staff has been able to forecast more accurately the effects of station operation. The higher economic costs identified by the staff would not alter the staff's previous conclusion as to the overall balancing of the benefits of the station versus the environmental costs, whereas the benefit from the reduction in the regional consumption of fuel oil is felt to add significantly to the total benefits of station operation. Additional environmental costs have been identified as: (1) removal of approximately 1.4 km (0.85 mile) of beach from unrestricted public use, (2) possible destruction of at least a portion of the San Onofre Kelp Bed during the summer months by the heated water discharge, (3) occupation of about 7.2 ha (17.8 acres) of land by new towers, access roads, and switchyards associated with new transmission facilities, (4) environmental effects of the uranium fuel cycle as enumerated in Table 5.8, and (5) environmental impacts of transportation of fuel and waste to and from nuclear power plants as indicated in Table 5.7. Consideration of these additional costs together with those identified in the FES-CP does not alter the position taken in the FES-CP that the environmental and social costs are acceptable and that these costs are outweighed by the primary benefits of operating SONGS 2 & 3.

11. DISCUSSION OF COMMENTS RECEIVED ON THE DRAFT ENVIRONMENTAL STATEMENT

Pursuant to 10 CFR Part 51, the Draft Environmental Statment and a supplement to the Draft Environmental Statement related to the operation of the San Onofre Nuclear Generating Station, Units 1 and 2, were transmitted, with a request for comments, to:

Department of Agriculture

Department of Army (Corps of Engineers)

Department of Commerce

Department of Energy

Department of the Interior

Department of Health, Education, and Welfare

Department of Housing and Urban Development

Department of Transportation

Environmental Protection Agency

Federal Energy Regulatory Commission

Advisory Council on Historic Preservation

California Department of Health (Water Pollution Control Commission, Air Pollution Control Commission, Occupational Health Office)

California Department of Natural Resources

California Department of Parks and Recreation

In addition, the NRC requested comments on the Draft Environmental Statement and its supplement from interested persons by a notice published in the Federal Register on December 6, 1978 (43 FR 25183) and January 13, 1981 (46 FR 7435), respectively. In response to the request referred to above, comments were received from:

Draft Environmental Statement

U.S. Department of Agriculture, Science and Education Administration (DASEA)
U.S. Department of Agriculture, Economics, Statistics and Cooperative Services (DAESC)
U.S. Department of Agriculture, Soil Conservation Service (DASCS)
Department of Housing and Urban Development (HUD)
Department of the Army, Corps of Engineers (COE)
Federal Energy Regulatory Commission (FERC)
U.S. Department of the Interior (DOI)
Rourke and Woodruff Law Offices (RWL)
U.S. Department of Commerce (DOC)
Department of Health, Education, and Welfare (HEW)
Southern California Edison Company (SCE)
U.S. Environmental Protection Agency (EPA)
Mr. Marvin I. Lewis (MIL)
Richard J. Wharton (RJW)

Supplement to the Draft Environmental Statement

U.S. Dearptment of Agriculture, Economics, Statistics and Cooperative Services (DAESC)
Federal Energy Regulatory Commission (FERC)
U.S. Department of the Interior (DOI)
U.S. Environmental Protection Agency (EPA)
Union of Concerned Scientists (UCS)
Richard J. Wharton (RJW)
Southern California Edison Company (SCE)
Frank H. Grundel (FHG)
San Diego Association of Governments (SAG)
U.S. Department of Agriculture, Soil Conservation Service (DASCS)

The comments are reproduced in this statement as Appendix A. The staff's consideration of the comments received and its disposition of the issues involved are reflected in part by changes in the text in the pertinent sections of this Final Environmental Statement and in part by the discussion in Section 11. The comments are categorized by subject and are referenced by the use of the abbreviations indicated above. The pages in Appendix A on which copies of the respective comments appear are indicated by each subject title relating to the comment, and in the index to Appendix A.

11.1 EROSION CONTROL (DASCS, A-4)

The applicant's erosion control plans are briefly discussed and referenced in Sections 6.2.2 and 6.3.2. In addition, the treatment of disturbed areas is addressed in the FES-CP. Such discussions are beyond the scope of the OL review.

11.2 LOSS OF PRIME LANDS (DASCS, A-4)

The discussion of prime lands lost to access roads and transmission towers, which is presented in Appendix E of the DES, is based on available information as a result of staff discussions with Mr. Jack Smith and Mr. Ted Thee of the Soil Conservation Service (SCS) Escondido Field Station and Mr. Jon Christianson of the SCS Tustin Field Office.

11.3 RECREATION RESOURCES (DOI, A-5; RJW, A-48)

The original plan to allow recreational use in the beach area immediately adjacent to the nuclear plant was altered in the course of hearings before the ASLB and ASLAB based on safety considerations. The staff reasserts its judgment that, while significant, the impact of beach closure is not sufficient to warrant denying the applicant an Operating License for SONGS 2 & 3. While the 1.4 km (0.85 mile) of beach to be closed must be considered a valuable recreational resource, there are approximately 5.6 km (3.5 miles) of State Beach immediately south of this area and almost 1.1 km (0.7 miles) immediately north which remain open to the public. Of those three parcels of beach, the one to be closed gets substantially less use than the other two and is directly adjacent to the SONGS complex, where the natural aesthetics of the area have been altered by plant development. Finally, while the 30 years of beach closure is clearly a long time, it does not represent an "irreversible and irretrievable commitment of resources" as the intervenors contend. For these reasons, it is the judgment of the staff that the closure of this stretch of beach, while significant, is not sufficiently adverse to warrant forbidding plant operations.

11.4 RADIOLOGICAL IMPACTS (HEW, A-10; SCS, A-30; EPA, A-40/A-42; MIL, A-45; RJW, A-50)

The NRC staff agrees it is appropriate to note that dose commitments to any individual will also meet EPA regulation 40 CFR 190 which requires that such doses will not exceed 25 mrem/year to any individual.

The recent AIF study* referred to in this comment was an effort to provide the potential impact of lowering the exposure limit to 500 millirems per year. The data were developed to fit the model that the AIF developed to evaluate the impact of the exposure limit reduction. The exposure data were meant to portray the <u>type</u> of exposure situations which occur at PWR's but are not likely to occur every year at each plant. (See Section 5.5.1.4 for staff consideration of occupational radiation exposures.)

Table 5.8 is based on NRC Table S-3, from 10 CFR Part 51, and is a generic discussion of impacts for the balance of the uranium fuel cycle. The staff is bound by the Commission standard as shown in Table 5.8. A discussion of alternative handling of HLW or TRU wastes is therefore inappropriate for considerations of licensing SONGS 1 & 2.

*"A Preliminary Assessment of the Potential Impacts on Operating Nuclear Power Plants at a 500 millirem per Year Occupational Exposure Limit," J. Vance, C. Weaver, E. Lepper, AIF, April 1978 (unpublished).

The staff has made its own independent and reasonably conservative estimates of potential doses to maximum individuals as a result of the operation of SONGS 2 & 3. Considering the uncertainties involved in such calculations, the staff finds a factor of 3 difference to be in very good agreement. Therefore, the staff rejects the request that Table 5.4 of the DES be revised in order to be consistent with applicant's estimated doses.

The staff calculation was for sport fish taken in the mixing zone, not 0-10 miles from the outfall, and is an independent and a reasonably conservative estimate of doses to a maximum individual. It is true that doses would be much less at greater distances from the outfall. However, the staff rejects the suggestion that Tables 5.6 (and 5.2 and 5.3) are in need of revision in order to be consistent with the applicant's estimates, particularly when both sets of estimates are orders of magnitude below the Appendix I design objective doses.

The staff agrees that the DES contains relatively little information regarding beach use at the SONGS site. Detailed discussion is presented in the Applicant's ER (e.g., pp. 2.1-4 to 2.1-7, and 5.2-1 through 5.2-54). In addition, more information regarding the staff conclusions and assumptions relating to doses to transient populations at the beach is presented in response to EPA comments.

The dose to individual users of the beach was not calculated for the following reasons:

1. The prevailing wind direction generally carries radioactive effluents away from the beach, thereby lowering potential exposures.

2. The beach is part of the exclusion area of the plant site, and public use (e.g., sunbathing and picnicking) is not permitted (e.g., see p. 2.105 of the applicant's ER).

3. The walkway connecting the south and north beaches is at the bottom of a 28-ft seawall which effectively shields passerbys from any direct radiation from the plant.

4. Although the dose rates at the site boundaries are expected to be low, annual doses to individuals would be even lower due to limited exposure times in transit between beaches.

Doses to individuals at the visitor center (0.1 mi E) were calculated, but occupancy factors result in much lower annual doses than calculated from permanent residents assumed living year-around at the WNW site boundary (0.36 mi) reported in the DES. As noted in Section 5.5.1.4, direct radiation (other than from the gaseous plume) from SONGS 2 & 3 is expected to be very low at the beach area. When coupled with limited exposure periods for transients, and shielding from the 28-ft-high seawall, the potential annual doses would be insignificant.

Population doses included transient populations by sector within 10 miles of the site. Transient populations were added to the projected resident populations for the year 2000 by assuming each transient spent one full day (24 hours) visiting during each year.

10 CFR Part 20 (10 CFR 20.105a) has been modified to include the provisions of 40 CFR Part 190. Also, the SONGS 2 & 3 technical specifications will require a demonstration to show compliance with 40 CFR Part 190 considering the operation of three reactors at the SONGS site.

Section 5.5.3 of the FES has been modified to include the long-term environmental effects associated with carbon-14, krypton-85, and tritium releases of the fuel cycle excluding the reactor releases. These modifications were added to the earlier discussion which focused largely on the radon-222 impacts.

Staff estimates of the longer term effects of carbon-14, tritium, krypton-38, and releases of the reactor contribute less than 30% of the total fuel cycle impacts presented in Section 5.5.3 of the FES. Health effects reported in the FES on a "per reactor year" basis can be multiplied by the reactor operating time (i.e., 30 years) to obtain the total or integrated estimate.

Nevertheless, the staff is in the process of modifying its calculation methodology to automatically consider the radiological impacts of effluent releases of the entire nuclear fuel cycle.

It is important to note that the FES results conservatively include the impacts of both uranium and plutonium recycle even though such operations are not currently permitted. Thus, the FES results are conservative for any recycle option, especially the "throw-away" cycle, the option currently allowed.

The NRC staff has reevaluated the proposed preoperational radiological environmental monitoring program for SONGS 2 and 3. The proposed program is based on the existing SONGS 1 operational program. That program will be revised in the near future to meet the Appendix I (10 CFR Part 50) requirements now being incorporated into the Environmental Technical Specifications for Unit 1, thereby updating the preoperational program for Units 2 and 3.

Response to specific EPA comments are as follows:

1. Current NRC criteria require collection and measurement of I-131 only, since it is the radioiodine which accounts for essentially all of the radioiodine environmental dose commitment (nearly all of which is through food pathways). The reason the applicant specified a maximum of 8 days was to be certain that the samples can be collected, transported to a laboratory (often at a considerable distance), and analyzed "within 8 days" under difficult circumstances (e.g., storms, trucking strikes, etc.). In most cases the elapsed time will be much less.

2. The intent of the air sampling program is to monitor continuously at all sites. However, experience has shown that occasionally air sampling equipment fails during a 7-day period, and the samples are of no value. The same experience indicates the applicant can almost always achieve 75-80% reliability.

   That is the only reason for mention of "a <u>minimum</u> of 10 samples per quarter" by the applicant.

3. The staff agrees that it might be desirable to have a TLD station along the walkway below the seawall. However, as noted in response to the previous comment, the walkway is 28 ft below the top of the seawall and there is no line-of-sight between the beach and any radiation sources on the site. The beach in front of the site is part of the exclusion area (i.e., no sunbathing, picnicking, etc. is permitted). Therefore, there is no possibility of any member of the public receiving a measurable radiation dose since individual exposure times would be very small.

4. The NRC has included U.S. population dose commitment estimates in Section 5.5 for a few years (see, for example, Table 5.5). In addition, the staff has been including discussion of the Rn-222 question since mid-1978 (see Section 5.5.3).

Table 5-8 says Rn-222 releases are "Presently under reconsideration by the Commission," and in footnote a, "These issues which are not addressed at by this table may be subject to litigation in individual licensing proceedings." The results of generic testimony by the staff at other hearings is summarized briefly on pp. 5-36 to 5-40. Contrary to Mr. Lewis' assertion, NEPA does not require quantification of the impacts of Rn-222 releases over the "full period of toxicity" (presumably he is referring to Th-230, the parent of Rn-222). The staff feels the conservative evaluation in Section 5.5.3 probably accounts for the releases and potential doses resulting from Rn-222 releases over periods of many millenia. In addition, the FES will provide a revised Section 5.5.3 which also includes potential impacts of C-14 over periods up to 1,000 years into the future.

The staff agrees that stabilization of surface tailings piles cannot be assured "forever." However, numerous options, including deep burial in worked-out open pit mines or underground mines, are being voluntarily used by some applicants and may be used increasingly in the future by others. It should be noted that if such tailings are exposed by acts of God (e.g., glaciation), the potential long-term impacts could be lower than for the natural uranium ore since milling will remove over 90% of the U-235 (the parent of Th-230).

Environmental releases from "nuclear waste materials, including the interim storage of spent fuel, on site" are so small relative to normal operational releases as to be inconsequential. Such releases and potential impacts have been estimated* and do not significantly change the estimated impacts presented in the DES for normal operations. In that sense, the releases have been included in the DES assessment of environmental impacts.

11.5 METEOROLOGY (SCE, A-16)

The onshore tracer test results indicated that measured ground-level centerline one-hour average concentrations were less than concentrations estimated from the usual staff calculations. But a reduction for annual average values would not be the same.

*Draft Generic Environmental Impact Statement on "Handling and Storage of Spent Light Water Power Reactor Fuel," NUREG-0404, U.S. Nuclear Regulatory Commission (March 1978).

Over a long period of time, such as a year, the wind direction within a sector should be randomly distributed, and thus the path of the plume should be randomly distributed. The time that any part of the plume is over a point within the sector contributes to the annual average at that point. This time integration and random path of plume have the net effect of uniformly distributing an effluent horizontally within a sector. Any enhanced dispersion due to additional horizontal plume spreading would not reduce the annual average concentration. In the staff calculations it was assumed that the effluent was uniformly distributed horizontally over the sector.

The ground-level annual average concentration would be dependent on the wind frequency and on the vertical distribution of the effluent within the plume. No direct measurements of vertical plume distributions were made during these onshore tests or the tests referenced in NUS-1927. Without a more definitive description of the vertical distribution of the plume, it has been the staff position not to adjust annual average dispersion estimates.

11.6 THERMAL ANALYSIS (SCE, A-20/A-21)

The air temperatures used by the staff in its thermal model are too high and, therefore, the staff's ambient temperature predictions are too high. However, nonlinear effects of the air temperature on the water temperature are negligible so that the staff's excess temperature predictions are correct despite the systematically high ambient air temperatures used in the mathematical model.

Higher near-shore predicted ambient water temperatures appear as a result of the depth-averaged format of the predictions. The near-shore region is shallow, resulting in near homogeneous vertical temperature structure. In deeper water, strong stratification is present so that the depth-averaged water temperatures are lower due to the presence of cool bottom water. The staff's actual ambient surface temperature predictions show no variation in the offshore direction. Ambient temperatures based on field measurement have been used in Section 5.4 of the FES.

A brief discussion of the applicant's error analysis is given in Section 5.3.1.1 of the FES.

Errors in the staff's mathematical model can be introduced in several ways. First consider the accuracy of the numerical method. The TEMPTWO algorithm is consistent and stable. The use of direct upwind differencing can produce numerical dispersion when the Courant Number is not equal to 1. To minimize this error, the staff used a time-step that produced a Courant No. of 1 near the diffusers. This essentially eliminated numerical dispersion error around the discharge areas. Far from the discharges, numerical dispersion exists; however, this makes the predictions less conservative. To correct for this, the staff could raise the predicted excess temperatures in the far field. The staff believes that inaccuracies due to numerical dispersion are slight and, therefore, corrections of such inaccuracies are unnecessary.

Errors could also have been introduced through the methods used to represent turbulent transport and surface heat transfer. In developing the model, an effort was made to incorporate formulations which are universal; that is, to create a model that requires no adjustment of coefficients on a site-specific basis. The TEMPTWO model has been applied to other plants and results have compared favorably with available data. Thermal predictions for the Peach Bottom Plant and the Anclote Plant, including comparison with field data, are shown in Figures 11.1 through 11.8. The Peach Bottom Plant is on an impoundment of a river in Pennsylvania and the Anclote Plant is located on the Gulf of Mexico. The success of the TEMPTWO model at two quite different sites indicates that the submodels for turbulent transport and surface heat transfer can confidently be applied to San Onofre.

The staff's model did not include plant-induced densimetric flows. The staff performed a scale analysis and determined this effect to be insignificant at the San Onofre site.

Individual jet mixing is not calculated within the staff's model. However, this effect was included based on the applicant's near-field results.

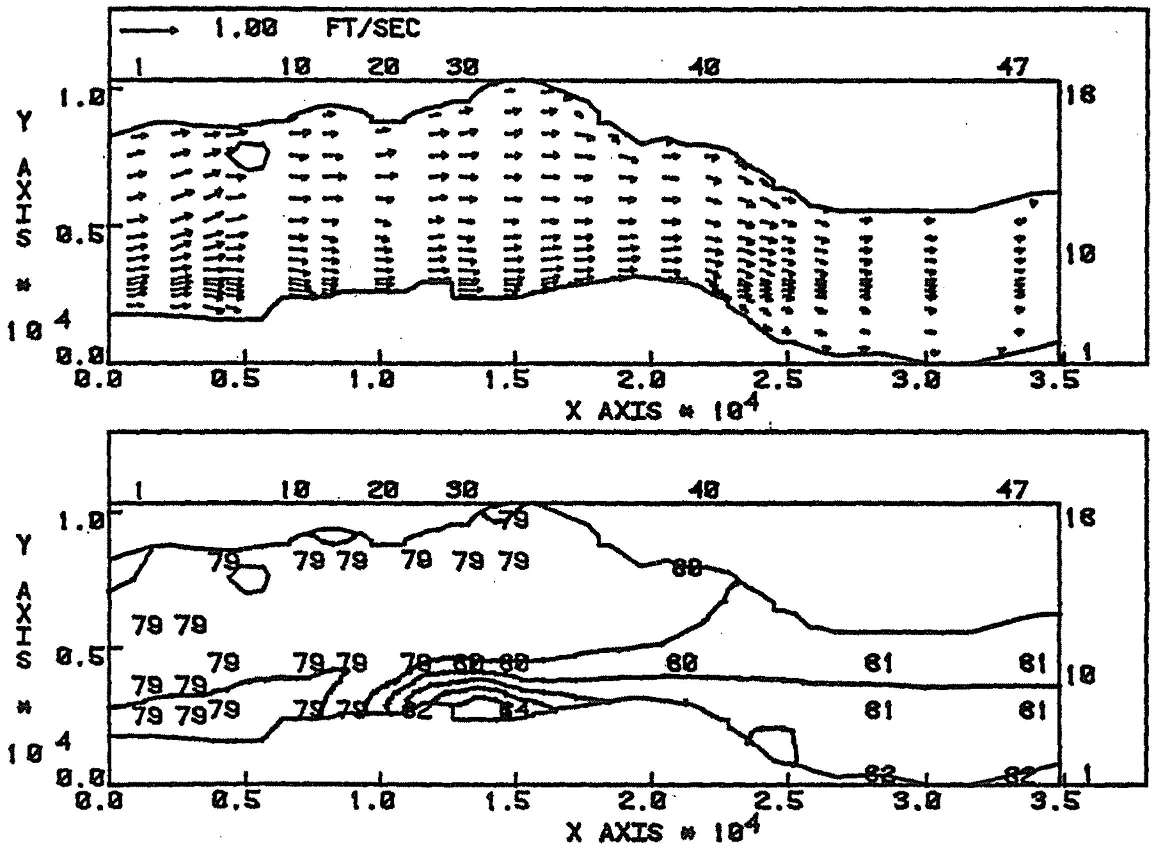

Figure 11.1 Computer simulation results for the two-dimensional depth-averaged (with self-similar vertical variation) flow conditions and temperature conditions (isotherms with 1°F gradation (1/1.8°C) in the Conowingo Pond Reservoir in the vicinity of the Peach Bottom Atomic Power Station at 9 a.m. on July 18, 1974, during reservoir conditions: downstream low flow after slack water.

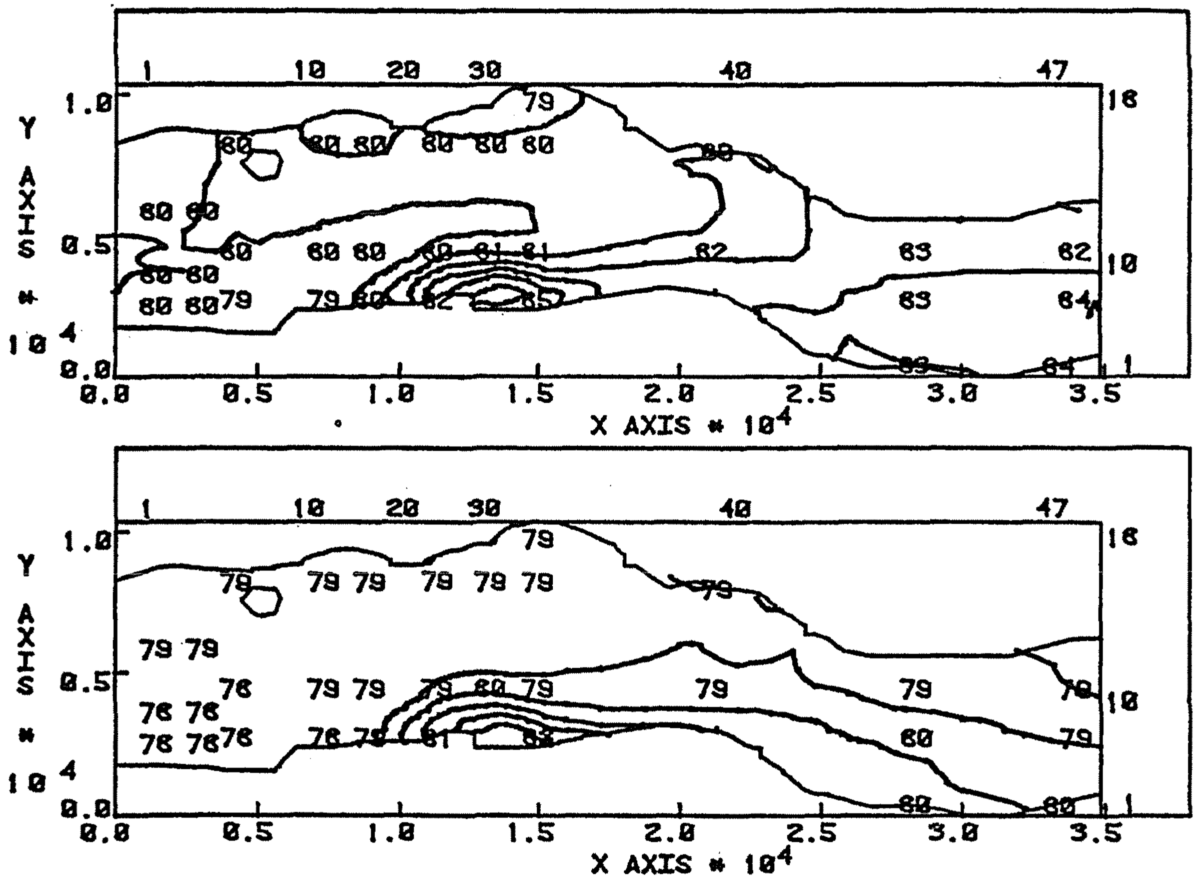

Figure 11.2 Computer simulation results for the surface and bottom temperature conditions (isotherms with 1°F gradation (1/1.8°C) in the Conowingo Pond Reservoir in the vicinity of the Peach Bottom Atomic Power Station at 9 a.m. on July 18, 1974, during reservoir conditions: downstream low flow slack water.

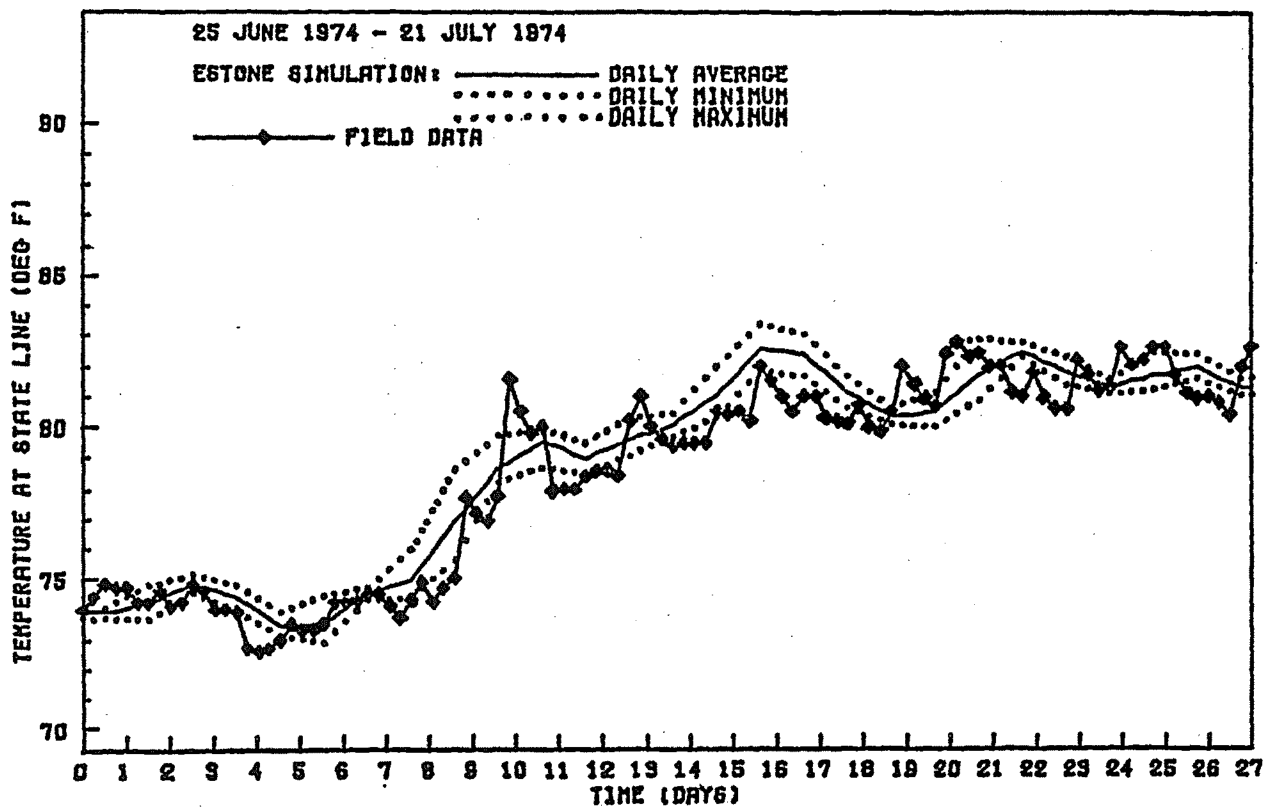

Figure 11.3 Estone simulation June 25, 1974 through July 21, 1974.

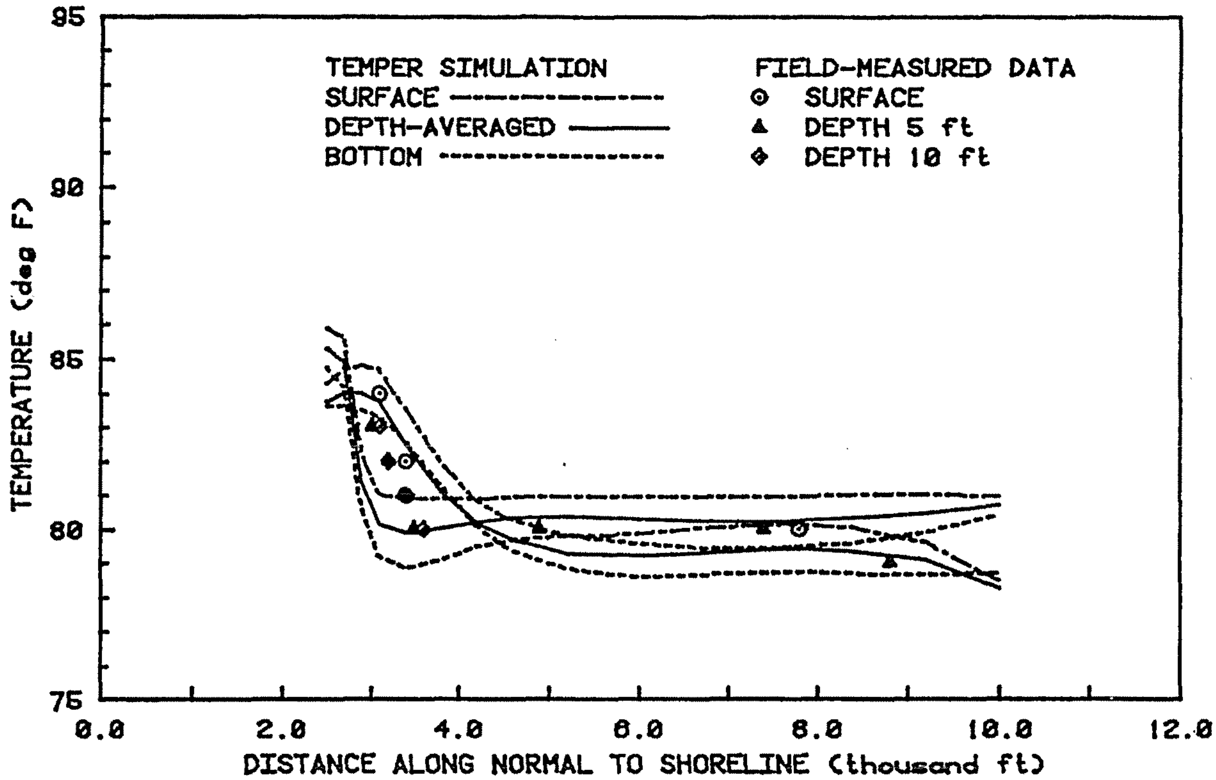

Figure 11.4 Comparison of the computer simulation results and the field-measured data for the temperature conditions along a transect at 1200 ft downstream from the discharge location of the Peach Bottom Atomic Power Station in the Conowingo Pond Reservoir from 8 a.m. to 1 p.m. on July 18, 1974.

(To convert ft to m, multiply by .3048.)

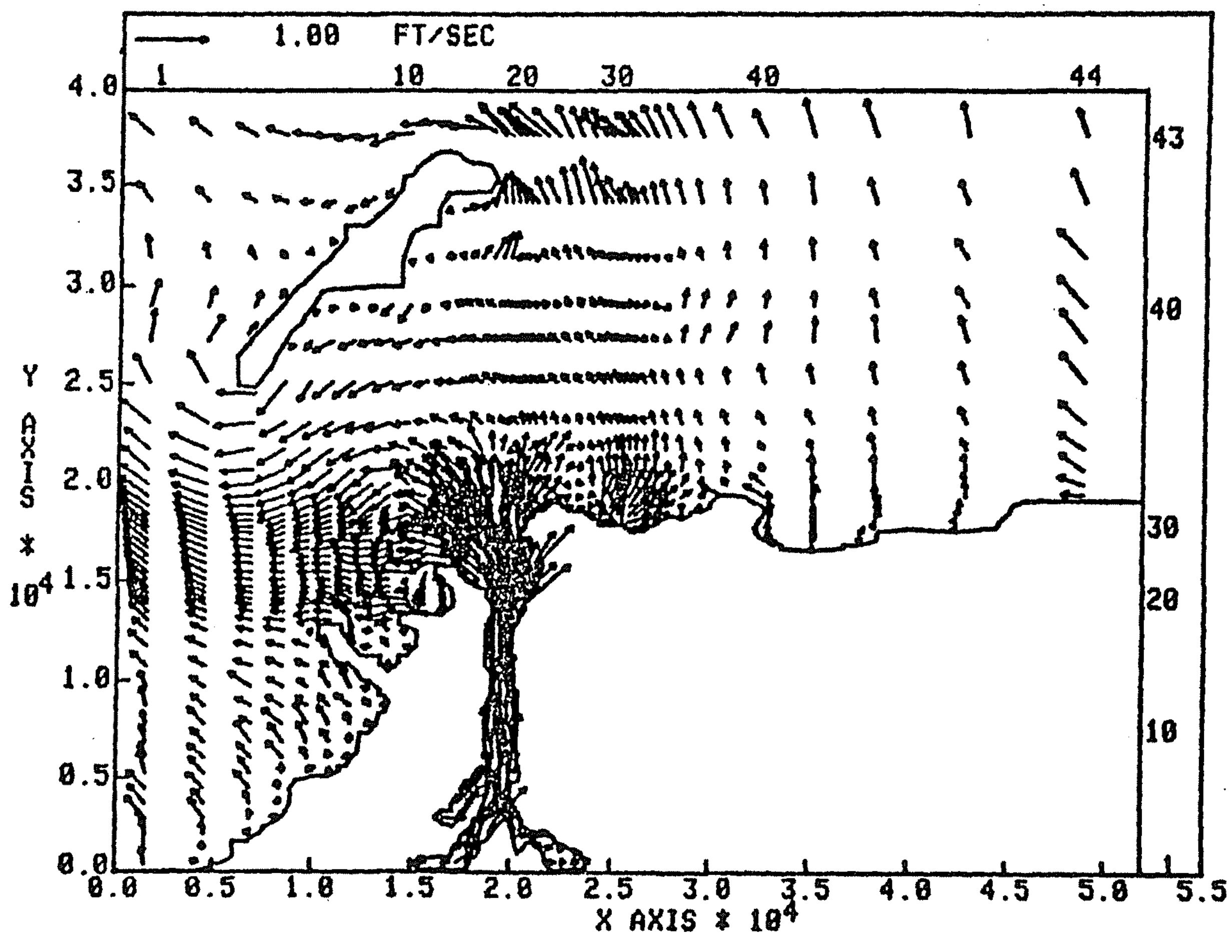

Figure 11.5 Computer simulation results for the two-dimensional depth-averaged flow velocity conditions in the Anclote Anchorage region for the actual Unit 1 operation of the Anclote Power Plant at 3 p.m. on June 25, 1975, during tidal stage: approximate maximum ebb.

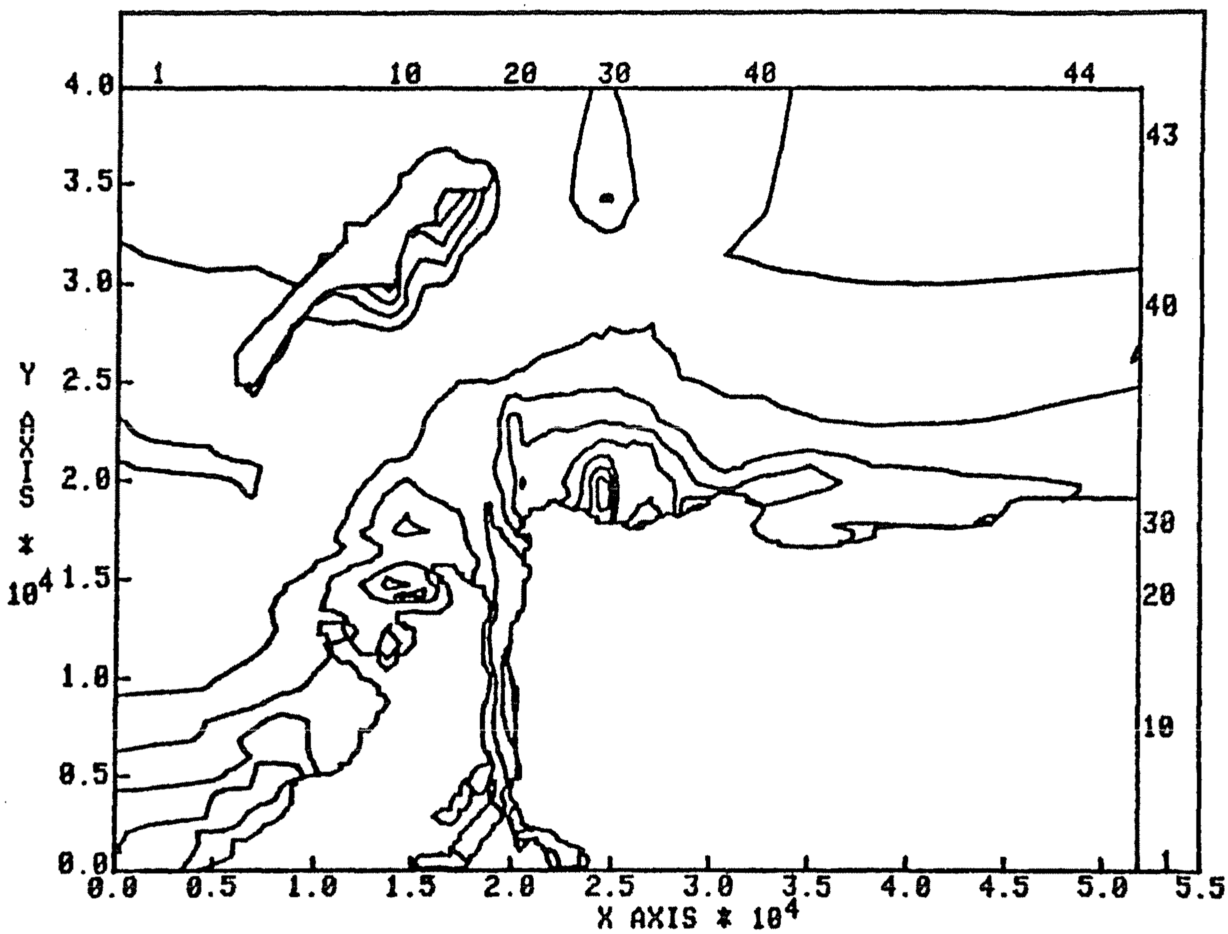

Figure 11.6 Computer simulation results for the two-dimensional depth-averaged water temperature conditions (isotherms with 1 F (1/1.8 C) gradation between minimum 84 F(28.9 C) and maximum 92 F(33.3 C)in the Anclote Anchorage region for the actual Unit 1 operational condition of the Anclote Power Plant at 3 p.m. on June 25, 1976, during tidal stage: approximate maximum ebb.

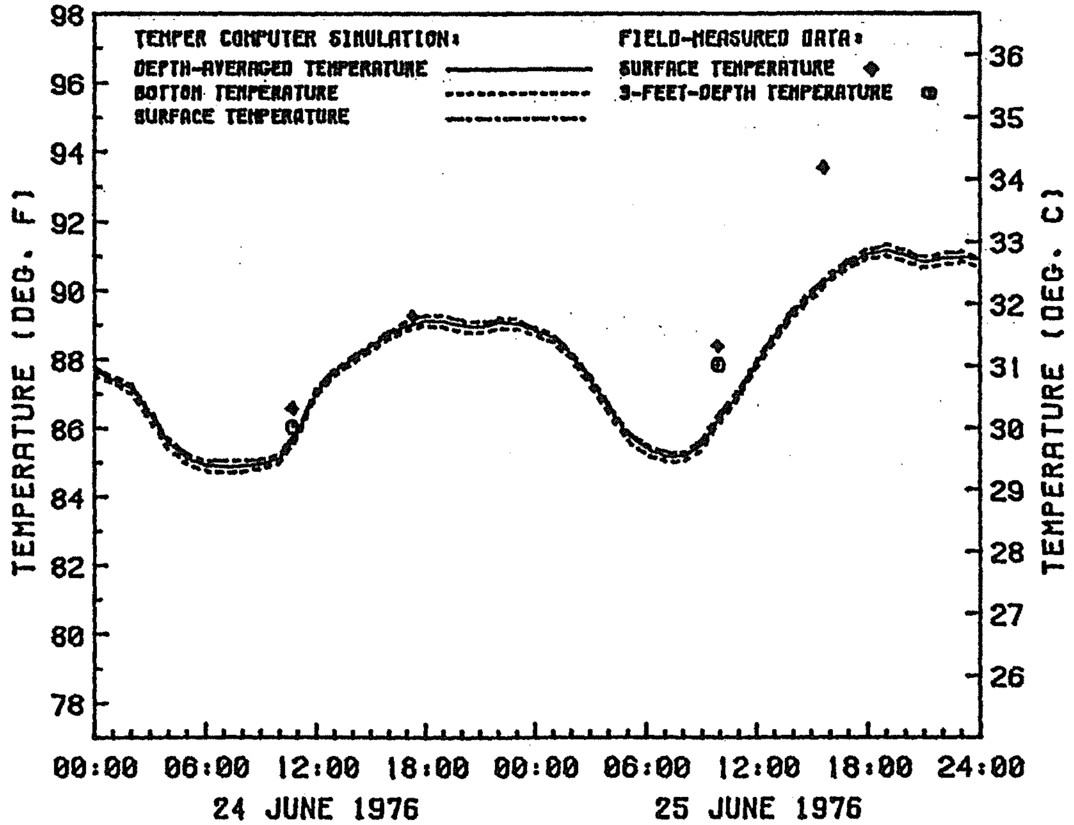

Figure 11.7 Comparison of the computer simulation results for the water temperature conditions (as continuous hourly variations) and the available field-measured water temperature data (intermittent) in the Anclote Anchorage region during the 2-day period June 24-25, 1976, at the field-sampling station 25.

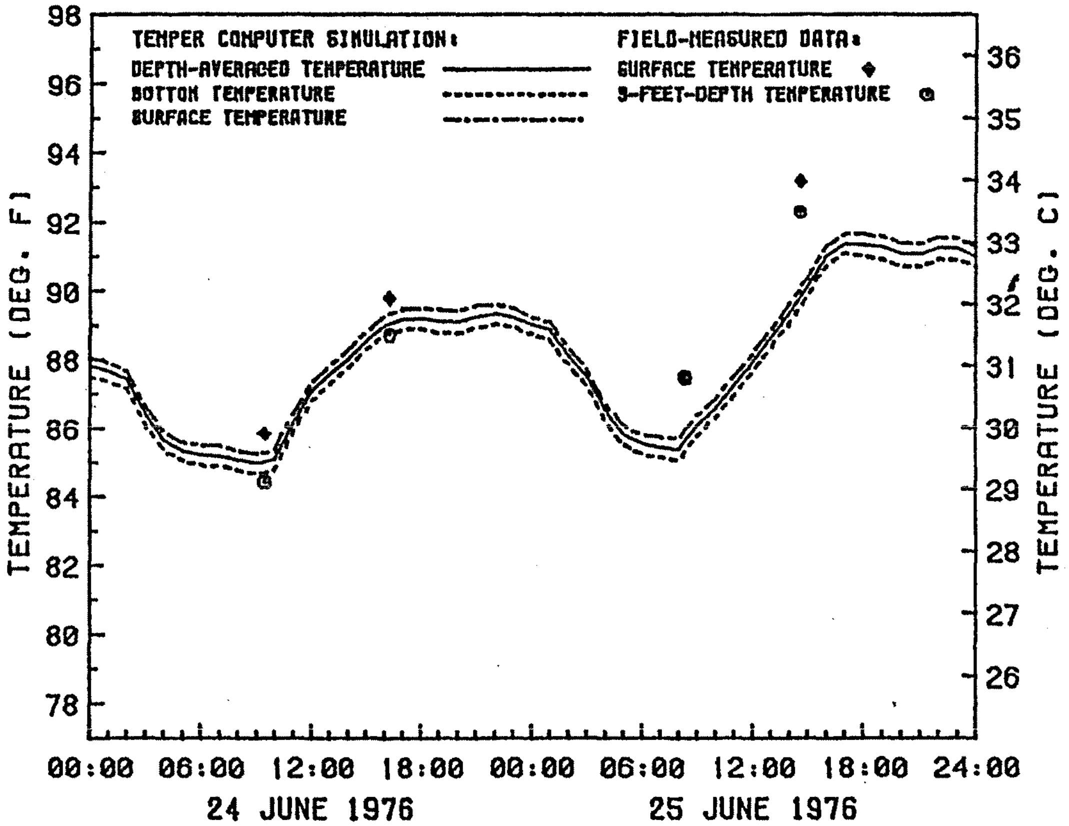

Figure 11.8 Comparison of the computer simulation results for the water temperature conditions (as continuous hourly variations) and the available field-measured water temperature data (intermittent) in the Anclote Anchorage region during the 2-day period June 24-25 1976, at the field-sampling station 1.

11.7 THERMAL EFFECTS (SCE, A-14, A-24/A-25)

It is true that the ambient temperature data supplied by the applicant (Attachment T) indicate the presence of lower ambient temperatures, at both the surface and the bottom, within the region of the San Onofre Kelp Bed than those predicted by the model. Typically, the discrepancy between the maximum values reported by the applicants and from the thermal model (for both surface and bottom) during the late summer is on the order of 4-5°C (7-9°F). However, the recently supplied values are for a period of record which spans only a few years (1975-1978). Thus, it is not possible to know if some of these data were collected during a period of time in which the waters are naturally warmer than long-term average. In evaluating the potential impacts of a long-lived facility such as SONGS (which will operate for up to 30 years), a worst-case evaluation is usually made to determine the effects which might occur under extreme conditions. Without knowledge of the relationship between the data supplied by the applicant and worst-case temperature conditions, these data cannot be relied upon for an assessment of the impacts on the kelp.

If the assumption is made that these data do include an interval in which there are temperatures which are warmer than usual (e.g., the warmest values reported in the last 15-20 years), then the conclusions of the applicant regarding the effects on kelp are probably correct. That is, the incremental temperature increase due to the operation of SONGS will not result in an adverse impact to the community, even under worse-case conditions.

The staff does not concur that the bottom water will necessarily remain unaffected.

The staff does not feel that the ambient temperature data available are complete enough for use in a worst-case analysis. Because such an analysis (based on the temperature data generated by the model) concluded that the impact to the benthic community will be insignificant (overall), it is clear that the effect under average conditions will likewise be insignificant. If the model does predict maximum temperatures which are unrealistically high, the conclusions based on such data provide additional assurances that the impacts will be negligible.

11.8 BIOLOGICAL RESOURCES (DOC, A-8/A-9; SCE, A-25/A-30; RJW, A-47)

The statement was not meant to imply that the only relationship between kelp beds and the commercial fishes is through the kelp detritus. Certainly, several of the commercially important species inhabit the beds (at least part of the time) for food-seeking activities and refuge. The paragraph was intended to portray, in brief, the ecological and commercial importance of kelp beds. Additional information on this subject is contained in the FES-CP.

Any revision to station design or operation for the express purpose of mitigating nonradiological impact to aquatic biota will be accomplished through procedures under the NPDES Permit Program administered by the California Water Quality Control Board. NRC is working closely with this Board and with other State resource agencies in the review of monitoring programs.

The cost-benefit analysis for the potential loss of biological resources due to the operation of SONGS 2 and 3 is addressed in the SONGS FES-CP, March 1973, Sections 13.2.4 and 13.4, and in Section 10 of this FES.

Technically, the statement is still correct. Although man-induced thermal effects may not be documented, their occurrence is likely in some areas.

It is true that the association of decreased kelp "health" with turbidity was made in conjunction with observations on the effects of sewage outfalls. However, the effect of turbidity on light attenuation is not a function of the source or type of the turbidity, except that a certain type of turbidity may not produce the same light reduction, at a given concentration, as another type of turbidity (e.g., as in the case of fine sand particles vs. suspended clay). Reference 15 includes a statement on the reduction of kelp "health" as a function of reduced available light for photosynthesis. It is reasonable to assume, therefore, that kelp "health" can be affected by many different types of turbidity.

It is true that nutrient depletion has been implicated in kelp canopy deterioration. It is also true that the exact mechanisms of kelp deterioration are not well known. Most studies have attributed cause-effect relationships between temperature and kelp demise, but the operating factors may well be complex, and may involve, for example, synergisms between several factors. To reflect this uncertainty, the text has been changed as per the suggested revision.

The study cited (number 13) gives one indication of the importance of kelp beds to fish communities. The relative importance of kelp for fish rearing, refuge, etc. may be disputed. However, for purposes of a worst-case analysis, it must be assumed that a more conservative interpretation is correct. It should be noted that the subject paragraph does not state that kelp beds are the most important fish habitat. Rather, it indicates that the community does have some unspecified importance.

The ecotypic variability of kelp temperature to tolerance is not well documented, though it may occur. Without definite knowledge, the more conservative values should be used in a worst-case analysis.

As stated earlier (see response to SCE, A-2), the ambient temperature data supplied by the applicants do not appear to be entirely adequate for an analysis.

Increased survace nutrient levels from outfall induced upwelling have not been adequately demonstrated, though the phenomenon may occur.

The discharge for SONGS will be more or less continuous (except during shutdowns and power reductions), although it is true that when the plume reaches the kelp bed it is not likely to impinge the bed for a long period of time. This is acknowledged in the text and is one major reason why the conclusion was reached that the effect on the kelp bed is not likely to be severe (p. 5-27, paragraph 5). To avoid ambiguity, the subject statement has been revised.

The reference to Sect. 5.3.1 as the basis for the 19°C figure has been deleted. It is, however, based on results of the staff's thermal model. If this temperature represents the extreme high end which occurs during an average year, then it may well represent a temperature which could occur over an extended period of time during a "warm year." Because the values from the model are conservative, the word "typical" has been deleted from that sentence.

The staff's thermal analysis (Sect. 5.3.1) does not support the conclusion that increases in bottom temperatures are unlikely. The statement remains valid, even if the turbid water is discontinuous and relatively low in suspended solids; i.e., the presence of any increased turbidity will add to the probability of detrimental effects occurring to the kelp bed.

The analysis of the effect of the operation of SONGS on the closest kelp bed (San Onofre) was based on the latest thermal-hydraulic predictions made by our staff. The staff agrees that if this assessment of temperature configurations proves to be inaccurate that the analysis of kelp bed effects would have to be reassessed.

The granting of a 316(a) exception for normal operation, if such is needed, will not affect the operating characteristics of the facility; thus, the pedicted impacts remain valid. If a 316(a) type process becomes required by the State which results in operational changes, the impacts of that altered operating mode will have to be assessed when such conditions are known.

11.9 WATER QUALITY (EPA, A-38/A-40)

Section 5.3.1.1 and Fig. 5.3 are based on the applicant's thermal analysis. Section 5.3.1.2 is a description of the staff's thermal analysis. This analysis includes all three units operating at 100% capacity and the ambient temperature is defined as the water temperature in the absence of all units. The possibility of recirculation among all units is an integral part of the staff's model. The results described in Section 5.3.1.2 address all aspects of the State thermal standards including excess temperatures at the surface of ocean substrates.

Additional information on the effects of the operation of the facility are found in the FES-CP, although in some cases the modification of operational characteristics since the CP stage has necessitated a reevaluation of the impacts. Such reanalyses are found in this document.

In the staff's opinion, the two documents (the FES-CP and FES-OL) provide "state-of-the-art" evaluations of how the acquatic ecosystem will be affected. In most cases, too little information is available to quantitatively predict the areal extent of an effect on a given species. For this reason, operational monitoring programs are required which are designed to detect significant changes which may occur so that mitigation can be instituted.

The terms "minimal," "acceptable," and "not significant" relate to a judgment made regarding the predicted impacts of the facility on the environment. A possible effect is termed insignificant if, for example, the impact is predicted to only occur locally in a nonunique, or widespread, population community of organisms, etc. When it is not possible to reach a firm conclusion regarding the significance of a projected impact (even under worst-case conditions), mitigation is either recommended immediately or an extensive monitoring program is stipulated.

The study report concerning use of the heat treatment process addresses a matter beyond the NRC's purview in accordance with the Federal Water Pollution Control Act Amendments of 1972. Thus, while the NRC must evaluate and consider the environmental impacts attributable to use of such heat treatment process, such consideration is limited to a determination of the impacts and their significance in terms of the cost-benefit analysis for this facility; any changes in the system or its use must be directed by the California Regional Water Quality Board and/or the Environmental Protection Agency. The applicant will provide the study report directly to those agencies, as well as to the NRC, when available.

For the foregoing reasons, we do not believe that the report itself is an integral part of the Draft Environmental Statement. Of course, as noted above, the NRC will consider the impacts attributable to the heat treatment process in the Final Environmental Statement as stated in Section 5.4.2.1. In this connection, the staff considers it to be no different than any other report of a study or analysis performed by a license applicant in support of its application. The staff is aware of no legal requirement which would give the report independent status such as EPA suggests, in the context of the NRC's licensing review. The status of this report in terms of the determination to be made under Section 316(a) of the FWPCA is a matter left to that agency charged with making that determination.

Sect. 5.4.2.2 concludes that significant impacts are unlikely, even under worst-case conditions. The effluent characteristics of SONGS must conform to the State standards prevailing at the time of the operation of the facility.

It is not the purpose of the staff analysis, as provided in the DES, to make rulings regarding statutory requirements, but rather to assess the impacts of proposed operation. In making this analysis it is not assumed that standards will be satisfied and, therefore, the environmental consequences of any violations resulting from the proposed plant operation is inherent in the staff's conclusions.

11.10 NEED FOR PLANT (MIL, A-45)

Table 2.2 of the FES relates to projected population growth within 16 km of the San Onofre site for the period 1976 to 2020.

Tables 8.3 and 8.4 are related to the electrical growth projected within the service areas of Southern California Edison Company and San Diego Gas and Electric Company for the periods 1976-1985. The combined annual growth rates for peak demand and energy for this period is 4.3 and 4.6%, respectively.

Population within 16 km of the site does not necessarily reflect electrical growth in the applicant's service areas.

11.11 SEISMOLOGY (EPA, A-40; MIL, A-45; RJW, A-49)

The staff's review and evaluation of the geological and seismological aspects of the San Onofre Nuclear Generating Station Units 2 and 3 is presented in the staff's Safety Evaluation Report, published December 1980. Included in the SER is a discussion of the potential for and nature of seismic activity at the site and its vicinity as well as of the design and construction measures taken by the applicants to prevent damage to the facility and its component parts. The staff considers that its assessment of the environmental impact of postulated accidents presented in Chapter 7 adequately accounts for the consequences of any accident caused by seismic activity. This chapter discusses the consequences of accidents regardless of cause.

Regarding the potential for affecting water quality and for offsite radiological contamination, to the extent such impacts are the result of airborne transportation of radionuclides, the consequences are included in the discussion in Chapter 7. The liquid pathway, because of the hydrological environment at the site, does not present a viable transport mechanism which could impact water quality or would otherwise result in offsite radiological consequences.

11.12 URANIUM PRICES (RJW, A-49)

The cost-benefit analysis in the DES is based on 1976 data, at which time the price of uranium was $18.10/kg ($40/lb) U_3O_8. Presuming SCE used the then existing U_3O_8 price in their cost-benefit analysis for SONGS 2 and 3, they would be using a price that reflected the rapid increase in prices in the 1973-1976 period. To extrapolate future prices on the basis of the 1973-1976 price increase would be erroneous in that uranium prices decreased 9% in real terms during 1977. Thus, it is inappropriate to consider a price escalation which is not even valid for a 5-year period of the uranium market for a cost-benefit analysis which covers the 30-year lifetime of a reactor. It would be just as appropriate (or inappropriate) to extrapolate the recent 9% decrease in uranium prices for use in the analysis. Many factors must be carefully investigated to estimate future uranium prices, and simplistic methods cannot be justified.

Long-term contracts are not generally tied to market prices at time of delivery or a 7% per year escalation, whichever is greater, based on current data. In fact, most long-term uranium requirements are not under contract, so it is inappropriate to make any generalization about the nature and terms of those contracts. Even if future contracts were based on the greater of market price or 7%/year escalation, it does not follow that fuel costs will increase to prohibitively high levels. If future prices were related to market prices and market prices do not increase substantially (it has not been established that they will), then the uranium cost component of fuel costs would not increase very much. And, if prices increase at 7%/year, they would probably just be keeping pace with inflation and thus not be relevant to a constant dollar analysis.

The cost of purchasing uranium is only one component of nuclear fuel costs, the other being, for example, separative work, UF_6 conversion, and fabrication. Thus, overall nuclear fuel costs would not escalate in proportion to the increase in uranium prices.

11.13 ACCIDENTS (HEW, A-10; MIL, A-45; RJW, A-49)

These comments were addressed to the Accident Section (Section 7) published in the Draft Environment Statement (DES), dated November 1978. In January 1981, the staff revised Section 7 and issued it for comment as a supplement to the DES. The January 1981 Supplement is included as Section 7 of this Final Environmental Statement (FES). The staff believes FES Section 7 is responsive to those accident comments previously addressed to the DES.

(FHA, A-53)

Part 50.13 of 10 CFR does not require a licensee "to provide for design features or other measures for the specific purpose of protection against the effects of (a) attacks...by an enemy of the United States...or (b) use or deployment of weapons incident to U.S. defense activities." The staff recognizes that acts of war would likely produce severe environmental impacts wherever they might take place.

(RJW, A-56, A-59)

The supplement is based on site-specific data, as described in Section 7.1.4.2. While not specifically stated in the supplement, U.S. average, year 2000 estimated, population data were used beyond 560 km (350 miles). The site-specific meteorological data used included lid heights to account for vertical mixing characteristics.

(RJW, A-58)

Both the staff and SAI used very similar methodologies in their analysis, and they both represent improvements over the Reactor Safety Study. There are some differences, however, in assumptions and data used in each study that lead to the variabilities or uncertainties that are inherent in such calculations. These differences appear in:

- accident release characteristics - probabilities and magnitudes;
- emergency response assumptions;
- meteorological data; and
- demographic data.

Specific consequence values that commentors quote from the SAI-OES report cannot be directly compared with those reported in the staff's draft supplement since the former are not associated with specified probability levels while the latter are. The staff has not made a

detailed comparison of the results of the two reports but judges that they are in agreement within the estimated bounds of uncertainties and assumptions associated with the current state of probabilistic risk assessments.

(RJW, A-58, A-59, A-60)

The studies of the San Onofre site relative to earthquake potential is extensively discussed in Section 2.5 of the Safety Evaluation Report (NUREG-0712, December 1980). The staff's position is that the safe shutdown earthquake is correctly determined for this site. A discussion of natural phenomena as initiators of accidents has been added to Section 7.1.4.2.

(RJW, A-58, A-59)

If Unit 1 had a meltdown, the staff agrees that it would impact the operation of Units 2 and 3. However, the ability to shut down both units following an accident at Unit 1 would not be impaired.

(RJW, A-59)

The reactor vessel was installed with its reference mark 180 degrees from the desired location. As discussed in the Safety Evaluation Report (Section 5.3.4), the flow skirt, which is not symmetrical, was installed in the direction to agree with the vessel's orientation and procedures for fuel handling, which reference the vessel orientation, were modified. No rewiring was necessary as a result of the error.

(RJW, A-59)

The dewatering well cavities were discussed in the Safety Evaluation Report in Section 2.5. It was determined that there would be no impact on seismic Category I structures.

(RJW, A-59)

The beach visitors were specifically addressed (e.g., Sections 7.1.3.2 and 7.1.4.6 and Table 7.1.4-5).

(RJW, A-60)

The staff has concluded that acts of sabotage, as initiating events, do not contribute significantly to the probability of accidents due to the Commission's safeguards requirements. Section 7.1.4.2 has been modified to discuss this point.

(RJW, A-60)

While it is true that one-half of the population of the State of California lies within 160 km (100 miles) of the San Onofre site, the staff does not consider this to be a relevant observation. The staff's focus on demographic data for site suitability and site comparison purposes has been traditionally within 80 km (50 miles) of plant sites.

The discussion in Section 7.1.4.3 indicates that most of the accident impacts occur within 50 miles of the site. The staff has compared the total population within 50 miles of the site with the total population within 80 km (50 miles) of other nuclear plant sites and has found that San Onofre does not have a uniquely large population. Moreover, it is important to note that, as stated in Section 7.1.4.2, the site-specific population projected to the year 2000 both in magnitude and distribution has been used in the calculations through all regions to 160 km (100 miles) and beyond. Those fractions of the consequences which take place up to 16, 48, 80, 160 km (10, 30, 50, 100 miles) or beyond, are accounted for in the results presented. The site does not have a uniquely large population contained within any of the above mentioned distances.

(RJW, A-60)

The San Onofre Units 2 and 3 at 3390 MWt are typical of the upcoming generation of reactors. The power level of each plant was specifically used in determining the inventory of the core for the risk calculations. Salem 1 is presently operating at a comparable power level of 3338 MWt.

(RJW, A-60)

The production of farm and dairy products is specifically considered in the calculation. Differences among the states (and countries) potentially impacted are taken into account.

(RJW, A-60)

The impacts within the Mexican borders were included in the evaluation. The method of determination of data for Mexican agricultural products is discussed in Section 7.1.4.2. Although not explicitly stated, the population within the Mexican border was included on a site-specific basis out to 560 km (350 miles) from San Onofre.

(RJW, A-61)

The staff recognizes the potential efficacy of drugs in mitigating consequences of offsite exposures. However, in the case of potassium salts of stable iodine, the staff does not require provision for distribution to the public.

(RJW, A-61)

Section 7.1.4.4 discusses that the condemning of foodstuffs was specifically considered and the interdiction of contaminated property "...until it is either free of contamination or can be economically decontaminated" was assumed.

(RJW, A-61)

The subject of filtered venting systems for the containment is being addressed in rulemaking, as discussed in NUREG-0660, 2.B.8. The whole subject of TMI-2-related improvements and the fact that no credit would be taken for them is discussed in the last paragraph of the section cited.

(RJW, A-61)

It is the staff's position that such a "worst case accident" is much too remote and speculative to require analysis under NEPA.

(UCS, A-63)

The staff believes that its treatment of a multiplicity of possible accident scenarios represents a reasonable and appropriate implementation of the guidance provided in the Commission's Statement of Interim Policy.

(UCS, A-63)

The probabilities of occurrence of releases in the nine categories are explicitly given in Table 7.3 and the probabilities of occurrence of specific levels of environmental consequences are given in Table 7.4. The staff judges that this is within the intent of the quoted part of the sentence and the additional directive in the Interim Policy which states: "The environmental consequences of releases whose probability of occurrence has been estimated shall also be discussed in probabilistic terms." See also the staff's answer to Joint Intervenors RJW, A-58.

(UCS, A-64)

The staff has presented a measure of individual risk in Figures 7.7 and 7.8. Table 7.4 and its associated figures and Table 7.5 provide group information. The discussion of relative susceptibility of various sub-groups of the population is given in Section 7.1.1.3. The staff judges that this conforms to the further directive that the discussion be "...in a manner that fairly reflects the current state of knowledge regarding such risks."

(EPA, A-66)

The Supplement is a replacement for Chapter 7 in the existing Draft Environmental Statement for the Operating License stage (November 1978). It is not a replacement for the accident sections of the Construction Permit stage Environmental Statements of 1973.

(EPA, A-66)

Nine tables could have been provided to show the impact contributions of the nine categories. It is the staff's judgment, however, that the summary table, reflecting sums of the contributions from all of the categories, is sufficient. Information regarding the relative contributions of the release categories is available in the Reactor Safety Study, WASH-1400.

(EPA, A-66)

The Design Basis Accidents are included because they are used in the Safety Evaluation Report to assess the adequacy of the performance of certain engineered safety features. In the SER, the DBAs are compared to the suitably small fractions of 10 CFR 100 for those accidents that are considered likely (infrequent accidents).

(EPA, A-66)

The DBAs are judged not to be significant contributors to environmental risks and have not been subjected to the same kind of probabilistic analysis as the more severe accidents that are treated.

(EPA, A-66)

The staff believes that it is more informative to discuss the environmental risks associated with accidents separated from those attributable to normal operations. Both may be found in the Final Environmental Statement. Risks associated with the operation of both Units 2 and 3 are, to a first approximation, the sum of the risks associated with each unit individually.

(EPA, A-67)

We agree certain biological changes in children and adults may be detected occasionally at doses as low as 10 rem (e.g., slight, temporary reductions in circulating lymphocytes). However, at doses of 25 rem or greater, such effects become measurable in nearly all exposed persons. In addition, although such changes have no physiologically significant impact, they can be clinically measured. We selected 25 rem as a point above which potentially serious effects due to radiation exposure (e.g., prodromal vomiting) become apparent to physicians and a point below which no difference between exposed and unexposed populations is apparent in terms of latent cancer incidence.

(EPA, A-67)

The NRC State Liaison Officer has informed us that the Region IX RAC has completed its review of the local plans for the environs of San Onofre. The licensee has transmitted to the NRC copies of emergency plans for the following:

San Onofre, San Clemente and Daheny State Park and Beach Areas

San Juan Capistrano City

Camp Pendleton

Orange County

Unified San Diego County

Interagency Agreement between San Diego County, Orange County, City of San Clemente, City of San Juan Capistrano; Marine Corps, Camp Pendleton; State Department of Parks, Pendleton Coast Area.

The staff preliminary review of these documents affirms its judgment that the plans are, in fact, in an advanced stage of development even though they have not been submitted for formal review. A full-scale exercise for the San Onofre site and its environs is scheduled for May 13, 1981.

(EPA, A-67)

The NRC staff Safety Evaluation Report, dated February 1981, states that the San Onofre onsite emergency plan, when revised in accordance with the applicant's commitments, will provide an adequate planning basis for an acceptable state of emergency preparedness, and will meet the requirements of 10 CFR Part 50 and Appendix E, thereto. This is still the staff's conclusion.

The SER states that the plan must be revised to address the final criteria and implementation schedule for the emergency centers and their functions, emergency manpower levels, and upgraded meteorological program, and to address the impact of earthquakes on emergency plans for the site and its environs. The NRC staff position is that the emergency plans are sufficiently complete to justify the estimates of parameters used in the consequence model.

It is true that the State of California does not use the U.S. EPA Protective Action Guides (PAGs). The State of California has elected to base its Protective Action Guides on the concept that no member of the general public should receive more than 500 millirem per year. The emergency plans of the local authorities in the environs of the San Onofre plant have followed the State's guidance. This guidance is more conservative than the EPA guidance, i.e., protective actions would be recommended at a lower projected dose. Consequently, it is reasonable to expect that if protective actions were to be taken at a lower value of projected dose, then exposures would be reduced.

(EPA, A-67)

The figure has been revised to present a more meaningful directional risk. The meaning of the new figures is discussed in Section 7.1.4.6. The scale of the figures has been expanded (a smaller distance from the plant shown) and it has been redrawn in an attempt to improve legibility.

(EPA, A-67)

Standard methods for estimating costs of reactor building cleanup and decontamination and replacement power for the economic risk calculations are under development. Reasonable estimates of plant decontamination and replacement power have been made, however, and are discussed in Section 7.1.4.6. Staff conclusions on the benefit cost balance are reported in Section 10 of the FES.

(SCE, A-68)

It is clearly stated in the third paragraph of Section 7.1.4.1 that the evaluations of the limiting faults and infrequent accidents are used to implement the provisions of 10 CFR 100. The conclusions regarding siting are in the Safety Evaluation Report and its supplements.

(SCE, A-69)

Section 7.1.4.2 states that the estimates of the consequences may have as large error bounds as for the probabilities. Any uncertainty in the fractions of nuclides released contributes to the error bounds on the consequences, as well as uncertainties in the meteorological and health effects models. The subject of releases of certain nuclides, mainly the radioiodines, is presently under review by the staff.

APPENDIX A

COMMENTS ON DRAFT ENVIRONMENTAL STATEMENT

APPENDIX A

COMMENTS ON DRAFT ENVIRONMENTAL STATEMENT

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UNITED STATES DEPARTMENT OF AGRICULTURE
SCIENCE AND EDUCATION ADMINISTRATION

OFFICE OF THE DEPUTY DIRECTOR FOR
AGRICULTURAL RESEARCH
WASHINGTON, D.C. 20250

Subject: NRC Draft Environmental Statement

To: William H. Regan, Jr.
U.S. Nuclear Regulatory Commission
Environmental Projects Branch 2
Division of Site Safety and Env. Analysis
Washington, D.C. 20555

We have reviewed the draft environmental impact statement entitled San Onofre Nuclear Generating Station, Units 2 and 3, Southern California Edison Company, San Diego Gas & Electric Company, dated November 1978.

We have no comments to add to the evaluation provided by your staff. We do appreciate the opportunity of reviewing this statement.

H. L. BARROWS
Acting Deputy Assistant Administrator

790103 0193

U.S. DEPARTMENT OF AGRICULTURE
ECONOMICS, STATISTICS, and COOPERATIVES SERVICE
WASHINGTON, D.C. 20250

December 8, 1978

SUBJECT: Draft Environmental Statement

TO: William H. Regan, Jr., Chief
Environmental Projects Branch 2
Division of Site Safety and
Environmental Analysis
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

We have no comments on the Draft Environmental Statement related to operation of San Onofre Nuclear Generating Station, Units 2 and 3 by Southern California Edison and San Diego Gas and Electric Companies.

MELVIN L. COTNER
Director
Natural Resource Economics Division

C002
E:

781214 0168

50-361
50-362 A

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
AREA OFFICE
2500 WILSHIRE BOULEVARD, LOS ANGELES, CALIFORNIA 90057

REGION IX
450 Golden Gate Avenue
P.O. Box 36003
San Francisco, California 94102

December 19, 1978

IN REPLY REFER TO:

U.S. Nuclear Regulatory Commission
Attention: Director, Division of Site Safety
and Environmental Analysis
Washington, D.C. 20555

Gentlemen:

Subject: San Onofre Nuclear Generating Station
Units 2 and 3
Draft Environmental Statement
Docket Nos. 50-361 and 50-362

We have reviewed the captioned document and have no comments to offer on it. There is no need to send this office a copy of the Final Environmental Statement.

Sincerely,

Roland E. Camfield, Jr.
Area Manager

C002
ES
/10

7901080142

DEPARTMENT OF THE ARMY
LOS ANGELES DISTRICT, CORPS OF ENGINEERS
P. O. BOX 2711
LOS ANGELES, CALIFORNIA 90053

50-361P
3620

SPLED-E

2 January 1979

Mr. Wm. H. Regan, Jr., Chief
Environmental Projects Branch 2
Division of Site Safety and Environmental Analysis
United States Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Regan:

This is in response to a letter from your office dated 30 November 1978 which requested review and comments on the Draft Environmental Impact Statement for the San Onofre Generating Station, Units 2 and 3, proposed by Southern California Edison Company and San Diego Gas and Electric Company.

The proposed plan does not conflict with existing or authorized plans of the Corps of Engineers. We have no comments on the environmental statement for the proposed action.

Thank you for the opportunity to review and comment on this statement.

Sincerely yours,

NORMAN ARNO
Chief, Engineering Division

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/10

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PD

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
2828 Chiles Road, Davis, CA 95616

January 9, 1979

William H. Regan, Jr., Chief
Environmental Projects Branch 2
Division of Site Safety and
Environmental Analysis
United States Nuclear Regulatory
Commission
Washington, D. C. 20555

Docket No.: 50-361
and 50-362

Dear Mr. Regan:

We acknowledge receipt of the draft environmental statement for San Onofre Nuclear Generating Station, Units 2 and 3, Southern California Edison Company, San Diego Gas & Electric Company in San Diego County, California, that was addressed to USDA Soil Conservation Service on November 30, 1978, for review and comment.

We have reviewed the above draft and have the following comments.

1) Provisions for erosion control and water management during construction as well as conservation treatment of disturbed areas following construction were inadequately addressed. We suggest that an erosion control plan be developed to adequately address the erosion hazard both during and following construction.

2) Approximately 10 acres of prime land will be lost to access roads and transmission towers. Mitigation or projected impacts from this loss were not adequately discussed. We suggest further discussion in the statement to address the prime land issue.

We appreciate the opportunity to review and comment on this proposed project.

Sincerely,

FRANCIS C. H. LUM
State Conservationist

C002 ES 1/0

D

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A-4

FEDERAL ENERGY REGULATORY COMMISSION
WASHINGTON, D.C. 20426

January 17, 1979

IN REPLY REFER TO:

Mr. William H. Regan
Division of Site Safety and
Environmental Analysis
Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Regan:

I am replying to your request of November 30, 1978 to the Federal Energy Regulatory Commission for comments on the Draft Environmental Impact Statement for the San Onofre Nuclear Station Units 2 and 3, California. This Draft EIS has been reviewed by appropriate FERC Staff components upon whose independent evaluation this response is based.

The staff concentrates its review of other agencies' environmental impact statements basically on those areas of the electric power, natural gas, and oil pipeline industries for which the Commission has jurisdiction by law, or where staff has special expertise in evaluating environmental impacts involved with the proposed action. It does not appear that there would be any significant impacts in these areas of concern nor serious conflicts with this agency's responsibilities should this action be undertaken.

Thank you for the opportunity to review this statement.

Sincerely,

Jack M. Heinemann
Advisor on Environmental Quality

C002 ES 1/0

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A-5

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

JAN 1 8 1979

In Reply Refer To:
ER 78/1161

Mr. William H. Regan, Jr.
Chief, Environmental Projects Branch 2
Division of Site Safety and
Environmental Analysis
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Regan:

The Department of the Interior has completed its review of the draft environmental statement for San Onofre Nuclear Generating Station Units 2 and 3. We have comments in only two areas of our jurisdictional concern as set forth below.

Recreation Resources

The discussion of recreation impacts states that restrictive use of the beach area was unanticipated at the time issuance of the construction permit was being considered. Since no explanation is given, it is unclear to us how such a significant impact, the loss of recreational and scenic open space, could have been overlooked during the earlier planning stages. The final statement should disclose the reasons which now require restrictions upon beach use.

Although there is now recognition of the impact, we see no attempt being made by the applicant to mitigate the loss of recreation space and opportunity. With respect to the scenic quality of the area, we find the intended plan to construct an eight foot chain-link fence extending over three-fourths of a mile along the beach quite objectionable. Design of the walkway deserves much more attention. Given the fact that this stretch of beach is rather removed from the developed portions of the state park units and therefore receives minimal use and given the scenic nature of the beach area and bluffs it would certainly seem more preferable and perhaps sufficient to consider posting the area as to its restrictive use. If a barrier is still needed, a more aesthetically sensitive, light railing may best fulfill the need to restrict access.

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50-361/362 A

Cultural Resources

We are pleased that the NRC staff has directed the applicant to consider historic, archeological, and Native American cultural resources in its planning process. We understand that existing and possible new transmission corridors will be surveyed for such resources. However, we strongly urge that the applicant allow enough flexibility in its planning to actually take the results of these surveys into account in its final placement of tower bases, access roads, and proposed substations. This would include allowing the State Historic Preservation Officer enough time to properly evaluate the surveys results and make appropriate recommendations. In addition, any new land used for material storage or other project activities outside the transmission corridors should also be checked for cultural resources.

We hope these comments will assist your efforts in preparing the final environmental statement.

Sincerely,

Larry E. Meierotto
Deputy Assistant SECRETARY

50-361
362

LAW OFFICES OF

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January 19, 1979

United States Nuclear Regulatory Commission
Washington, D. C. 20555

Attention: Director, Division of Site, Safety and Environmental Analysis

Gentlemen:

Pursuant to the notice published in the Federal Register with respect to comments on the Draft Environmental Statement (DES), the Cities of Anaheim and Riverside, California wish to submit the following comments.

Anaheim and Riverside believe the Final Environmental Statement (FES) should be amended in Section 8, entitled "Need for the Station", to reflect probable ownership by the Cities of a portion of Southern California Edison Company (SCE), 80% interest in Units 2 and 3.

A-6

The Applicants and Anaheim and Riverside, entered into a Letter Agreement dated November 1, 1977 which incorporated other proposed Agreements, including a Participation Agreement which provides for Anaheim to acquire 1.66% of SCE's 80% interest in Units 2 and 3, and for Riverside to acquire 1.79% of Edison's 80% interest in Units 2 and 3. The Letter Agreement was entered into by the Parties because a question was raised as to whether SCE or SDG&E would lose the investment tax credit with respect to its ownership share of Units 2 and 3 due to Anaheim and Riverside, public agencies, owning an undivided interest in Units 2 and 3. The Letter Agreement further provides, however, that when this question is satisfactorily resolved in the opinion of each party to said Agreement, the Participation Agreement attached thereto will be executed by the Parties.

The Internal Revenue Service has issued Revenue Ruling 78-268, which holds that undivided ownership in property by exempt and non-exempt entities does not of itself disqualify the portion of the property owned by the non-exempt entity from taking investment tax credit with respect to its share of such property. Moreover, SCE and SDG&E received a private letter ruling, dated August 16, 1978 which holds with respect to San Onofre Nuclear Generating Station, Units 2 and 3, that SCE and SDG&E will not lose investment tax credit with respect to their undivided interest in Units 2 and 3 after the sale of the interest to Anaheim and Riverside. However, that Private Letter Ruling contained language which SCE and SDG&E believe to be ambiguous and therefore on October 27, 1978 they filed a Request for Clarification of the Private Letter Ruling of August 16, 1978. The Request for Clarification is still pending before the Internal Revenue Service, but we believe it will be favorably acted upon in the next several weeks.

Anaheim and Riverside are currently, and have for some years, been wholesale

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customers of SCE. Anaheim and Riverside purchase all of their capacity, and most of their energy requirements from SCE. Anaheim and Riverside have agreements with Nevada Power Company wherein each City purchases economy non-firm energy from Nevada Power Company. These agreements will expire by their own terms in 1980. Anaheim and Riverside do not currently own any generating resources.

In 1978 Anaheim's peak demand was 388 megawatts. The estimated peak demand for 1978 was 394 megawatts. During 1978 Anaheim purchased two billion kilowatt hours of energy. For the period 1979 through 1990 it is estimated the peak demand for Anaheim will increase in differing amounts. The smallest amount of increase for electrical demand in any year during that period is estimated to be 3.1 percent and the highest amount of increase for any year 4.8 percent. It is also estimated for the same period of time that energy requirements for Anaheim will increase with the lowest estimated annual increase being 3.6 percent and the highest estimated annual increase being 5.0 percent.

In 1978 Riverside's peak demand was 278 megawatts. The estimated peak demand for 1978 was 260 megawatts. During 1978 Riverside purchased over one billion kilowatt hours of energy. For the period 1979 through 1990 it is estimated the peak demand for Riverside will increase with the smallest annual increase to be 4.0 percent and the highest annual increase to be 5.4 percent. It is also estimated for the same period of time that the energy requirements for Riverside will increase with the lowest annual increase to be 4.0 percent and the highest annual increase to be 5.4 percent.

The acquisition of an ownership interest in Units 2 and 3 by Anaheim and Riverside does not change the conclusion that the Units are needed to meet the electrical load served by SCE, Anaheim and Riverside. The load forecasts of SCE include the loads served by Anaheim and Riverside. Therefore, whether you include the loads of Anaheim and Riverside in the SCE forecast of loads or break them out and identify them separately, the need for the station is the same.

Very truly yours,

Alan R. Watts

ALAN R. WATTS
Special Counsel
Cities of Anaheim and Riverside

ARW:jm:D:11

cc: Attached Listing

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Southern California Edison Company
2244 Walnut Grove Avenue
P. O. Box 800
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Mr. Mark Medford
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Wm. H. Regan, Jr.
Environmental Projects Branch 2
Division of Site Safety and Environmental
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Washington, D. C. 20555

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3900 Main Street
Riverside, CA. 92522

A-7

UNITED STATES DEPARTMENT OF COMMERCE
The Assistant Secretary for Science and Technology
Washington, D.C. 20230
(202) 377-~~3111~~ 4335

50-361
362

January 22, 1979

Director, Division of Site Safety
and Environmental Analysis
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Sir:

This is in reference to your draft environmental impact statement entitled "San Onofre Nuclear Generating Station, Units 2 and 3, Southern California Edison Company, San Diego Gas & Electric Company." The enclosed comments from the National Oceanic and Atmospheric Administration are forwarded for your consideration.

Thank you for giving us an opportunity to provide these comments, which we hope will be of assistance to you.

We would appreciate receiving 10 copies of the final statement.

Sincerely,

Sidney R. Galler
Sidney R. Galler
Deputy Assistant Secretary
for Environmental Affairs

Enclosures from: Gordon G. Lill--National Ocean Survey
Gerald V. Howard--National Marine Fisheries Serv

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UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SURVEY
Rockville, Md. 20852

OA/C52x6

JAN 10 1979

TO: PP - Richard L. Lehman

FROM: OA/Cx1 - Gordon G. Lill

SUBJECT: DEIS #7812.06 - San Onofre Nuclear Generating Station, Units 2 and 3

The subject statement has been reviewed within the areas of NOS responsibility and expertise, and in terms of the impact of the proposed action on NOS activities and projects.

The following comments are offered for your consideration.

Section 2.3.1, Surface-water hydrology, has been found to be very adequate for the purposes intended. The authors are to be commended for the thorough bibliography on the subject.

NOS concurs with and encourages the oceanographic monitoring program described in Section 6.2.2. We feel this program will ensure environmental protection and help allay public concern.

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southwest Region
300 South Ferry Street
Terminal Island, California 90731

Date : January 8, 1979 FSW33/JJS

To : EC, Office of Ecology and Conservation

Thru : F7, Kenneth R. Roberts, Acting Director, Office of Habitat Protection

From : FSW, Gerald V. Howard, Regional Director, Southwest Region

Subject: Review of DEIS No. 7812.06 - San Onofre Nuclear Generating Station, Units 2 and 3 (NRC)

The subject DEIS which accompanied your memorandum of December 8, 1978, has been reviewed by the National Marine Fisheries Service. The following comments are offered for your consideration:

Specific Comments

5. Environmental Effects of Station Operation

5.4 Environmental Impacts

5.4.2 Impacts on the aquatic environment

Page 5-26, paragraph 7, Kelp

In paragraph 7 little information is included documenting the importance of kelp to coastal commercial fish species. Information available in the California Department of Fish and Game Fish Bulletin 139 (Quast, 1968) provides some insight in that regard.

Data developed by Jay Quast of the then U.S. Bureau of Commercial Fisheries, and included in that publication, indicate that in his studies he found more than twenty commercially important fish species occurring in the kelp beds off southern California. According to those studies the relationship of many of those species to the kelp habitat was more extensive than indicated by the final sentence of the subject paragraph. This should be reflected in the text of the final EIS.

6. Environmental Monitoring

6.3 Operational Monitoring Programs

6.3.3 Aquatic biological monitoring

Page 6-7, paragraph 1

The concept of continuing a kelp study program into the operational stage of SONGS is a good one. However, should those studies determine that significant harm is occurring to that resource, then some method of compensation satisfactory to the National Marine Fisheries Service would need to be developed. This should also apply to the studies being conducted on fish impingement at SONGS 2 and 3.

If such measures are not adopted and adverse impacts do appear the monitoring program may be merely documenting the demise of a valuable coastal resource.

10. Benefit-Cost Summary

10.7 Summary of Benefit-Cost

Page 10-3, paragraph 3

The potential additional cost of compensating for loss of biological resources due to the operation of SONGS 2 and 3 should be addressed.

LITERATURE CITED

Quast, Jay C. 1968. 8. Observations on the food of the kelp-bed fishes. In: California Department of Fish and Game, Fish Bulletin 139. Pp 109-142.

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
FOOD AND DRUG ADMINISTRATION
ROCKVILLE, MARYLAND 20857

January 25, 1979

Mr. William H. Regan, Jr., Chief
Environmental Projects Branch 2
Division of Site Safety
and Environmental Analysis
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Regan:

The Department of Health, Education, and Welfare has reviewed the health aspects of Draft Environmental Statement related to operation of the San Onofre Generating Station, Units 2 and 3, Southern California Edison Company and San Diego Gas and Electric Company and has the following comments to offer.

Section 5.5 Radiological Impacts

The individual doses as identified in Table 5.3 are all within Appendix I, 10CFR50 design objectives and should assure adequate radiation protection of the public for routine releases. However, it should be recognized in this section that 10CFR190 promulgated by EPA became effective in January 1979. A statement should be included indicating that SONG 2 and 3 will also meet this standard.

It is recognized that there are many variables that influence occupational exposure for a specific plant. However, a recent Atomic Industrial Forum study of occupational exposures showed for a PWR a total of 694 man-rem per year as a representative PWR exposure pattern. As a conservative estimate the projected occupational exposure impact of the two-unit San Onofre Station would be 1400 man-rem per year.

The summary of environmental consideration for uranium fuel cycle shown in Table 5.8 appear to be within acceptable radiation protection limits. However, some additional explanation within the test or by a footnote is needed for the disposal of solids. In particular, the statement that TRU and HLW would be buried at a Federal Repository should be modified to indicate alternatives for disposal of these waste in the event the Federal repository is not operational when required by plant operations.

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Section 6.2.5 Radiological Monitoring Program

The preoperational monitoring program presented in Section 6.1.5 of the Environmental Report is adequate for meeting the objective stated in this section. The establishment of the radiological monitoring program prior to start of operations should provide the necessary data to verify the effectiveness of in-plant controls and to provide assurance that undetected radioactivity will not build-up in the environment.

Section 7 Environmental Impact of Postulated Accidents

The estimated exposure of the population within a 50 mile radius of the plant shown in Table 7.2 cannot be adequately evaluated without some specific data in the text on the source term. Without such data it is possible to assume that the environmental consequence as a result of a class 8 accident could be more severe than indicated in the unlikely event of such an accident.

There is no indication in this section or previous chapters on emergency response planning to mitigate the consequences of an accident that could impact on the offsite population. A discussion of the arrangement that has been made with State and local authorities should be included in this section.

The discussions in paragraph 4, page 7-2 on the Reactor Safety Study (WASH-1400) relative to discussion with EPA is outdated (1973), and since it discusses scope of the study, and not results, should be removed. More importantly, a statement should be included on the technical review or conclusions that have been provided by EPA, other Federal agencies or independent reviewers. Such a statement would be helpful in accepting the low environmental risks associated with the postulated radiological accidents.

On the basis of this review it is concluded that the San Onofre Nuclear Generating Station, Units 2 and 3 can be operated to meet current radiation protection guidance and provide adequate protection of the public health and safety.

Sincerely yours,

Charles L. Weaver
Consultant
Bureau of Radiological Health

Southern California Edison Company

P. O. BOX 800
2244 WALNUT GROVE AVENUE
ROSEMEAD, CALIFORNIA 91770

J. H. DRAKE
VICE PRESIDENT

TELEPHONE
213-572-[illegible]

February 2, 1979

Director, Office of Nuclear Reactor Regulation
Attention: William H. Regan, Jr., Chief
Environmental Projects Branch 2
Division of Site Safety and Environmental Analysis
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Gentlemen:

Subject: San Onofre Nuclear Generating Station
Units 2 and 3
Docket Nos. 50-361 and 50-362

In accordance with your request of November 30, 1978, the Southern California Edison Company and the San Diego Gas & Electric Company have reviewed the Draft Environmental Statement (DES) related to the operation of San Onofre Nuclear Generating Station, Units 2 and 3. Enclosed are comments generated from this review.

Should have any questions or require clarification regarding these comments, please contact me.

Very truly yours,

J. H. Drake

Enclosure

7903080252

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ATTACHMENTS

A	Figure 6.14, page 61 of Reference (5)
B	Figure 6.29, page 76 of Reference (5)
C	Figure 6.34, page 81 of Reference (5)
D	Figure A-7, page A-15 of Reference (5)
E	Figure 6.8, page 47 of Reference (5)
F	NOAA Climatological Data, July 1975
G	" " , July 1976
H	" " , April and July 1977
I	" " , July 1978
J	Air Temperatures at SONGS
K	Del Mar Current Meter and Temperature Data, May-December 1978
L	San Onofre Area Current and Temperature Data, May-August 1978
M	Pages 103-106 of DES reference 8
N	Figure 1 Surface Isotherms for 0.0 knots
O	Figure 2 " " " 0.1 "
P	Figure 3 " " " 0.25 "
Q	Reference (19)
R	Reference (20)
S	Reference (21)
T	Temperature Data from References (8), (22), (23) and (24)
U	Reference (2)
V	Bottom (30') Water Temperatures at San Onofre, July and Aug. 1976-78
W	Pages 41 and 71 of Reference (16) and page 42 of Reference (17)
X	Revised DES Table 8.1
Y	Revised DES Table 8.3
Z	Revised DES Figure 3.5

AA	Reference	(1)
BB	"	(12)
CC	"	(13)
DD	"	(14)
EE	"	(18)

COMMENTS

BY

SOUTHERN CALIFORNIA EDISON COMPANY

SAN DIEGO GAS & ELECTRIC COMPANY

ON THE

DRAFT ENVIRONMENTAL STATEMENT

RELATED TO THE OPERATION OF

SAN ONOFRE NUCLEAR GENERATING STATION, UNITS 2 AND 3

DOCKET NOS. 50-361 AND 50-362

PREPARED BY THE

U. S. NUCLEAR REGULATORY COMMISSION

OFFICE OF NUCLEAR REACTOR REGULATION

TABLE OF CONTENTS

A-14

INTRODUCTION

The Draft Environmental Statement (DES) has been reviewed by the Southern California Edison Company and the San Diego Gas & Electric Company (hereinafter referred to as Applicants).

Comments resulting from this review are to identify inaccuracies in the data or discussion and provide clarification or correction. The comments follow the organization and numbering in the DES and should be read in conjunction with the referenced section.

SUMMARY AND CONCLUSIONS

Comment A-1

(page iii, item 2)

The DES states, "Each unit will produce up to 3410 MWe and a net electrical output of 1057 MWe".

It should be noted that 1057 MWe as stated in the applicants' ER-OLS* and in the DES was calculated using the Turbine-Generator (T-G) manufacturer's guaranteed output of 1127 MWe, which corresponds to an NSSS output of 3266 MWe, and an estimated in-plant consumption of 70 MWe.

However, when the NSSS is operating at 3410 MWe, and the T-G is at the wide-open valve condition (normal operating condition) the T-G output will be 1181 MWe. Current estimates of in-plant consumption have been revised to 75 MWe. Therefore, it is suggested that the net electrical output value be expressed as being in the range of 1052 MWe to 1106 MWe per unit when the NSSS is operating in the 3266 MWe to 3410 MWe range respectively.

*ER-OLS will be revised to reflect the range of 1052 MWe to 1106 MWe output per unit, in a future amendment.

Comment A-2

(page iii, item 3a)

The applicants do not agree with the conclusion reached by the staff on the possible destruction of at least a portion of the San Onofre kelp bed as a result of the thermal discharge from San Onofre Nuclear Generating Station. The assessment of impacts to the aquatic environment is invalid because of the use of inappropriate data from the staff's numerical model. A reassessment of the impacts is needed using ambient temperatures from actual field data. Actual field data are appended to these comments. Using appropriate ambient temperatures in the assessment, the excess temperature from thermal plume predictions made by either the applicants or staff will not create adverse effects on the San Onofre kelp bed. (Attachment T)

Comment A-3

(page iv, item 6(B)(2))

The preoperational monitoring program outlined in Section 6 goes beyond the applicants' program approved by the NRC by letter dated July 6, 1978, and is apparently based on inappropriate predictions of impact to the San Onofre kelp bed. The operational monitoring program outlined in Section 6 is an extension of the preoperational monitoring program. The operational environmental monitoring programs are under development for Units 2 and 3 Environmental Technical Specifications (ETS) and will be submitted in the near future.

1. INTRODUCTION

1.1 HISTORY

Comment 1-1

(page 1-1, paragraph 2)

The net electrical output for each unit is in the range of 1052 to 1106 MWe. Refer to Comment A-1 for discussion.

2. THE SITE

2.4 METEOROLOGY

2.4.4 Atmospheric dispersion

Comment 2-1

(page 2-8)

The DES indicates that the onshore tracer test conducted by SCE substantiates the acceptability of data measured on the San Onofre onsite (bluff) tower for use in calculating atmospheric dispersion. However, the DES does not consider the enhanced dispersion estimates derived from the onshore tracer test results. Consideration should be given to the enhanced dispersion estimates derived from the onshore tracer test results.

2.5 SITE ECOLOGY

2.5.2 Aquatic ecology

Comment 2-2

(page 2-9)

Oceanographic data reports from the past have incorrect consultant sources referenced. The first source in the list of three sources should be:

"(1) a thermal effects study performed jointly by Environmental Quality Analysts, Inc. and Marine Biological Consultants, Inc. in 1973 using data and results obtained from 1964-1972 by Bendix Marine Advisors, Inc., and Intersea Research Corporation."

3. THE PLANT

3.2 DESIGN AND OTHER SIGNIFICANT CHANGES

3.2.1 Plant water use

Comment 3-1

(page 3-1, paragraph 2)

Delete the words, "makeup to," in the second sentence.

Comment 3-2

(page 3-1, paragraph 3)

The word, "makeup" should be corrected to "cooling," in the second sentence.

Comment 3-3

(page 3-1, paragraphs 2 and 3)

In the discussion of plant water use, the flushing of traveling bars and screens is incorrectly described. Seawater will be used for the flushing of the traveling bars and screens, not fresh water.

3.2.2 Heat dissipation system

Comment 3-4

(page 3-1)

The discussion should also include a description of the Seismic Category I Auxiliary Intake Structure of the circulating water system. The description of this design change can be found in Section 3.4.1 of the ER-OLS and Section 9.2.5 of the FSAR.

Comment 3-5

(page 3-1, paragraphs 4 and 5)

The seawater used for "cooling" has been incorrectly labeled "makeup." This error appears in the second sentence of paragraph 4 and the first sentence of paragraph 5.

Comment 3-6

(page 3-1, paragraphs 5 and 6)

The word "screenwell" should refer to the intake screenwell structure shown in Figure 3.3 and not the traveling screens. Lines 6 and 7 of paragraph 5 use "screenwells" where "traveling bars and screens" are being described. Also, in the second sentence of paragraph 6 "screenwells" is used instead of "traveling screens" and should be corrected.

Comment 3-7

(page 3-3, Fig. 3.2)

Figure 3.2 has been revised by the applicants to include the design details of the Auxiliary Intake Structure (Comment 3-4) and show the elimination of the manhole on the velocity cap. The revised figure can be found in Section 3.4 of the ER-OLS, Figure 3.4-2.

Comment 3-8

(page 3-5, paragraph 1)

The seawater used for "cooling" has been incorrectly labeled "makeup." This error occurs on lines 2 and 5, and should be corrected.

Comment 3-9

(page 3-5, paragraph 1)

The third sentence should read:
"To achieve the temperature required to control biofouling each unit has a recirculation and crossover gate."

A-17

2.3.1 Liquid Radioactive Waste Treatment System

Comment 3-10

(page 3-7, paragraph 7)

The flashed steam is routed to the "third point heater", not the "main condenser hotwell".

Comment 3-11

(page 3-8, Fig. 3.5)

The figure should be changed to reflect the correction identified in Comment 3-10. See revised Fig. 3.5 (Attachment Z).

Comment 3-12

(page 3-11, line 1)

The discussion on steam generator blowdown is incorrect. There are two steam generators for each unit, not four.

Comment 3-13

(page 3-13)

The discussion on the containment ventilation system should include a description of the 2,000 cfm mini-purge system. The description of this design change can be found in Section 9.4.1 of the FSAR.

2.4.1 Chemical Effluents

Comment 3-14

(page 3-16, paragraph 1, line 4)

The statement, "maintain a clean circulating water system," should be changed to read, "maintain a clean condenser system."

Comment 3-15

(page 3-16, paragraph 3, line 11)

The applicants will use a nitrite base compound or potassium chromate (K_2CrO_4) as the corrosion inhibitor for the turbine and component cooling water system. The statement in line 11, "will be treated with Nalco 39 to inhibit corrosion," should be changed to read, "will be treated with a nitrite based compound or potassium chromate to inhibit corrosion."

3.2.5 Transmission Lines

3.2.5.1 SCE Transmission Lines

Comment 3-16

(page 3-19, line 3)

The reference number for the description of retrofitting should be "4" not "1."

Comment 3-17

(page 3-20, Fig. 3.9)

An additional note should be added to the figure as follows:

> "The drawing depicts the four-circuit structure that will be used by SCE. SDG&E will use a similar structure with five circuits."

3.2.5.2 SDG&E Transmission Lines

Comment 3-18

(page 3-20, paragraph 1)

In the discussion of SDG&E's transmission lines, Talega Substation has been misspelled consistently throughout.

3.2.6 Probable Maximum Flood Berm

Comment 3-19

(page 3-23, line 1)

The reference number for the letter to the NRC should be "5" not "4."

5. ENVIRONMENTAL EFFECTS OF STATION OPERATION

5.3 IMPACTS ON WATER USE

5.3.1 Thermal discharges

General Comment Concerning Section 5.3

Applicants and the NRC both have evaluated the thermal effects of the diffuser system proposed for SONGS 2&3. The applicants applied a physical hydraulic model study. The NRC staff applied a depth-averaged numerical model. Applicants' model predicts compliance with all state and federal water quality requirements. The NRC Staff model predicts similar compliance for all realistic conditions but predicts potential violations of state thermal regulations for certain admittedly unrealistic conditions.

For reasons inherent in the input and methodology of the NRC staff model, applicants do not consider the staff's predictions to be valid. Further, applicants' model does not predict violations of the State Thermal Plan even under the unrealistic conditions postulated by NRC staff. Specific comments on DES Section 5.3 are discussed below:

5.3.1.1 Applicant's thermal analysis

Comment 5-1

(page 5-1, paragraph 6)

In the discussion of the physical model, the temperature difference of the discharged water is reported to be 30°F higher than the surrounding water. The 30°F delta T was necessary to achieve dynamically correct scaling of the actual delta T of 20°F and this fact should be mentioned in the discussion to avoid confusion.

Comment 5-2

(page 5-2, paragraph 3)

The statements are made, "The staff has reviewed the applicant's thermal analysis and believes that the physical model does not adequately represent certain hydrodynamic mechanisms and certain physical features of the prototype. The most significant of these is the limitation of the duration of the simulation by the size of the model basin." and "In fact, for the conditions represented in Figure 5.3,

an increase in simulation time would likely have resulted in predicted excess temperatures that violate state thermal standards." The applicants do not agree with these statements. The assumption that the size of the model basin limits the ability of the model in terms of representing valid results for longer time duration conditions are not considered to be valid. The conditions represented in DES Figure 5.3 represent a worst case condition and it is illustrated in the following paragraph that equilibrium had already been reached. An increase in simulation time would not have changed the predicted results.

In Figure 6.14, page 61 of Reference (5) (Attachment A) it is shown that for the circumstances represented in the DES Fig. 5.3, the hydraulic model had clearly reached an equilibrium peak temperature. The prototype period of time represented in this hydraulic model test of a zero drift situation is in excess of 30 hours of continuous operation at full load. Referring to Attachment A it can be seen that the peak temperature measured in the hydraulic model basin (the upper curve) quickly reaches an equilibrium level in a time of approximately 12 prototype hours. For the subsequent 18 hours of operation at zero drift velocity, the only variation in temperature is that associated with the experimental fluctuations. The behavior is similar for the lower curve, which is the peak temperature measured at a distance equivalent to anywhere beyond 1000 ft. from the point of discharge.

The results given in Attachment A, and the detailed error analysis performed in Reference(5), show quite clearly that there is no basis for the assertion that the hydraulic simulation represented in Fig. 5.3 of the DES, if continued, would lead to a violation of the state thermal standards. To the contrary, it is clear that in a no-drift situation an equilibrium peak temperature of 2.3°F (beyond 1000 ft.) would be reached within about 12 hours and this peak temperature would not be exceeded for longer durations.

The DES further states, "Once the thermal plume reaches a lateral boundary of the tank, the simulation must be terminated. The length of the simulation is thus dictated by the size of the model basin rather than by the natural time scales of the problem."

The tests do not have to stop when the thermal plume reaches a boundary because a large prototype area is represented by the model basin and the maximum temperatures are close to the diffusers. Furthermore, the natural time scale of the problem is that associated with the initial jet mixing and establishment of the steady induced offshore drift of the

thermal field. The time scale associated with the establishment of steady state conditions in the model was found to be 12 hours at the most. The size of the basin does not limit the results until more than 40 hours, as shown in Attachment A. It is also confirmed by the results given in Figures 6.29 and 6.34, pages 76 and 81 of Reference (5) (Attachments B and C). The results shown are for a situation where the hydraulic model was operated for the accelerating current pattern given on Attachment B. The outcome of the model is shown in Attachment C. It can be seen that the peak temperature rapidly reduces as the current velocity increases, showing that the natural time scale or response time is only a few hours. Indeed, it is because of the short time scales of the problem that the hydraulic model is appropriate.

The reason for the short time scale can be seen in Figure A-7, page A-15, of Reference (5) (Attachment D) and in Figure 6.8, page 47, of Reference (5) (Attachment E) which both clearly show a surface layer of warm water overlying a cooler bottom layer. The diluting water for the discharge jets is always drawn from this cooler bottom layer so the dilution is fixed by the rate of supply of bottom water. When there is no drift the bottom flow is generated by the jet entrainment. When an ambient current is present the flow of diluting water is even greater so the peak temperatures are reduced.

A-20

Comment 5-3

(page 5-2, paragraph 4)

The DES states, "Although the problem of underprediction is inherent in all the applicant's results, it is less significant for the realistic cases." It cannot be concluded that the hydraulic model consistently underpredicts delta T's with respect to what will really occur; rather, the only conclusion that can be drawn is that the math model gives consistently higher values than the physical model.

The basic hydraulic model report (Reference (5)) discusses possible errors in hydraulic modeling and deduces a laboratory target value of 2.5°F so that all possible errors will be included within the 4°F limit; but the report does not imply that there is an expected bias in the results as the errors could as well be negative as positive.

5.3.1.2 Staff's thermal analysis

Comment 5-4

(pages 5-3, 5-4, and Fig. 5.6)

Atmospheric data purported to be typical of July are used in the NRC mathematical model to predict ocean temperatures. Specifically, air temperatures with a maximum of approximately 82°F and a minimum of 65°F were used in the model (see DES Fig. 5.6, page 5-7).

Actual field data measured at coastal sites in Southern California for July show mean daily maxima and mean daily minima substantially lower than these temperatures. In addition, temperature summaries for the San Onofre site presented in Table 2.3-6 of the FSAR and Table 2.3.2-4 of the Applicants' Environmental Report OL Stage show mean daily maxima and mean daily minima temperatures on the order of 67°F and 61°F respectively.

Published U.S. Climatological Data for July 1975, 1976, 1977, 1978 (Attachments F, G, H and I) give temperatures for two coastal stations (Newport Beach Harbor and Santa Monica Pier). Data at San Onofre are from the meteorological tower maintained at the site: (Attachment J).

Actual Air Temperatures For The Month Of July

	Newport Beach Harbor mean daily		Santa Monica Pier mean daily		San Onofre mean daily	
	max	min	max	min	max	min
1975	69.8°F	62.1°F	68.0°F	61.5°F	66.6°F	59.5°F
1976	72.4°F	64.4°F	71.1°F	63.5°F	67.6°F	63.3°F
1977	70.7°F	61.4°F	67.9°F	61.2°F	67.5 F	61.5°F
1978	70.7°F	62.0°F	68.1°F	59.8°F	67.5 F	61.2°F

The indication is clear that a typical July daily atmospheric maximum temperature at San Onofre should be in the order of 68°F with a typical minimum of about 61°F.

These atmospheric data are an important feature of the numerical model since high air temperatures will lead to high ambient water temperatures being produced by the numerical model in the inshore region. An indication that this has in fact occurred, are the water temperatures used in Section 5.4 (in the benthic section ambient depth-averaged temperatures of 27.8°C (82°F) and in the kelp section ambient bottom temperatures of 21.5-24°C (71-75°F)). These temperatures are considerably higher than have actually been measured in the field (References (8),(22) and (23)). High ambient water temperatures in the inshore region will, in turn, be reflected as high temperature increments offshore due to the inshore water being transported offshore by the net offshore drift produced by the diffusers. It is quite likely that these features of the numerical model could be responsible for the possible temperature excess violations predicted by the staff's numerical modeling.

Comment 5-5

(page 5-4, paragraph 2)

The DES omits computed ambient temperature maps (without heated water discharge) and computed temperature maps with thermal discharge from which the delta T maps were derived as presented in DES Figures 5.8, 5.10, 5.12, 5.14, 5.16, 5.18, 5.20, 5.22. DES Section 5.4, environmental impacts, refers to this section (5.3.1) and discusses absolute values of ambient temperatures.

Since the basis for the prediction of temperature excess associated with the operation of SONGS Units 2 and 3 is the difference between the numerically predicted temperature distributions for operating and ambient conditions, these temperature maps should be made available to the applicants for evaluation and interpretation, or included in the FES. In addition, these temperature maps are essential to the assessment of impacts on marine life and necessary to provide the basis for much of DES Section 5.4.

Comment 5-6

(page 5-7, paragraph 2)

The DES states, "The net downcoast drift used for these simulations is based on limited data for mid-July. During other times of the year, the data indicate that an absense of drift can persist for up to several days. Although there are no data to confirm a no-drift assumption during mid-July, the staff believes that this situation is at least possible, and therefore, should be considered." Applicants disagree with the assumpation that a no-drift situation is possible.

Current data analyses have been previously supplied to NRC (References (3) and (4)). In Reference (3), pages 59 and 60, it was concluded that current speeds are higher in summer than in winter and that, during winter, periods of very low currents could exist lasting a few days, but that tracks indicated no evidence of currents with no net transport during this period. The available current record for summer, published in Reference (3), shows no evidence of any period of no net drift.

In Reference (4) more recent data obtained by Winant and Severance for the Marine Review Committee were analyzed. These data were collected using a newer type of current meter less susceptible to clogging than the meters used for the data previously analyzed (obtained from Intersea Research Corporation). Reference (4) makes it clear that at no time in the current meter records are there data to indicate that there is a period of zero drift. In fact, the records indicate a substantial drift either upcoast or downcoast with a speed of the order of 0.1 to 0.2 knots (5-10 cms/sec). The data therefore confirm the drogue and current meter data initially obtained by Intersea Research Corporation (IRC). The data appear to indicate that in fact IRC's meters may have been underrecording the magnitude of the currents.

In the past year (1978) more data have been collected at Del Mar (15 miles downcoast from San Onofre) by Winant of Scripps Institution of Oceanography and also at San Onofre by Brown and Caldwell Engineers under contract to the Marine Review Committee of the California Coastal Commission. Winant's data (Attachment K) show substantial longshore currents always occur at Del Mar. The Brown and Caldwell data obtained at the San Onofre site appear to be well correlated with the Del Mar data and also indicate strong drift currents either upcoast or downcoast for periods of several days. The change in direction is always a rapid process. These most recent data further corroborate the previous conclusion that there exist no periods of zero drift (Attachment L). A zero drift period is not considered to be credible, and should not be postulated for evaluating compliance with the state thermal requirements.

Comment 5-7

(page 5-7, paragraph 3)

The DES states, "Although the thermal numerical model is depth-averaged, it is still possible to address the state standards with model results because the buoyancy and shear generated by the diffuser discharge produce a hydrodynamic instability, resulting in the water column's being well mixed within several diffuser lengths of the discharge[8]. Therefore, within the specified mixing zone, the depth-averaged predictions are reasonable representations of surface temperatures."

Reference 8. C. W. Almquist and K. D. Stolzenbach, Staged Diffusers in Shallow Water, Report No. 213, Ralph M. Parsons Laboratory for Water Resources and Hydrodynamics, Massachusetts Institute of Technology, Cambridge, Massachusetts, 1976.

A-22

Referring to pages 103-106 of DES Reference 8 (Attachment M) it is clear that the hydrodynamic instability claimed as the basis for application of depth-averaged numerical modeling definitely will not occur with the San Onofre diffusers. It is therefore evident that depth-averaged modeling is inappropriate to the San Onofre configuration so that drawing conclusions about violation of the California thermal standards on the basis of the results of such a model is not valid. It cannot be concluded that depth-averaged predictions are reasonable representations of surface temperatures. For the same reasons, the bottom temperatures cannot be predicted correctly from the NRC depth-averaged numerical model.

Comment 5-8

(page 5-7, paragraph 4)

The DES states that, "The model numerical is inadequate for addressing the issue of bottom temperature. However, at worst, the 4°F excess temperature should only touch the bottom over a very limited area in the vicinity of the Unit 2 and 3 diffusers."

The applicants agree that the numerical model is inadequate for addressing the bottom temperature issue as noted above. In view of the staff's admission of this inadequacy, there is no basis for the staff's statement concerning the 4°F excess bottom temperatures. In the assessment of San Onofre 2&3 diffuser plume extent, Figures 1, 2 and 3 have been formulated from Reference (5) (Attachments N, O and P). These show hydraulic modeling results in the horizontal and vertical and with respect to the San Onofre kelp bed area under conditions of no ambient currents, and two typically encountered downcoast ambient currents.

It should be noted that the vertical profiles in Figures 1, 2 and 3 (Attachments N, O and P) stop at a depth of 35 feet but the actual bottom depth is deeper. These figures show no indication of impingment of a 4°F isotherm on the bottom or even present in the water column.

Figure A-7 (Attachment D) shows an actual vertical cross-section of the modeling results from surface to bottom along the centerline of the San Onofre 2 & 3 diffusers. This figure shows that the thermal plume does not impinge substantially anywhere on the bottom and that a temperature increase of 0.4°C (0.8°F) is not exceeded on the bottom.

Comment 5-9

(pages 5-2 through 5-24)

The DES omits any reference to error analysis for either applicants' hydraulic modeling or the staff's numerical modeling. Such an analysis is essential in determining the bounds within which the results are accurate or applicable.

The applicants' modeling has been subjected to a comprehensive error analysis, Reference (7), which discussed possible sources of error and determined appropriate error margins. This error analysis should be referenced in the DES.

There is no discussion of errors for the staff's math model. As with all math models, various assumptions and coefficients are necessary and the results must be viewed with consideration of the potential error inherent in the model. It is a particular concern with this math model which appears to be deficient in representing the real phenomenon occurring, specifically two-layer stratified shear flow and individual jet mixing. Because of this, the range of possible error for the math model is considered to be greater than for the hydraulic model. An error analysis for the staff's math model should be presented, or at least referenced and made available to the applicants.

Comment 5-10

(page 5-7, paragraph 5)
(page 5-24, paragraph 1)

The DES states, "In the absence of drift, the 4°F excess temperature will not reach the shore. However, state thermal standards would be violated since the 4°F surface isotherm will extend beyond the 1000 ft. radius during most of the tidal cycle. The staff concludes that although there exists a remote possibility that state thermal standards could be violated by the operation of Units 2 and 3, violations would, at worst, be infrequent and for short periods. There is no evidence in available drift data to indicate that such an occurrence would take place during the summer when thermal impacts would be the most severe."

A-23

The applicants do not agree that the state thermal standards limitation for the 4°F surface isotherm beyond 1000 ft. for more than one half of a tidal cycle will be violated in the absence of drift or under any other circumstance. The applicants' thermal modeling studies addressed a no-drift condition, showing no violation of state thermal standards (DES Figure 5.3). It is the position of the applicants that the mathematical model predictions are excessively high, mainly as a result of inappropriate inputs and assumptions. The staff selected inputs include air temperatures that are about 10°F too high (see Comment 5-4), unsubstantiated two day no-drift conditions along the open coast at San Onofre in July (see Comment 5-6), and modeled ambient depth average water temperatures that are higher than ever recorded in the area's field data (see Comment 5-8). Also, such violations predicted (as remote) by the staff are derived from output of their mathematical model when the model itself could be approaching its limits of validity. Yet, this can not be proven, mainly because an error analysis that would substantiate the claimed applicability of the numerical model is not included in the DES (see Comment 5-9).

For these reasons, the staff's conclusion, that even a remote possibility of a violation of the state thermal standard exists, cannot be justified on a technical basis.

5.4 ENVIRONMENTAL IMPACTS

5.4.1 Terrestrial environment

Comment 5-11

(page 5-24)

The discussion on environmental impacts to the terrestrial environment should also include an assessment of the Probable Maximum Flood (PMF) berm. The applicants submitted an environmental assessment of the PMF berm, by letter dated February 14, 1978. The assessment indicated that the PMF berm should have no adverse environmental impact on the terrestrial ecological characteristics.

5.4.2 Impacts on the aquatic environment

5.4.2.1 Effects of the heat dissipation system

Thermal effects

Comment 5-12

(page 5-24, paragraph 8)

The discussion of the proposed heat treatment states, "the applicant proposes to heat treat portions of the intake system to remove biological growth (Sect. 3.2.2)." This statement is incomplete since the applicants also propose to heat treat the discharge system. The text should be changed to reflect this point.

Comment 5-13

(page 5-25, paragraph 2)

While the applicants do not agree that the area to be affected by thermal discharges will be greater than previously thought, the applicants do concur that even assuming a larger plume, the impact to the aquatic environment is expected to be minimal and of an acceptable nature.

A-24

Fish

Comment 5-14

(page 5-25, paragraph 5)

The applicants agree that cold kills of fish are not likely to occur, but for the reason that the extent of the thermal plume is relatively small, and the difference between the ambient and the induced temperatures is less than the rapid temperature changes that occur naturally.

Comment 5-15

(page 5-25, paragraph 4)

It is stated that, "However, with more area to be influenced by the effluent, more fish potentially will be affected."

This appears to be an oversimplification since the thermal plume will not be uniformly distributed with depth but rather the more buoyant heated water will be on the surface with the bottom water remaining unaffected. This means that an increase in the surface area of the plume would only effect fish species which inhabit the upper water column and no additional effect would be expected for fish associated with the bottom. Fish are not uniformly distributed within the water column and actually exhibit a distribution opposite to that of the thermal plume, that is with a greater concentration of fish associated with the bottom and fewer fish associated with the surface. During the 1976 ETS studies a comparison of surface versus bottom gill net data showed that 88% of the fish were found on the bottom and only 12% in the surface waters. Therefore, the area potentially effected by a larger plume would be only the surface waters, which have a relatively small percentage of the total fish abundance.

Benthic fauna

Comment 5-16

(page 5-25, paragraph 8)
(page 5-26, paragraph 1)

In the discussion of DES reference 11 (Ford, et al., 1976), it is not made clear that effects upon growth and mortality of S. franciscanus, P. ochraceus and R. poulsoni occurred only in the experiment simulating a location 84 meters from the discharge and not at 335 m away.

The applicants recommend that clarification be added to these paragraphs in order that the reader be clearly informed that the effects discussed in the DES were limited to the simulation of the 84 location meter distant from the point of discharge.

Benthic fauna

Comment 5-17

(page 5-26, paragraph 2)

Ambient water temperatures in DES Section 5.3.1 are referenced here but no ambient temperatures are included in that section. As previously noted, in Comment 5-5, maps of these ambient temperatures should be presented.

The ambient temperatures used in the discussion of the assessment of benthic fauna are apparently taken from the staff's mathematical model. The ambient temperatures used are clearly too high, as example, "temperatures potentially as high as 27.8°C (82°F) may occur naturally,..." This is far in excess of actual measurement of natural ambient water for the area.

The maximum surface water temperature reported in the vicinity of San Onofre is approximately 23°C (References (8),(22), (23), (16) and (17)). Mean San Onofre natural surface temperatures for July and August of the past three years are on the order of 19°C and the corresponding bottom temperatures are about 17°C.

University of California Scripps Institution of Oceanography (SIO) data reports entitled "Surface Water Temperatures at Shore Stations - United States West Coast" give mean surface water temperatures at San Clemente pier, five miles North of San Onofre, References (16) and (17)):

Mean Surface water Temperatures at San Clemente

	July	August	September
1977	18.27	20.48	18.53°C
1976	19.59	17.95	19.77
1975	18.58	17.01	17.91
3 year mean	18.8	18.5	18.7°C

With surface temperatures in the 18-19°C range it should further be noted (for benthic assessment) that corresponding bottom temperatures will be even lower: all San Onofre field data support the existence of vertical temperature stratification in depths greater than about 30 feet when surface temperatures are in this range. (see Attachment T).

Comment 5-18

(page 5-26, paragraph 3)

The DES states, "On the basis of the 1977 study[11] the staff concludes that several components of the benthic fauna in the vicinity of SONGS would probably be adversely affected in areas where weekly mean temperatures of 22°C prevail for one month or more or where daily temperatures reach or exceed 24°C. It is not, however, anticipated that temperatures averaging 22°C will occur for more than 2 to 3 weeks or that the areas experiencing temperatures of 24°C or greater as *a result of SONGS operation will be considerably larger than* the area experiencing these temperatures under natural conditions."

Based upon historical temperature records between 1975 and 1978 (References (8),(22) and (23)) the use of weekly mean bottom temperatures of 22°C appears to be inappropriate and should be lowered to 17°C.

The applicants recommend, therefore, that the sentence indicating 22°C weekly mean temperature could exist on the bottom for 2 to 3 weeks be changed and that a summary sentence be added to indicate that the components of the benthic fauna previously discussed will not be adversely affected.

Also, the date of DES reference 11 (Ford, et. al.) is 1976, not 1977, as stated in the first sentence of the paragraph.

Kelp

Comment 5-19

(page 5-26, paragraph 5)

The DES states, "Although this deterioration may have been partially a result of overharvesting, much of it is probably caused by the increased alteration of the near-shore environment by human activities. In particular increased temperatures and increased turbidity have been shown to be inimical to kelp survival."

The thermal effects on kelp cited in Phillips (1974) were for naturally occurring events and not as induced by human activities. Man induced thermal effects on kelp have not been demonstrated.

The turbidity comment by Phillips (1974)(Reference (15)) was in reference to work conducted by North (1960)(Reference (12)) on effects of sewage outfalls on kelp health. The type of *turbidity generated by a sewage outfall is not equivalent* to the surface turbidity which may be associated with a cooling water discharge.

It is recommended that the discussion be changed to reflect that the deterioration may have been partially a result of overharvesting, much of it is probably caused by increased alteration of the near-shore environment by human activities,

in particular, sewage treatment facilities and industrial/chemical discharges. The toxic element of each discharge has not been isolated to date, i.e., heavy metals, sedimentation, oils, turbidity, etc.

Comment 5-20

(page 5-26, paragraph 6)

The DES states, "Typically, canopy tissue deteriorates during the warmest time of the year leaving the basal portion of the plant (which is in cooler water) for regeneration when temperature and light conditions permit."

It has been documented that kelp deterioration occasionally occurs when (apparently) surface temperatures exceed critical thermal limits. However, it appears that seasonal kelp deterioration may be due to synergistic effects and not just to a thermal component. In the open coast setting, an inverse relation often occurs between temperature and dissolved nutrients. As the temperature increases, the nutrient content often decreases, to or perhaps below levels critical to kelp. Additionally, the highest nutrient concentration is found on the bottom near the basal tissues and the lowest concentration near the surface where most kelp deterioration occurs (Reference (2)).

Other evidence (Reference (13)) implies that when Macrocystis pyrifera is placed in a bay, which are typically much higher in nutrients than found in the open coast, the kelp remains in the healthy state even when the entire plant is subjected to 25-26°C (77-79°F) for extended periods.

At this time, it is not known clearly if temperature, nutrients, and/or other unknown components of the water contribute the most to kelp deterioration. However, there is a possibility of a beneficial effect from Units 2 & 3 operation if outfall upwelling creates a surface nutrient plume that will occasionally come in contact with kelp plants during the warm water months.

It is recommended that the DES be changed to reflect the fact that typically, canopy tissue deteriorates during the warmest time of the year leaving the basal portion of the plant (which is in the cooler water) for regeneration when temperature and light conditions permit; and that reduced surface nutrients and higher bottom nutrient concentrations may contribute to canopy deterioration and basal tissue regeneration, respectively (Reference (2)).

Comment 5-21

(page 5-26, paragraph 7)

The DES states, "It is estimated that the larval, juvenile, and adult stages of 25 main sport fish use kelp beds for refuge and food gathering (eating the associated invertebrates, the kelp itself, or other algae) and the average standing crop of fish is estimated to be 300 kg/ha (300 pounds per acre)."

For many years it was believed that the kelp beds, especially the canopy region, represented spawning and nursery grounds of many sport and forage fish (Reference (1)). No evidence is available to support the therory that the canopy is widely used as a spawning area (Reference (6)). Larvae of a few fishes are found in greater abundance in kelp beds than elsewhere. These include the topsmelt, kelp goby, kelp clingfish and striped kelpfish (Reference (1)); species not considered important sport fish.

Many juvenile fishes inhabit the kelp canopy. However, those of recreational or commercial value are found to be more numerous in rocky areas away from kelp, i.e., kelp bass. The only common juvenile fish that are reported to be at higher concentrations within kelp beds are kelp surfperch, kelp pipefish and kelp clingfish (Reference (1)).

Only one adult species, the kelp clingfish, is considered to be obligate to kelp plants. All other fish species will persist in the environment with or without kelp plants present. Diversity of fish species is not altered significantly by the presence or absence of kelp. A highly varied bottom topography appears to be the most important factor for extensive fish-life and to be of greater significance in this respect than kelp (Reference (14)).

The DES should be changed to reflect the fact the kelp beds do not appear to be spawning grounds, rearing grounds, or refuge areas for recreationally or commercially important fish species (Reference (1) and (14)). Only the kelp clingfish appears to be obligate to kelp beds for survival.

A-27

Comments 5-22

(page 5-26, paragraph 8)

The DES states, "Kelp is an important commercial commodity ...harvested yearly at a landed value of $2 million."

The commercial value of kelp is well documented, although, a kelp bed is only considered commercially important when it has: high stand density, extensive areal coverage and close proximity to a commercial harbor. The San Onofre kelp bed does not now nor has it ever met these criteria because of the limited extent of substrate suitable for attachment. The DES should be revised to reflect the fact that the kelp beds in the vicinity of San Onofre are not commercially harvested.

Comment 5-23

(page 5-27, paragraph 2)

The DES states, "It has been rather well established that temperatures above 18-20°C (64-68°F) cause deterioration of kelp, and the degree of degradation is directly related to the duration of exposure to these temperatures. Increased surface temperatures caused by SONGS operation (all three units) would have the effect of extending the period of canopy absence. During the hottest time of the year, data in Section 5.3.1 suggests that the closest kelp bed (San Onofre bed) will experience an average surface temperature increase (over a 24-hour period) of 1.4°C (2.6°F); the range of temperature increase will be 0.6-2.2°C (1-4°F)."

The statement in Reference (15), of 18-20°C (64-68°F) thermal exposure causing kelp deterioration was based on comments made in Reference (12), which refers to the colder water variety of kelp found near Monterey, California. For kelp plants located in southern California waters, the critical thermal maximum is more in the range of 20-22°C (68-72°F) (Reference (21)).

During the warm water months of the year, data in Section 5.3.1 suggests that the closest kelp bed (San Onofre bed) will experience average surface water temperatures increases due to the operation of SONGS of less than 0.6°C (1°F); the range of temperature is 0-0.9°C (0-1.5°F).

Temperatures taken in the vicinity of San Onofre between July and September over a three year period show a range of averages of 18.5 to 18.8°C (65.3-65.8°F) for the surface waters (References (16) and (17)). Clearly, the predicted maximum temperature increase of 0.9°C from plant operation when added to the ambient temperature in the vicinity of San Onofre of 18.8 C will not exceed the critical thermal limits established by North. The DES should be revised to reflect this fact.

Comment 5-24

(page 5-27, paragraph 3)

The DES states, "Although daily natural temperature variations of 1°C (2°F) are not uncommon in the area (ER page 2.2-28) they would not be continuous in nature and would thus not affect the bed as severely as the continuous SONGS discharges would. Prediction of the degree to which canopy disappearance would be prolonged is impossible. Regeneration would be quicker in years with naturally cooler ocean temperatures, assuming the regenerative tissues remain unaffected (see below)."

The operation of SONGS 1, 2, and 3 will not have a continuous effect on the San Onofre kelp bed. Power plant thermal discharges will contribute no more than 0.9°C surface temperature increases to the kelp bed and thus will only occur with downcoast currents. The more recent current meter data, as discussed in Comment 5-6 must be considered in regard to this kelp section. It is seen from these data that summer upcoast currents, which would result in no kelp bed plume impingement, occur during approximately half of the summer season. Further, the increase in temperature will be dependent on the strength and duration of the current. Increased surface temperatures due to the operation of SONGS 1, 2 and 3 will always be less than the measured natural surface temperature variations of the area, and will be sporadic.

The staff is requested to revise the DES to reflect the fact that increased nutrients brought to the kelp bed surface waters by outfall induced upwelling may help resist the natural seasonal canopy deterioration and provide beneficial effects from station operation when an outfall induced nutrient plume drifts over the kelp bed during warm water months.

Comments 5-25

(page 5-27, paragraph 4)

The DES shows ambient bottom temperatures in July reaching as high as 23-24°C (74-76°F) with temperature of 22-23°C (72°F and 73°F) for a week at a time. These temperatures are the outcome of the staff mathematical model (DES Section 5.3.1) and are an inaccurate representation of existing natural conditions occurring at San Onofre. Applicants' Comment 5-17 suggests that a bottom temperature of 17°C (63°F) is a more realistic representation.

Also, this section references DES Section 5.3.1 as a basis for a typical bottom temperature range of up to 19°C (66°F) in August and September, however, these referenced temperatures are not found in DES Section 5.3.1. Such a temperature appears to represent more adequately the extreme or high end of the range of summer bottom temperatures at San Onofre. As indicated above, an appropriate representation of a monthly or weekly mean bottom temperature would be 17°C (63°F).

Comment 5-26

(page 5-27, paragraph 4)

The DES states, "...a several week period could exist in which temperatures exceed 19°C."

Results of the applicants' thermal analysis demonstrates that the temperature increase at the bottom in the San Onofre kelp bed will be much less than 0.6°C (1°F) under any current condition. Under most conditions it is predicted that there will be no increase in bottom temperature in any portion of the kelp bed. Bottom temperatures measured at San Onofre during July and August over a three year period show a range of averages of 12-18°C (55-64°F). The addition of less than 0.6°C (1.0°F) to measured ambient temperatures should have no adverse effects to kelp basal tissues from which the canopy is regenerated annually.

Comment 5-27

(page 5-27, paragraph 5)

This paragraph summarizes the staff's conclusions that, based on assumed natural bottom temperatures of 21.5 - 24°C (71 - 75°F) and bottom temperature increases in the San Onofre kelp bed of 1 - 1.5°C (2 - 3°F) due to operation of Units 1, 2 & 3, damage to the kelp basal tissue might result if slack currents occur for several days. Further, if this scenerio occurs frequently, the bed might not recover fully, resulting in long term damage. While the staff admits this is unlikely, it recommends additional extensive monitoring of the San Onofre kelp bed.

It is the applicants' conclusion that an assessment based on appropriate ambient bottom temperatures (17°C or 63°F) derived from actual field data, and temperature increases recognizing that the thermal plume will be stratified (0.6°C/1.0°F maximum) will yield a conclusion that damage to basal tissues will not occur, even under worse case conditions. Also, there is no evidence to support the use of an assumption that a condition of several days of slack current will ever occur, or that it would occur frequently. The applicants believe that the proper conclusion to be drawn from the relevant data is that the operation of San Onofre Units 1, 2 & 3 will have no significant adverse effects on the San Onofre kelp bed.

The greatest adverse effect which could be expected is a slight prolongation of the natural summer surface canopy deterioration period which does not effect the basal tissues or the regeneration of the kelp in the fall.

Based on the above evaluation, the extensive monitoring recommended by the staff is not justified, and monitoring presently being accomplished is sufficient to assess potential effects of San Onofre Units 1, 2 & 3. Specific comments on the monitoring are contained in Comment 6-3.

5.4.2.1 Turbidity and Sediment Transport Effects

Comment 5-28

(page 5-27, paragraph 6)

The DES is deficient in that it fails to substantiate the assertion that larger thermal plumes directly imply larger turbid plumes.

Comment 5-29

(page 5-28, paragraph 1)

The DES states, "The effect on the kelp would potentially be decreased photosynthesis, possibly causing many of the plants to die if the exposure is continuous (a 1% increase in the absorption coefficient has been found to result in a 20% loss in net photosynthesis at 15m)[13] and burial of the holdfasts in particles which settle out, inhibiting regeneration and recolonization. Regardless of the magnitude of these effects, their presence would add to the probability that the kelp bed would be adversely affected (see preceding section)".

A-29

As discussed in Comment 5-24, the plume from SONGS 1, 2 and 3 will not have continuous contact with the San Onofre kelp bed.

Reductions in photosynthesis from power plant induced turbidity has not been demonstrated. The net reduction in photosynthesis referred to by Phillips (1974)(Reference (15)), was based on work by North (1958)(Reference (18)). The model (computation) was based on a uniform dispersal of light absorbtive material throughout the water column. This model was designed for the turbidity generated by a sewage outfall. For thermal diffusers, there would be an uneven distribution of natural turbidity and the equation does not apply.

Sewage outfalls generate a substantial amount of turbidity that is dispersed throughout the water column. A thermal outfall does not create turbidity, but rather, can occasionally redistribute portions of a naturally occurring dense bottom turbid layer to the surface. Therefore, there is no net gain in the amount of suspended matter in the water. The major effect is that the turbidity on such occasions can be seen on the surface. Further, the turbid plume characteristics sometimes experienced at Unit 1 should not be applied to Units 2 and 3.

A surface plume can be seen at Unit 1 when the surface waters are relatively clear and the bottom water is turbid. The intake and outfall withdraws and upwells, respectively, portions of the bottom turbid layer and pumps it to the surface. The bottom turbid layer qualitatively appears to be essentially a nearshore phenonemon that is generated from wave agitated bottom sediments. Units 2 and 3 outfalls are located in deeper and clearer ocean waters, although the intakes are at a depth comparable with Unit 1. It is predicted that on occasions when naturally occurring turbidity is present the Units 2 and 3 intakes will withdraw turbid bottom water like Unit 1, however, the Units 2 and 3 outfalls will be upwelling clearer bottom waters. Additionally, Units 2 and 3 effluent will be initially diffused through 63 ports each and then mixed with the receiving water at an estimated ratio of 10:1 (Unit 1 dilution ratio is approximately 3:1). Given the situation of clearer water at the outfalls and increased mixing of effluent, it is predicted that a turbid plume will not normally be detected.

In terms of effects, Unit 1 can be viewed as potentially creating more severe effects than Units 2 and 3, i.e., single port outfall and reduced mixing (3:1). The environmental evidence indicates that there is no adverse impact on benthic faunal or floral groups near the outfall. In fact, results from the Environmental Technical Specifications benthic program demonstrate that the fauna and flora near the Unit 1 outfall are more abundant than those from the control station (References (8), (9) and (10)).

No relationship has been established between a turbid plume and thermal plume. The factors that influence the intensity and extent of each constituent are different and may not be interrelated.

The applicants' conclusions are that a turbid plume emanating from Units 2 and 3 operation may occur under certain oceanographic conditions, however, it should be less intense than observed at Unit 1 because (1) of increased mixing of the discharge and (2) the diffusers are located in deeper, clearer waters. Environmental Technical Specifications benthos study results show that redistributing a natural turbid layer has no adverse effects on faunal and floral groups for Unit 1 (References (8), (9) and (10)). Therefore, no adverse effects on faunal or floral biota are predicted.

Entrainment

Comment 5-30

(page 5-29, paragraph 2)

The DES states, "The staff's analysis of entrainment effects in the FES-CP remains valid (FES-CP, p. 5-7 to 5-12). A program on the mortality experienced by entrained ichthyoplankton is being planned currently at SONGS 1 and is expected to be submitted to the NRC staff in December, 1978, for approval."

Refer to (applicants' Comment 6-5).

Impingement

Comment 5-31

(page 5-29, paragraph 4)

The DES states, "The majority of the fish impinged at SONGS 1 are anchovy,..."

A review of last three years (1975-1977) of ETS in-plant impingement monitoring reveals that the Queenfish, Seriphus politus has been the most predominant species impinged at Unit 1 in terms of both numbers and weight.

Entrainment of anchovy has been sporadic and shows occasional high numbers entrapped probably reflecting the schooling behavior of the species. Early impingement information (pre-ETS-1975) indicating high impingement of anchovy may have been biased by a combination of sampling frequency and these chance occurrences.

It is recommended that the word anchovy be replaced with "Queenfish" to reflect the most recent data available. This change does not effect the overall assessment result indicating no significant effect on recreational or commercial fishing resources.

Offshore Current Induction

Comment 5-32

(page 5-29 paragraph 5)

The applicants agree that there are no detrimental effects of induced circulation on the aquatic environment. However, the discussion of the analysis in the DES concerning the effects of the induced circulation on the aquatic environment should mention that the analysis is based on the diffuser design described in Section 3.4 of the ER-OLS and Section 9.2 of FSAR.

5.5 RADIOLOGICAL IMPACTS

Comment 5-33

(page 5-33, Table 5.4)

Table 5.4 of the DES shows calculated annual doses nearly a factor of 3 greater than the values provided by the applicants in Table 5.2-12 of the Environmental Report - Operating License Stage (ER-OLS). The doses shown in Table 5.2-12 of the ER-OLS were calculated using annual average meteorology.

It appears that the staff has used short term 15th percentile meteorology (valid only for purge releases instead of continuous long-term releases) in calculating the doses shown in Table 5.4 of the DES. The staff is requested to revise the doses consistent with Table 5.2-12 of the ER-OLS.

Comment 5-34

(page 5-34, Table 5.6)

Table 5.6 of the DES shows that the dilution factor used for the dispersion of liquid release is 1. However, Section 5.2.4.3 of the applicants' Environmental Report-Operating License Stage (ER-OLS) shows that the dilution factor is 10 between 0-10 miles and 12.5 between 10-50 miles. The values reported by the applicants were derived consistent with Regulatory Guide 1.112.

The staff is requested to revise the values in Table 5.6 of the DES to be consistent with the dilution factors shown in Section 5.2.4.3 of the ER-OLS.

5.6 SOCIOECONOMIC IMPACTS

5.6.1 Introduction

Comment 5-35

(page 5-40, paragraph 8)

The second sentence should read:

"The central portion of Orange County ...".

5.6.5 Impact on recreational resources

Comment 5-36

(page 5-44 and 5-45)

The NRC staff concludes in this section and other sections (5.6.5, 9.1, 10.5, and 10.7) of the Draft Environmental Statement (DES), that the applicants' current plan to restrict the public use of the beach in front of the San Onofre Nuclear Generating Station, within the exclusion area, is a significant cost of the project unanticipated at the issuance of the construction permit. Applicants disagree with the conclusion that there will be any significant loss of recreation area.

Subsequent to the issuance of the Final Environmental Statement (FES) required for the construction permits of SONGS 2 and 3, the ASLAB in its initial decision dated December 24, 1974 (ALAB-248) questioned whether recreational activities within portions of the exclusion area should be permitted, and the adequacy of the applicants' authority to control activities in the exclusion area. By Decision dated April 25, 1975 (ALAB-268) the ASLAB ruled that the applicants' authority to control activities within the exclusion area was insufficient and remanded the issue for further hearing.

On October 10, 1975, the applicants submitted Amendment No. 22 to the PSAR consisting of information concerning a proposal for a reduced exclusion area. Amendment No. 22 also provided estimates of the number of persons anticipated within the proposed reduced exclusion area. Applicants' experts estimated the maximum number of persons within the proposed reduced exclusion area would be 31.

The NRC Staff evaluated applicants' assessment of potential beach use as provided in Amendment No. 22 to the PSAR and concluded that applicants' estimates of the maximum number of people on the beach or in the water within the proposed reduced exclusion area were conservative.

The ASLAB Memorandum of Order dated January 22, 1976 (ALAB-308) resolved the issue concerning authority to control activities within portions of the new reduced exclusion area landward of the mean high tide line in the applicants' favor. However, the Board declined to deal with the question concerning the tidal beach and remanded this issue to the ASLB.

The ASLB held hearings on May 19-21, 1976, at which time evidence was heard on several issues concerning the tidal beach, including the anticipated public use of the beach.

Applicants' expert witnesses provided testimony regarding activities within the beach areas in the vicinity of the San Onofre Nuclear Generating Station and the projected number of persons that would be anticipated within the reduced exclusion area. With respect to activities within the beach areas, applicants' expert witness indicated that distances from parking and beach access points to the area in front of the station are such that there will be a low level of activity on beaches within the reduced exclusion area as compared to other beach areas in the San Onofre State Beach because beach users tend to remain relatively close to their point of beach access. With respect to the projected number of persons within the reduced exclusion area, the applicants' expert witness conservatively assumed the total number of persons which could ultimately be accommodated by all park facilities developed to their planned ultimate capacity would occupy the beach at the same time. Based upon a probabilistic distribution of that population , an estimated 35 persons would be located within the reduced exclusion area. Further, based upon actual observations of persons using the San Onofre State Beach, in addition to similar observations on other beaches, it was predicted that the average and maximum number of people using the beach in front of the station, within the exclusion area, would be 7 and 31, respectively.

NRC Staff supported the applicants' contentions and indicated in both written and oral testimony that the area directly in front of the plant was the least desirable both from an aesthetic point of view and for swimming, surfing or sunbathing, and also indicated that when one is laden with beach blankets and other recreational gear, migration up or down the beach would be discouraged, therefore, beach users would congregate relatively close to the paths up the bluffs of the San Onofre State Beach.

ASLB Order dated January 6, 1977, ordered applicant to provide all data collected since March 14, 1976, reflecting the actual daily count of persons using the beach within the applicants' exclusion area, including the tidal beach. Oral Arguments were held on February 1, 1977, during which the applicants' provided an analysis of the daily counts previously submitted to the ASLB. That analysis showed less than 10 persons were observed on the beach in the exclusion area for approximately 57.6 percent of the time, and that, on the average, only 12 to 15 percent of the total number of people observed in the study area (area in front of the station and adjacent areas 1/4 mile north and 1/4 mile south) were in the exclusion area. There was a peak number of 108 persons observed in the exclusion area, however, the 108 persons (40 percent stationary, 19 percent in transit, 20 percent swimming, and 21 percent surfing) represent about 36 percent of the total number observed in the study area. It should be noted that the administrative features proposed in Amendment 22 will only effect stationary persons within the exclusion area. Transit through the exclusion area as well as activities below the mean high tide line such as, swimming, fishing and surfing will remain unrestricted.

The ASLB Initial Decision dated May 20, 1977, ruled in the applicants' favor ordering that the Construction Permits shall be continued in effect.

Given the following facts that:

1. The conclusions drawn by the NRC staff in the DES appear to be based upon the Final Environmental Statement Construction Permit Stage.

2. The ASLAB and ASLB have given detailed consideration, in hearings, regarding usage of the beach in front of the San Onofre Nuclear Generating Station within the exclusion area.

3. The applicants provided expert testimony supporting the fact that the beach in front of the station was the least desirable from the standpoint of aesthetics for swimming, surfing or sunbathing and does not receive significant usage and that people tended to congregate near the paths of the state beach away from the exclusion area.

4. The staff supported the applicants' contention regarding minimal beach usage and undesirability of the beach in front of the station.

In view of the above, the appropriate sections of the DES should be revised to conclude that limiting the use of the beach within the exclusion area boundary and above the mean high tide line to a passage way does not represent a significant loss of recreational space.

6. ENVIRONMENTAL MONITORING

6.2 PREOPERATIONAL MONTIORING PROGRAM

Comment 6-1

(page 6-2, Fig. 6.1)

The legend is in error, the triangle symbol should represent DO, pH and Heavy Metals. The square symbol should represent continuous temperature.

6.2.1.5 Intertidal Organisms

Comment 6-2

(page 6-3, paragraph 5 and 6)

The monitoring described in the first paragraph was a requirement for Unit 1 which was deleted in September, 1977, because no effects had been detected. Although this study has been deleted as a requirement, SCE has continued an intertidal study program somewhat reduced in scope. The applicants contend continued conduct of this present cobble intertidal sampling program as described below will meet the objectives outlined in the second paragraph of Section 6.2.1.5 of the DES.

The applicants recommend replacing the existing paragrpah with the following paragraph:

"Although not a required component of the monitoring programs, quarterly observations are made along cobble intertidal transects at four monitoring stations and one control station. Predominant macroscopic species and substrate composition are identified and enumerated within three permanent 0.25m^2 (2.69-$ft.^2$) quadrats along a line perpendicular to the beach. Photographs are also taken of each quadrat for a permanent record of ecological changes."

6.2.1.6 Requirements

Comment 6-3

(page 6-3, requirement 2)

The staff requires extensive monitoring of the San Onofre kelp bed based on predictions made in Section 5.4.2.1.

Kelp investigations are currently in progress with the Construction Monitoring Program, which is a special study of the Preoperational Monitoring Program. Detailed methods are outlined in Reference (11). A brief outline of the scope of effort, at all three San Onofre region beds, is as follows:

1. Three benthic stations are located in and about the San Onofre kelp bed and one each at Barn kelp and San Mateo kelp. Stations are quantatively assessed quarterly.

2. Kelp canopies and rock substrate are mapped for areal extent on a quarterly basis.

3. Water nutrient analysis for ammonia, nitrates, nitrites and phosphate taken monthly at all three beds. Water samples are taken for the surface and bottom from within each bed and offshore of each bed. An additional offshore station serves as a monitoring area for upwelling.

4. Kelp tissue analysis for nutrient content is conducted on a monthly basis at all three kelp beds. Each leaf is analyzed for nitrogen content.

5. Assessments of the health of kelp plants in the San Onofre region beds are made on a quarterly basis. Parameters assessed include: success of juvenile recruitment, density of kelp plants, amount of encrusting organisms and grazing by herbivores and abundance of senile and diseased plants.

Based upon the applicants' extensive comments dealing with the predicted impact of the San Onofre thermal plume on the San Onofre kelp bed, the applicants contend that requirement number 2 in Section 6.2.1.6 is unwarranted and should be deleted.

6.3.1 Water quality monitoring program

Comment 6-4

(page 6-6)

The entire section is in error and should be deleted. The program that the staff discusses in the DES is actually a 1976 draft of the applicants' proposed preoperational oceanographic program. An operational program for San Onofre 2 and 3 has not yet been established.

6.3.3 Aquatic biological monitoring

Comment 6-5

(page 6-7, paragraph 2)

This paragraph states, "The applicant intends to forward a description of the study with a schedule for completion to NRC by December, 1978, (see ER, Suppl. 1, p. S1-31)."

In keeping with efforts to avoid duplication and utilize the 316(b) study results, the study plan submittal to the NRC will be made after the completion of the methods development phase of 316(b). We presently anticipate that the 316(b) method development phase will be completed in early 1979, and, therefore, the study plan should be submitted to the NRC by mid-1979.

6.3.3 Aquatic biological monitoring, and

6.3.5 Requirements for Environmental Technical Specifications

Comment 6-6

(page 6-6 and 6-7)

The DES states in Section 6.3.3, paragraph 2 and in requirement number 3, Section 6.3.5, that "...the ichthyoplankton study now being conducted and the required

kelp preoperational program should be continued during operation of the facility until such time as it is possible to state credibly that no significant impacts result from the facility."

The ichthyoplankton study being conducted is a one year program to provide a baseline for comparison with the operational ichthyoplankton study which is also envisioned to be a one year program. Further, as stated in applicants' Comment 6-4, the required kelp preoperational program is considered to be unwarranted and the requirement should be deleted.

8. NEED FOR THE STATION

8.2 APPLICANT'S SERVICE AREAS AND REGIONAL RELATIONSHIPS

8.2.1 Applicant's service areas

Comment 8-1

(page 8-1, paragraph 2)

The reference number used in the discussion appears to be incorrect.

8.3 BENEFITS OF STATION OPERATION

8.3.1 Minimization of production costs

Comment 8-2

(page 8-3, Table 8.1)

Table 8.1 was derived from the applicants' ER-OLS, Table 1.1-3 and page S.2-188. However, the data found on ER-OLS Table 1.1-3 is not the most current for 1976 and will be updated in a future amendment to the ER-OLS. The applicants have revised Table 8.1 of the DES to reflect changes in data as reported to the Federal Power Commision on Form 1, Annual Operating Report for Southern California Edison Company for the year ending December 31, 1976.
(Revised Table 8.1 (Attachment X))

8.3.2 Energy demand

Comment 8-3

(page 8-4, paragraph 2)

The discussion on the overestimation of peak demands in the 1973 forecast should also mention load management programs. The applicants suggest the last sentence be rewritten as follows:

> "These peak demands were overestimated because the 1973 forecast did not foresee the Arab oil embargo, the following period of economic recession, the nationwide effort to promote energy conservation, and load management."

A-35

Comment 8-4

(page 8-4, paragraph 3 and Table 8.3)

The staff's evaluation is based on the 1976 forecast data provided by the applicants in their ER-OLS. The data found on ER-OLS Table 1.4-1[a] is based on an early 1976 forecast and does not reflect the revised forecast (July 23, 1976) data found on ER-OLS Table 1.1-1. SCE has revised Table 8.3[b] of the DES based on ER-OLS Table 1.1-1 and their revised 1976 forecast. The last line in the second paragraph has been changed by the applicants to be consistent with the revised data and reads as follows:

> "SCE's revised 1976 forecast shows a peak demand growth rate of 3.9% from 1976 to 1985, and energy requirements are expected to experience a growth rate of 4.3% in the same period."

a. ER-OLS Table 1.4-1 will be revised in a future amendment to the ER-OLS.

b. Revised Table 8.3 (Attachment Y).

Comment 8-5

(page 8-5)

The discussion of the three forecasts that states, "their projections do not reflect non-price-induced conservation...," this does not consider current SCE forecast methodology. Non-price-induced standards were incorporated into SCE's peak demand forecasts, e.g., the peak demand for 1985 includes a 2.4% reduction due to load management and the "weather sensitive demand" for 1985 was reduced 29% because of building insulation and air conditioning efficiency standards (Reference 19 and 20). Therefore, the discussion on page 8-5, specifically paragraphs 1, 3 and 4 should be modified.
(see Attachments Q and R)

10. BENEFIT-COST SUMMARY

10.2 BENEFITS

Comment 10-1

(page 10-1, paragraph 2, and page 10-2, Table 10.1)

The net power output for each unit is estimated to be in the range of 1052 to 1106 MWe (see Comment A-1 for discussion). The regional generating capacity will be increased 2104 to 2212 MWe with the addition of Units 2 and 3. The discussion on the primary benefit and Table 10.1 should be revised to reflect the estimated net power output.

10.7 SUMMARY OF BENEFIT-COST

Comment 10-2

(page 10-3, item (2))

The "possible destruction of at least a portion of the San Onofre Kelp Bed during summer months by the heated water discharge" is listed as an additional environmental cost. Because this cost is based on an assessment performed by the staff using disputed data, the applicants request that this cost be deleted if the reassessment of Section 5.4.2.1 Effects of the heat dissipation system warrants such a change.

A-36

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
215 Fremont Street
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Project # D-NRC-K06002-CA

William H. Regan, Jr., Chief
Environmental Projects, Branch 2
Division of Site Safety & Environmental Analysis
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

FEB 13 1979

Dear Mr. Regan:

The Environmental Protection Agency has received and reviewed the draft environmental statement for the SAN ONOFRE NUCLEAR GENERATING STATION, UNITS 2 and 3, SOUTHERN CALIFORNIA EDISON COMPANY, SAN DIEGO GAS AND ELECTRIC COMPANY.

EPA's comments on the draft environmental statement have been classified as Category ER-2. Definitions of the categories are provided on the enclosure. The classification and the date of EPA's comments will be published in the Federal Register in accordance with our responsibility to inform the public of our views on proposed Federal actions under Section 309 of the Clean Air Act. Our procedure is to categorize our comments on both the environmental consequence of the proposed action and the adequacy of the environmental statement.

EPA appreciates the opportunity to comment on this draft environmental statement and requests three copies of the final environmental statement when available.

If you have any questions regarding our comments, please contact Betty Jankus, EIS Coordinator, at (415)556-6695.

Sincerely,

Sheila M. Prindiville
for Paul De Falco, Jr.
Regional Administrator

Enclosure

Water Quality Comments

1. In Section 5.3.1.1., some assessment is made of the effects of the discharge of heated cooling water on the receiving coastal waters with regards to the California State thermal standards. When evaluating thermal discharge, all effects of Units 2 and 3 should be considered in conjunction with the effects of Unit 1. The natural background is a situation where none of the three units is operating. The natural receiving water temperature as defined by California Thermal Plan (see next paragraph) is "the temperature of the receiving water at locations, depths, and times which represent conditions unaffected by any elevated temperature waste discharge". Unless Units 2 and 3 are not planned to operate concurrently with Unit 1, their effects will occur in concert. All modeling, graphs, and maps produced from models should include Unit 1 effects when evaluating SONGS' effects on the receiving water temperature.

   Under Section 316(a) of the Federal Water Pollution Control Act of 1972 (FWPCA) and under the Water Quality Control Plan for Control of Temperature in the Coastal and Interstate Waters and Enclosed Bays and Estuaries of California (1975 Thermal Plan) (EPA approved State water quality standards), there are several criteria which discharges to coastal waters must fulfill. These should be addressed in any EIS on operating a new coastal discharge of elevated temperature wastes. These are as follows:

   a. In part 3.B.(3.) of the Thermal Plan, it is stated that "the maximum temperature of thermal waste discharges shall not exceed the natural temperature of receiving waters by more than 20°F." Part 3.2.2. of the DEIS states that the cooling water "experiences an 11.1°C (20°F) temperature rise across the condenser." Since the waters in the vicinity of the intakes for Units 2 and 3 are close to the discharge structures for these units, it is possible that these intake waters are already heated beyond their natural temperature. Some evaluation of this effect must be included in the FEIS. The influence of the heated discharge from Unit 1 must also be described. In addition, the intake

and discharge facilities and their depths and how temperature stratification profiles relate to the 20°F requirement should be discussed.

b. In Part 3.B.(4) of the Thermal Plan, it is stated that "the discharge of elevated temperature wastes shall not result in increases in the natural water temperature exceeding 4°F at (a) the shoreline, (b) the surface of any ocean substrate, or (c) the ocean surface beyond 1,000 feet from the discharge system. The surface temperature limitation shall be maintained at least 50 percent of the duration of any complete tidal cycle." Figure 5.3 of the DEIS represents projected incremental increases above natural surface temperatures for the study area. This figure should be changed in the FEIS to include the Unit 1 intake and discharge structures and the increase of surface temperatures already caused by Unit 1 discharges in conjunction with those of Units 2 and 3 so as to compare the increases with the true natural surface water temperature.

c. In addition, the FEIS should document the estimate (Section 5.3.1.2) of the increase in temperatures at the surface of the ocean substrate around the discharges. This estimate indicates that "violations of the state thermal standards are unlikely." Again, such estimates should compare natural temperatures to the combined effects of Units 1, 2, and 3. These temperatures are of special concern because of the importance of low basal temperatures to maintaining the nearby kelp bed.

d. Finally, the Thermal Plan and Section 316(a) of the FWPCA assert the need to "assure the protection and propagation of a balanced, indigenous population of shellfish, fish, and wildlife in and on the body of water into which the discharge is to be made". In Section 5.4.2.1 of the DEIS, biological/ecological evaluations refer to the effects of the discharges on various types of organisms, indicating the effects to be minimal and acceptable. For plankton, the effects will be "species composition changes" and

"greater respiration rates", also, "significant effects should be localized". For fish, the effects will be mainly "shifts in the types of species (and their numbers) which inhabit the area". For benthic fauna, adverse effects may be expected if "weekly mean temperatures of 22°C prevail for one month or more or where daily temperatures reach or exceed 24°C. It is not, however, anticipated that temperatures averaging 22°C will occur for more than 2 to 3 weeks or that the area experiencing temperatures of 24°C or greater as a result of SONGS operation will be considerably larger than the area experiencing these temperatures under natural conditions". For kelp, the information "suggests that the thermal discharges from SONGS 1, 2 and 3 may result in the destruction of at least a portion of the San Onofre Kelp Bed during the summer months". All of these statements indicate that the indigenous populations will be altered, giving no specific documentation that these effects will be minimal or acceptable. A detailed evaluation of how the aquatic ecosystem will be affected, over what area each species or type of fauna may be influenced, and what constitutes a significant adverse effect should be made and presented clearly in the FEIS.

2. Section 5.4.2.1. Thermal Effects, mentions a final report due on December 29, 1978. This study, provided for under the Thermal Plan and Section 316(a) of the FWPCA, is to be used in evaluating the heat-treatment process which is used to clear the intake facilities of biological growth. EPA considers this study to be an integral part of the assessment of the environmental effects of the thermal discharges from the Units. As such, it must be distributed, along with biological and water quality assessments and conclusions (perhaps in the form of a supplement to the DEIS) to all recipients of this DEIS, with the allowance of a comment period prior to incorporation in the Final EIS.

3. Section 5.4.2.2 includes a discussion of the potential effects of chlorine discharges. The discussion evaluated potential "significant impacts" of the periodic 15-minute chlorine dosing period. The FEIS should include a comparison of effluent concentrations with the State Standards contained in the Water Quality Control Plan for the Ocean Waters of California (1978 Ocean Plan), Table B and Footnote 11, should appear in the EIS. Should the comparison predict that the discharges exceed the requirements, the plans to lower the discharge concentration to agree with the State Standards must be described in the FEIS.

4. No assessment appears in the DEIS of the potential seismic effects of nearby faults on the units, although there is a fault within a mile of the plant (the Christianitos Fault and others in the vicinity). The FEIS should address the potential of seismic events and the resultant damage from fault movement, with particular emphasis on the water quality and off-site radiological contamination.

Radiological Comments

Beach Regulation

This DEIS gives little information on the anticipated beach population. The presence of thousands of daytime beach users and hundreds of overnight campers within 1.5 miles from the reactors has significant security, emergency planning, and radiation dose implications. Consequently, we believe this issue warrants a thorough discussion in the Final EIS so that those reviewers who will not read the Environmental Review and Emergency Plan will be aware of this situation and have an opportunity to evaluate it.

We agree with the decision to restrict usage of the beach in front of the reactors since it will simplify the security and emergency planning problems and will reduce the radiation doses to the population from routine release. However, the practical effectiveness of this restriction should be addressed in the FEIS (e.g., is the prohibition against restricting the area seaward of mean high water, coupled with permitting viewing and pedestrian passage going to make enforcement difficult?).

It would be helpful to briefly mention the Emergency Response Plan that is in effect for the Nuclear Station and relate it to the transient population.

As mentioned under the Dose Commitment section, it is not clear whether beach users and Visitor Center users are included in the individual and population dose calculations.

Environmental Dose Commitments

Page 5-31-34 of the DEIS:

The estimated maximum individual dose and the population dose were independently checked by EPA with results similar to those presented in the DEIS. However, we do have several questions about assumptions used in the DEIS calculations. The FEIS should clarify the following items:

1. The manner in which the individual and population dose to users of the beach is calculated is unclear. For example, what allowance is made for direct radiation doses, especially to those using the walkway between the south and north beaches, and to those at the Visitors Center? Do the individual and population doses include these users of the beach and the Visitors Center and, if so, what assumptions were made on hours of exposure, shielding factors, etc.? Also, it would be helpful if the habits of "a maximum individual" were described so it could be determined to what extent these various pathway dosages are additive.

2. The actual maximum individual dose from present operation of Unit 1 should be described. This dose should be added to those being projected for Units 2 and 3 (from all pathways). This, in turn, should be compared with the 25 millirem per year limit (75 millirem per year to the thyroid) of the Uranium Fuel Cycle Standard (40 CFR 190).

EPA is encouraged that the NRC is now calculating annual population dose commitments to the U.S. population, which is a partial evaluation of the total potential environmental dose commitments (EDC) of H-3, Kr-85, C-14; iodines and "particulates." This is a big step toward evaluating the EDC which EPA has urged for several years. However, it should be recognized that several of these radionuclides (particularly C-14 and Kr-85) will contribute to long-term population dose impacts on a world-wide basis, rather than just in the U.S. To the extent that the draft statement (1) has limited the EDC to the annual discharge of these radionuclides, (2) is based on the assumption of a population of constant size, and (3) assesses the doses during 50 years only following each release, it does not fully provide the total environmental impact. Assessment of the total impact would (1) incorporate the projected releases over the lifetime of the facility (rather than just the annual release), (2) extend to several half-lives or 100 years beyond the period of release, and (3) consider, at least qualitatively or generically, the world-wide influences on the total environmental impact or specify the limitations of the model used.

Environmental Monitoring

The pre-operational and operational radiological environmental monitoring program (as described in Section 6.1.5 of the Environmental Report) appears adequate with the following exceptions which the FEIS should address:

1. A delay of 8 days before analyzing charcoal filter air samples would permit over 99% of the Iodine-133 and 50% of the Iodine-131 to decay before being counted. The decay would be much greater for contamination occurring at the beginning of the 7-day sampling period. The maximum time before analyzing filters should be shortened significantly in order to detect as many incidences of sporadic contamination as possible.

2. It is not clear why a minimum of only ten 7-day air particulate samples are required per quarter. The intent should be to monitor all 13 weeks in a quarter.

3. No TLD stations are indicated for the walkway along the seawall or the mean high water exclusion area in front of the reactors. It would be desirable to include TLD's at these locations to monitor the direct radiation at a site boundary where the public has access.

Reactor Accidents

The EPA has examined the NRC's analyses of accidents and their potential risks. The analyses were developed by NRC in the course of its engineering evaluation of reactor safety in the design of nuclear plants. Since these issues are common to all nuclear plants of a given type, EPA accepts NRC's generic approach to accident evaluation in the DEIS. However, the NRC is expected to continue to ensure safety through plant design and accident analyses during the licensing process on a case-by-case basis.

In 1972, the AEC initiated an effort to examine reactor safety and the resultant environmental consequences and risks on a more quantitative basis. The final report of this effort was issued in October 1975 by the U.S. Nuclear Regulatory Commission as the Reactor Safety Study, WASH-1400 (NUREG-75/014). The EPA's review of this study

included in-house and contractual efforts, and our comments were released in a report in June, 1976. In subsequent discussion with NRC we determined that of the concerns we expressed, those having the most significance with regard to the results of the study were on (1) the latent cancer health effects and (2) the probability of BWR scram failure where we differed by factors of four and a maximum of ten, respectively. We believe that the methodology of the Reactor Safety Study should continue to be used as a tool in the evaluation of nuclear systems that vary from the models chosen for the study, and that a generic analysis should be made of the acceptability of the present risks and the necessity for increased levels of safety.

High-Level Waste Management

The techniques and procedures used to manage high-level radioactive wastes will have an impact on the environment. To a certain extent, these impacts can be directly related to the individual projects because the spent fuel from each new facility will contribute to the total waste. The AEC, on September 10, 1974, issued for comment a draft statement entitled "The Management of Commercial High-Level and Transuranium-Contaminated Radioactive Waste" (WASH-1539). In this regard, EPA provided extensive comments on WASH-1539 on November 21, 1974. Our major criticism was that the draft statement lacked a program for arriving at a satisfactory method of "ultimate" high-level waste disposal. At present, DOE is preparing a new draft statment which will discuss waste management and emphasize ultimate disposal in a more comprehensive manner. EPA concurs with this decision and will review and comment on the new draft statement replacing the September 10, 1974 version when it is available.

EPA is cooperating with both NRC and DOE to develop an environmentally acceptable program for radioactive waste management. In this regard, on November 15, 1978, EPA issued proposed environmental radiation protection criteria (43 FR 53262) for the management of all radioactive waste and will propose environmental radiation protection standards for high-level waste in 1979.

Transportation

In its earlier reviews of the environmental impacts of transportation of radioactive material, EPA agreed with AEC that many aspects of this program could best be treated on a generic basis. The NRC has codified this generic approach (40 FR 1005) by adding a table to its regulations (10 CFR Part 51) which summarizes the environmental impacts resulting from the routine transportation of radioactive materials to and from light-water reactors. These regulations permit the use of the impact values listed in the table in lieu of assessing the transportation impact for individual reactor licensing actions if certain conditions are met. Since San Onofre appears to meet these conditions and since EPA agrees that the routine transportation impact values in the table are reasonable, the generic approach appears adequate for this plant.

The impact value for routine transportation of radioactive materials has been set at a level which covers 90 percent of the reactors currently operating or under construction. However, the basis for the impact, or risk, of transportation accidents is not as clearly defined. At present, EPA, DOE, and NRC are each attempting to more fully assess the radiological impact of transportation risks. The EPA will make known its views on any environmentally unacceptable conditions related to transportation. On the basis of present information, EPA believes there are no unique characteristics of the San Onofre site which would result in greater accident risks than from the "typical" site being studied generically.

Fuel Cycle and Long-Term Dose Assessments

EPA is responsible for establishing generally applicable environmental radiation protection standards to limit unnecessary radiation exposures and radioactive materials in the general environment resulting from normal operations that are part of the total uranium fuel cycle as well as those of the facilities. The EPA has concluded (in 40 CFR 90) that environmental radiation standards for nuclear power industry operations should take into account the total radiation dose to the population, the maximum individual dose, the risk of health effects attributable to these doses (including the future risks arising from the release of long-lived radionuclides to the environment), and the effectiveness and costs of effluent

control technology. EPA's Uranium Fuel Cycle Standards are expressed in terms of dose limits to individual members of the general public and limits on quantities of certain long-lived radioactive materials released to the general environment.

A document entitled "Environmental Survey of the Uranium Fuel Cycle" (WASH-1248) was issued by the AEC in conjunction with a regulation (10 CFR 50, Appendix D) for application in completing the cost-benefit analysis for individual light-water reactor environmental reviews (39 FR 14188). This document is used by NRC in draft environmental statements to assess the incremental environmental impacts that can be attributed to fuel cycle components which support nuclear power plants.

Recently, the NRC decided to update the WASH-1248 survey. We believe this is a prudent step and commend the NRC on initiating this update. In providing comments to the NRC on this subject, dated November 14, 1978, we encouraged NRC to express environmental impacts in terms of potential consequences to human health, since for radioactive materials and ionizing radiation the most important impacts are those ultimately affecting human health. We believe the presentation of environmental impact in terms of human health impact fosters a better understanding of the radiation protection afforded the public.

A second major concern of EPA deals with the discharge and dispersal of long-lived radionuclides into the general environment. In the areas addressed in WASH-1248, there are several cases in which radioactive materials of long persistence are released into the environment. The resulting consequences may extend over many generations and constitute irreversible public health commitments. This long-term potential impact should be considered in any assessment on health impact. EPA has consistently found inadequate the NRC's estimates of population doses for these persistent radioactive materials. In particular, the NRC has generally limited their analysis to the population within 50 miles of a facility or, in rare cases, to the U.S. population, and to doses committed for a 50-year period by an annual release. These limitations produce incomplete estimates of environmental impacts and underestimate the impact in some cases, such as from releases of tritium, Krypton-85, Carbon-14, Technetium-99, and Iodine-129. The total impact of these

persistent radionuclides should be assessed, qualifying such estimates as appropriate to reflect the large uncertainties. In this regard, we note that NEA is addressing this approach in making assessments and that NRC is represented in this effort.

Another major consideration in updating WASH-1248 is the health impact from Radon-222 from the uranium mining and milling industry. Estimates made by EPA, among others, indicate that Radon-222 contributes the greatest fraction of the total health impact from nuclear power generation. In preparing an updated WASH-1248, we believe NRC should:

1. include the Radon-222 contribution from both the uranium mining and milling industries;

2. determine the health impact to larger populations, not only the local populations;

3. recognize the persistent nature of the Radon-222 precursors (Th-230 and Ra-226) by estimating the health impact for a period reflecting multi-generation times.

Decommissioning

The NRC has published a proposed rulemaking on Decommissioning Criteria for Nuclear Facilities in the Federal Register on March 13, 1978. EPA comments were sent to NRC on July 5, 1978, dealing with the decommissioning issue.

In summary, we believe that one of the most important issues in the decommissioning of nuclear facilities is the development of standards for radiation exposure limits for materials, facilities, and sites to be released for unrestricted use. We have included the development of such standards among our planned projects. The work will require a thorough study to provide necessary information, including a cost-effectiveness analysis for various levels of decontamination.

The development of standards for decommissioning must, of course, include consideration of the many concurrent activities in radioactive waste management and radiological protection. EPA has developed proposed Criteria for Radioactive Waste for management of all

radioactive wastes which will provide guidance for decommissioning standards. From the decommissioning view, probably the most important criterion is that limiting reliance on institutional controls (guards and fences) to a finite period. EPA believes that the use of institutional control to protect the public from retired nuclear facilities until they can be decontaminated and decommissioned should be limited at the most to 100 years and preferably less than 50 years. This includes nuclear reactors shut down and mothballed or entombed for a period of time under protective storage. After the allowable institutional care period is over, the site will have to meet radioactive protection levels established for release for unrestricted use. We believe EPA's proposed criteria would be directly applicable, as above, to decommissioning of nuclear facilities and should be given serious consideration by the Nuclear Regulatory Commission (NRC).

The availability of adequate funds when the time to decommission arrives is also most important; it should be the responsibility of the NRC to assure that such provisions are made. We recognize the great complexity of providing funds at construction for decommission in 40 years. However, if it can be determined that the total cost of decommissioning in current dollars is a very small fraction of initial capital costs, provision of escrow funding may not be necessary. Therefore, we urge the NRC to conduct the necessary studies and assessments to determine unequivocally costs of decommissioning and to compare such costs to initial capital costs. It is only through a definitive analysis, and perhaps through realistic demonstrations, that this issue can be resolved.

EIS CATEGORY CODES

Environmental Impact of the Action

LO--Lack of Objections

EPA has no objection to the proposed action as described in the draft impact statement; or suggests only minor changes in the proposed action.

ER--Environmental Reservations

EPA has reservations concerning the environmental effects of certain aspects of the proposed action. EPA believes that further study of suggested alternatives or modifications is required and has asked the originating Federal agency to reassess these aspects.

EU--Environmentally Unsatisfactory

EPA believes that the proposed action is unsatisfactory because of its potentially harmful effect on the environment. Furthermore, the Agency believes that the potential safeguards which might be utilized may not adequately protect the environment from hazards arising from this action. The Agency recommends that alternatives to the action be analyzed further (including the possibility of no action at all).

Adequacy of the Impact Statement

Category 1--Adequate

The draft impact statement adequately sets forth the environmental impact of the proposed project or action as well as alternatives reasonably available to the project or action.

Category 2--Insufficient Information

EPA believes that the draft impact statement does not contain sufficient information to assess fully the environmental impact of the proposed project or action. However, from the information submitted, the Agency is able to make a preliminary determination of the impact on the environment. EPA has requested that the originator provide the information that was not included in the draft statement.

Category 3--Inadequate

EPA believes that the draft impact statement does not adequately assess the environmental impact of the proposed project or action, or that the statement inadequately analyzes reasonably available alternatives. The Agency has requested more information and analysis concerning the potential environmental hazards and has asked that substantial revision be made to the impact statement.

If a draft impact statement is assigned a Category 3, no rating will be made of the project or action, since a basis does not generally exist on which to make such a determination.

Marvin I. Lewis
6504 Bradford Terrace
Phila. PA 19149
3-6-79.

Director, Division of Site Safety Environmental Analysis
Office of nuclear Reactor Regulation
USNRC
Washington. /d.C. 20555

Sir:

NUREG 0490 does a lot of things , but it does not in any way justify the operation of the San Onofre Nuclear Generating Station.

Although the NUREG does provide a lot of good information, this information actually contradicts the usefulness of the SONGS, Sa n Onofre Nuclear Generating Station. For instance, the growth rate in Table 2.2 ,Page 2-2, is 3.5 % or less for the period 1976 to 1990. The growth rate in Table 8.3 and 8.4 on Pages ~~it~~ 8-4and 8-5 is close to 5% for the same period. Inotherwords , the growth rates in various parts of the report are 'selected ' to provide justification for whatever the writer wishes to fustify in any ~~XXXXX~~ partiiular part of the report. This technique is called 'fiction'.

In Appendix D-23 Page 2.5 Seismology is dismissed in a few paragraphs. Considering the recent and continuing ~~xix~~ seismic discoveries at the Hosgri fault at Diablo Canyon (which is in a similar -in fact same- gelological domain), passing off seismology this cavalierly ~~ix~~ is indefensible.

Page 5-37. First you state in a Table that the Commissioner has directed that Radon 222 will be reconsidered elsewhere; then, the Staff includes Radon 222 in this Nureg in a convoluted and artificial manner which does not in any way investigate or acknowledge Radon 222's full period of toxicity as required by NEPA.

Page 5-39 Tailings are not required to be stabilized forever, and even if it ~~xxxxx~~ were required , forever stabilization is a God like requirement which may be impossible to mortal men.

Chapter 7. This is based entirely on the Rasmussen Wash 1400 . Commissioner Kennedy has already stated on October 18, 1978, "It (Rasmussen Report) found some deficiendies which suggest that the absolute values of the risks presented in the Study should not be used uncritically either in the regulatory process or for public policy purposes."

The DES for operation of SONGS proves unequivocally that this nuclear power plant is unnecessary and dangerous. This is despite the Stall evaluation which ignores all important negative effects.

DO NOT LICENSE THIS NUCLEAR POWER PLANT TO OPERATE AT THE EXPENSE

OF HUMAN LIVES.

Marvin I. Lewis

Southern California Edison Company
P. O. BOX 800
2244 WALNUT GROVE AVENUE
ROSEMEAD, CALIFORNIA 91770

J. H. DRAKE
VICE PRESIDENT

TELEPHONE
213-572-2288

April 6, 1979

Director, Office of Nuclear Reactor Regulation
Attn: Wm. H. Regan, Jr., Chief
Environmental Projects Branch 2
Division of Site Safety and
Environmental Analysis
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Gentlemen:

Subject: San Onofre Nuclear Generating Station
Units 2 and 3
Docket Nos. 50-361 and 50-362

Mr. Oliver Lynch, Jr., of the NRC staff called on March 27, 1979, to request clarification of Applicants' Comment 6-4 to the Draft Environmental Statement for San Onofre Nuclear Generating Station, Units 2 and 3. Applicants' Comment 6-4 was submitted with other comments by letter to you dated February 2, 1979.

In response to Mr. Lynch's request, a revised Comment 6-4 is enclosed for your information. If you have additional comments regarding this comment, please contact me.

Sincerely,

Enclosure

C002 ES/1

7904240399

6.3.1 Water Quality Monitoring Program
Comment 6-4 (Revised April 6, 1979)
(Page 6-6)

The first five paragraphs of this section of the DES describe a proposed operational monitoring program which was presented in the ER-OLS (Section 6.2) and was based upon the proposed preoperational monitoring program also presented in the ER-OLS. The ER-OLS was developed in 1976 and submitted in 1977 to the NRC.

Since that time, the Preoperational Monitoring Program has been revised to incorporate the latest site specific study results and recent developments in marine ecological study techniques. The revised Preoperational Monitoring Program was approved by the NRC and implemented in 1978. It is the Applicant's intention to develop an operational monitoring program which incorporates results of the Preoperational Monitoring Program and submit it in the near future for approval. It was the intention of Comment 6-4 to indicate that the specific details of the operational monitoring program proposed in the ER-OLS in 1976 (and contained in the DES) should not be considered to represent the program which will actually be implemented. While the program which will ultimately be implemented will be similar to the one included in the ER-OLS, it will not be identical, and the differences between the two cannot be specified at this time because the development process is still underway.

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Attorney for Intervenors

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of SOUTHERN CALIFORNIA EDISON COMPANY, et al., (San Onofre Nuclear Generating Station, Units 2 and 3)	Docket Nos. 50-361 OL 50-362 OL COMMENTS ON DRAFT ENVIRONMENTAL STATEMENT - SAN ONOFRE NUCLEAR GENERATING STATION, UNITS 2 AND 3

We have carefully reviewed the above draft environmental statement in relation to the requirements imposed by Section 102(2)(c) of the National Environmental Policy Act (NEPA) and 10 CFR Part 51 of the NRC Regulations, and have set forth below intervenors' comments on the proposed action and on this draft statement pursuant to 10 CFR Part 51.25. Intervenors find this draft statement inadequate in a) the discussion and assessment of environmental effects, both beneficial and adverse, associated with the operation of the San Onofre Nuclear Generating Station, Units 2 and 3, and b) the discussion and consideration of available alternatives to the proposed action. Intervenors specifically identify the following deficiencies:

1. The evaluation of cooling water discharge impacts is

inaccurate and misleading. The heated water will very likely result in the destruction of at least a portion of the San Onofre kelp bed during the summer months, the long-term thermal impacts are likely to be severe, and violations of the state standards will occur. On page 5-7 of the DES it is stated: "The staff concludes that although there exists a remote possibility that state thermal standards could be violated by the operation of Units 2 and 3, violations would, at worst, be infrequent and for short periods. There is no evidence in available drift data to indicate that such an occurence would take place during the summer when thermal impacts would be most severe." This conclusion was apparently based on applicants' "worst case" modeling theory; however, in light of recent findings as a result of studies presently being performed by the Marine Review Committee (MRC) at the request of the California Coastal Commission, it has been determined that the state thermal standards will not be met. The following excerpts from the "Supplemental Staff Report And Recommendations - Review of Thermal Requirements For San Onofre Nuclear Generating Station, Units 2 and 3" prepared by the California State Water Quality Control Board staff are appropriate: "The Report of the MRC confirms the previous prediction that, under normal operating conditions, the proposed discharge will violate the 20 degree F temperature differential in the "receiving waters" i.e., waters at the location and depth of the diffusers of Units 2 and 3. This Report notes: '...if the "receiving" waters are defined as in this paragraph, the standards of the State Thermal Plan will probably be exceeded by the operation of Units 2 and 3.' Although the Report indicates that the discharge will "likely" or "probably"

or "may" violate the temperature differential, there really is no question that such violations will occur." (pp. 4-5)

In a hearing for the purpose of interpreting the term "receiving waters" held on December 21, 1978, the California State Water Quality Control Board held that "...the temperature at the intake point does not represent conditions at the receiving waters," (p. 3 of Opinion of Chairman Bryson and Board Member Mitchell) contrary to applicants' requested interpretation. The net result of this ruling is that the state thermal discharge limitation will be exceeded by operation of SONGS Units 2 and 3.

The DES states at p. 5-27 "The greatest threat of SONGS to the long-term survival of the San Onofre kelp bed is the possibility of injury to the basal tissues from which the canopy is regenerated each year...under extreme worst case conditions (e.g., several days with high ambient temperatures and slack currents, and with all the plants operating continuously), destruction of the basal regenerative tissues might result." The DES further states: "...the community (kelp bed), if destroyed frequently, could never achieve a stable state characteristic of other kelp beds in the area. Furthermore, constant temperature increases coupled with added turbidity would be inimical to interim reestablishment...The perennial occurrence of worst case conditions seems highly unlikely and the staff thus concludes that the long-term thermal impacts from normal station operation are not likely to be severe." (p . 5-27) It is clear that since the state thermal discharge limitation will be exceeded during normal operation of SONGS 2 and 3, the staff's conclusion was based on a faulty premise. Dischargers' normal plant operation will result

in continuous high temperature discharge approximating the worst case conditions and resulting in both short and long-term thermal impacts on the San Onofre kelp beds. The DES states at p. 5-27 "It has been rather well established that temperatures above 18-20 degrees C. (64-68 degrees F) cause deterioration of kelp, and the degree of degradation is directly related to the duration of the exposure to these temperatures."

2. The DES is inadequate in its discussion of the 316(a) exception process as related to thermal pollution caused by the proposed action. Section 6.4.1 of the DES discusses the "thermal exception studies" as related only to periodic "heat treatment" to control fouling organisms. The DES fails to consider the 316(a) exception required for continuous high ambient temperature discharges during the normal operations of Units 2 and 3. It is highly likely that a 316(a) exception request will be forthcoming from applicants in light of the recent denial by the California State Water Quality Control Board of applicants' requested interpretation of the term "receiving waters" as used in the State Thermal Plan. Had applicants' interpretation been approved, it would have obviated applicants' need for a 316(a) exception to the requirements of the FWPCA. Because a 316(a) exception is necessary for the operation of Units 2 and 3 in their present design mode, the DES is inadequate for failure to consider the implications, both short and long-term, on the aquatic environment if such an exception is granted. With respect to the maximum temperature of thermal waste discharges, and contrary to the requirements of 10 CFR Part 51.23(c), due consideration was not given to "...compliance of the facility construction or operation

and alternative construction and operation with environmental quality standards and requirements which have been imposed by Federal, State, regional, and local agencies having responsibility for environmental protection, including applicable zoning and landuse regulations and water pollution limitations or requirements promulgated or imposed pursuant to the Federal Water Pollution Control Act."

3. The DES is inadequate in its evaluation and analysis of the social and economic impact of operating SONGS 2 and 3.

A. With respect to the environmental impact of SONGS on recreational resources, the DES recognizes the failure of applicants to comply with the terms and conditions of the construction permit: "The current plan to restrict the use of approximately 25% of the 3 1/2 mile San Onofre Beach for the 30-year operating life of the plant is a significant loss of valuable recreational and scenic space and represents a substantial change in action between issuance of the FES-CP and application for an operating license." (Section 5.6.5) Staff reiterates previous statements made in the FES-CP that "the beach...is considered to be a unique and scarce recreational resource," (FES-CP, p. 2-11) and "that closure even for a brief period is objectionable" (FES-CP, p. 8-11). Despite the re-affirmation of these judgments, staff concludes that the social and economic impact of operating SONGS 2 and 3 - with the significant exception of restricting public use of the beach - will be only "moderate". The overall impact will be more severe than "moderate" if the beach access restriction is factored into the balancing process. Staff's treatment of this issue is misleading and inconsistent

with the purpose and intent of NEPA, section 102(2)(c), which calls for preparation of a detailed statement on, among other things, any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented. Restriction of the public's use of this beach is such an irreversible and irretrievable commitment of resources.

B. With respect to the economic impact of SONGS 2 and 3, the DES provides no analysis of the effects of the Jarvis-Gann Amendment (Proposition 13). The DES states that "The applicant should reassess the potential tax benefits accruing to these jurisdictions and districts in light of Proposition 13." (p . 5-44) This is a wholly inadequate treatment of the economic impact of SONGS 2 and 3, inasmuch as the revenue from the plant and its allocation within communities will be "significantly different from what was assumed" - to use the staff's own words - in this economic impact analysis. (p . 5-44, section 5.6.4)

4. The DES inadequately evaluates the environmental impact of postulated accidents in that Class 9 occurrences were omitted from consideration. (Section 7-1) The DES states on p. 7-2 with respect to Class 9 occurrences that "Their consequences could be severe." The DES fails to discuss the probability of Class 9 occurrences in a complete and comprehensive manner. In view of the recent earthquake fault discoveries near the San Onofre site and the existence of the dewatering-well cavities found beneath the site, a full discussion of failures more severe than those required for consideration in the design bases of protective systems and engineered safety features (Class 9) is warranted. Further, the estimated dose of 1400.00 man-rems to population in

the 50-mile radius for a large-break loss of coolant accident (Table 7.2, p. 7-3, Class 8.1) is substantial and inadequately discussed, if at all, in the text.

5. The DES is inadequate in that it fails to discuss the environmental impacts to the region in the event of an accidental release of radiation requiring evacuation. No discussion is contained in the DES as to the adaptability of the San Onofre site to adequate evacuation processes including evacuation of the nearby beach areas during times of peak use; no discussion is contained in the DES as to the suitability of existing evacuation plans; no discussion is contained in the DES as to the effects which adoption of the NRC/EPA Task Force Report on Emergency Planning (NUREG-0396) will have on evacuation within the new and expanded Emergency Planning Zone as distinct from the presently designated Low Population Zone (NRC Regulations 10 CFR Part 100).

6. The DES is inadequate in that it fails to reassess the seismic design basis for SONGS 2 and 3 in light of a) the dewatering-well cavities and b) the recent earthquakes and faults discovered since the current design basis was established.

7. The DES is inadequate in that the cost/benefit analysis fails to provide consideration for the greatest possible escalation of uranium prices, based on recent occurrences, for SONGS 2 and 3 over the operating life of the plant. The projected fuel costs identified as $87,900,000/yr for 1981 (Table 10.1, p. 10-2), will possibly escalate to a prohibitively high level since long-term uranium contracts are generally tied to market price at delivery or 7$ per year escalation, whichever is greater Staff admits (section 10.3) that since the issuance of the FES-CP

the fuel, operating, and maintenance costs of nuclear plant operation have escalated more rapidly than anticipated. The DES does not discuss adequately the possibility of additional future escalation of costs with respect to the fuel requirements of San Onofre, and does not utilize a "worst possible case" approach to determine total fuel costs over the operating life of the plant. The cost/benefit analysis contained in the DES is therefore invalid.

8. The DES is inadequate in that it fails to discuss the possibility that decommissioning costs may escalate to prohibitively high levels by the end of the operating life of the plant, at which time the applicant is required to prepare a proposed decommissioning plan for review by the NRC. (Section 9.4) Although NRC regulations do not require the applicant to have developed a decommissioning plan at the time an operating license is obtained, the discussion of alternative decommissioning methods and their associated costs found in the DES is misleading and does not present an accurate projection of what the actual decommissioning costs for SONGS will be. Staff calculations for determining decommissioning costs per unit of electricity generated do not utilize a start-up date of 1981 or an escalation rate based on the current rate of inflation. Staff's projection that "For the SONGS Units 2 and 3 the decommissioning costs would be about double that indicated for all of the decommissioning one-unit alternatives" (p. 9-17) is wholly inadequate for purposes of making an informed cost/benefit judgment. As a consequence, the cost/benefit analysis for SONGS 2 and 3 is invalid.

9. The DES is inadequate in that it fails to comprehensively

discuss the temporary storage of nuclear waste materials, including the interim storage of spent fuel, on site.

10. The DES is inadequate in that it fails to discuss the issue of plant security and provide assurances that all nuclear materials will remain accounted for and protected from the risk of terrorist or criminal activity or sabotage.

Because due consideration was not given to compliance with the requirements of 10 CFR Part 51.23(c), and because this DES fails to consider all environmental impacts of the proposed action and alternatives to the proposed action as required by Section 102(2)(c) of NEPA, staff's conclusion that the action called for is the issuance of operating licenses for Units 2 and 3 of SONGS is premature and founded on insufficient and inaccurate data.

For the foregoing reasons, intervenors request that the NRC either a) adequately address the issues raised above in the final environmental statement for SONGS 2 and 3, or b) deny applicants' request for licenses to operate SONGS 2 and 3.

Dated: Jan 30, 1979 Respectfully submitted,

Richard J. Wharton
RICHARD J. WHARTON
Attorney for Intervenors

COMMENTS ON SUPPLEMENT TO DRAFT ENVIRONMENTAL STATEMENT

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FEDERAL ENERGY REGULATORY COMMISSION

WASHINGTON 20426

IN REPLY REFER TO:

January 23, 1981

Mr. Frank J. Miraglia
Acting Chief, Licesning Branch
No. 3
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Miraglia:

I am replying to your request of January 16, 1981 to the Federal Energy Regulatory Commission for comments on the Supplement to the Draft Environmental Impact Statement related to the operation of the San Onofre Nuclear Generating Station, Units 2 and 3. This Draft EIS has been reviewed by appropriate FERC staff components upon whose evaluation this response is based.

This staff concentrates its review of other agencies' environmental impact statements basically on those areas of the electric power, natural gas, and oil pipeline industries for which the Commission has jurisdiction by law, or where staff has special expertise in evaluating environmental impacts involed with the proposed action. It does not appear that there would be any significant impacts in these areas of concern nor serious conflicts with this agency's responsibilities should this action be undertaken.

Thank you for the opportunity to review this statement.

Sincerely,

Jack M. Heinemann
Advisor on Environmental Quality

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810???408

United States Department of Agriculture
Economics and Statistics Service
Washington, D.C. 20250

January 26, 1981

Mr. Frank J. Miraglia
Acting Chief, Licensing Branch No. 3
Division of Licensing
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Miraglia:

Thank you for forwarding the Supplement to the Draft Environmental Statement for the San Onofre Nuclear Generating Station, Units 2 and 3.

We have reviewed the material, Docket Numbers 50-361 and 50-362, and have no comments at this time.

Sincerely,

MELVIN L. COTNER
Director, Natural Resource
Economics Division

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810202041A

Oceanside, California
January 6, 1981

Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Gentlemen:

I wish to comment on the environmental impact report your organization supplied on the installation and licensing of the nuclear installations at San Onofre which are practically in our back yards:

1.- From what I read in the Oceanside Blade-Tribune no mention was made re. the extreme hazards and the potential of submarines from an enemy action shelling these huge nuclear concrete domes, shattering them thereby releasing that deadly nuclear radiation which could wipe out this entire area. We think this is a tremendous oversight and needs to be studied along with earthquake consideration;

1a.- A remedy in the area of earthquakes and war-time action would be to pipe some of that 100 trillion cubic feet of natural gas that CBS's "60 Minutes" said exists under the U.S. continent. (President Reagan's own people admit to this). And fire the San Onofre steam boilers with this gas and eliminate all of the dangers on which you debate. I pray to God that you consider this alternative and act upon it. People's lives and health are more important than corporate profit.

2.- We believe that due to the fact that SD G&E will control only 20% of the nuclear output and Southern California Edison will control 80% and by grid move all of this 80% of this generated power to areas that are not threatened by radiation that there should be (if these plants are activated) from 60% to 30% rate discounts for people who live close to this operation. This proposal is now before the Calif. Public Utilities Commission. If you license these plants we would appreciate your recommendation to the PUC. France and Japan presently are allowing this type of discount due to the hazards of nuclear energy. So the proposal does have precedent. 8102110284

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Office of Nuclear Reactor Regulation (2) February 6, 1981

3.- To be complete and legally valid we believe that all elements relating to the subject need to be included in the EIR. Apparently the subject of potential enemy action on these nuclear plants was not included and it needs to be discussed.

In closing may I request an answer to the positions expressed in this letter. I will be extremely grateful. I remain

Very sincerely

Frank H. Grundel
1888 Blackhawk St
Oceanside, Calif 92054

Perspective

TIMES-ADVOCATE

SUNDAY, JANUARY 25, 1981 C-1

C-4 TIMES-ADVOCATE, ESCONDIDO, CA., SUNDAY, JAN. 25, 1981

Nuclear neighbor asks for discount

By DICK PHILLIPS
T-A Staff Writer

OCEANSIDE — An Oceanside man is working to achieve a considerable reduction in utility rates for those living near the San Onofre nuclear power plant.

Frank Arundel, 1888 Blackhawk St., proposed the compensation for those residents he thinks live in a danger zone — near San Onofre. He thinks they should get a 60 percent discount in electrical rates.

Residents within 30 miles should receive 50 percent rate reduction, he says, and those within a 30- to 40-mile radius a 40 percent rate reduction; people living in a 40- to 50-mile radius should have their rates cut by 30 percent.'

"People here are being gouged to death by utility rates," said Arundel, 73. "With this plan, the next time they build a nuclear plant, they'll put it out of the umbrella of people where it wouldn't be troublesome in case of earthquake or war. They wouldn't put these plants at our backdoor.

"If we have to live here and bear the brunt of nuclear power, we should be beneficiaries of cheap electricity, particularly if 60 percent of the energy produced there will be transmitted outside this area anyway."

Arundel's plan did not impress the Public Utilities Commission, which has indicated there is little chance of seeing the policy implemented statewide.

The "chances of this plan flying are slim" because it would be discriminatory ratemaking, one PUC spokesman said.

San Onofre, 19 miles north of Oceanside, has one operating nuclear plant, which was shut down for repairs through most of 1980. Units 2 and 3 are nearing completion, at a cost of $2.3 to $5 billion. Both are designed to produce 1,100 megawatts of electricity.

Southern California Edison, based in Los Angeles, holds 80 percent interest in the nuclear plant and SDG&E has 20 percent. The SDG&E service area consumes about 2,300 megawatts of electricity.

Martin Mattes, legal adviser to John Bryson, PUC chairman, said copies of Arundel's proposal have been given to the commissioners for study. "But, I don't know of any action planned on the subject," Mattes said.

He said the commission reaches decisions in three ways. Under one, a consumer may apply for a rate change. "This is one way Arundel could intervene and advocate his proposal," Mattes said.

"Or, he could file a complaint against a utility for discriminatory rates, for example. But, the burden of proof is upon the complainant and it's difficult to win a case this way," Mattes said.

The commission can also initiate an investigation into an area of interest. "It's possible the PUC may decide to pursue this and investigate," Mattes said.

In his reply to Arundel, Mattes said he discussed several problems with the discounted rate plan. "If the PUC adopts rate discounts based on unfavorable aspects of having a utility company in the neighborhood, people will make other demands based on similar situations," the adviser said.

For example, those living near an operating fossil fuel plant suffer because of pollution, he said. Transmission lines may be another unfavorable aspect. "The commission is already faced with substantial complications in ratemaking procedures," Mattes said.

Arundel disagrees: "If we're going to put up billions of dollars for these plants and they're going ahead and build them anyway, we should be the beneficiaries." He said 220,000 area residents would fall under the discount plan

Frank Arundel: 'We bear the brunt'

United States Department of Agriculture

Soil Conservation Service

2828 Chiles Road
Davis, CA 95616
(916) 758-2200

February 11, 1981

Mr. Frank J. Miraglia
Acting Chief, Licensing Branch No. 3
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Miraglia:

The Soil Conservation Service has reviewed the Supplement to the Draft Environmental Statement for San Onofre Nuclear Generating Station, Units 2 and 3. We find no controversial items within the realm of SCS responsibilities.

This Environmental Statement Supplement reveals no conflicts with any of the ongoing projects within our jurisdiction. No prime land will be lost to the proposed project.

We appreciate the opportunity to review and comment on this report.

Sincerely,

FRANCIS C. H. LUM
State Conservationist

cc: Norman A. Berg, Chief, SCS, Washington, D.C.
Jack Smith, Area Conservationist, Escondido, CA

8102180359

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

ER 81/80

MAR 2 1981

Mr. Frank J. Miraglia
Acting Chief
Licensing Branch No. 3
Division of Licensing
Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Miraglia:

We have reviewed the supplement to the draft environmental statement for San Onofre Nuclear Generating Station, Units 2 and 3, San Diego, California, and find we have no comments. The opportunity to review this document is appreciated.

Sincerely,

CECIL S. HOFFMANN
Special Assistant to
Assistant SECRETARY

A-55

RICHARD J. WHARTON
Attorney at Law
University of San Diego
Alcala Park, California 92110

(714) 291-6480 Ext. 4376

Attorney for Intervenors

RECEIVED MAR 12 1981 U.S. NUCLEAR REGULATORY COMMISSION

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of SOUTHERN CALIFORNIA EDISON COMPANY, et al. (San Onofre Nuclear Generating Station, Units 2 and 3)	DOCKET Nos. 50-361 OL 50-362 OL JOINT INTERVENORS COMMENTS ON SUPPLEMEN TO DRAFT ENVIRONMENTAL STATEMENT RELATE TO OPERATION OF SAN ONOFRE NUCLEAR GENERATING STATIONS, UNITS 2 and 3 (NUREG-0490)

The Supplement to Draft Environmental Statement (NUREG-0490, December, 1980), hereinafter referred to as NUREG-0490, prepared by the Office of Reactor Regulation (Staff) of the United States Nuclear Regulatory Commission (NRC) related to the operation of San Onofre Nuclear Generating Station, Units 2 and 3 (SONGS 2 and 3) has been reviewed by Intervenors in relation to the requirements imposed by the National Environmental Policy Act (NEPA) (42 U.S.C. § 4321, et seq.), 10 C.F.R. Part 51, and 40 C.F.R. Part 1502. Intervenors comments on the proposed action and on NUREG-0490 are made pursuant to 10 C.F.R. Part 51.25 and 40 C.F.R. Part 1503.

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The purpose of NUREG-0490 was "to identify and evaluate the site-specific environmental impacts attributable to accident sequences that lead to releases of radiation and/or radioactive materials including sequences that can result in inadequate cooling of reactor fuel and to melting of the reactor core." NUREG-0490, p. vi. These accident sequences are commonly referred to as meltdowns or Class 9 accidents.

The NRC's historic first site-specific impact study of a meltdown accident at a California nuclear reaction is inadequate, incomplete and misleading. NUREG-0490 is misleading because it does not provide decision-makers with sufficiently detailed information regarding the potential environmental impacts of a meltdown at SONGS 2 and 3 to aid them in a substantive decision whether or not to proceed with granting an operating license to this federal nuclear project in light of the economic and other consequences of an accident at SONGS 2 and 3. NUREG-0490 does not encourage public participation because it does not make adequate information available to the public in non-technical language about the potential economic and environmental impacts that could affect the lives of twelve million people. NUREG-0490 appears inadequate and incomplete when compared with other independent meltdown impact analyses.

After the Three Mile Island accident, which resulted in mass evacuations and temporary relocation of many people, the California State Legislature passed a law (Senate Bill 1183, now Section 8610.5 of the Government Code), which required the State

Office of Emergency Services (OES) to prepare Emergency Response Plans for potentially severe nuclear accidents involving the release of large amounts of radiation. In order to plan for such accidents, the State required information of the potential scenarios and consequences that could result from meltdowns in California reactors. The State lead agency, OES, contracted with a conservative consulting group, Science Applications, Inc. (SAI), to study the consequences and potential scenarios of meltdowns at California reactors. SAI has conducted research for the NRC, the Department of Energy, nuclear military projects, nuclear utilities, and the nuclear industry. The SAI-OES study was released to the public in Sacramento, California on July 15, 1980. The portion of the SAI-OES study which relates to SONGS 2 and 3 was based on extensive site-specific data whereas NUREG-0490, while it purports to be based on site-specific data, considers mainly excerpted "data, methodology and assumptions" from the WASH-1400 study. The inadequacies of this approach are demonstrated by the following comparison between the SAI-OES study and NUREG-0490 consequence analyses:

The SAI-OES study indicates that the maximum consequences for a nuclear meltdown at SONGS 2 and 3 would be $180 billion in economic cost consequences, NUREG-0490 estimates $35 billion; SAI-OES estimates 16,000 square miles of land contaminated with radiation, NUREG-0490 estimates 3,000 square miles; SAI-OES estimates eight to ten million Southern Californians would be required to relocate and leave their homes and property for up to ten years. Four to five million of them would have to be relocated longer than ten

years, NUREG-0490 gives no estimates for the magnitude of the population affected by relocation. SAI-OES estimates that in 1975 there were 7.7 million people living within 60 miles of the San Onofre site. Within 100 miles there are approximately 12 million people. The SAI-OES study acknowledges that "Latent deaths from San Onofre can occur within 100 miles, which includes half of the population of California." Another report done for the California State Legislature, discussed below, warns that children within 100 miles downwind from the reactor would receive damage to their thyroid glands and would require surgery due to exposure to radioactive iodine gases. The SAI-OES study also estimates that $6.6 billion in cost consequences could occur within 500 miles of San Onofre following a meltdown. Reports to the President's Council on Environmental Quality warn that areas as far away as 1,000 miles or more could be affected, and that up to 125,000 square miles of land could suffer some contamination or crop or milk interdiction. The possibility exists that Southern California could be permanently contaminated after a meltdown at SONGS 2 and 3. This is not surprising when we look at other accident scenarios and compare their estimates.

One NRC analysis of reactor accidents, WASH-740, estimated that an area the size of Pennsylvania could be permanently contaminated by a meltdown at a reactor significantly smaller than either Unit 2 or 3 at San Onofre. Another report, the Rasmussen report, WASH-1400, estimated that 3,000 square miles of land would be contaminated, but assumed that effective

evacuations would take place out to 30 miles downwind from the reactor accident. NUREG-0490, estimates the maximum consequences of a San Onofre meltdown to be $35 billion in costs for mitigating actions (evacuations, relocations, land interdiction, emergency response by local, county, state and federal teams), 1 million people would receive more than 25 rems, there would be 130,000 acute fatalities, and 300,000 latent cancers in the population within 50 miles who would be exposed to 30 to 40 billion person rems released during the accident.

The consequences of nuclear power plant core melt accidents have also been estimated at the request of the California State Legislature and the President's Council on Environmental Quality by Dr. Jan Beyea and Dr. Frank von Hippel, nuclear physicists with the Princeton University's Program on Nuclear Policy Alternatives of the Center for Energy and Environmental Studies. Dr. Beyea noted in his analysis that a meltdown with a release of radioactive gases from a large reactor could involve "health effects and possible land use restrictions have been considered out to distances of 1,000 miles and for periods of decades after the release." He estimates that up to 175,000 square miles of land could be under some form of interdiction or restricted use following the meltdown. He explains this by saying "The number of health effects and the . . . land contamination can range so high because a substantial fraction of the released radioactivity can be carried for hundreds of miles downwind

before being removed from the atmosphere by deposition on the ground. Dr. Beyea told the President's Council on Environmental Quality (CEQ) that "early fatalities could occur up to 30 miles downwind" of a reactor meltdown. Dr. Frank von Hippel testified before the California State Legislature after Three Mile Island that "the thyroid could receive a radiation dose tens to hundreds of times higher than the rest of the body. Exposed children more than a hundred miles downwind would suffer thyroid damage which would require surgery years later." (emphasis added) NUREG-0490 did not reference the SAI-OES study, in spite of the fact that the Atomic Safety and Licensing Board (ASLB) and the NRC Staff were made aware of the report by Intervenors during July and August of 1980, six months before NUREG-0490 was issued.

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The SAI-OES study is a conservative report in that it calculates its predictions and models based on site-specific data. NUREG-0490 is not conservative and is inadequate because it is not sufficiently based on site-specific data. The SAI-OES report used extensive site-specific data regarding the nearby population centers and the various weather conditions in Southern California. That report identified several site-specific unique features which should have warranted a different conclusion from the NRC Staff than "there are no special or unique features about the San Onofre site and environs that would warrant special or additional engineered safety features for the San Onofre plants." Joint Intervenors conclude there are special and unique features that exist at the San Onofre site which are listed as follows:

(1) The three reactors at San Onofre are uniquely located near the intersection of two major Fault Zones, the Cristianitos and the Newport-Inglewood. Prior to 1980, the NRC believed there was no structural relationship between the two Fault Zones. However, in 1980, federal and state marine geologists discovered a new zone of faults which they named "Cristianitos Zone of Deformation" which project directly beneath the three reactors. Thus, the possibility of damage to the reactors during earthquakes is higher now because of the possibility of surface rupture directly under the reactors. This was not factored into the Rasmussen Report, WASH-1400, the Lewis Report, SAI-OES or NUREG-0490. NUREG-0490 does not even mention geologic-seismic site-specific events as a significantly possible factor in the probabilistic risk assessment.

(2) The San Onofre site is uniquely located on the Pacific plate, near the Plate Tectonic Boundary Fault, the San Andreas. San Onofre is moving north in relation to the North American Plate. These reactors are uniquely migrating north on a geologic time scale. Plate Tectonics were not understood when the San Onofre site was originally chosen in 1962. It was not until 1969 that the plate tectonics theories were accepted.

(3) The San Onofre site has the unique feature of being sited close to San Onofre Unit 1. If Unit 1 had a meltdown, it would severly affect operations of Units 2 and 3, resulting in various consequences, none of which were considered in NUREG-0490. The older reactor at the site, San Onofre Unit 1,

was identified by the SAI-OES analysis as having the highest probability of a meltdown of any reactor in California for two primary reasons. "The first reason is that the Unit One auxiliary feedwater system depends on operators to align and initiate the system. Potential failures due to human factors make the system less reliable than automated systems. The second reason relates the long term recirculation mode of emergency core coolant, which requires at least one of two pumps located in the containment. In the event of a pump failure, repairs cannot be made because the pump is inside the containment and would be isolated during an accident." NUREG-0490 does not consider the proximity of SONGS 2 and 3 to Unit 1 to be a unique or special feature.

(4) San Onofre Unit 1 has been shutdown for approximately one year due to leaky corroded steam generator tubes. The NRC issued a report in 1976 (NUREG-0900-5, Report to Congress on Abnormal Occurrences) which explained that "The failure of a number of steam generator tubes as a result of the pressure transients during a loss of coolant accident could render the emergency core cooling system ineffective." The Unit 1 was not designed for the magnitude of ground motions that Units 2 and 3 were. An earthquake could conceivably only damage Unit 1, because of its structurally weak steam generator tubes, but that could result in a LOCA (loss of coolant accident) and a meltdown, which would affect the two other reactors and the environment.

(5) The San Onofre reactors are special and unique in that the reactor core of Unit 2 was installed backwards, necessi-

tating total rewiring of the control room and other systems.

(6) The San Onofre site is unique also in that San Onofre Unit 2 was constructed above earthquake faults that were not discovered until 1974 during construction excavations.

(7) SONGS 2 and 3 are underlain by dewatering cavities that developed during construction. Intervenors believe this also is a special of unique feature at SONGS 2 and 3 which must be considered.

(8) The Southern California region, including San Onofre, frequently has weather inversions. During these inversions, air pollutants, including accidentally leaked radioactive gases, can be trapped beneath the inversion layer, where they can only mix and travel horizontally. Thus, a meltdown at SONGS 2 and 3 could affect the nine to ten million people who live in the air basins that share the same East Pacific high pressure zone inversion layers. Although NUREG-0490 admits that "accident consequences are very much dependent on the weather conditions existing at the time . . ." they do not specifically consider the unique Southern California high pressure inversion layers which are a predominant characteristic of the San Onofre site.

(9) The San Onofre reactors are uniquely located on a Southern California beach state park that stretches for many miles, but which is inaccessible and inescapable except by driving past the reactors on the old-highway, now running parallel to Interstate-5. On a typical summer day, 25,000 persons drive close to the reactors on a narrow and curving road. These beach-goers could be trapped during a meltdown, especially if

an earthquake occurred at the same time or caused it.

(10) Another unique or special feature of San Onofre is its proximity to roads used by thousands of uncontrolled travelers per day which presents a unique possibility for sabotage accidents that could lead to releases of radioactivity.

(11) The San Onofre site is special and unique in that one-half of the population of the State of California lives within 100 miles of the site.

(12) It is a unique feature of SONGS 2 and 3 to be the largest reactors ever considered for operating licenses.

(13) The San Onofre site is unique in that it is sited within contamination distance of a major portion of the nation's fresh produce farms, especially in the winter months.

(14) The San Onofre site is also unique in that it could cause international economic and environmental impacts by contamination of a significant part of Baja California's agricultural resources.

After the Kemeney Commission and the Rogovin Report were issued on Three Mile Island, the Council on Environmental Quality wrote a letter to the Nuclear Regulatory Commissioners on March 20, 1980. The letter released the results of the CEQ review and critized the NRC's lack of compliance with NEPA laws in the EIS analyses of potential accidents at reactors. The CEQ stated that the NRC's EIS discussions of "potential accidents and their environmental impacts was found to be largely perfunctory, remarkably standardized, and uninformative to the public." The CEQ also advised the NRC that "site specific treatment of data

should be substituted for "'boilerplate' assessment of accident initiating events and potential impacts, and EIS's should be comprehensible to non-technical members of the public..." Intervenors comment upon the fact that NUREG-0490 contains 29 pages of text with about 8 pages of site-specific information which is selective and slanted. NEPA requires detailed statements of aspects of proposed action significantly affecting the quality of the human environment and Intervenors feel NUREG-0490 is inadequate in that it is"largely perfunctory, remarkably standardized and uninformative to the public."

NUREG-0490 is also inadequate in that it failed to consider earthquake induced core melt accidents. While the Reactor Safety Study(RSS), WASH-1400, concluded that the probability of core melt accidents in nuclear power plants from seismic events was insignificant compared to core melt probabilities from other accidents, recent assessment of the potential for earthquake induced core melt accidents suggests that the probability of such events may be significant when compared to core melt accidents from other causes considered by RSS. Intervenors contend that the seismic design basis for SONGS 2 and 3 is inadequate and, therefore, consider it prudent to evaulate the potential for seismic-induced core melt accidents at SONGS 2 and 3 to establish if they may be significant factors. The purpose of NUREG-0490 was to identify and evaluate site-specific environmental impacts. It does not evaulate the potential for seismic-induced core melt accidents and, therefore its probabilistic assessment of risk at SONGS 2 and 3 is inadequate.

NUREG-0490 is further inadequate and particularly misleading in its assessment of health affects avoidance (Section 7.1.1.4). NUREG-0490 did not mention thyroid blocking in its assessment of health affects avoidance, relying only on restriction of contaminated property and foodstuffs. Dr. Frank von Hipple in his testimony before the California State Legislature states:

> The thyroid can be protected against absorbing radioiodine, however, if before the cloud arrives you take about one thousand times your ordinary daily iodine intake in the form of potassium iodide (the form of iodine present in iodized salt). This will saturate the thyroid with ordinary iodide and reduce its ability to absord the radioactive iodide when it arrives. This strategy was recommended in the American Physical Society's reactor safety study four years ago. The Food and Drug Administration approved potassium iodide for emergency thyroid 'blocking'. . . I would recommend that California do two things with regard to this thyroid protection strategy:
>
> 1) Develop a stockpile of potassium iodide in the appropriate dosage in either sealed foil wrapped pills or liquid solution. This would not be costly. Based on a 1972 study for the Defense Civil Preparedness Study, it appears that enough pills for the entire nation could be produced for a few million dollars.
>
> 2) The more difficult part of the job would be to develop an effective distribution system. If one waited until a cloud of radioiodine had been released before distributing the blocking chemical and informing the public of its use, one might well be too late. (A week after the beginning of the crisis at Three Mile Island, the Pennsylvania state government refused to distribute the chemical to the population within 10 miles of the site - despite the joint recommendation to do so from the Surgeon General, the Food and Drug Commissioner, and the Director of the National Institutes of Health who thought that sufficient warning time might not be available to protect this population in case a release occurred. On the other hand, if people were given potassium iodide to keep in their medicine cabinets along with asprin, it is likely that many would lose track of it pretty quickly. Perhaps it should be attached by the local utility to household electricity meters and its presence announced in case of need. The best strategy is obviously a problem well worth a study. California could break some important ground here."

Section 7.1.1.4. is particularly misleading in its statement that "radiation hazards in the environment tend to disappear by the natural process of radioactive decay (but) can continue for a relatively long period of time -- months, years or <u>even decades</u>." (emphasis added) This misleading statement fails to note that some ratioactive wastes from nuclear accidents such as radioactive Strontium and Cesium can enter the food chain and remain a hazard for 1,000 years or more. Other isotopes remain a hazard for 1 million years or more.

NUREG-0490, Section 7.1.3. entitled Mitigation of Accident Consequences is inadequate in that it fails to note that consequences could be reduced by retrofitting SONGS 2 and 3 with filtered venting systems to prevent accidental releases of radioactive gases.

NUREG-0490, Section 10 is misleading, inadequate and incomplete. The Section contains three sentences with regard to its conclusions and Re-Evaluated Benefit-Cost Balance. This section should be expanded because the environmental risks of a Class 9 accident involve the entire region of Southern California, Norther Baja California, Mexico, and parts of Arizona. These regions could be permanently contaminated with radiation following a coremelt at SONGS 2 and 3. The risks involve the

value of all real and personal property, both public and private in those regions. The risks involve fatalities, latent cancer deaths and genetic damage. The risks involve compensation to victims in the event of such accidents. Section 10 of NUREG-0490 concludes that the environmental risks of Class 9 - coremelt accidents - "does not change the results of the cost-benefit balance contained in the Draft Environmental Statement (Section 10)."

CONCLUSION

NUREG-0490 concludes "that there are no special or unique features about the San Onofre site and environs that would warrant special or additional engineered safety features for the San Onofre plants." Intervenors conclude there are unique characteristics at SONGS 2 and 3 that warrant additional engineered safety features especially in light of the unique earthquake hazard which could cause a coremelt accident and common-cause failure of essential safety systems at SONGS 2 and 3. A future earthquake near the San Onofre site could be the common cause for failure of the cooling systems of all three reactors on the San Onofre site and all three of the spent fuel pools simultaneously. This would be the worst case accident that should be analyzed by the NRC and this analysis should be a part of a revised NUREG-0490.

CERTIFICATE OF SERVICE

I hereby certify that the JOINT INTERVENORS COMMENTS ON SUPPLEMENT TO DRAFT ENVIRONMENTAL STATEMENT RELATED TO OPERATION OF SAN ONOFRE NUCLEAR GENERATING STATIONS, UNITS 2 AND 3 (NUREG-0490) have been served on the following by deposit in the United States mail, first class, postage prepaid, this 9th day of March, 1981:

Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D. C. 20555

Attention: Director, Division of Licensing

Executed on March 9, 1981 at San Diego, California.

DARITY WESLEY

Union of
CONCERNED
SCIENTISTS

9 March 1981

Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Attention: Director, Division of Licensing

Dear People:

Re: Supplement to the Draft Environmental Statement (NUREG-0490) related to the operation of San Onofre Nuclear Generating Station, Units 2 and 3

Herewith are some brief comments on the above Supplement, in response to your invitation.

We are pleased that the NRC has finally published a document providing a hint of the consequences of severe accidents at the San Onofre Station. We consider, however, that this Supplement does not satisfy the intent of the Commission's Statement of Interim Policy of 13 June 1980 (Federal Register, 45, 40101). Nor does this Supplement provide the public with information sufficient to make a reasoned assessment of the risks of severe accidents at this plant.

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You will recall that the Commission's Statement of Interim Policy followed a letter of 20 March 1980 from the Chairman of the Council on Environmental Quality (CEQ) to the Chairman of the NRC. Included in this letter was the statement:

> "The results of our review of impact statements prepared by the NRC for nuclear power reactors are very disturbing. The discussion in these statements of potential accidents and their environmental impacts was found to be largely perfunctory, remarkably standardized, and uninformative to the public."

This Supplement must be substantially revised and improved before it overcomes these CEQ criticisms. For guidance during this process of revision and improvement, the NRC staff should consult the report "NRC's Environmental Analysis of Nuclear Accidents: Is It Adequate?", prepared for CEQ by the Environmental Law Institute (ELI) in February 1980. A copy of this

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report was provided to the NRC with the CEQ Chairman's letter.

Part 5 of the ELI report recommends that the NRC should continue, with some substantial improvements, its previous practice of studying a selection of accident scenarios. The ELI report recommends that this selection should be expanded to include "Class 9" accidents. Section 7 (Environmental Impact of Postulated Accidents) of the San Onofre Draft Environmental Statement (dated November 1978) exemplifies this previous practice; it estimates radiation doses for a number of selected accidents in Classes 1 through 8. This Supplement, however, merges nine release categories, weighted by assumed probabilities. The results of this analysis are confusing for the public; one might suspect that this is by intention.

Each accident scenario should be considered alone. For each scenario, the NRC should provide a clear account of:

(i) the nature of the postulated accident

(ii) the estimated nature of the radioactive release

(iii) the estimated nature of the environmental consequences of that release.

The Commission's Statement of Interim Policy directs:

> " . . . approximately equal attention shall be given to the probability of occurrence of releases and to the probability of occurrence of the environmental consequences of those releases."

This Supplement does not satisfy the intent of that directive. It merges these two probabilities although they are of quite different natures. One might suspect that this approach is selected in order to persuade the public that severe consequences have extremely low probabilities. This form of analysis and presentation does not fulfill the NRC's obligation to accurately inform the public.

As the NRC staff should well know, probabilities in nuclear accident analysis fall into two distinct categories:

(i) probability of occurrence of release
This category of probability concerns engineering estimates. These are very difficult to make since there is a limited statistical base and much of the uncertainty relates to human behaviour.

Office of Nuclear Reactor Regulation
9 March 1981
Page 3.

(ii) <u>probability of occurrence of environmental consequences, given a particular release</u>
This category of probability concerns factors such as wind speed and direction. These factors can be estimated from a good statistical base.

The NRC staff should revise this Supplement so as to exhibit their estimates of these probabilities separately, within each accident scenario studied.

The Commission's Statement of Interim Policy also directs:

> " . . . consequences shall be characterized in terms of potential radiological exposures to individuals, to population groups, and, where applicable, to biota."

This Supplement does not fulfill the intent of that directive. It provides very limited information on the geographical variation of potential exposure. More seriously, it provides essentially no information on the significance of exposure for different population groups. As the NRC staff should well know, certain population groups (especially children and fetuses) are at greater risk for a given release.

The importance of revising this Supplement, so as to accurately inform the public, can be illustrated by two estimates which can be gleaned from the supplement itself:

(i) <u>probability of occurrence of the "PWR2" core melt accident</u>
This release is one of the most severe accidents considered in the Reactor Safety Study (WASH-1400) and this Supplement. Table 7.1.4-2 of the Supplement estimates its probability as 7×10^{-6} per reactor-year. Section 7.1.4.2 concedes that this estimate could be low by a factor of 100. One thus finds (assuming a reactor life of 30 years) that this Supplement admits that a "PWR2" accident could have a 4% probability of occurrence during the life of San Onofre Units 2 and 3.

(ii) <u>potential for serious health effects</u>
Table 7.1.4-4 of this Supplement admits that a severe accident at San Onofre could lead to 130,000 acute fatalities, 300,000 subsequent fatal cancers, and 600,000 genetic effects.

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9 March 1981
Page 4.

In the light of the grave hazard shown by these estimates, the NRC has a clear duty to provide the public with more complete information than is contained in this Supplement.

Thank you for your attention.

Sincerely,

G. R. Thompson

Gordon Thompson, Ph.D.
Staff Scientist

GT:VN

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
215 Fremont Street
San Francisco, Ca. 94105

RECEIVED MAR 20 1981

16 MAR 1981

Project # DS-NRC-K06002-CA

Frank J. Miraglia, Acting Chief
Licensing Branch No. 3
Division of Licensing
Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Miraglia:

The Environmental Protection Agency (EPA) has received and reviewed the Draft Supplement (DS) to the Draft Environmental Impact Statement (DEIS) for the project titled SAN ONOFRE NUCLEAR GENERATING STATION, UNITS 2 AND 3.

In our previous reviews of environmental documents dealing with Light Water Reactors (LWR) EPA has consistently emphasized the need for a thorough evaluation of the environmental impacts from different LWR accident scenarios to include Class 9 accidents. The discussion of the environmental and societal impacts of a core melt down accident included in the Supplement to the Draft Environmental Impact Statement for the San Onofre Nuclear Generating Station, Units 2 and 3 is a step forward in this respect and, as a result, EPA applauds the Nuclear Regulatory Commission's (NRC) decision to prepare this Supplement.

The assessment of environmental impacts for severe accidents at the plant uses methodologies originally developed in the Reactor Safety Study (WASH-1460) and the Liquid Pathway Generic Study (NUREG-0440). Because these two studies will be the cornerstones for similar assessments for other nuclear power plants environmental statements, we would refer NRC to EPA's original technical comments on these studies. These comments can be found in "Reactor Safety Study (WASH-1400): A Review of the Final Report" and a letter from EPA's Office of Federal Activities to NRC dated February 8, 1977.

Our specific comments on the San Onofre Supplemental DEIS and generic comments are attached. The EPA appreciates the opportunity to comment on this Draft Supplement. Should the NRC choose to revise other sections of the EIS, EPA would like to review these documents. If you have any questions regarding our comments, please contact Susan Sakaki, EIS Review Coordinator, at (415)556-7858.

Sincerely yours,

Jake Mackenzie, Director
Surveillance and Analysis Division

Attachment

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EPA Technical Comments on the Supplement to the Draft Environmental Statement Related to the Operation of the San Onofre Generating Station Units 2 and 3 (NUREG-0490)

General Comments

The Final EIS for San Onofre Units 2 and 3 is dated March 1973. This statement contains a Section 7, titled "Environmental Impact of Postulated Accidents." It is not clear if the Supplement is to replace the original information or if the Supplement is supplemental. If this information is supplemental then we would suggest that the original Section 7 be revised to agree with the supplemental statements and data.

It would also be hoped that any previous information and conclusions would be revised if it is impacted by events occurring since 1973 or by a change in Commission consideration. For instance the supplement refers to the original Section 5.5 and further mentions 10 CFR Part 20 and 10 CFR Part 50. However, the supplement does not make any mention of the Commission's implementation of 40 CFR 190 for normal operation.

Specific Comments

Table 7.1.4-4

This table should correspond on a one-to-one basis with the release categories (PWR 1-9) in Table 7.1.4-2. It is also not readily apparent how the PWR 1-9 compares to the original Table 7.1.

Design Basis Accidents

In the discussion of accident risk and impact assessment of Design Basis Accidents (DBAs), Section 7.1.4.1, we do not understand the intent of the comparison of the results in Table 7.1.4-1 to the Reactor Site Criteria of 10 CFR 100. First, the infrequent accidents listed in Table 7.1.4-1 do not meet the requirements of 10 CFR 100 for purposes of site analysis. Footnotes to 10 CFR 100 state:

(1)...calculations should be based upon a major accident, hypothesized for the purposes of site analysis...that would result in potential hazards not exceeded by those from any accident considered credible, and

(2)...this 25 rem whole body value and the 300 rem thyroid value have been set forth as reference values, which can be used in the evaluation of reactor sites with respect to potential reactor accidents of exceedingly low probability of occurrence, and low risk of public exposure to radiation.

Secondly, by the description of infrequent accidents in the supplement ("events that might occur once during the lifetime of the plant"), these accidents have an annual probability of occurrences on the order of 10^{-2}, are considered credible, and are not of exceedingly low probability of occurrence. Reference to 10 CFR 100 and its implementation provide a misleading inference that, since the results shown in Table 7.1.4-1 are within the dose values of 10 CFR 100, the risk of those infrequent accidents is small and therefore acceptable. Also, the radiation doses listed in Table 7.1.4-1 are calculated using a conservative model approach which is relevant to safety evaluations and not consistent with the realistic approach to the assessment of environmental risks of normal operation and severe core melt accidents.

The discussion of impacts of infrequent accidents and limiting faults, in both the original DES and the Supplement, addresses probabilities of occurrence qualitatively. Yet, in the discussion of the more severe core melt accidents the probabilities of occurrence are quantified (Table 7.1.4-2). For consistency in the presentation of all environmental risks, the probabilities of occurrence of infrequent accidents and limiting faults DBA's should also be provided.

It is not clear whether the risks listed in Table 7.1.4-5, Annual Average Values of Environmental Risks Due to Accidents, include those from infrequent accidents and limiting faults (Table 7.1.4-2), postulated accidents (Table 7.2 of the original DES), and accidents leading to the PWR 1-9 release categories (Table 7.1.4-2). The risks should include all those from moderate frequency accidents, infrequent accidents, limiting faults and severe core melt accidents. Although the risk of the infrequent accidents and limiting faults is "judged to be extremely small" and appear to be overshadowed by the risk from core melt accidents, they should be fully presented. The risks from the more probable yet lower consequence accidents may indeed be significant to the individual risk and should be listed in the Supplement. It would also be beneficial to extend Figures 7.1.4-3, 7.1.4-5, and 7.1.4-7 to include the higher probability accidents.

It would be helpful to provide a summary table of the annual average value of environmental risks from operation of all the reactors at the San Onofre site. The risks

should include all those from normal operations, moderate frequency accidents, infrequent accidents, limiting faults and severe core melt accidents. Both societal and individual risks should be presented.

7.1.1.3 Health Effects

The statement that a dose greater than about 25 rem is necessary before any physiological effects to an individual are clinically detectable should be reviewed. Information contained in a World Health Organization technical report No. 123 would seem to indicate that physiological changes can occur at exposures as low as 10 rem.

7.1.3.3 Emergency Preparedness

It is unclear what is the basis of the statement, "Emergency preparedness plans including protective action measures for the San Onofre facility and environs are in an advanced, but not yet fully completed stage." The plans (seven) are at this date undergoing informal review by the Region IX Regional Assistance Committee (RAC). Thus, there has been no request for formal review, there has been no drill schedule established and there has been no full scale exercise. We do not concur in the Commission's statement that these plans are in an advanced stage.

Table 7.1.4-5

It is not clear from the information presented regarding risk and protective action that protective actions can be taken to reduce exposures by 10-20 times or in fact to prevent exposures determined by the State of California to be unacceptable considering the following:

1. The emergency preparedness plans and protective action measures for the San Onofre facility are not yet complete.
2. The State of California does not use the EPA's Protective Action Guides (PAG's).

In view of the above, we feel the statements made are premature.

Figure 7.1.4-8

This figure, "Relative Directional Risk to Individuals," might be a useful risk analysis. However, as presented, the figure is illegible and lacking in background information. It should be presented more clearly, with an accompanying table or coding explaining the significance of the numbers.

Decommissioning

The cost of reactor decommissioning and replacement power costs are as large as the costs from the Three Mile Island accident. It would seem that these costs could significantly change the cost-benefit information originally provided in Section 13. Future EIS's or Supplements to EIS's should include an evaluation of these costs.

San Diego
ASSOCIATION OF
GOVERNMENTS

Suite 524, Security Pacific Plaza
1200 Third Avenue
San Diego, California 92101
(714) 236-5300

March 19, 1981

Mr. Dino C. Scaletti
San Onofre Project Manager
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, DC 20555

Dear Mr. Scaletti:

On March 16, 1981, the Board of Directors of the San Diego Association of Governments (SANDAG) adopted a resolution supporting the operation of San Onofre Nuclear Power Plant Units 2 and 3 and requested the Nuclear Regulatory Commission to grant an operating license for these units subject to federal regulations regarding the safety of nuclear power plant operations and emergency planning for nuclear power plant accidents. This resolution and the supporting staff report are attached.

Please call me or have your staff call Steve Sachs of my staff if you have any questions about the Board of Directors action.

Sincerely,

for RICHARD J. HUFF
Executive Director

RJH/SS/sc

Attachments

cc: Patricia Fleming, SDG&E
Fred Massey, SCE

San Diego ASSOCIATION OF GOVERNMENTS

RESOLUTION No. 81-36

RESOLUTION SUPPORTING THE OPERATION
OF SAN ONOFRE NUCLEAR POWER PLANT
UNITS 2 AND 3
SUBJECT TO FEDERAL REGULATIONS REGARDING THE
SAFETY OF NUCLEAR POWER PLANT OPERATIONS AND
EMERGENCY PLANNING FOR NUCLEAR PLANT ACCIDENTS

WHEREAS, the Energy 2000 Task Force, appointed by Mayor Wilson of the City of San Diego, presented the conclusions and recommendations of its report to the SANDAG Board of Directors on February 23, 1981; and

WHEREAS, one of the recommendations of the Energy 2000 Task Force is to support the completion and operation of San Onofre Plants 2 and 3; and

WHEREAS, San Onofre Units 2 and 3, if completed and operated on schedule, will supply approximately half of the additional electricity needs forecast for the San Diego region between now and 1995; and

WHEREAS, the Nuclear Regulatory Commission will begin licensing hearings for San Onofre Units 2 and 3 in June 1981; and

WHEREAS, federal regulations concerning nuclear power plant safety and emergency response planning will have to be met in order for a license to be granted; NOW THEREFORE

BE IT RESOLVED that the Board of Directors supports the operation of San Onofre Nuclear Power Plant Units 2 and 3 and requests the Nuclear Regulatory Commission to grant an operating license for these units subject to federal regulations regarding the safety of nuclear power plant operations and emergency planning for nuclear plant accidents.

PASSED AND ADOPTED this 16th day of March 1981.

ATTEST: SECRETARY CHAIRMAN

SAN DIEGO ASSOCIATION OF GOVERNMENTS

RESOLUTION NO. 81-36 DATE CONSIDERED: 3/16/81

AGENCY	YES	NO	ABSENT	ABSTAIN
CARLSBAD	X			
CHULA VISTA	X			
CORONADO	X			
DEL MAR		X		
EL CAJON	X			
IMPERIAL BEACH	X			
LA MESA	X			
LEMON GROVE	X			
NATIONAL CITY	X			
OCEANSIDE	X			
SAN DIEGO	X			
SAN MARCOS	X			
SANTEE	X			
VISTA	X			
TOTALS	13	1		

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I certify from personal observation and count that the above results are an accurate record of the SANDAG Board of Directors vote and action.

Bettie Black

San Diego Association of Governments

BOARD OF DIRECTORS

DATE: March 16, 1981 AGENDA REPORT No.: R-95

CONSIDERATION OF SUPPORT FOR OPERATION OF
SAN ONOFRE NUCLEAR POWER PLANT UNITS 2 AND 3

Introduction

The Board requested this report as the basis for considering a resolution to support the operation of San Onofre Nuclear Power Plant Units 2 and 3. Three important points the Board should consider before taking a position are:

- The risks to health and life of both present and future generations and the costs of reducing these risks associated with almost all aspects of the nuclear fuel cycle, are extremely controversial. There is little scientific or technical consensus on the severity of the risks and the effectiveness or cost of strategies to reduce these risks.

- San Onofre Units 2 and 3 would provide 440 MW of electric power to the San Diego region - almost one-half of the additional power requirments forecast to be needed between now and 1995 for the SDG&E Service Area by SDG&E and the California Energy Commission. These forecasts include the effects of existing conservation and alternative energy source programs which will reduce electricity demand. Potential additional electricity supplies and conservation and alternative energy sources which could result in a balance between demand and supply over the next 10 to 20 years without San Onofre Units 2 and 3 have been identified (see attachment for a partial list) but are not yet committed. In some cases, these sources may be infeasible or unavailable.

- The construction of San Onofre Units 2 and 3 is nearing completion. About one-half of the total $3.4 billion projected construction cost has been expended. The plant is currently undergoing U.S. Nuclear Regulatory Commission review in order to obtain an operating license.

It is my

RECOMMENDATION

that the Board of Directors support the operation of San Onofre Nuclear Power Plants 2 and 3 and request the Nuclear Regulatory Commission to grant an operating license for these units subject to federal regulations regarding the safety of nuclear power plant operations and emergency planning for nuclear plant accidents.

Discussion

San Onofre Units 2 and 3 are scheduled to have a total capacity of 2,200 megawatts (MW) of electricity. SDG&E is a 20% partner in the pla. is therefore entitled to 440 MW of the electricity generated. The other 1,760 MW is scheduled to be used by Southern California Edison Company (76%) and Municipal Utilities serving the Cities of Anaheim and Riverside (total of 4%).

The Nuclear Regulatory Commission (NRC) is the federal agency responsible for issuing nuclear power plant operating licenses. The NRC will hold hearings on the license applications for San Onofre Units 2 and 3 starting in June 1981.

There are many environmental and economic issues related to the operation of San Onofre Units 2 and 3 which include:

- Cost and reliability of nuclear power
- Risk of accidents from transport of uranium, spent nuclear fuel and operation of the plants.
- Cost of decommissioning the plants.
- Ability of the plants to withstand earthquakes.
- Hazards, cost and technical feasibility of long-term storage of radioactive wastes.
- Scope and adequacy of emergency plans to reduce radiation exposure in the event of an accident.

At the licensing hearings in June, it appears that the most controversial issues will be the ability of the plants to withstand earthquakes and the adequacy of emergency planning in case of an accident that could impact surrounding areas. The Plant must meet federal standards in both of these areas before a license will be issued.

RICHARD J. HUFF
Executive Director

San Diego Association of Governments

RESOLUTION No. 81-36

RESOLUTION SUPPORTING THE OPERATION
OF SAN ONOFRE NUCLEAR POWER PLANT
UNITS 2 AND 3
SUBJECT TO FEDERAL REGULATIONS REGARDING THE
SAFETY OF NUCLEAR POWER PLANT OPERATIONS AND
EMERGENCY PLANNING FOR NUCLEAR PLANT ACCIDENTS

WHEREAS, the Energy 2000 Task Force, appointed by Mayor Wilson of the City of San Diego, presented the conclusions and recommendations of its report to the SANDAG Board of Directors on February 23, 1981; and

WHEREAS, one of the recommendations of the Energy 2000 Task Force is to support the completion and operation of San Onofre Plants 2 and 3; and

WHEREAS, San Onofre Units 2 and 3, if completed and operated on schedule, will supply approximately half of the additional electricity needs forecast for the San Diego region between now and 1995; and

WHEREAS, the Nuclear Regulatory Commission will begin licensing hearings for San Onofre Units 2 and 3 in June 1981; and

WHEREAS, federal regulations concerning nuclear power plant safety and emergency response planning will have to be met in order for a license to be granted; NOW THEREFORE

BE IT RESOLVED that the Board of Directors supports the operation of San Onofre Nuclear Power Plant Units 2 and 3 and requests the Nuclear Regulatory Commission to grant an operating license for these units subject to federal regulations regarding the safety of nuclear power plant operations and emergency planning for nuclear plant accidents.

PASSED AND ADOPTED this 16th day of March 1981.

ATTEST: ______________________ SECRETARY ______________________ CHAIRMAN

ATTACHMENT
(From Energy 2000 Task Force Report)

Potential Supply Alternatives
For the SDG&E Service Area*
1980-2000

San Onofre 2 and 3	440 MW	(nuclear)
Arizona (renewed contract)	400 MW	(imported)
New Mexico (renewed contract)	150 MW	(imported)
Washington (renewed contract)	100 MW	(imported)
Mexico (purchase)	300 MW	(imported)
Geothermal	800 MW	(geothermal)
Blythe site	1,000 MW	(coal gasification)
Hydroelectric	34 MW	(hydroelectric)
Cogeneration	100 MW	(cogeneration)
Wind	30 MW	(wind)
TOTAL	3,354 MW	

SOURCE:

San Diego Gas and Electric Company, September 1979

*Some of these sources may be infeasible or unavailable. For example, Arizona Public Service Company would have to agree to a renewed contract for 400 MW of imported power from Arizona; the feasibility of 1000 megawatts from a coal gasification plant at Blythe has not been proved.

Southern California Edison Company
P. O. BOX 800
2244 WALNUT GROVE AVENUE
ROSEMEAD, CALIFORNIA 91770

K. P. BASKIN
MANAGER OF NUCLEAR ENGINEERING, SAFETY, AND LICENSING

TELEPHONE
(213) 572-1401

March 24, 1981

Director, Office of Nuclear Reactor Regulation
Attention: Darrel G. Eisenhut, Director
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Sir:

Subject: Docket Nos. 50-361 and 50-362
San Onofre Nuclear Generating Station
Units 2 and 3

References: Realistic Estimates of the Consequences of Nuclear Accidents, M. Levenson and F. Rahn, EPRI, November, 1980.

This letter provides Southern California Edison Company's comments to the Supplement to Draft Environmental Statement related to the operation of San Onofre Nuclear Generating Station Units 2 and 3 NUREG-0490. In our review of this document we have found two points which we feel are in need of further clarification prior to the issuance of a Final Environmental Statement.

1. The following statement contained in Section 7.1.4.3,

> "The 200-rem whole-body dose figure corresponds approximately to a threshold value for which hospitalization would be indicated for the treatment of radiation injury. The 25-rem whole-body (which has been identified earlier as the lower limit for a clinically observable physiolgical effect) and 300-rem thyroid figures correspond to the Commission's guideline values for reactor siting in 10 CFR Part 100."

requires clarification, to prevent the statement from being misconstrued to state that San Onofre does not meet the Commission siting guidelines of 10 CFR 100.

In order to clearly differentiate between the Class 9 accident and the design basis accidents used in the Commission siting criteria, specific clarification is needed. The traditional Design Basis Accidents (DBA's) are hypothetical and conservative scenarios, evaluated in accordance with regulations and other regulatory guidance which define the required assumptions and methodology. In contrast, the Class 9 accident scenario is defined with no consideration of mitigation by engineered safety features, assumes highly conservative and consequence maximizing behavior of natural mitigation processes. Since the Class 9 accident uses much more conservative, unrealistic, assumptions, it is not considered in the evaluation of reactor siting.

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2. Although uncertainties in probability calculations are discussed in Sections 7.1.4.2 and 7.1.4.7 of the Supplement, the uncertainties in the source terms, and hence the consequences of the accident, are not discussed in either Section 7.1.4.3 or 7.1.4.7. These radiation source terms have been shown to be conservative by experiments performed at Rockwell, Karlsruke, Oak Ridge National Laboratory, General Electric (Aircraft Nuclear Propulsion Department), Bettis National Laboratory, Hanford National Laboratory, and tests performed in the Idaho Reactor Test Site. The results of these tests and experiments, summarized in a paper by M. Levenson and F. Rahn of the Electric Power Research Institute, indicate that natural processes are operating which prevent the release of radioactive nuclides from molten nuclear reactor fuel (Reference 1). Dr. Chauncey Starr, former President of the Electric Power Research Institute advised the Commission, at the Commissions November 18, 1980 meeting in Washington, D.C., that,

> "The important issue is that the initial review of this subject appears to indicate that under any conceivable realistic circumstance, the real source term is likely to result in risk to the public that is less by factors of 10 to 100 than that which was previously estimated."

Using Dr. Starr's estimate of a realistic maximum release into the atmosphere would lower the consequences (acute fatalities and cancer deaths) from a Class 9 accident by 1 to 2 orders of magnitude.

The Final Environmental Statement for San Onofre Units 2 and 3 should be accurate, concise, and not leave room for misinterpretation. Where applicable, all sources of error, and the relative magnitude of error, should be indicated. We hope that these comments will help to make the FES for SONGS 2 and 3 such a document.

Very truly yours,

K P Baskin

APPENDIX B

NEPA POPULATION DOSE ASSESSMENT

Appendix B

NEPA POPULATION DOSE ASSESSMENT

Population dose commitments are calculated for all individuals living within 80 km (50 miles) of the facility employing the same models used for individual doses (see Regulatory Guide 1.109, in preparation). In addition, population doses associated with the export of food crops produced within the 80-km region and the atmospheric and hydrospheric transport of the more mobile effluent species such as noble gases, tritium, and carbon-14 have been considered.

B.1 NOBLE GAS EFFLUENTS

For locations within 80 km of the reactor facility, exposures to these effluents are calculated using the atmospheric dispersion models in Regulatory Guide 1.111 and the dose models described in Section 5.5 and Regulatory Guide 1.109. Beyond 80 km and until the effluent reaches the northeastern corner of the United States, it is assumed that all of the noble gases are dispersed uniformly in the lowest 1000 m (3280 ft) of the atmosphere. Decay in transit was also considered. Beyond this point, noble gases having a half-life greater than one year (e.g., Kr-85) were assumed to mix completely in the troposphere of the world with no removal mechanisms operating.

Transfer of tropospheric air between the northern and southern hemispheres, although inhibited by wind patterns in the equatorial region, is considered to yield a hemisphere average tropospheric residence time of about two years with respect to hemispheric mixing. Since this time constant is quite short with respect to the expected mid-point of plant life (15 years), mixing in both hemispheres can be assumed for evaluations over the life of the nuclear facility. This additional population dose commitment to the U.S. population was also evaluated.

B.2 IODINES AND PARTICULATES RELEASED TO THE ATMOSPHERE

Effluent nuclides in this category deposit onto the ground as the effluent moves downwind, which continuously reduces the concentration remaining in the plume. Within 80 km of the facility, the deposition model in Regulatory Guide 1.111 was used in conjunction with the dose models in Regulatory Guide 1.109. Site-specific data concerning production, transport, and consumption of foods within 80 km of the reactor were used. Beyond 80 km, the deposition model was extended until no effluent remained in the plume. Excess food not consumed within the 80-km distance was accounted for, and additional food production and consumption representative of the eastern half of the country was assumed. Doses obtained in this manner were then assumed to be received by the number of individuals living within the direction sector and distance described above. The population density in this sector is taken to be representative of the eastern United States, which is about 410 persons per km^2 (160 persons per mi^2). (This approach is conservative for San Onofre because population densities in the western United States are considerably lower than those in the eastern portion.)

B.3 CARBON-14 AND TRITIUM RELEASED TO THE ATMOSPHERE

Carbon-14 and tritium were assumed to disperse without deposition in the same manner as krypton-85 over land. However, they do interact with an atmospheric residence time of 4 to 6 years with the oceans being the major sink. From this, the equilibrium ratio of the carbon-14 to natural carbon in the atmosphere was determined. This same ratio was then assumed to exist in man so that carbon-14 to natural carbon in the atmosphere was determined. This same ratio was then assumed to exist in man so that the dose received by the entire population of the United States could be estimated. Tritium was assumed to mix uniformly in the world's hydrosphere, which was assumed to include all the water in the atmosphere and in the upper 70 m (230 ft) of the oceans. With the model, the equilibrium ratio of tritium to hydrogen in the environment can be calculated. The same ratio was assumed to exist in man, and was used to calculate the population dose, in the same manner as with carbon-14.

B.4 LIQUID EFFLUENTS

Concentrations of effluents in the receiving water within 80 km of the facility were calculated in the same manner as described above for the Appendix I calculations. No depletion of the nuclides present in the receiving water by deposition on the bottom of the Pacific Ocean was assumed. It was also assumed that aquatic biota concentrate radioactivity in the same manner as was assumed for the Appendix I

evaluation. However, food consumption values appropriate for the average individual, rather than for the maximum, were used. It was assumed that all of the sport and commercial fish and shellfish caught within the 80-km area were eaten by the U.S. population.

Beyond 80 km, it was assumed that all of the liquid effluent nuclides except tritium have deposited on the sediments so they make no further contribution to population exposures. The tritium was assumed to mix uniformly in the world's hydrosphere and to result in an exposure to the U.S. population in the same manner as discussed for tritium in gaseous effluents.

APPENDIX C

EXPLANATION AND REFERENCES FOR BENEFIT-COST SUMMARY

Appendix C

EXPLANATION AND REFERENCES FOR BENEFIT-COST SUMMARY

C.1 ECONOMIC IMPACT OF STATION OPERATION

C.1.1 Direct benefits

C.1.1.1 Energy

2114 MWe x 1000 kW/MW x 365 days x 24 hr/day x capacity factor (0.5 or 0.7). This product ranges from 9.3×10^9 kWhr/year (0.5 capacity factor) to 13.0×10^9 kWhr/year (0.7 capacity factor).

C.1.1.2 Reduced regional oil consumption

Section 8.3.1 shows that the applicants primarily have oil/gas fired units, which would have to be operated to a greater extent if SONGS 2 & 3 are not operated. The additional fuel oil consumption (assuming a 50% capacity factor for the nuclear units) is calculated as follows:

$$\frac{9.3 \times 10^9 \text{ kWhr} \cdot 9{,}000 \text{ Btu/kWhr} \cdot 1 \text{ bbl oil}}{6.29 \times 10^6 \text{ Btu}} = 13.2 \times 10^6 \text{ bbl oil.}$$

C.1.2 Economic costs

C.1.2.1 Fuel

From Sect. 8.3.1, the staff's estimate of fuel cost is $10.8 per megawatt-hour in 1983. Assuming a 60% capacity factor or 11.1×10^6 MWhr/yr gives the value in Table 10.1.

C.1.2.2 Operating and maintenance

Using the staff's OMCST computer code, operating and maintenance costs are estimated to be 4.05 mills/kWhr at 60% capacity, which multiplied by 11.1×10^9 kWhr/year gives the values in Table 10.1.

Decommissioning: Based on estimates given in Sect. 9.4, the cost of decommissioning each unit will be $66.7 million in 1978 dollars or $85.4 million in 1980 dollars at the end of the useful life of the plant. If this value is discounted from 2013 to 1983, then annualized over a 30-year life assuming a real interest and discount rate of 4.76%, and then multiplied by 2 units, the value in Table 10.1 is obtained.

APPENDIX D

CULTURAL RESOURCES

STATE OF CALIFORNIA—THE RESOURCES AGENCY EDMUND G. BROWN JR., Governor

DEPARTMENT OF PARKS AND RECREATION
P.O. BOX 2390
SACRAMENTO 95811
(916) 445-8006

DEC 18 1980

Mr. Dino Scaletti
Environmental Projects
Division of Site, Safety,
and Environmental Analysis
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Scaletti:

San Onofre Nuclear Generating Station,
Units #2 and #3, Operating License Stage

My staff has recently completed review of the "National Register Assessment Program of Cultural Resources of the 230 KV Transmission Line Rights-of-Way from San Onofre Nuclear Generating Station to Black Star Canyon and Santiago Substation and to Encina and Mission Valley Substation", prepared by WESTEC Services, dated September 1980.

In accordance with the provisions of the Advisory Council on Historic Preservation's Procedures set forth in 36 CFR 800, Section 106 of the National Historic Preservation Act of 1966 and the Memoranda of Agreement of October 29, 1979, I have the following comments to offer:

1. Based on the information I have been provided, I concur that the following sites are not eligible for National Register of Historic Places: CA-Ora-419, Ora-823, Ora-786, Ora-787, Ora-700, Ora-782, Ora-784, Ora-785, Ora-832, SDi-6693, SDi-6131, SDi-5444, SDi-6136, SDi-6137, SDi-6150, SDi-6151, and SDi-6152.

2. Sites CA-Ora-640, Ora-458, and SDi-6133 are outside the area of potential environmental impact for this undertaking.

3. I do not concur that site CA-Ora-824 is not eligible for the National Register of Historic Places. I feel that this site may be eligible based on Bean and Vane's findings in 1979 that this site possesses a high potential for significance.

4. I concur that the following sites are eligible for inclusion in the National Register as important components of the proposed San Joaquin Archeological District: CA-Ora-495, Ora-496, and Ora-499.

5. The following sites have been determined eligible for inclusion in the National Register as important components of the Upper Aliso Creek Archeological District: CA-Ora-447, Ora-438, and Ora-725.

6. The following sites should also be included as eligible properties within the Upper Aliso Creek Archeological District: CA-Ora-905, Ora-828, Ora-825, Ora-826, and Ora-827.

Mr. Dino Scaletti
Page 2

7. I concur that the following sites are eligible for inclusion in the National Register as significant components of the proposed Santiago Creek Archeological District: CA-Ora-829, Ora-830, and Ora-831.

8. I concur that the following sites are eligible for inclusion in the National Register as significant components of the proposed Agua Hedionda Archeological District: CA-SDi-6135, SDi-6133, and SDi-6140.

9. I also concur that the following sites are locally significant and are eligible for the National Register under Criterion "d" (36 CFR 1202.6): CA-Ora-498, SDi-4538, SDi-6130, SDi-6138, and SDi-6149.

10. Formal determinations of eligibility for these sites and districts should be sought from the Keeper of the Register in accordance with 36 CFR 1204.

11. I concur with the report's findings that this undertaking will have No Effect on eligible sites CA-Ora-905, Ora-828, Ora-826, Ora-827, Ora-829, and SDi-4538.

12. I concur with the report's findings that operation and maintenance (O&M) of access roads will affect the following eligible sites: CA-Ora-498, Ora-824, Ora-495, Ora-447, Ora-496, Ora-499, Ora-825, Ora-725, Ora-830, Ora-831, and SDi-6130. However, I feel that there will no No Adverse Effect on these resources if one of the two following conditions can be met:

    a. Access roads can be covered with a chemically inert, visually distinguishable fill within the boundaries of these sites in a manner which will preclude future ground disturbance of the cultural deposit during future O&M activities on access roads, or;

    b. O&M activities can be restricted to access roads, and the remaining research potential of surface artifacts within the provenience of existing access roads can be used to define the important factors which should be considered in determining the effects of continued disturbances as proposed in the Cultural Resource Management Plan on page 359 of the subject report. This program should be oriented towards defining the value of research potential and the effects that various activities may have on disturbed surface sites in similar environmental contexts. The program should also be responsive to the Advisory Council's Supplementary Guidance for Treatment of Archeological Properties supporting a No Adverse Effect Determination.

Mr. Dino Scaletti
Page 3

13. The information I have been provided indicates that undisturbed cultural deposits will be affected by O&M of access roads in the vicinity of site CA-Ora-438. However, it is my opinion that there will be No Adverse Effect if one of the two following conditions can be met:

    a. Access roads can be covered with a chemically inert, visually distinguishable fill within the boundaries of this site in a manner which will preclude future ground disturbance of the cultural deposit during future O&M activities, or;

    b. O&M activities can be restricted to access roads, and a Data Recovery Plan is implemented in accordance with the Advisory Council's Supplementary Guidance for Treatment of Archeological Properties supporting a No Adverse Effect Determination. The rationale for this recommendation is stated in the above referenced Guidance on pages 10 and 11, "An Undertaking may be taken to have no adverse effect...if the agency is committed to a data recovery program...if...the property is shown to be subject to destruction and deterioration regardless of the undertaking, so the agency's action is only slightly hastening a process that is inevitable in any event."

14. O&M activities and construction will have an effect on sites CA-SDi-6135, SDi-6138, SDi-6149, and SDi-6140. However, it is my opinion that there will be No Adverse Effect on these sites if a Data Recovery Plan is implemented in accordance with the Advisory Council's Supplementary Guidance for Treatment of Archeological Properties supporting a No Adverse Effect Determination. The rationale for this recommendation is the same as that cited in Item 13.b. above.

15. Concurrence of these determinations of effect should be sought from the Advisory Council in accordance with 36 CFR 800.4.c.

If you should have any questions, please contact Daniel Bell of my staff at (916) 322-8702.

Sincerely,

Dr. Knox Mellon
State Historic Preservation Officer
Office of Historic Preservation

D-6317D

Mr. Dino Scaletti
Page 4

cc: Mr. L. Jack Brunton
Licensing and Environmental Department
San Diego Gas and Electric Company
P.O. Box 1831
San Diego, CA 92112

Mr. David White
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La Jolla, CA 92037

Ms. Roxanna Phillips
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Mr. Charles Niquette
Advisory Council on Historic Preservation
Lake Plaza-South, Suite 616
44 Union Boulevard
Lakewood, CO 80228

APPENDIX E

CALIFORNIA COASTAL COMMISSION, MARINE REVIEW COMMITTEE REPORT

CALIFORNIA COASTAL COMMISSION
631 Howard Street, San Francisco 94105 — (415) 543-8555

TO: State Commissioners

FROM: Michael Fischer, Executive Director

SUBJECT: Report of San Onofre Nuclear Power Plant Marine Review Committee (For Commission consideration at theFebruary 17-19 Meeting.)

Summary

The 1974 permit for the San Onofre Nuclear Power Plant's Units 2 and 3 established a three member Marine Review Committee (MRC) to study the effects of the Plant's cooling system on ocean life and to make recommendations to the Commission. Units 2 and 3 of the Plant are not yet operational. The MRC has submitted a report (conclusions attached) predicting effects on fish, kelp, plankton and other ocean life. The MRC recommends against any design changes to the cooling sustem at this time. Staff recommends the Commission take note of the MRC recommendations and endorse a future monitoring program to determine actual effects on ocean life in the future after system operation. If substantial adverse effects are found, the Commission can impose design or operational changes or mitigation measures, based on MRC recommendations. But, given MRC predictions, major system design changes in the future seem unlikely.

E-1

Background

The Commission's predecessor Coastal Zone Commission approved the construction of Units 2 and 3 of the San Onofre Nuclear Generating Station (SONGS) on February 20, 1974 (Permit No. 183-73). Condition B of the Permit provided for the establishment of an applicant funded Marine Review Committee (MRC) composed of an appointee of the State Commission, an appointee of Southern California Edison Company, and an appointee of the appellants. The appellants are coordinated by Friends of the Earth. The Condition provides for the MRC to undertake a "comprehensive and continuing study of the marine environment offshore from San Onofre...to predict, and later to measure, the effects of San Onofre Units 2 and 3 on the marine environment..." (Condition B1).

The MRC can make recommendations to the Commission, based on MRC studies, and the recommendations can include changes that the MRC believes necessary in the cooling system for Units 2 and 3. This cooling system takes in large amounts of seawater to cool the units and then discharges the heated water back to the ocean. Condition B6 of the Permit states:

> Should the study at any time indicate that the project will not comply with the regulatory requirements of State or Federal water quality agencies, or that substantial adverse effects on the marine environment are likely to occur, or are occurring, through the operation of Units 1, 2, and 3, the applicants shall immediately undertake such modifications to the cooling system as may reasonably be required to reduce such effects or comply with such regulatory requirements (which can be made while construction is going on and could be as extensive as requiring cooling towers if that is the recommendation). The State Commission shall then further condition the permit accordingly.

Thus, the Commission can impose new conditions on the cooling system only if the conditions are based on MRC recommendations and the Commission judges the conditions to be "reasonable". New conditions can be based only on an MRC finding that "substantial adverse effects on the marine environment are likely to occur, or are occuring, through the operation on Units 1, 2, and 3...."

Since its beginning, the MRC has submitted a number of reports to the Commission. After receiving an MRC report in mid-1979 the Commission, at its November 21, 1979 meeting, asked the MRC to take one final "best shot" at predicting effects on the marine environment prior to the start of Nuclear Regulatory Commission (NRC) hearings on the operating license for Units 2 and 3. The MRC has now submitted that report, MRC Document 80-04(I). The conclusions are attached to this staff report, and the MRC will present the conclusions to the Commission at its January 20-22 meeting.

Staff Analysis

The Marine Review Committee has, over the last six years, conducted monitoring and predicting studies that seem to be as comprehensive and thorough as possible given the state-of-the-art in predicting effects on the large and dynamic nearshore ocean environment. It is possible that the square kilometer offshore SONGS is the most heavily sampled and studied patch of the ocean anywhere. Predicting the effects of the SONGS cooling system on ocean life has had to face a number of inherent difficulties, including: understanding the life cycles of ocean organisms; obtaining enough samples over a long enough time period to enable statistical analyses; developing quantitative models of water flows, turbidity and population dynamics; and, most important, attempting to separate out effects or likely effects of the cooling system from other major factors affecting ocean life, including storms, water temperature and chemistry changes, fishing, changes in nutrient levels, changes in migratory habits, and natural population fluctuations.

Design Changes. The MRC has needed to use models and numerous assumptions in assessing possible effects on living ocean populations. Such exercises can give scenarios, but not high confidence predictions. The MRC report consequently presents a number of estimates of future effects on fish larvae, small shrimp, plankton, and and a kelp bed. It does not, however, state that these effects are likely or certain to occur, and, therefore, it does not state that "substantial adverse effects on the marine enviroment are likely to occur", as required in Condition B6 for modification of the cooling system. The report, then,explicitly recommends against design changes in the cooling system at this time, while stating "it is possible that we have grossly underestimated the ecological consequences of SONGS Units 1, 2, and 3" (Page 7). The actual effects can only be determined through monitoring the ocean environment after the Units become operational. The MRC has extensive results from pre-operational sampling and data collection and will be in a position to implement a useful post-operational monitoring program. Staff is therefore recommending the Commission endorse a continued MRC monitoring program and ask that the program design and budget be submitted to the Commission. If the MRC finds "substantial adverse effects" the Commission may still impose conditions accordingly.

Mitigation. One such condition could involve mitigation for damage determined by the MRC. The Commission directed the MRC to explore mitigation alternatives. This last attempt at predictions has taken up most MRC time, and the MRC report states it will recommend to the Commission which mitigation measures, in addition to artificial reefs for kelp, should be examined.

Radiological Monitoring. A 1979 MRC report detailed a number of inadequacies in the radiological monitoring program in the ocean around SONGS. The Commission directed staff to report these inadequacies to the Southern California Edison Co., the Nuclear Regulatory Commission, and the California Department of Health Services and to pursue remedies. SCE has since revised its radiological monitoring program extensively and has submitted it to the NRC. Both the NRC and the MRC author of the previous report are evaluating the revised program at present.

Staff Recommendation

Staff recommends the Commission adopt the following resolution:

The Commission thanks the Marine Review Committee for the report "Predictions of the Effects of San Onofre Nuclear Generating Station and Recommendations", adopted unanimously by the members of the MRC. The Commission notes that the MRC does not predict at this time that substantial adverse effects on the marine environment are likely to occur from the operations of the SONGS cooling system, and that the MRC recommends against system design changes at this time. However, the Commission also notes that the MRC states it may have grossly underestimated these effects. The Commission agrees, therefore, that the MRC should conduct a comprehensive and thorough monitoring program of the effects after SONGS becomes operational and requests that the MRC submit the design and cost of such a program to the Commission. If such monitoring discovers substantial adverse effects on the marine environment, the Commission can, at that time, based on MRC recommendations, impose new conditions including design or operating changes or mitigation measures. The Commission recognizes, given the MRC predicted effects of the cooling system, that future imposition of any major design changes to the cooling system is unlikely.

F-2

marine review committee

Office: (805) 961-3104
DEPT. OF BIOLOGICAL SCIENCES
UNIVERSITY OF CALIFORNIA
SANTA BARBARA, CA 93106

November 17, 1980

RECEIVED
NOV 24 1980
CALIFORNIA
COASTAL COMMISSION

Mr. Bill Ahearn
California Coastal Commission
4th Floor
631 Howard Street
San Francisco, California 94105

Dear Bill:

This letter formally transmits to the California Coastal Commission, under separate cover, the Marine Review Committee's predictions concerning the effects of San Onofre Units 1, 2 and 3 upon the marine ecosystem. The Report also contains a study of options and a set of recommendations to the Commission. These predictions and recommendations have been agreed upon unanimously by the Committee. The Appendices will follow in approximately two weeks.

A later report will discuss mitigation in more detail.

Yours sincerely,

Rimmon C. Fay

Rimmon C. Fay

Byron Mechalas

Byron Mechalas

W. Murdoch

William W. Murdoch
(Chairman)

E-3

**REPORT OF THE MARINE REVIEW COMMITTEE
TO THE CALIFORNIA COASTAL COMMISSION:
PREDICTIONS OF THE EFFECTS OF
SAN ONOFRE NUCLEAR GENERATING STATION
AND RECOMMENDATIONS
PART I: RECOMMENDATIONS, PREDICTIONS, AND RATIONALE**

Marine Review Committee

William W. Murdoch, Chairman
University of California

Byron J. Mechalas
Southern California Edison Company

Rimmon C. Fay
Pacific Bio-Marine Labs, Inc.

MRC Document 80-04(I)

CONTENTS

INTRODUCTION

The Marine Review Committee was charged, in Permit No. 183-73 of the California Coastal Commission, to carry out "a comprehensive and continuing study of the marine environment offshore from San Onofre . . . to predict, and later to measure, the effects of San Onofre Units 2 and 3 on the marine environment, . . . in a manner that will result in the broadest possible consideration of the effects of Units 1, 2 and 3 on the entire marine environment in the vicinity of San Onofre." This Report responds to the charge to predict the effects of Units 2 and 3.

San Onofre Nuclear Generating Station (SONGS) Unit 1 has been operating since 1968. Almost 150 billion gallons of seawater per year circulate through the Plant. Water flows in through a single intake and is discharged through a single discharge pipe at 19°F above the intake temperature. The construction of SONGS Units 2 and 3 is virtually completed. Each has a single intake, each drawing in seawater at a rate of 830,000 gallons per minute, which will result in an estimated flow of almost 700 billion gallons per year. Each also discharges its heated effluent through a series of 63 diffuser ports set along a kilometer-long pipe that tapers from 18' to 10'-14' in diameter (Figure 1, Maps 1 and 2). This discharged water moves rapidly towards the surface, entraining and moving with it roughly 10 times its own volume of water. As it spreads, this water mass moves various distances offshore, depending upon the prevailing currents. MRC has measured these currents, and Southern California Edison has produced a physical model of SONGS' water movement.

The effects of the cooling system of Unit 1 upon the marine ecosystem were described in MRC Annual Reports for 1978 and 1979. The documented effects are restricted to a region within a kilometer or two of SONGS. In seeking to predict the effects of Units 2 and 3, MRC has looked at the loss of organisms taken into the intakes, the possible losses caused by water movements driven by the diffuser plumes, and the effects of the diffusers and heat treatments on the physical environment, and hence upon the biota.

The predictions presented in this Report are in most cases close to final. Although we can and will obtain some more information on the major parts of the ecosystem near SONGS before Units 2 and 3 begin operation, we have obtained most of the information it is possible to obtain with a feasible expenditure of effort. Where major uncertainties remain, further study will not in general resolve them; they are largely an inescapable result of the practical difficulties in studying real ecological systems, and of the nature of such systems. The exceptions are kelp, where future work should provide more, and important, information, and some modelling studies that have not yet been completed. At this point, however, future work on predictions is aimed mainly at guiding our monitoring studies.

Following this Introduction, the Report presents our recommendations. There follows a brief statement of predictions for each major part of the community, and a more extensive Rationale, which explains how we arrived at the predictions. The Rationale unavoidably contains some technical discussion, but we have tried to write it so that the reader unfamiliar with the study can follow it. Finally, a series of separate Appendices accompanies this Report. These appendices are the reports of various contractors, and

analyses (by MRC and its consultants) of a number of difficult technical issues. The <u>Rationale</u> refers to those Appendices, where necessary, by project, number and, if appropriate, page number.

We would like to stress two findings that have general importance for management of and planning for nearshore coastal waters in California. First, we reiterate a previous conclusion that, in open coastal situations, a diffuser design is likely to be ecologically more damaging than a single point discharge, even though the latter would violate present State thermal discharge standards.

Second, we have recently obtained evidence that the early (larval) stages of nearshore sport and commercial fish species (e.g. bass, halibut) are particularly sparse very close to shore, while the larvae of fodder fish species are abundant right into shallow waters. Fodder fish populations are probably better able than sport and commercial species to withstand additional mortality on their larval stages. If this pattern holds along the whole California coast, it should be used as basic information in future planning - e.g. the placement of intakes and outfalls. This is not a blanket recommendation for placing structures close to shore, but rather a recommendation to weigh the possible losses of fish larvae in such decisions.

<u>OPTIONS AND RECOMMENDATIONS</u>

<u>Options</u>

San Onofre Kelp bed (SOK) and nearshore fish populations are the major parts of the marine ecosystem that SONGS Units 1, 2 and 3 could significantly harm. Mysids, and perhaps zooplankton, are of less direct interest to society, but they also might sustain significant and quite large impacts. In the light of the predictions, MRC reviewed a number of possible recommendations that could be made to the Commission:

1. Make no design changes at this time. Monitor the effects.
2. Make no design changes at this time. Examine the feasibility of mitigating some or all of the effects, with a view to recommending mitigation measures to the Commission.
3. Extend the intake pipes to beyond the 30 meter depth.
4. Redesign the diffusers of Units 2 and 3, to convert them to single point discharges, located either 4 to 5 km offshore or very close inshore.
5. Convert the once-through cooling system to cooling towers.

<u>Option 1</u> would require only a monitoring program, which would be carried out over several years to determine the effects of SONGS on the marine ecosystem. This program, in addition, would generate important information for future coastal planning, and would test how well we can predict the ecological consequences of a major coastal installation.

<u>Option 2</u> MRC has completed a short "paper" feasibility study of certain kinds of mitigation (Mitigation Appendix). This study describes various methods of enhancing the production of economically important species, such as reef fish and abalone. Southern California Edison has

established an experimental reef aimed at producing a kelp bed and associated organisms, including fish and abalone. Other mitigation measures may be feasible.

It should be stressed that mitigation could not be expected to replace completely the biota lost through SONGS' operation. San Onofre Kelp bed could perhaps be replaced by a similar kelp bed, but fish losses would probably be replaced (partially) by a somewhat different mix of species. Lost mysids and plankton are not likely to be replaced by any known mitigation measure. An adequate mitigation study would therefore need to address the acceptability of "replacing" losses of one species by increasing the production of another.

Option 3 The possibility of extending the intakes out to deeper water was suggested previously (MRC 1979 Interim Report) as a means of (1) reducing the turbidity of intake water, so that the effects on SOK would be reduced, and (2) reducing the kill of nearshore fish larvae. With regard to aim (1), the turbidity study (Turbidity Appendix) suggests that much of the turbid water passing over SOK will originate at the inshore segment of the diffusers and will be carried offshore by secondary entrainment, so that the gain from changing the intakes would be relatively small. With regard to aim (2), our recent analyses show that the larvae of nearshore sport and commercial species are relatively sparse in the present intake area, and are quite dense out to about 7 km offshore. The gain in moving the intakes offshore would therefore be mainly a reduction in fodder fish kills, while we would likely kill more of sport and commercial species.

Option 4 The diffusers carry turbid water over the kelp bed. They

also will cause an unknown, but probably significant, amount of mortality in mysids, plankton and fish larvae. A single point discharge would greatly reduce this latter mortality, and moving the discharge either close inshore or further offshore would remove the kelp bed from the influence of the discharge. A single point discharge would violate the State thermal tolerances, but MRC believes this would cause much less ecological damage than the diffusers. It might be possible to make practical use of the waste heat from an inshore discharge. MRC has not evaluated in detail the ecological consequences of these two alternatives.

Recommendations

We recommend Options 1 and 2, and recommend against design changes at this time (Options 3, 4 and 5).

Monitoring is needed to measure the effects of Units 1, 2 and 3, as required by the Permit. It is also essential that the effects are measured and compared with MRC's quantitative predictions. Part of our study is a unique effort to make such predictions, and it is only by testing them that we can determine if such prediction is possible, how accurate it is, and what changes are needed to make better predictions in future planning. Predictions of probable effects, whether made explicit or not, are of course an integral part of all coastal planning.

We also recommend that MRC's remaining and ongoing prediction efforts be completed. These are now small studies. Such quantitative predictions are important, not only in themselves, but as a guide to the future monitoring program.

It is important to monitor the success of Southern California Edison's experimental reef, now established some 5 km south of SONGS. The evidence

on the efficacy of reefs, especially as a basis for new kelp beds, is equivocal and in contention, and this experiment will allow us to judge the best available California reef technology. MRC will present to the Commission, at a later date, a recommendation on whether or not other mitigation measures should be examined.

We recommend against moving the intake pipes (Option 3), for the reasons given under that Option. We also recommend against Options 4 and 5 at this time. Destruction of the offshore portion of the kelp bed is a major possible effect of the diffusers. However, at this moment we are not certain this will occur, and it is also possible that the effect could be mitigated. Some mitigation of fish losses may also be possible.

It is possible that we have grossly underestimated the ecological consequences of SONGS Units 1, 2 and 3. If monitoring proves this to be the case, we will re-examine the possibility of recommending major design changes.

PREDICTIONS

FISH

Introduction

Most fish caught in Southern California are netted by commercial fishermen, and most come from fishing areas more than a few kilometers off the coast. By contrast, most sport fish in Southern California are caught close to the land - within the 33 California Fish and Game "fishing blocks" that are contiguous with the shore. In this Report we are concerned mainly with those sport fish and with commercial catches taken close to shore, for it is only this nearshore group of fish that SONGS is expected to affect. In evaluating the predictions, therefore, it should be kept in mind that SONGS is <u>not</u> expected to influence the great bulk of the fish populations that are harvested by California fishermen.

The species that concern us are fish that live as adults mainly within about 4 or 5 km of shore and that produce planktonic (drifting) eggs and larvae in the same zone. Among these species there are two groups: the nearshore sport and commercial species, the harvest of which is made up mainly by halibut, white seabass, kelp bass and sand bass, and the nearshore fodder fish (or forage fish) that form a major portion of the prey of the sport and commercial species.

In the predictions, we present various numbers to help the reader evaluate the likely effects of SONGS. It is easy to misinterpret these numbers, and we give here some essential background information. If we know the abundance and sizes of all of the halibut, say, in some area along the

coast, we can calculate the total living weight (biomass) of halibut in that region. This is called the standing stock. Each year, there are additions to this standing stock - some individuals that were larvae grow up to become adults, and many of those already adult grow and gain weight. If we could add up all the accumulated growth (in weight) we would be able to say how much new biomass had been added to the population. This is the annual production of new halibut tissue. We cannot estimate this directly, but a general rule of thumb is that a sport and commercial population gains about 60% of its standing stock weight per year. If our harvesting techniques were perfect we could take all of this production each year as harvest, and keep the standing stock steady from one year to the next. However, inevitably some fish die of disease and parasites, others are eaten by predators, and so on. The annual harvest, therefore, is always less than the annual production. In these nearshore sport and commercial species near San Onofre we estimate the harvest is roughly a quarter of production.

As long as the harvest plus other factors do not take more than the annual production, the population will not decline. However, if, on average, harvest plus other losses are greater than production, the population will decline. If they are less than production, the population will increase, until it approaches a limit (say its food supply), at which time production will begin to decline and the population will level off.

We stress that the numbers given below are in all cases approximate. They give us an indication of the likely size of effects, but they do not tell us precisely what losses will be.

Predictions

1. Nearshore Sport and Commercial Fish

It is probable that, because of SONGS' activities, somewhere between 27 and 60 tons of nearshore sport and commercial fish production will be lost annually (Table 1). We feel the lower figure is more probable than the upper figure. Halibut is the species that will be most affected. Fish move about, so any loss of production will be spread over some area. We do not know how large an area, and provide a comparison between the consequences of spreading the loss over a small (45 km) and a large (300 km) stretch of coastal waters.

A loss of 27 tons would be equivalent to about 6% of the annual production of nearshore sport and commercial fish in the four fish blocks covering about 45 km of coastline near SONGS. It is equivalent to about one-third of the most recently documented (1975) harvest of these species from these four fishing blocks (85 tons). This does not mean that all of the losses will occur in these four blocks, or that the harvest can be expected to decline by either 6% or one-third.

If the losses were to be spread evenly over 300 km (about three-quarters of the length of the California Bight), then the loss in annual production over this area would be 1%. The loss in harvest could be more than 1% of that caught over 300 km. For example, to take an extreme case, if all natural losses are unavoidable, then all of the loss would come out of the harvest, which, for the 1975 harvest, would decline by roughly 10%.

There is quite strong evidence that the stocks of nearshore sport and commercial fish (especially halibut) have declined in the past two decades. We believe that these populations are unlikely to be able to compensate for

(i.e. make up for) significant additional mortality. However, the projected loss of sport and commercial fish, caused by SONGS, is sufficiently small that we believe it will not, in itself, have a significant effect on these populations.

Although SONGS alone is expected to have a minor effect upon the populations of nearshore sport and commercial fish, the cumulative effect of a number of sources of mortality of this order would be expected to contribute to continued decline in these populations. Future planning in the California Bight, therefore, should not evaluate additional installations and other environmental insults as independent events, but should consider their cumulative effects.

2. Fodder Fish

Anchovies probably contribute more than any other species to the diet of nearshore sport and commercial fish. Although enormous numbers of anchovy larvae will be killed by SONGS, we do not expect this vast population to be affected as a result of the operation of SONGS.

Nearshore fodder fish species are also important in the diets of nearshore sport and commercial fish. The two most abundant nearshore fodder fish are queenfish and white croaker. SONGS is expected to cause a loss in production of nearshore fodder fish of at least 300 tons per year.* Unlike the sport and commercial species, there is no evidence that the fodder fish populations are declining, so that we could expect some compensation for these losses. We do not know how much, so we cannot predict a precise net loss. Fodder fish in general move around more than sport and commercial species, and the populations in the entire Bight may well be thoroughly

*All weight figures are wet weight and are in metric tons.

mixed, so that losses would be spread over the Bight (roughly 400 km). If the losses were spread over the Bight, and if no compensation occurred, they would be equivalent to about 7% of the annual production of these fish.

The projected loss of the equivalent of 300 tons of fodder fish production is owing mainly to the loss of larvae in the intakes. We expect there will be additional losses caused by the diffusers carrying larvae to inhospitable environments offshore. These losses could be very large - greater than those caused by the intakes - but we cannot predict them accurately.

The projected intake losses alone are sizeable. While we cannot estimate how the populations will be affected (because we do not know enough about compensation), the accumulation of effects of this order would be expected eventually to cause declines in these stocks. Thus, while SONGS itself may not cause such declines (and we do not know whether it will or not), we would be concerned about accumulating additional losses of this magnitude in the future.

We expect that the direct impingement of juvenile and adult fodder fish (mainly queenfish) in the intakes will cause measurable changes in the age structure and sex ratio of this species to a distance of several kilometers from SONGS.

3. Mechanisms

Fish losses are caused by three main mechanisms: (1) direct impingement of juvenile and adult fish in the intakes, (2) loss of immature stages (especially larvae) in the intakes, and (3) loss of immature stages in the diffusers. Mechanisms (2) and (3) are the most important. The diffusers could kill larvae (a) through subjecting them to turbulent shear and (b) by

carrying inshore larvae to an inhospitable environment offshore (translocation).

Intake losses: Our recent analyses have yielded a critical piece of information that may be important in the placement of intakes. We have evidence that the larvae of nearshore sport and commercial fish species are unlike most nearshore larvae and are quite sparse very close to shore where the intakes are. Because of this peculiar distribution, we estimate the loss of sport and commercial fish production, owing to larval mortality via the intakes, to be only 20 tons per year, rather than 160 tons per year as previously expected, thus reducing the predicted impact to one that is relatively minor.

Diffuser losses: We estimate that relatively few fish larvae will be killed by turbulent shear, and believe that this will be a minor effect. We also do not expect the larvae of sport and commercial species to suffer translocation mortality in the plume. However, translocation may cause very large losses of fodder fish larvae.

4. Upwelling Effects of SONGS

SONGS' diffusers will bring extra nutrients to the surface, and move them offshore. This could result each year in the production of roughly 460 tons of anchovy. We believe this will have a negligible effect on sport and commercial fish production, and virtually no effect on nearshore sport and commercial fish production.

Table 1. Summary of predicted effects of SONGS Units 1, 2 and 3 upon nearshore fish species. Numbers are metric tons per year.

	In biomass	In production	In sport and commercial production
(1) Losses by direct impingement of juvenile and adult fish in intakes			
Fodder fish	31-51	25-41	0-4
Sport and commercial fish	7-12	4-7	4-7
Electric rays	7-13	5-8	---
Other fish	5-8	3-5	---
		Subtotal	4-11
(2) Losses by kill of planktonic stages in intakes			
Fodder fish	358	287	3-29
Sport and commercial fish	34	20	20
		Subtotal	23-49
(3) Damage to kelp bed	0-9	0-3	0-3
		TOTAL	27-63

KELP

Introduction

Kelp beds constitute a distinct and important habitat in the nearshore marine ecosystem in Southern California. Over 760 species of animals (invertebrates and fish) and over 120 species of plants have been found in kelp beds in Southern California. At least two fish species (kelp perch and kelp clingfish) are rarely found outside of kelp beds, and many invertebrate species occur most commonly in this habitat. In the San Onofre kelp bed (SOK) alone we have recorded 164 species of animals and 16 species of plants - certainly an underestimate of the actual diversity. In the three local kelp beds (SOK, San Mateo kelp and Barn kelp) we have recorded 384 species of animals and 36 species of plants. Kelp beds are highly productive of sport fish, including the highly valued kelp bass.

Kelp plants grow very rapidly, and as plants die, or parts of plants break off, they produce food for bottom-dwelling animals. In December 1978, for example, SOK produced an estimated 9 tons of detritus per day.

San Onofre is in an area where kelp beds are (now) rather scarce. However, the local beds maintain ecological continuity between the more extensive beds to the north and south.

Historically, San Onofre kelp bed has exhibited two states: (a) the "normal" state in which much of the available rocky substrate is covered by kelp as is now the case, but the degree of cover varies; (b) periods following catastrophic die-offs of adult plants, during which the bed is non-existent, at very low coverage, or is recovering.

Predictions

(1) It is likely that SONGS Units 2 and 3 will alter the normal state by reducing the density of kelp plants in the offshore portion of the bed. This is the major area of the bed. The reduction could be very small or very large. There are several confounding factors which prevent us from stating a most likely extent of reduction in abundance at present.

(2) SONGS probably will lengthen the periods during which the bed is absent, or very sparse, following catastrophic die-offs.

(3) We expect to see some reduction in the abundance of shrimp species in the canopy in a portion of the kelp bed. No quantitative prediction is possible. This change could alter the diets of fish in the bed.

Mechanisms

Turbidity: SONGS will affect the bed mainly by increasing the turbidity downstream from the points of discharge. This increase will be small in summer, but in spring it is predicted to lower light levels in the water column. The reduction at the bottom in the offshore portion of the bed is predicted to be about 40%. The lower light intensities that result will probably reduce the frequency of successful recruitment of young kelp plants. It is also likely to reduce the growth of kelp plants. Both effects are likely to reduce both the biomass of kelp in the bed and the number of plants.

Fouling: SONGS' plumes are also likely to increase the degree of fouling of kelp plants by various invertebrates that settle on to and live on kelp. Increased turbidity, and perhaps turbulence, are among the mechanisms that could increase fouling. Fouling is likely to 1) decrease the rate

of kelp growth, 2) increase the rate of loss of parts of the plant, and 3) perhaps increase the death rate of plants.

Sea Urchins: Urchin populations may also be increased because SONGS will increase the supply of particulate organic matter that the urchins can use as food. Our studies show that urchins kill a large fraction of kelp plants in parts of the bed, and they probably also interfere with recruitment by grazing on small, young kelp plants.

Sedimentation: The operation of SONGS is not expected to alter the sedimentation rate in SOK.

Temperature: Temperature changes caused by the SONGS plume will be small and are not likely to affect the bed significantly.

Nutrients: Part of the time, the concentration of nutrients may be somewhat increased in the water surrounding adult kelp plants, as a result of upwelling via entrainment. This may increase the growth rate of kelp plants.

Competitors: When kelp is removed from the substrate other plants and animals can grow in its place. These organisms may prevent or slow the recolonization of kelp, by taking up the space. Although we have information on these organisms, it is not possible to predict whether SONGS will significantly influence these interactions.

Toxic Substances: During the course of the studies at SONGS, circumstantial evidence has been found for the existence of toxic materials in the discharged water from Unit 1. We can make no definitive statement as to whether or not such toxic substances will be discharged by Units 2 and 3, except that chlorine will continue to be used on an intermittent basis.

MYSIDS

Introduction

Mysids are small shrimp-like creatures that live in shallow water just above the ocean floor, or amongst kelp canopy and other benthic algae. At night some of them rise several meters into the water column, and at this time they are more likely to be entrained by SONGS. Unlike true plankton, they can swim against weak currents, and so can maintain their position to some extent.

Mysids were chosen as a target organism for several reasons.

1) They have similar biology to a number of other groups of "hypoplankton" that live close to the bottom.

2) They are important food items for a number of fodder fish (e.g. queenfish), which in turn are fed on by sport and commercial fish.

3) Like a number of plankton species, some mysid species live only close to shore and will be taken into the SONGS cooling system and will also be transported offshore by the diffusers. However, since they have a longer generation time than plankton, they are likely to recover more slowly from such extra mortality, and are therefore more likely to show local depressions in density. Mysids are therefore expected to be a good "marker" group for the effects of SONGS.

Predictions

1. Our mysid studies indicate that we should see a reduction in density of about 50% for several kilometers away from SONGS, and smaller depressions on the order of 10 km long. There are several factors that prevent us from

being certain about these effects. First, we are forced to make assumptions about the numbers killed by the diffusers, since we cannot measure this loss. Second, we do not know how strong compensation will be.

2. SONGS intakes will kill several billion mysids per year, weighing 50-60 tons. The diffusers could kill several hundred tons of mysids. If, for example, 10% of those entrained by the diffusers were killed by being carried offshore to unfavorable habitat, the annual kill would be rather less than 200 tons. We are unable, at the moment, to give a most probable estimate of diffuser losses.

Mysids constitute about one-half of the total of epibenthic organisms that are subject to entrainment. A similar mortality rate for all of this group would thus give an annual kill of all organisms of this type of about 350 tons.

If these 350 tons were lost to the fodder fish, we could expect an annual loss of fodder fish production on the order of 30 tons. However, the MRC fish study group believes that much of the mysid biomass killed and moved offshore will be eaten by these same fish species in the region of the diffusers. Some mysid material will, of course, fall uneaten to the ocean floor. There it will join food webs that lead in part to benthic fish. These food webs are less efficient than the mysid → fodder fish chain, so we could expect some overall loss of fodder fish production, although much less than 30 tons per year. We do <u>not</u> predict, therefore, that the mysid losses will have a significant effect on sport and commercial fish production.

PLANKTON

Introduction

The plankton is made up mainly of small drifting organisms that are generally moved about passively by currents. Phytoplankton are single-celled plants that form the basis of most animal production in the oceans. Zooplankton are small animals, some of which can swim actively and control their movements to some degree. They include the meroplankton, such as clam larvae, which are the planktonic stages of bottom-dwelling organisms, and holoplankton, which spend their entire life in the plankton. The predictions focus on the plankton as a balanced indigenous community, and as food for fish.

Predictions

1. The plankton studies have established that some zooplankton species are restricted close to shore (within 3-4 km), and it is probable that SONGS will reduce the local density of this group. It is probable that there will also be changes in the relative abundance of species in the zooplankton assemblage in the inner nearshore zone. The magnitude and extent of these changes cannot be predicted, and will depend on mixing rates, the ability of the populations to compensate, and on interactions between species. As an indication of the likely scale of the effects, we expect them to be somewhat less extensive than the predicted mysid effects.

2. SONGS' intakes probably will kill on the order of 10 trillion of the larger zooplankton per year, weighing about 1200 tons. Most of the zooplankton withdrawn at the intakes will enter the benthic food chain and will be lost as a direct food source for fodder fish. The fate of these diverted zooplankton is discussed in the Soft Bottom Community predictions.

We cannot yet estimate precisely the kill of plankton entrained by the diffuser plumes. If 10% of those entrained were to be killed by being moved offshore to unfavorable habitat, the annual kill would be on the order of 4000 tons. This transported plankton will be eaten largely by the same species of fodder fish that would have eaten it inshore, before SONGS began operation. We therefore do not expect to see significant changes in the overall abundance of fodder fish or sport and commercial fish as a consequence of this shift in biomass.

3. About half of the time, the diffuser discharges will bring to the surface, offshore, relatively nutrient-rich water from closer to the shore and nearer the bottom. We estimate that this will result in the annual production of an extra 84,000 tons of phytoplankton in the mid or outer near-shore waters. The fate of this extra biomass is discussed in the Fish predictions.

SOFT BOTTOM COMMUNITIES

Introduction

The soft benthos community is made up largely of invertebrates (worms, clams, crustacea, etc.) that live in and on the sand, silt and mud bottom. These bottom types cover roughly 80% of the area in the general San Onofre region. The distribution and abundance of these species is strongly influenced by the physical characteristics of the sand, silt and mud and by the amount of food material in the area. The communities close to shore (out to a depth of about 10 meters) are less diverse and less abundant than those further offshore. Most of the species are planktonic in their early stages. Although these communities are not as productive of fish, on a per area basis, as are reefs and kelp beds, because they are so extensive they help to support large populations of fodder fish and hence of sport and commercial fish species.

Predictions

1. SONGS Units 1, 2 and 3 will alter the bottom sediments. Close to the diffusers (within 1 km) the sediments will be coarsened and enriched. Beyond this area, in a pattern and at distances that we cannot yet predict, the sediments will become somewhat finer, and they will be enriched. The general result of these changes will be an increase in the abundance, number of species, and, probably, in annual production of biomass in the enriched region.

2. SONGS could have a negative influence on the soft benthos community by killing some of the organisms that live on the bottom but that occasionally rise into the water column. (This group of organisms bears a broad similarity

to mysids.) It will also reduce the number of larvae of some species available for settlement, by killing the early stages that float in the plankton. This could affect the adult density of some species, especially those living in the intertidal and shallow water zones. Among this group, lobster is a sport and commercial species. However, too little is known about the population dynamics of the early stages to hazard a prediction about possible effect on adult densities. We suspect it will not have a significant effect on the overall production of the community.

3. The enrichment of the soft benthos is not expected to influence the production of sport and commercial fish.

HARD BOTTOM COMMUNITIES

Boulders and reefs near SONGS are covered by a variety of organisms in addition to kelp. These include smaller species of algae and sedentary animals that permanently attach to the rock surfaces. Apart from their intrinsic value as part of the community, these organisms provide both a source of food for fish and important habitat structure, and they may compete for attachment surfaces with kelp.

There are distinct inshore (intake depth) and offshore (around SOK depth) communities. Turbidity is higher inshore, and inshore species are more tolerant of this higher turbidity. They also grow more rapidly than offshore species. It is thus possible that increases in turbidity in the offshore portion of SOK will lead to a change in the community such that inshore species will tend to replace the resident offshore species. Conceivably these inshore species could also slow the recruitment of kelp by outcompeting it for space.

While these possibilities exist, there is no strong evidence to suggest they will occur.

RATIONALE

E-16

FISH CONTENTS

In this section on fish we do not give a separate rationale for each prediction, since the same types of analyses underlie predictions 1 and 2.

A. The affected fish species

SONGS Units 1, 2 and 3 are most likely to have a significant effect upon fish species that live as adults mainly nearshore (within about 4 km of shore), and that produce planktonic (drifting) eggs and larvae in the same zone. Most species of fish in the SONGS area are of this type. However, most individuals, and most of the total tonnage of fish are Northern anchovies. Anchovies also extend well offshore. There are several hundred billion anchovies in the California Bight, they move enormous distances, and SONGS will not significantly affect the population of this abundant species, although the Plant will kill large numbers of anchovies. They are not considered in most of the analyses below (but see Section I), which concern nearshore species only. A numerically small group of nearshore species either carry their young internally, or have planktonic larvae but lay attached, not free-floating, eggs. This group is also excluded from subsequent analyses.

We will be concerned mainly with those nearshore fish species that produce both planktonic eggs and planktonic larvae. These species fall into one of two groups. (1) Forage or fodder fish. These species eat plankton, small bottom-dwelling organisms, mysid shrimps, etc., and are themselves food for sport and commercial species. The major species in this category are queenfish (Seriphus) and white croaker (Genyonemus).

(2) Sport and commercial fish are the second group. Among nearshore species, halibut and white seabass are the main commercial species while kelp bass and sand bass, and halibut, are the main sport species. These four

species made up over three-quarters of the 1975 sport and commercial catch of nearshore fish in the fish blocks near SONGS.

B. Mechanisms

There are six known or suspected mechanisms through which SONGS can affect fish populations. These are:

(1) Killing juvenile and adult fish as they are taken into the intakes of the cooling system (via impingement and entrapment).

(2) Killing planktonic eggs and larvae that are taken into the intakes.

(3) Killing planktonic eggs and larvae that are caught up (entrained) by water jetting out of the discharge or diffuser systems.

(4) Loss of fish from special habitats (e.g. kelp).

(5) Loss of fish food that is moved by the cooling system.

(6) (Sub)lethal effects of discharged organochlorines.

We have no evidence that mechanisms (5) and (6) will operate to affect sport and commercial fish production, and they will not be discussed further in this Report.

C. Estimation of probable losses of fish

(1) Direct kill of juveniles and adults in intakes

Unit 1 kills, on average, 16.7 tons of fish per year. The fish are disposed of on land. Of these fish, 10.2 tons are fodder fish, 2.5 tons are electric rays (which are of scientific and economic importance), 2.4 tons are nearshore sport and commercial fish species, and 1.6 tons are other species.

The intake structures of Units 2 and 3 have been modified to reduce the fraction of fish taken in by the intakes. In addition, a fish-return

system has been devised to return those caught back to the ocean. This system has not been tested. The MRC fish study group feels that the fish-return system is likely to kill or fatally injure most fish that pass through it. If the new systems are 50% efficient, the total intake mortality will triple. If they are completely inefficient, total intake mortality will increase about 5-fold since all three structures provide about five times as much attractive "reef structure" as Unit 1. (The volume of water taken in by all three units will be six times that taken in by Unit 1.) If the fish-return system is not more than 50% efficient, the annual impingement fish kill will fall between 3 and 5 times that of Unit 1, or 50-84 tons, of which 7-12 tons will be near-shore sport and commercial fish. This is equivalent to 4-7 tons of nearshore sport and commercial fish <u>production</u>.

The losses to Unit 1 already produce measurable effects on queenfish. The population of this species within ½ km of the intake (and perhaps as far as 2 km) has fewer young fish and fewer females than more distant populations. Young and female fish are precisely the groups taken in selectively by the intakes. Two-thirds (by weight) of the fodder fish taken in are queenfish. Some 31-51 tons of fodder fish will be impinged. These fish would otherwise have contributed 25-41 tons of fodder fish <u>production</u> (Table 1).

(2) <u>Killing of planktonic fish eggs and larvae in intakes</u>

Most nearshore species spend 2-4 months as planktonic eggs and larvae and throughout this stage can be caught up by the intakes or diffuser water. This is the major source of mortality. It is estimated by a somewhat complex procedure involving a model of fish mortality, and we describe the methods only briefly. There are a number of steps in this procedure.

(a) The density of eggs and larvae of various ages, in water at various depths and distances offshore, is estimated from samples. (There is a tendency for older larvae to occur inshore and nearer the bottom, at diffuser and intake depths.) Next, the rate at which SONGS will withdraw water from each of these locations is estimated (from a model of SONGS hydrodynamic behavior). This gives the <u>number</u> of eggs and larvae that will be entrained. Finally, an assumption is made about the fraction of entrained eggs and larvae that will be killed. All of those passing through the intake are assumed to die. (Similar calculations can be made for those caught up by the diffusers, but we cannot yet estimate the fraction of those taken up that will be killed.)

These various estimates allow calculation of the expected number of eggs and larvae that will be killed per unit time (say, each day), immediately after the Plant is turned on (Fish Appendix 1).

We cannot assume this kill rate will continue indefinitely. For example, some water that has been affected by the Plant may remain in or return to the vicinity and mix with "new" water that moves into the area. When this happens, the local density of eggs and larvae will be lower than elsewhere, and fewer eggs and larvae will be killed per unit time.

A detailed model of the current regime in the SONGS area could be used to estimate the rate of replenishment of water in the area, and hence the local density of eggs and larvae exposed to SONGS. Such a model was not available when the present calculations were made.

(b) Instead, a model was used that simply assumed that SONGS will draw eggs and larvae only from some specified region along the coast. Inside this region, all eggs and larvae are assumed to be equally vulnerable (good mixing

is assumed). No egg or larva outside the region can be killed by SONGS and no eggs or larvae can leave the region. The model has the following features (Fish Appendix 1):

- Eggs are produced in this region at a constant annual rate that is the same as elsewhere. (This is essentially the conservative assumption that, even if SONGS kills many plankters and subsequently lowers adult density in the region, reproductive fish will move in from elsewhere.)

- The model calculates the chance that an egg or larva of a given age, within the region, is killed by SONGS before it reaches the next age class (which is 2.5 days older). This is done for all age classes up to the point when the larva becomes a juvenile (4 months in queenfish, for example). Since eggs and larvae die off extremely rapidly due to natural causes, most of them are not killed by SONGS but die of natural causes. This natural death rate is taken into account by the model.

- The chance of any individual being killed by SONGS before it moves out of its age class depends on the size of the region chosen (the chance is smaller when the region is bigger because within 2.5 days a smaller fraction of the water in the region passes through SONGS). Clearly, if a very small region is chosen, a given individual can be exposed to risk on different occasions since the same parcel of water passes through SONGS many times. In this case, the density is rapidly depleted, the fraction killed is high, and most larvae do not grow very old. On the other hand, the number killed is somewhat smaller.

- Since the natural mortality rate is high, there are always far fewer older larvae than younger larvae and eggs. This is reflected in the predicted

SONGS kill. For example, under one set of assumptions, SONGS will kill in a year 16 billion eggs and 4 billion larvae of nearshore fish.

Clearly the choice of the size of the "affected region" is somewhat arbitrary. Choosing a very small region (say 1 km) is equivalent to assuming virtually no currents along the shore, and hardly any replenishment of the waters around SONGS by "new" water. This will overestimate the degree of local suppression, but will underestimate the number killed - larvae from elsewhere that in reality would get to SONGS are not counted. On the other hand, choosing a very large region (say several hundred kilometers long) is equivalent to assuming that fish eggs and larvae move huge distances in their lifetimes. This would maximize the number killed, but (especially since thorough mixing is assumed) it would spread the effect out very thinly. We feel that this latter scenario is closer to the real situation. 50 km was chosen as a compromise between smaller regions within which complete mixing can be assumed, and larger regions within which all doomed fish larvae are certain to have been produced. SONGS <u>will</u> kill billions of eggs and larvae, and the degree of movement of eggs and larvae will determine whether there is a pronounced local depression or a less obvious, but much more extensive, depression. If there is no re-entrainment of "old" water by SONGS, a choice of 50 km will underestimate the number of eggs and larvae killed.

The result of the model's calculations is a predicted number of eggs and larvae killed per year (breeding season) in each age class.

(c) These predicted losses of eggs and larvae are then converted into an equivalent number of 13 month old fish (Fish Appendix 1). (An age of 13

months is chosen primarily because this corresponds in size to that of the average fodder fish eaten by sport and commercial fish.) The idea involved in calculating 13 month old equivalents is as follows: an egg has roughly 1 chance in a million, under natural conditions, of becoming a 13 month old adult. Therefore, if SONGS kills an egg, this is equivalent to killing only one-millionth of a 13 month old fish, because in all likelihood the egg would have died anyway. However, if SONGS kills a 4 month old larva it has killed the equivalent of .4 of a 13 month old adult, because a 4 month old larva under natural conditions has a 40% chance of becoming a 13 month old adult. It is predicted that SONGS will kill the equivalent of several million 13 month old adults of nearshore fish species.

At the moment, age distributions of larvae are available for only the two major fodder fish species. To estimate losses of sport and commercial species we have therefore assumed that, averaged over the season, the sport and commercial species have the same age distribution as these two fodder fish species. The estimates of sport and commercial losses owing to larval mortality therefore are based on this, as yet untested, assumption.

(3) Diffuser losses

(a) Turbulent shear losses

There is evidence from the literature that fish larvae die when they are subjected to shear forces on the order of several hundred dynes/cm^2 over a period of several minutes. Losses due to this mechanism were estimated in two steps (Fish Appendix 1). First, the fraction of secondarily entrained water that is likely to be subjected to shear forces on the order of 100/cm^2, or greater, was calculated. Second, the number of larvae subjected to this

stress was estimated from known larval densities and from the estimated amount of water entrained. These calculations suggest that only a relatively small number of larvae will be killed in this way.

(b) Translocation losses

Nearshore fodder fish larvae show a very clear pattern, in which density falls off very rapidly several kilometers from shore. The pattern suggests that larvae that are carried farther offshore die. During some parts of the year, SONGS' diffuser plumes are expected to move some inshore water to an area 5 km or more offshore.

The larvae of sport and commercial fish species extend from close to shore to about 7 km offshore. We therefore do not expect SONGS to cause translocation mortality in this group.

At some times of the year, especially when they are older and "more valuable", the larvae of both queenfish and white croakers do not extend beyond 2 km from the shore. We therefore expect large translocation losses of fodder fish larvae, but we are not able to make a quantitative prediction. Some idea of the possible magnitude of these losses can be gained by noting that if 10% of larvae entrained by the diffuser plumes were to be killed, total fodder fish losses would roughly double.

(4) Losses from damage to kelp bed

Damage to the kelp bed and its biota may be anything from negligible to extreme (see Kelp Predictions).

D. Conversion of losses to biomass (weight of standing stock of fish)

The losses of 13 month old "adult-equivalents" were divided between sport and commercial fish and fodder fish according to the frequencies of these two

types in the larvae affected. Among nearshore planktonic spawning species, in general, four-fifths of the larvae are fodder fish and the remaining one-fifth are sport and commercial fish. However, their relative frequencies vary with proximity to the shore and with position in the water column, and these differences were taken into account.

Next, numbers lost were converted to a weight (biomass) for each group (sport and commercial fish live longer than fodder fish and are larger, so the conversions are different) (Fish Appendix 1). The idea here is that, once SONGS has been operating for several years, 1, 2, 3, . . . year old fish are all affected and each year there will be an average loss of fish weight, spread over all ages, in each species.

E. Conversion of losses to annual production

Each year, each fish population produces a certain tonnage of "new" biomass, through reproduction and growth. In a perfectly balanced fishery, each year this same amount of tonnage would be consumed - by natural deaths plus the fish harvest. The annual production of a typical sport and commercial population is reckoned to be about 60% of the standing stock (biomass). Thus, when the equivalent of 100 tons of sport and commercial biomass is lost as larvae and eggs, this is equivalent to a loss in production of 60 tons. Similar calculations are possible for fodder fish, where the figure is thought to be 80%.

F. Conversion of fodder fish losses to sport and commercial losses

Sport and commercial fish depend predominantly on fodder fish and, since the biomass of the latter is expected to be reduced, there should be less food for sport and commercial fish. It is difficult to know how to estimate the

effects on sport and commercial species of this predicted loss of fodder fish production. A standard rule of thumb is to assume that 10 pounds of fodder fish production yields one pound of sport and commercial production - a 10% "transfer efficiency". However, if sport and commercial fish population are being held at relatively low densities, say by fishing (Section G), then changes in food supply may have little or no effect on their production. In addition, the fodder fish losses may be partly or largely compensated for (see next section). These considerations suggest that 10% is too high a figure. We think it unlikely that sport and commercial fish production is totally unrelated to fodder fish production, and so assume a 1% relationship as a lower (and more likely) bound.

G. Compensation and declines in nearshore fish species

It is possible that reductions in larval fish density caused by SONGS would lead to higher survival of the remaining fish larvae (for example, by making more food available to each larva). There is, at the moment, no good evidence for such compensation in marine larval fish, and there are a priori reasons for suspecting such compensation would at best be weak. First, fish larvae are already very sparse. Second, it is likely that "chance" (density independent) factors dominate the mortality of these small organisms. Third, much of their food will be killed along with the larvae themselves.

Another possibility is that juvenile or adult fish might survive, grow, or reproduce better in response to lowered density of juveniles. We think this is possible for fodder fish because there is no evidence that their numbers have been declining. However, we think it unlikely that compensation in nearshore sport and commercial fish would be adequate in the face of significant

extra mortality. The main reason for this view is that these species appear to have declined in Southern California since the mid-60s (Fish Appendix 1).

The evidence for declines in nearshore sport and commercial fish species is by no means unequivocal. We have to rely on indirect measures of fish stocks. The major evidence is from California Department of Fish and Game records of sport and commercial catches. These suggest strongly that halibut, in particular, has declined, that kelp bass and sand bass may have declined, and that the more desirable nearshore sport and commercial species as a group have declined.

Several arguments can be made against these conclusions. Counter-evidence, together with comments, is as follows:

(1) Populations fluctuate naturally, and these species showed strong declines in the 1950s, followed by a recovery.

Populations do fluctuate. But this is not evidence that current declines are "natural" and can be ignored. The declines in the 1950s, for example, may have been caused by loss of kelp bed habitat, and DDT in the Bight, and these two mechanisms are now diminished.

(2) Catches of fish in power plants do not show clear evidence of declines.

However, the data from impingement by power plants suffer several defects. First, such data are highly influenced by catchability of fish (which is influenced by annual variations in the weather), as well as by their density. They usually are available for only a few years in the 1970s, and such variations in catchability could easily obscure real trends. Second, the data are extremely variable, and this could obscure trends over this short period.

Third, the data are for only the 1970s, often not for the whole decade, and the Fish and Game data show that the decline was most precipitous in the mid to late 60s and has been rather slight in the 1970s. (The Fish and Game data are much less variable than the Power Plant data, especially in the 1970s.) Thus, we would not even necessarily expect to see a decline in these Power Plant data.

On balance, we believe the data support the conclusion of a decline in desirable nearshore sport and commercial fish.

H. On-shore off-shore water movements

The predictions have not taken into account the possibility of large scale onshore and offshore movements of water. (MRC is now measuring this phenomenon.) Such movements could create "circulation cells" that would slow down the longshore movement of eggs and larvae (although it is possible that, by choosing water layers, larvae could escape from such cells). This would reduce the estimated loss of larvae, but would create a more detectable local depression in larval density around SONGS.

I. Upwelling caused by SONGS

Some of the water entrained by SONGS' diffusers will come from below 7 m depth. Water at this depth in the region of the diffusers is rich in nutrients, but has low light levels, so that it produces little phytoplankton. The diffuser plume will generally move this (and other inshore water) closer to the surface, where there is more light, and farther offshore. This will result in an absolute increase in phytoplankton production in this region.

We estimate (Fish Appendix 2) that, each year, some 84,000 tons of additional phytoplankton will be produced. Most of this will be eaten by

zooplankton. Although it is not possible to say exactly how this production will pass up the food chain, a reasonable estimate is that half of the phytoplankton will be eaten by microzooplankton, then by macrozooplankton, and then fodder fish. The other half of the phytoplankton will be eaten by macrozooplankton, and then by fodder fish. In this region (roughly 3½ km offshore) the major fodder fish is the anchovy, and most of the new production should pass to this species. A transfer efficiency of 10% would produce, in tons of fodder fish:

$$[4.2 \times 10^4 \times 10^{-2}] + [4.2 \times 10^4 \times 10^{-3}] = 460 \text{ tons.}$$

During these transitions the new production (as phytoplankton and zooplankton) will be moved away from the area of production and thoroughly mixed. The anchovy population is also extremely mobile and well mixed, so this production of anchovies would be expected to be spread over a very large fraction of the Bight population.

460 tons is a miniscule fraction of yearly California anchovy production, which is about 1-2 million tons. We believe it would not result in any real increase in yield to sport and commercial fish. It should be remembered that we have made a similar argument for ignoring anchovy losses: each year, SONGS will kill on the order of 10 times as many anchovy larvae as other fodder fish larvae, and the fodder fish losses themselves are equivalent to more than 300 tons of production, but we predict no effect from these losses. Clearly, in "production equivalents", the anchovy losses are much greater than 300 tons, but we believe it is sensible to assume that perturbations of this order, spread over the whole anchovy population, will have no effect on adult anchovy standing stock, and hence production.

As discussed in Section F, the transfer efficiency from fodder fish to sport and commercial fish probably lies somewhere between 1% and 10%, and we have argued it is likely to be close to 1%. If the increase in anchovy production <u>were</u> to be passed on, we would expect it to produce an extra 5-46 tons of sport and commercial fish, and believe the lower figure much more likely. Most of this production would <u>not</u> be in nearshore sport and commercial fish, since the mass of the anchovy population is offshore.

KELP CONTENTS

I. Biology of Kelp

We begin by looking at the basic population dynamics of the San Onofre kelp bed.

(A) "Normal" conditions

It appears that, even in the absence of catastrophic events, the kelp bed is rarely in a "steady-state" or equilibrium condition. It is instead dominated by physical and oceanographic conditions that are highly variable. In the present study (1976 to 1980), only by the end of 1979 did SOK cover most of the cobble substrate available. Naturally,the amount of kelp (number of plants and areal extent) on any section of the bed fluctuates in response to changes in bottom conditions, storms that tear adult plants from their sites of attachment, water temperature, availability of light and nutrients, grazing by sea urchins and probably fish, fouling, and periodic recruitment. Patches of kelp within the bed increase and decrease and even disappear and reappear under normal conditions.

Recruitment of new plants is a major dynamic event that is episodic, in response to seasonal and annual variation in physical and chemical conditions. It appears that recruitment occurs, on average, only once every three years. (However, recruitment rate has been examined, in this and other studies, for a total of only 12 years or so.) Although kelp has a complex life cycle (Figure 1), for present purposes there are only two important processes affecting recruitment of adults: (i) the ability of the tiny male and female stages (gametophytes) to reproduce and hence produce the microscopic first stage of the actual kelp plant (sporophyte); (ii) the ability of juvenile plants to grow up into adult kelp plants. Experiments have shown that light

is an essential factor (but not the only factor) controlling these two processes.

We need to look briefly at the dynamics of the life cycle.

(1) Reproduction, and recruitment of juvenile plants

The adult plants produce minute propagules (zoospores) that settle on the bottom and become either tiny male or female stages called gametophytes. Each adult plant produces extremely large numbers of these propagules, perhaps continually throughout the year. Thus it is probable that there are gametophytes present, most of the time, in abundance, on suitable areas of the bottom close to adult plants. The critical factor is the occurrence of a combination of suitable physical conditions (including, at least, adequate light and nutrients) that allow gametophytes to reproduce. The gametophytes that do reproduce, produce microscopically small kelp plants. This type of life cycle is known as alternation of generations. In kelp the microscopic gametophytes are the sexual stage. The sporophyte (the actual kelp plant) is the asexual stage. It is also microscopically small to begin with, but passes through juvenile and subadult stages to become the massive adult kelp plant.

Gametophytes are killed by a variety of factors - abrasion, burial by sediments, and grazing by animals - and only a small fraction of them survive to produce sporophytes (Kelp Appendix 1, p. 150). Even so, after a successful reproductive "set", there are thousands of tiny sporophytes per square meter of cobble substrate. Unfortunately, it is extremely difficult to study these microscopically small plants in natural conditions. Quantitative studies have been done only on larger plants that have reached a height of

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more than 10 cm (4 inches). At about 40 cm (16 inches) the plant becomes a juvenile (Figure 1). Once again, a variety of factors kill most of the sporophytes before they become juvenile plants.

It appears that the physical environment affects these processes in the following way. Reproduction by gametophytes requires adequate light and, probably, a high concentration of nutrients in the bottom water. When these conditions prevail, the gametophytes absorb sunlight and nutrients each day, until they mature to a reproductive condition. Field experiments show that very few sporophytes ever appear from gametophytes planted out more than 40 days. Thus, in the field, 40 days apparently is the maximum period during which this stage can accumulate the sunlight needed for survival and reproduction. Over this period they need an average of at least .43 Einsteins per m^2 per day (Kelp Appendix 2, p. 5). (Under good field conditions it is likely that the average successful gametophyte manages to accumulate enough light in about 20 days.) The critical question for sporophyte recruitment, in any given year, is therefore: during the period in which gametophytes are present, what is the probability (a) that enough light can be accumulated during at least one 40-day period (called a "light window"), and (b) that nutrients are also adequate during the light window?

It appears that these two conditions co-occur only rarely. (a) The frequency of light windows varies with the situation. In a very sparse part of the kelp bed, where adults were absent and vegetation had been cleared, all of the spring season consisted of light windows (Kelp Appendix 3, Table 1, p. 5). However, in darker portions of the bed, where adults are present in abundance, none of the 40-day periods appeared to have received adequate light

on the bottom. With a light understory of other algae, and heavy adult canopy, about 30% of 40-day periods were light windows on the bottom.

(b) It appears likely that nutrients are adequate only during periods of upwelling. In any given spring these periods last for only a few days, and occur not more than a few times per season (Kelp Appendix 1, Figure E1, p. 260).

Suitable conditions for reproduction occur mainly in the spring, although occasionally also in the fall. It appears that adequate conditions for reproduction occur, on average, only once every three years (Kelp Appendix 2). At any one time the bed is thus generally dominated by a "cohort" of adult plants from a single episode of reproduction.

As discussed below, SONGS is predicted to decrease the frequency at which conditions become suitable for reproduction. We cannot predict whether or not SONGS will affect the number of sporophytes or juvenile plants that arise from any given successful reproductive set. It is likely, however, that some factors will not have much effect on the number produced:

(a) Each adult plant produces enormous numbers of gametophytes. Thus, unless the density of adult plants is catastrophically reduced, we assume that there will be enough gametophytes present to replenish the bed even when adult density is low. (This is equivalent to assuming there is density "compensation" in the survival of these small stages.) There must be some very low density of adult plants at which replenishment through a single reproductive set is not possible, but we make the conservative assumption that it is very low, lower than is encountered during "normal" conditions.

(b) With respect to light levels, reproduction is all-or-nothing. When adequate light is available, the number of tiny new plants (sporophytes) produced is independent of the light level. The number produced appears, instead, to be associated with the amount of nitrogen in the bottom waters, and this is not expected to be affected by SONGS.

The survival of sporophytes to the juvenile stage is determined by a range of factors (abrasion, sedimentation, grazing).

(2) Survival from juvenile to adult stage

Juveniles frequently suffer a higher death rate than adults (Kelp Appendix 1, pp. 93 and 95), so anything that prolongs the juvenile stage will reduce both the eventual number of adults and the average density of kelp plants. Light affects the growth rate, and so does fouling. These factors are discussed later.

The growth rate of juvenile kelp plants is highly variable. Some plants in a group develop from juvenile to adult in less than three months, while others take more than 13 months. The survivorship from juvenile to adult stage is also highly variable, and depends on, among other factors, both the initial number of juveniles and the number of adults present. The fraction surviving tends to be higher when (a) fewer juveniles are present initially (Kelp Appendix 1, p. 82), and (b) fewer adults are present (Kelp Appendix 1, p. 84, and Kelp Appendix 2, p. 10). These relationships reflect an important result: except when very low densities of juveniles are present, the final number of adults present is roughly constant. (This means there is strong "compensation" or "density-dependence". If some factor reduces juvenile density, the number of adults produced may be relatively unaffected.)

(3) <u>Summary of "normal" kelp population dynamics</u>

A final piece of information completes the picture of "normal" kelp bed population dynamics, namely that the average adult plant survives for about 12 months (Kelp Appendix 2, p. 11). That is, if we start out at some point in time with a cohort of adults produced by a successful reproductive "set" a year or more earlier, we can expect roughly half to die within 12 months. By the end of two years roughly 25% of these adults will remain alive, and by the end of three years, roughly 12½% will remain alive. At this time, <u>on average</u>, we could expect another cohort of adults to appear. In reality, of course, the dynamics would not follow this average pattern, but would vary around it. For example, deaths occur mainly in winter storms, which vary in their severity from year to year; again, reproductive sets will sometimes be spaced one or two years apart, and sometimes four or five years apart.

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The <u>number</u> of kelp plants in the bed thus fluctuates, rising rapidly after a successful recruitment event, and declining thereafter. However, the canopy area of the bed will not clearly follow this pattern since the surviving plants will continue to grow. The canopy area can thus increase even though the number of plants may be decreasing.

(B) Catastrophes

We know little about the frequency of catastrophes in the SONGS area before the 1950s. Certainly the kelp beds in the general area were more extensive and continuous when they were observed at various times earlier in the century than they have been since (Kelp Appendix 1, p. 12). It is likely that much of the cobble in this area has been covered by sediments since then. We do not know, however, if the beds were severely reduced between the infrequent

observations made before 1950.

Two catastrophic die-offs have occurred since 1956 (Kelp Appendix 1, p. 12). The first, in 1958-59, was associated with high summer temperatures (but may have been caused by associated low levels of nutrients). At this time 90% of Southern California kelp beds were destroyed. SOK was not re-established for a period of 12 years (by 1972). In 1976, again a year of unusually high temperatures, SOK suffered a partial die-off, being reduced to less than 10% of its former extent, and only in the offshore segment did plants remain. Recruitment occurred about a year later, and recovery of the canopy took almost two more years.

There are two means by which kelp disperses and, hence, beds recover or become re-established. First, the adult plant casts its microscopic offspring varying distances. Many offspring probably fall very close (a few meters) to the plant. (Observations at SOK show that some offspring may be dispersed one or two hundred meters from the bed, but we do not know if these were offspring from plants attached in the bed, or from plants that became detached and drifted from the bed.) Secondly, adult plants, torn loose in storms, drift and sometimes cast spores on suitable substrate far from their point of origin. Re-establishment of a bed therefore depends on chance events, and seems more likely when a source of "colonists" is close by. This is one reason why the longshore continuity of beds is important. Recovery of a kelp bed that has been drastically reduced, but not exterminated, depends mainly on local reproduction. Observations at SOK, in the very successful reproductive season of 1978, suggest that a large "set" of new plants can arise from quite a sparse kelp bed, and that recovery can be rapid if the catastrophic

die-off is followed quickly by successful recruitment. By contrast, the 1958 catastrophe suggests that major catastrophes can be followed by very long recovery periods because no or extremely few plants survive locally.

II. Estimating the Effects of SONGS Units 2 and 3

(A) Predicted effects on kelp reproduction

The two major factors affecting reproduction are light and nutrients. Increased turbidity caused by SONGS' discharge will reduce the light in SOK during spring, the main reproductive season. The probable effects on reproduction were estimated by first calculating the expected reduction in light and, second, by calculating how this should affect reproduction. SONGS is not expected to alter nutrients on the bottom, where reproduction occurs.

The probable levels of light that will prevail in the kelp bed once Units 2 and 3 are operating were calculated in four steps (Kelp Appendix 1, pp. 222-241, and Turbidity Appendix). First, ambient light levels near the bottom were recorded. Second, a computer simulation model of water movements near SONGS, including those caused by SONGS' intake and diffuser systems, was developed. This was based on information obtained from current meters placed in the ocean near SONGS, and from a physical model of SONGS-induced water movements produced for Southern California Edison. Third, measurements of natural turbidity levels were made in spring and summer. This information allowed prediction of expected levels of turbidity in the kelp bed for these two seasons. Finally, measurements of light and turbidity levels in the field yielded a strong quantitative relationship between light and turbidity. The calculations predict (conservatively) that in spring, in the (most important) offshore half of the bed, subsurface light levels on average will be reduced

by from 25% to 55%, with a roughly 40% reduction being most likely. No significant reduction in light is expected in the already turbid inshore segment. The offshore half of the bed has been the most persistent during catastrophe, has the densest canopy cover, and constitutes 70% of the total SOK canopy cover. Subsurface light will be much less affected in late summer.

A 40% reduction in subsurface light will reduce the number of 40-day light windows, and hence the probability of recruitment. The amount of reduction depends on the prevailing light regime. In a clear part of the bed, where all 40-day periods are suitable, a 40% reduction in light would cut the number of light windows by 20-30%. At other parts of the bed, where light windows are already scarce, the reduction could be close to 100%. We will use a 20% reduction as a conservative estimate, since the most critical recruitment events occur when the bed is sparse and therefore ambient light levels will be high.

To estimate the potential effect of this reduction in underwater illumination on reproduction, a model of reproduction is useful. A crude model, assuming that <u>only one</u> coincidence of adequate light and nutrients is needed to provide successful recruitment in a season, is as follows. In a season of D days, there is, each day, probability w that the day is the first of a light window, probability n that nutrients are adequate, and probability g that there is an adequate supply of gametophytes. The probability that a given day will initiate successful recruitment is then wgn. If 40-day periods can be treated independently, then the probability that at least one day in the season will initiate recruitment is $1-(1-wgn)^D$ (Kelp Appendix 4).

This model can be used to estimate how a reduction in the number of light windows will affect recruitment. Suppose we reduce the number of light windows to a fraction (p) of their original number (in the case of a 20% reduction, $p = .8$). The probability a given day will begin a light window then becomes pw, and our model is $1-(1-pwgn)^D$. We assume that only when SOK is destroyed is $g < 1$, so except when the bed is absent, the model becomes $1-(1-pwn)^D$.

If wgn, or wn, is small, $(1-pwgn)^D \approx 1-Dpwgn$, and the reduction in the probability of successful recruitment will be by a factor close to p. Otherwise the reduction will be less than p. There are three cases: normal SOK population dynamics, SOK absent (when it is destroyed), and SOK reduced (when it is at very low densities).

In normal times there is very little light in the bed and w is small. Furthermore, those partially shaded areas that do provide some windows suffer a greater than 20% reduction in windows. Thus a 20% reduction seems to be a conservative estimate. Note, with $p = .8$, the average time between recruitment events increases by a factor of $1/p = 1.25$. That is, the average time between recruitment events would be expected to increase from about three years to almost four years.

In the absent phase, g is very small, since recruitment depends on the rare event of a drifting kelp plant dropping spores on suitable substrate. Thus a 25% increase in the time to recruitment is a reasonable estimate. Even in the reduced phase, when w is intermediate and $g \approx 1$, n is likely to be very small and the time between recruitment events should increase by 25%.

Overall, therefore, it is reasonable to predict a 20% reduction in the probability of successful recruitment, and therefore a 25% increase in the average time between recruitment events.

(B) Predicted effects on kelp growth and survival

Light and fouling of kelp plants are the major factors that are expected to affect kelp growth. We discussed expected changes in light, above. Here we first describe fouling and then discuss the relationships among light, fouling, and growth and survival of kelp.

Fouling: Several species of small invertebrates settle and attach to kelp plants. Some build tubes from particles in the water, others merely live on the kelp blades. Under normal conditions in SOK, fouling of juvenile kelp plants is rather light, although the fouling organisms are present.

Several experimental studies show that the abundance of these fouling organisms on kelp plants and other surfaces is greater the closer they are to the discharge plume of Unit 1. This increase is caused by (probably several) factors associated with the plume, including increased particles in the water, and increased turbulence which stimulates the planktonic stages of some organisms to settle. It is also associated with lower light levels, but is probably not caused directly by reduced light.

There is evidence (Kelp Appendices 2 and 5) that increased fouling can reduce the growth of kelp plants, and damages them by causing them to lose blades, causing fronds to sink, and attracting fish and other predators.

The relationships between light, fouling and growth were examined in an experiment in which juvenile kelp plants were transplanted to the Unit 1 plume and to other areas in which underwater light levels varied (Kelp Appen-

dix 1, pp. 101-121; Kelp Appendix 2, Table 11; Kelp Appendix 3, p. 6). A multiple regression of growth rate (Δ log length in cm/day), versus irradiance ($E/m^2/d$) and percent cover by Membranipora (a bryozoan that is a major fouling organism), explained 99% of the variance in growth in the experimental juvenile plants at four locations at different distances from the SONGS Unit 1 discharge.

This experiment suggests very strongly that decreases in light and increases in fouling will have a detrimental effect on kelp growth. Unfortunately, the relationships among the three factors (light, fouling and growth) are complex, and this complexity prevents us from making a confident quantitative prediction. The uncertainty arises because (1) the effects of light and fouling on growth are confounded, (2) the relationship between growth and light is different inshore and at SOK, (3) growth and light do not always show a consistent relationship, and (4) we cannot predict quantitatively how fouling will change at SOK.

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(1) Lower light was always associated with greater fouling in this experiment, and so we cannot tell how much of the reduction in growth was caused by each of these factors. Fouling alone explained 95.3% of the variance in growth, and light explained 99.5% of the remaining variance, a significant fraction, so we know light has some effect. Light alone explains 99.7% of the variance in growth, and fouling explains 93.1% of the remaining variance (which is not a statistically significant fraction). We have, so far, been unable to separate the effects of these two factors upon growth.

(2) The relation between kelp growth and light in SOK is different from the experimental relationship established inshore. At a given light level kelp grows faster in SOK than it does inshore.

(3) There is one pair of observations in SOK that shows kelp growing at similar rates at different light levels (Annual Report, p. 110, Table 4.2).

(4) Fouling appears to be increased by an increasing concentration of particles in the water, and by turbulence. We do not know the quantitative relationships involved, and we do not have a precise prediction for these two variables under SONGS' operation. Furthermore, the organisms may 1) behave differently, 2) be a different mix of species, and 3) differ in abundance at SOK and inshore. Thus, we cannot predict the extent of fouling at SOK once SONGS Units 2 and 3 begin operation.

Experiments now underway should help resolve the relationship between light and growth.

In spite of difficulties of interpretation, however, the transplant experiment predicts that kelp growth will be reduced when SONGS 2 and 3 are operating. Reduced growth would be expected to (a) reduce the average size of plants, and so reduce kelp biomass and cover, and (b) reduce the number of kelp plants. We next explore question (b).

Reduced growth should reduce plant density because death rates of juvenile and sub-adult stages are generally higher than those for adults, and plants would spend longer in the high death rate phases. According to one set of calculations, this would lead to a 70% reduction in the number of plants produced from a cohort of new juveniles (Kelp Appendix 2, pp. 13-17). If compensation operation, the reduction could be as small as 25%.

We cannot place much reliance on these particular figures because different sets of plausible assumptions and relationships give us different

estimates that range from a negligible effect to an even greater than 70% reduction in abundance (Kelp Appendix 5). Furthermore, we still have the problems of the confounding effects of fouling, and one pair of observations of similar growth at different light levels in SOK.

No firm quantitative prediction can be made about growth and survivorship.

(C) Other factors associated with SONGS

(1) Sedimentation

Sedimentation appears to reduce the recruitment of new plants by smothering them and increasing abrasion. However, SONGS is expected to have no effect on the sedimentation rate on the bottom at SOK.

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(2) Sea urchins

Sea urchins (Lytechinus) have caused a large amount (about 45%) of adult mortality in parts of the bed. They also appear to interfere with recruitment by grazing on the microscopic and very small stages of kelp.

SONGS will probably increase the amount of particulate organic matter (POC) at SOK. Schroeter et al. (Kelp Appendix 5) show that urchins grow more inshore than offshore, and argue that this was caused by higher POC levels there. They conjecture that SONGS will therefore increase urchin populations, and hence grazing pressure, in SOK. This seems a reasonable prediction, but we cannot be certain it will occur because other factors (predation, etc.) also affect the abundance of sea urchins.

(3) Toxins

Reduced growth and settlement of various organisms in the Unit 1 discharge plume have led investigators to postulate that the plume contains

small quantities of toxin(s) - perhaps copper or chlorine. Southern California Edison claims that Unit 1 releases extremely small amounts of copper, that copper will be virtually absent from the plumes of Units 2 and 3, and that these units will also use little chlorine.

There are no usable data on toxins from SONGS, and we cannot evaluate their possible role. This point requires investigation.

(4) Temperature

SONGS is expected to have very little effect on water temperatures in SOK (a less than 0.5°C average increase, a maximum of a 1°C increase, and a non-detectable increase over most of the bed).

(5) Nutrients

The concentration of nutrients is expected to increase in SOK in surface and mid waters at some periods of the year. We have no quantitative prediction of this effect, nor do we know the relationship between nutrient levels and adult plant growth. This mechanism could lead to greater plant growth (Plankton Appendix 2).

(D) Overall effects on the kelp bed

The predicted reduction of recruitment, and an increase in mortality, would lead to a reduced density of kelp plants in the offshore portion of the bed. These two effects plus reduced growth of individual plants and greater grazing by urchins would reduce the amount (biomass and cover) of kelp in the bed. Increased midwater nutrients could cause an increase in kelp growth. We cannot make a quantitative estimate of the overall effects.

(E) Effects on shrimp in the kelp canopy

Experiments carried out at various distances from Unit 1 discharge

showed that shrimp densities on settling plates were lower close to the discharge. These spatial differences tended to disappear when SONGS was not operating. It was also shown that the death rate of shrimp in experimental containers was greater closer to the Plant.

The mechanism causing these effects is not known, so no quantitative predictions of the effects of Units 2 and 3 can be made.

Shrimp are important in the diets of various fish species that live in SOK (Kelp Appendix 5, pp. 12-13).

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MYSIDS

1. Annual loss of mysids

From the field sampling program we know how mysid densities change as one goes offshore. Several species, constituting most of the mysid population, are restricted to within 3 or 4 km of the shore (Mysid Appendix 1). Maximum mysid density occurs in the intake zone.

These data, plus information on the rate of SONGS' intake of water, allow us to calculate how many mysids will be taken into SONGS' intakes. Sampling at Unit 1, and laboratory studies, suggest that all mysids taken into the cooling system will be killed.

We are much less certain of the number that will be killed by the discharge plume, which will entrain about 10 times its own volume of water. There are two possible sources of mortality. First, some mysids will die from turbulent shear forces created by the discharging water. We believe this will be a relatively minor source of mortality. Second, some mysids will be carried further offshore in the plume and deposited offshore of their normal habitat. There is as yet no reliable method for predicting the number of mysids dying in this way.

2. Mysid depression

(a) Depression caused by intake and diffuser mortality

If mysid mortality is of the order calculated in Section 1, we would expect there to be a lowering of mysid density downstream from the Plant. The extent and depth of the depression depends upon the rate of mixing with water that has not passed through the Plant, and on the ability of surviving mysids to compensate with increased reproduction, growth or survival.

The probable extent of the depression was estimated using a model that combines a description of water movements and the biology of the mysids (Mysid Appendix 4). The model describes both the ambient current regime and SONGS' plume, and moves mysids about accordingly. It incorporates the natural mortality rate of mysids (as determined from samples) and imposes on this rate the expected SONGS-induced mortality. The model incorporates 100% intake mortality and 20% mortality in the plume. (The model assumed that this was caused by turbulent shear. It is more likely that any diffuser losses will be caused by translocation; however, we use the output as an indication of the scale of possible effects.)

The model predicts that, for much of the year, depressions on the order of 50% should exist out to 5 km or more from the Plant, and that lesser depressions should extend for more than 10 km.

We need to view these predictions with caution. The model is not a precise description of reality; in particular, it becomes less accurate as it predicts events more distant from the Plant. Also, the amount of translocation mortality is not known. What the model does tell us is that we can expect to see a measurable depression in mysid density, at least several km long, for much of the year, and it probably indicates the maximum size of the depression that could be caused by these mechanisms.

(b) Depression caused by an unknown factor

The Mysid Study group has data suggesting that Unit 1 presently causes a depression in mysid density of almost 50% that extends 6 km downstream (Mysid Appendix 3). This is the difference observed in the longshore pattern of abundance between samples taken when the Plant is on, and when it is off.

There is statistical support for this claim, but there is a difficulty in that the "Plant on" samples were taken in October, while the "Plant off" samples were taken in spring, and the general level of mysid abundance was greatly different at these two seasons. Samples are being taken now, while the Plant is off, to resolve this issue.

The Committee feels there is a further problem with these results. Even if it can be shown statistically that a depression occurs when the Plant is on, but not when it is off, we know of no mechanism that is likely to produce such an effect. (The actual kill via intake and plume mortality would not depress the population for such a distance, and the plume from Unit 1 rarely extends more than 3 km from the Plant.) One suggested mechanism is that organochlorine compounds from the Plant adhere to very small particles and settle out over a distance of 6 km. We have no evidence concerning this mechanism. If the new studies confirm the existence of this depression, further work will be required on this question.

If indeed there is a depression to 6 km caused by Unit 1, then it may be reasonable to expect that the enormous additional kill rate of Units 2 and 3 will extend the depression to 10 km or so. Notice, however, that there is no evidence that the plume from Units 2 and 3 will extend further downcoast than that from Unit 1. Thus there is no certainty that the additional intake and plume losses from Units 2 and 3 would extend an already existing depression.

3. Significance of mysid losses

Mysid populations are extensive along the coast, and our predictions do not imply that SONGS would have a significant effect on the coastal populations. As stated in the "Predictions", we do not expect these effects to have a major

impact on the local populations of fodder fish, although this is certainly a prediction that we need to check when Units 2 and 3 begin operating.

PLANKTON

1. The evidence that some zooplanktonic species are restricted close to shore can be found in Plankton Appendix 1. The centers of abundance of the inner nearshore species are in the areas of the intake and diffusers, and these species are therefore subject to greater SONGS pressures than other less restricted species. Some of the zooplankton restricted to the inner nearshore tend to live closer to the bottom where the longshore currents are slower (MRC Interim Report 1979-02 (II), p. 17), and as a consequence their longshore replacement (mixing) rates could be lower than those for other species. In addition, some of the non-restricted species could be replaced by individuals from farther offshore. All of this would favor the non-restricted species in the recovery from SONGS losses and would tend to promote a shift in relative abundance.

2. Synoptic samples taken in the intake and discharge ports of SONGS Unit 1 demonstrate that few of the withdrawn zooplankton occur in the discharged waters (MRC Interim Report 1979, and Plankton Appendix 2). Presumably, they are consumed during their journey through the intake conduit by the benthic organisms that live on the inner walls. These benthic organisms are purged from the cooling system during heat treatment and reverse flow, and become part of the inshore benthic food chain. The estimates of plankton densities used in predicting intake losses can be found in Plankton Appendix 2.

The estimate of zooplankton entrainment by diffusers is based on total macrozooplankton (zooplankton greater than .2 mm in width) plus the microzooplanktonic species Euterpina acutifrons. Euterpina was included because

it forms a major part of the diets of most fish larvae and some fodder fish in the area. Using the field samples from 20 dates for macrozooplankton and from 5 dates for Euterpina, the mean concentrations were calculated for different positions expected to be affected by diffuser entrainment (Plankton Appendix 2). This estimate of about 4 x 10^4 metric tons of zooplankton entrained per year was based on the assumption that equal entrainment occurred at all depths over the full length of the diffusers. The assumption that 10% of those entrained are killed results in an estimate of 4000 metric tons.

Most of the zooplankton biomass moved offshore by diffuser entrainment is likely to be eaten by adult and juvenile anchovies, top smelt, and blacksmiths. According to the MRC Fish Group, the blacksmith should increase in abundance because the diffuser rip-rap provides new habitat and the diffuser plume provides a continual source of zooplankton. In the absence of SONGS these secondarily entrained zooplankton would have been available to the same predators and to the late larval stages of the fodder fish Genyonemus and Seriphus.

3. The diffuser discharges will result in replacement of part of the offshore surface water by a plume consisting of a mixture of nutrient-rich waters from closer to shore and nearer the bottom. The detailed methods used in estimating the amount of nitrate plus nitrite added to the surface waters, and the conversion of these estimates to estimated phytoplankton production, are explained in Plankton Appendix 3.

SONGS will induce a real net increase over present primary production off San Onofre. First, in surface and mid waters where chlorophyll is high, nutrients are low, suggesting that when nutrients get into the high chlorophyll

waters they are taken up rapidly. Conversely, the presence of deeper waters high in nutrients and low in chlorophyll presumably indicates that the phytoplankton there are utilizing nutrients at a lower rate (Plankton Appendix 3). Therefore the nutrients in the bottom waters upwelled by the diffusers will be utilized at a far higher rate when they reach the surface.

Second, the waters replacing the entrained waters will also be high in nutrients and low in productivity. During periods of moderate to strong longshore currents, entrained water will be replaced primarily from longshore and similar depths. Under very sluggish conditions most of the entrained waters will come from offshore. In both cases, the water will be rich in nutrients (Plankton Appendix 3).

SOFT BOTTOM COMMUNITIES

The basis for the predictions can be found in Soft Bottom Communities Appendices 1 and 2.

1. Probable sediment effects were estimated by establishing the existing statistical relationships among abundance, diversity and characteristics of the sediments. Probable changes in the sediments were estimated (very approximately) from information about the weights of various materials in the SONGS' plumes, from information about water movements, and from information about the settling rates of various classes of materials.

2. Some 17% of the benthic species at some time rise into the water column and are at risk to entrainment by the intake or the discharging water. Too little is known about this group to make a firm quantitative estimate of losses, but we expect them to be roughly the same as mysid losses.

We are very uncertain about possible losses of planktonic larvae and the potential effects. This group of plankton is very poorly known. We do have data showing that the larvae of some intertidal and nearshore species are restricted inshore. However, we cannot estimate losses of benthic larvae because we do not know how to estimate mortality caused by the plume. Finally, although we know for some rocky bottom species that have been studied, that larval settlement far exceeds the number needed to maintain the adult population, we do not know if this is always the case, or if it is true for soft bottoms. If it were, likely reductions in larval settlement would have no effect on adult numbers.

It is possible that some intertidal and shallow water species will show reduced adult densities close to SONGS. However, it seems likely that total

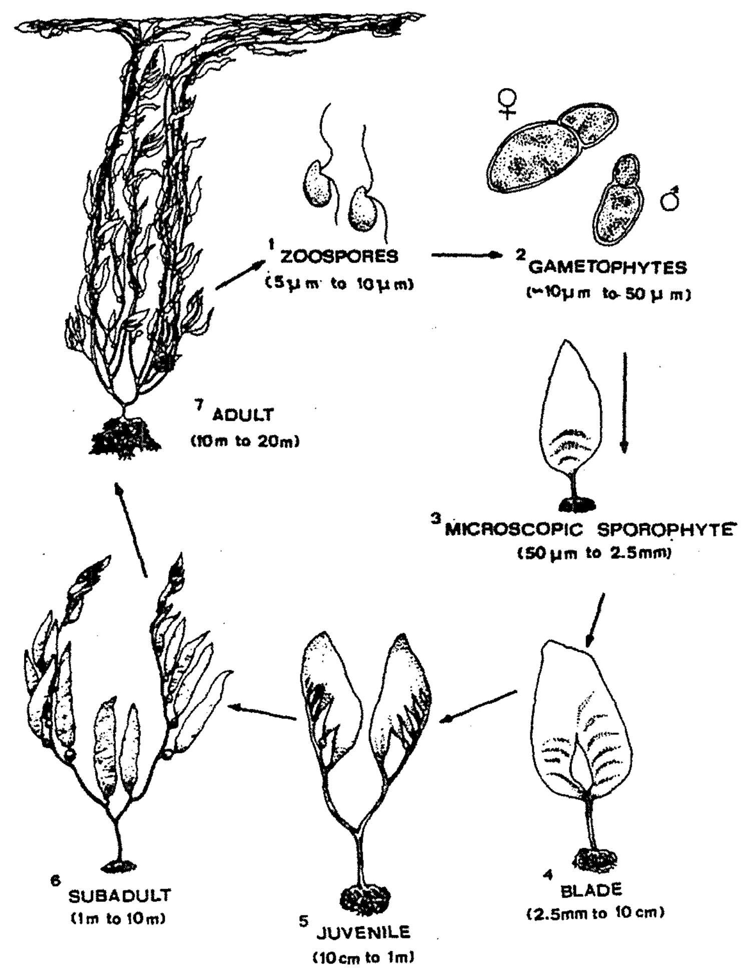
densities will not be significantly reduced, and that any reduction of a particular species will be made up by increased density of others.

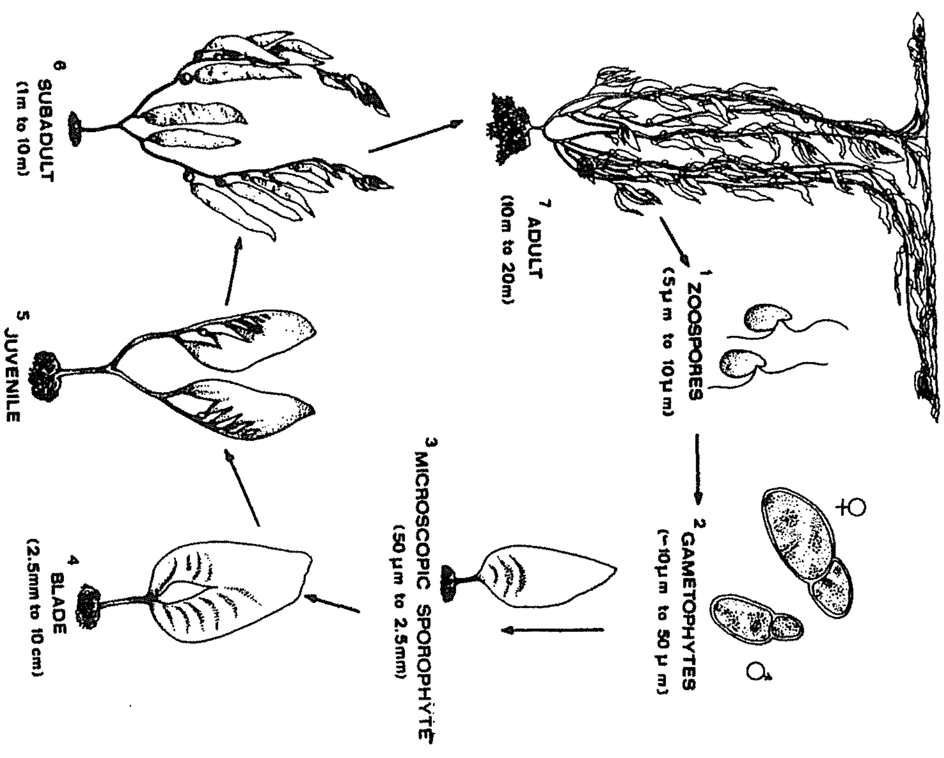
3. The enrichment of bottom sediments should have virtually no effect on the production of sport and commercial fish. The enrichment derives from SONGS' killing of organisms in the water column, and so represents a shift of material. The food chains on the soft bottom eventually lead to the same group of sport and commercial fish species as do planktonic food chains; however, there should be some additional losses of this material as it passes up the benthic food chain.

HARD BOTTOM COMMUNITIES

The Hard Benthos Project (Hard Benthos Appendix) has shown clear differences between nearshore and offshore communities on the underside of experimental panels, and some degree of similarity between the communities on panels and on natural boulders. There is also a correlation between these differences and turbidity; and the inshore species grow faster than offshore species at high turbidity.

We believe there is no strong evidence that major changes will occur in this community. Several factors prevent us from making quantitative predictions, including the lack of close similarity between experimental panels and the tops of boulders, and the lack of quantitative relationships between possible changes and turbidity levels.





A diagrammatic representation of the *Macrocystis* life cycle. Stage names and approximate sizes are given.

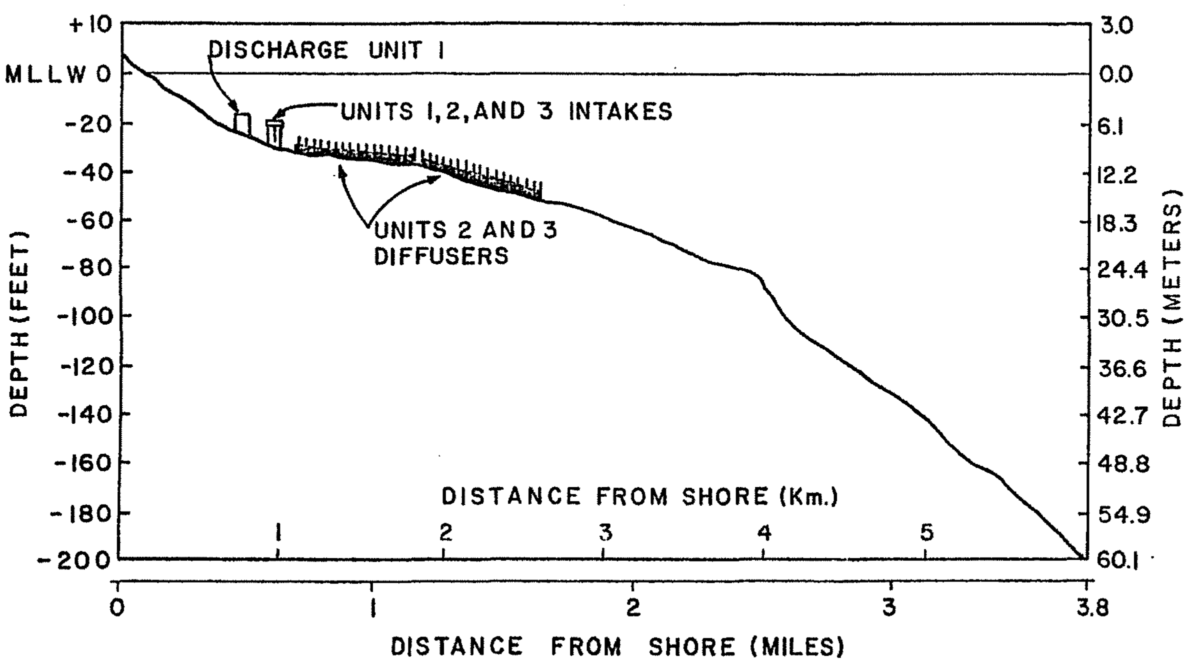
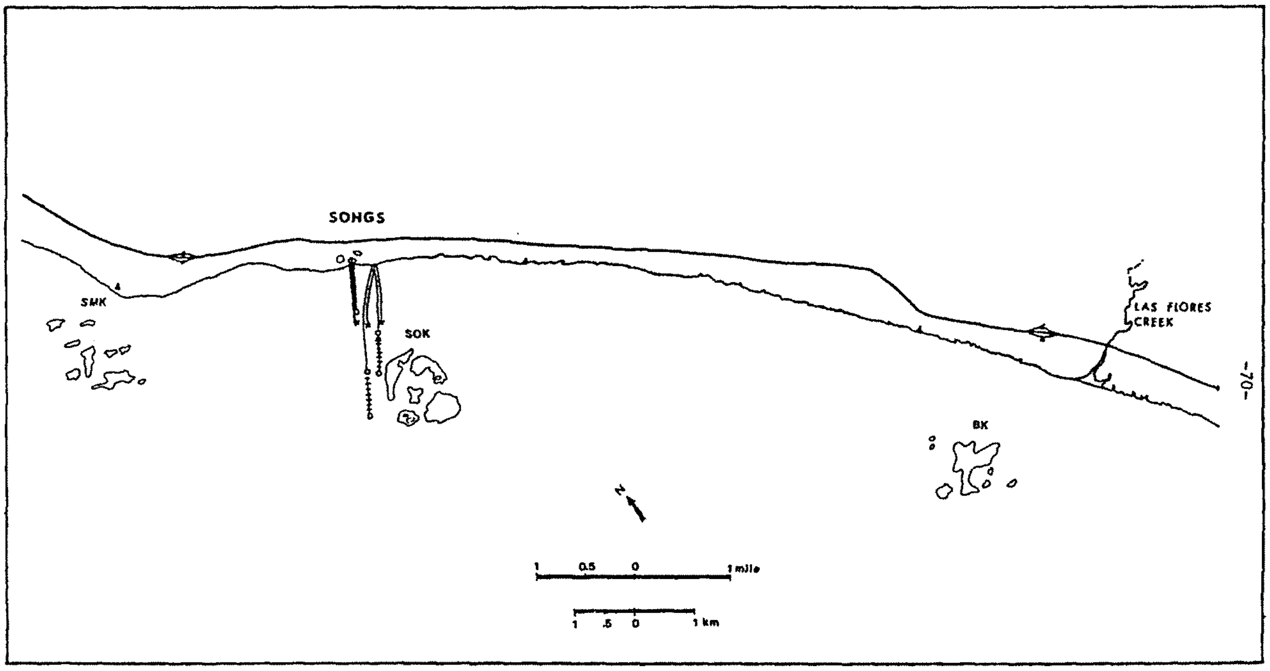
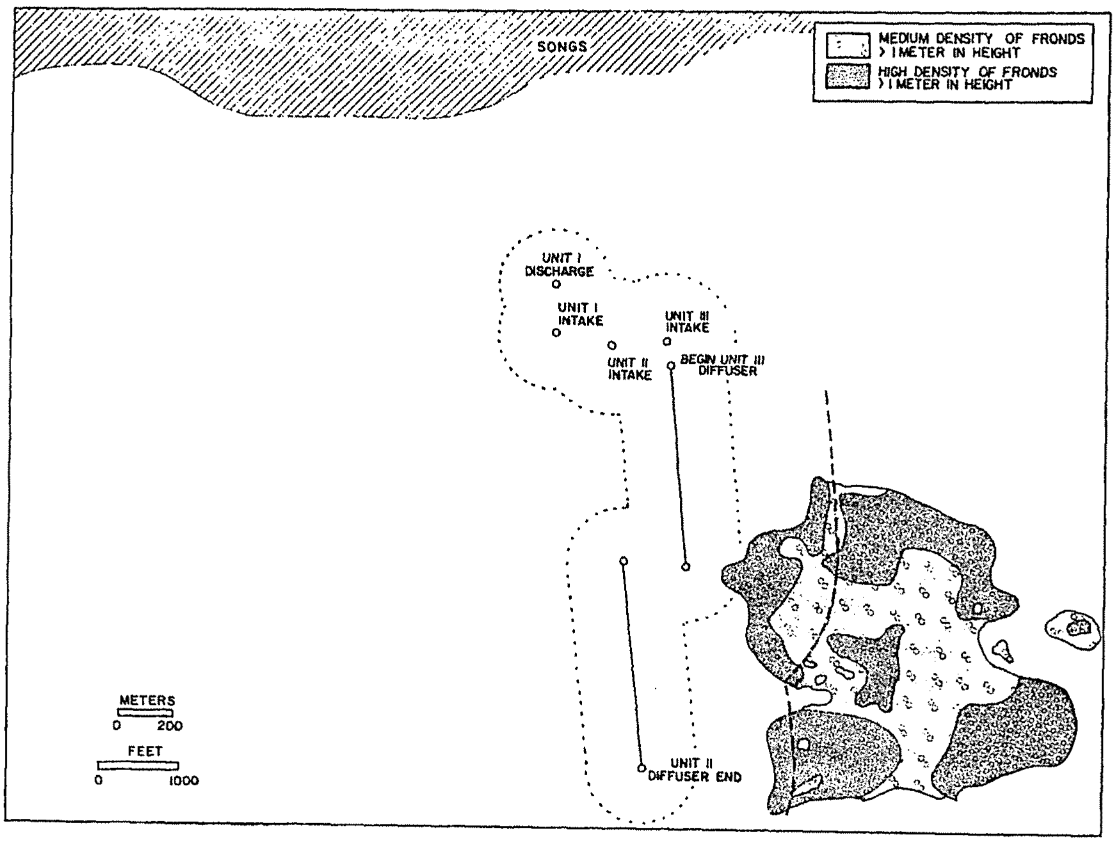


Figure 1. Offshore profile of the cooling system of SONGS Units 1, 2 and 3. (Modified from Figure II-3, Southern California Edison, San Diego Gas and Electric Company, Thermal Effect Study, San Onofre Nuclear Generating Station Units 2 and 3, Vol. 2, September, 1973.)



Map 1. Map of the region near SONGS. The kelp beds shown are the high density portions of San Mateo (SMK), San Onofre (SOK), and Barn (BK) kelp beds, as measured in December, 1978.



Map 2. Map of the coast near San Onofre showing the cooling systems of SONGS Units 1, 2 and 3 and the medium to high density areas of kelp measured in December, 1978, within the San Onofre Kelp (SOK) bed. The boundaries of the areas where the sediments are modified are indicated by dashed lines. The dotted line delimits the area within 1,900 feet of the diffusers as specified in the Coastal Commission Permit of February 28, 1974, Page 3, Item C.

APPENDIX F

EVACUATION MODEL

APPENDIX F

EVACUATION MODEL

"Evacuation," used in the context of offsite emergency response in the event of substantial amount of radioactivity release to the atmosphere in a reactor accident, denotes an early and expeditious movement of people to avoid exposure to the passing radioactive cloud and/or to acute ground contamination in the wake of the cloud passage. It should be distinguished from "relocation" which denotes a post-accident response to reduce exposure from long-term ground contamination. The Reactor Safety Study[1] (RSS) consequence model contains provision for incorporating radiological consequence reduction benefits of public evacuation. Benefits of a properly planned and expeditiously carried out public evacuation would be well manifested in reduction of acute health effects associated with early exposure; namely, in the number of cases of acute fatality and acute radiation sickness which would require hospitalization. The evacuation model originally used in the RSS consequence model is described in WASH-1400[1] as well as in NUREG-0340.[2] However, the evacuation model which has been used herein is a modified version[3] of the RSS model and is, to a certain extent, site-emergency-planning oriented. The modified version is briefly discussed below.

The model utilizes a circular area with a specified radius (such as a 16-km (10-mi) plume exposure pathway emergency planning Zone (EPZ)), with the reactor at the center. It is assumed that people living within portions of this area would evacuate if an accident should occur involving imminent or actual release of significant quantities of radioactivity to the atmosphere.

Significant atmospheric releases of radioactivity would in general be preceded by one or more hours of warning time (postulated as the time interval between the awareness of impending core melt and the beginning of the release of radioactivity from the containment building). For the purpose of calculation of radiological exposure, the model assumes that all people who live in a fan-shaped area (fanning out from the reactor) within the circular zone, with the downwind direction as its median (i.e., those people who would potentially be under the radioactive cloud that would develop following the release) would leave their residences after a specified amount of delay time* and then evacuate. The delay time is reckoned from the beginning of the warning time and is the sum of the time required by the reactor operators to notify the responsible authorities; the time required by the authorities to interpret the data, decide to evacuate, and direct the people to evacuate; and the time required for the people to mobilize and get underway.

The model assumes that each evacuee would move radially outward in the downwind direction with an average effective speed* (obtained by dividing the zone radius by the average time taken to clear the zone after the delay time), over a fixed distance* from the evacuee's starting point, which is somewhat greater than the zone radius. This distance is selected to be 24 km (15 mi) when the selected zone radius is 16 km (10 mi). After reaching the end of the travel distance the evacuee is assumed to receive no further radiation exposure. Persons who are outside the evacuation radius are assumed to remain in place for seven days prior to relocating, unless remaining for that long a period of time would produce a dose greater than 200 rem to the whole body. In that case, relocation takes place after 24 hours, with a dose appropriate to that time period.

The model incorporates a finite length of the radioactive cloud in the downwind direction, which would be determined by the product of the duration over which the atmospheric release would take place and the average windspeed during the release. It is assumed that the front and the back of the cloud formed would move with an equal speed, which would be the same as the prevailing windspeed; therefore, its length would remain constant at its initial value. At any time after the release, the concentration of radioactivity is assumed to be uniform over the length of the cloud. If the delay time were less than the warning time, then all evacuees would have a headstart, i.e., the cloud would be trailing behind the evacuees initially. On the other hand, if the delay time were more than the warning time, then depending on initial locations of the evacuees, there are possibilities that (a) an evacuee will still have a headstart, (b) the cloud would be already overhead when an evacuee starts to leave, or (c) an evacuee would be initially trailing behind the cloud. However, this initial picture of cloud-people disposition would change as the evacuees travel, depending on the

*Assumed to be constant value for all evacuees.

relative speed and position between the cloud and the people. The cloud and an evacuee might overtake one another one or more times before the evacuee would reach his or her destination. In the model, the radial position of an evacuating person, while stationary or in transit, is compared to the front and the back of the cloud as a function of time to determine a realistic period of exposure to airborne radionuclides. The model calculates the time periods during which people are exposed to radionuclides on the ground while they are stationary and while they are evacuating. Because radionuclides would be deposited continually from the cloud as it passed a given location, a person who is under the cloud would be exposed to ground contamination less concentrated than if the cloud had completely passed. To account for this, at least in part, the revised model assumes that persons are (a) exposed to the total ground contamination concentration which is calculated to exist after complete passage of the cloud after they are completely passed by the cloud, (b) exposed to one half the calculated concentration when anywhere under the cloud; and (c) not exposed when they are in front of the cloud. The model provides for use of different values of the shielding protection factors for exposure due to airborne radioactivity and contaminated ground. Breathing rates for stationary and moving evacuees during delay and transit periods are specifically included.

It is realistic to expect that authorities would evacuate persons at distances from the site where exposures above the threshold for causing acute fatality could occur, regardless of the EPZ distance. Figure F-1 illustrates the reduction in acute fatalities that can occur by extending evacuation to distances up to 48 km (30 mi) from the San Onofre site. (The evacuation distance used in the Reactor Safety Study[1] was 40 km (25 mi).) Also illustrated in Figure F-1 is a more pessimistic case for which no early evacuation is assumed. For this case, all persons within 16 km (10 mi) of the plant are assumed to be exposed for the first 24 hours following an accident and are then relocated. Compared to the pessimistic scenario, evacuation of a 48 km (30-mi) zone shows a reduction in acute fatalities of a factor of 10 at 10^{-8} probability.

The model has the same provision for calculation of the economic cost associated with implementation of evacuation as in the original RSS model. For this purpose, the model assumes that for atmospheric releases lasting three hours or less, all people living within a circular area of 8-km (5 mi) radius centered at the reactor plus all people within a 45-degree angular sector within the plume exposure pathway EPZ and centered on the downwind direction will be evacuated and temporarily relocated. However, for releases exceeding three hours, the cost of evacuation is based on the assumption that all people within the plume exposure pathway EPZ would be evacuated and temporarily relocated. For either of these situations, the cost of evacuation and relocation is assumed to be $125 (1980 dollars) per person which includes cost of food, and temporary sheltering for a period of one week.

REFERENCES

1. "Reactor Safety Study," WASH-1400, USNRC Report NUREG-75/014, October 1975.*

2. "Overview of the Reactor Safety Study Consequences Model," USNRC Report NUREG-0340, October 1977.*

3. "A Model of Public Evacuation for Atmospheric Radiological Releases," SAND 78-0092, June 1978.**

*Available from the NRC/GPO Sales Program, Washington, DC 20555, and the National Technical Information Service, Springfield, VA 22161.

**Available for inspection and copying for a fee in the NRC Public Document Room, 1717 H St. N.W., Washington, DC 20555.

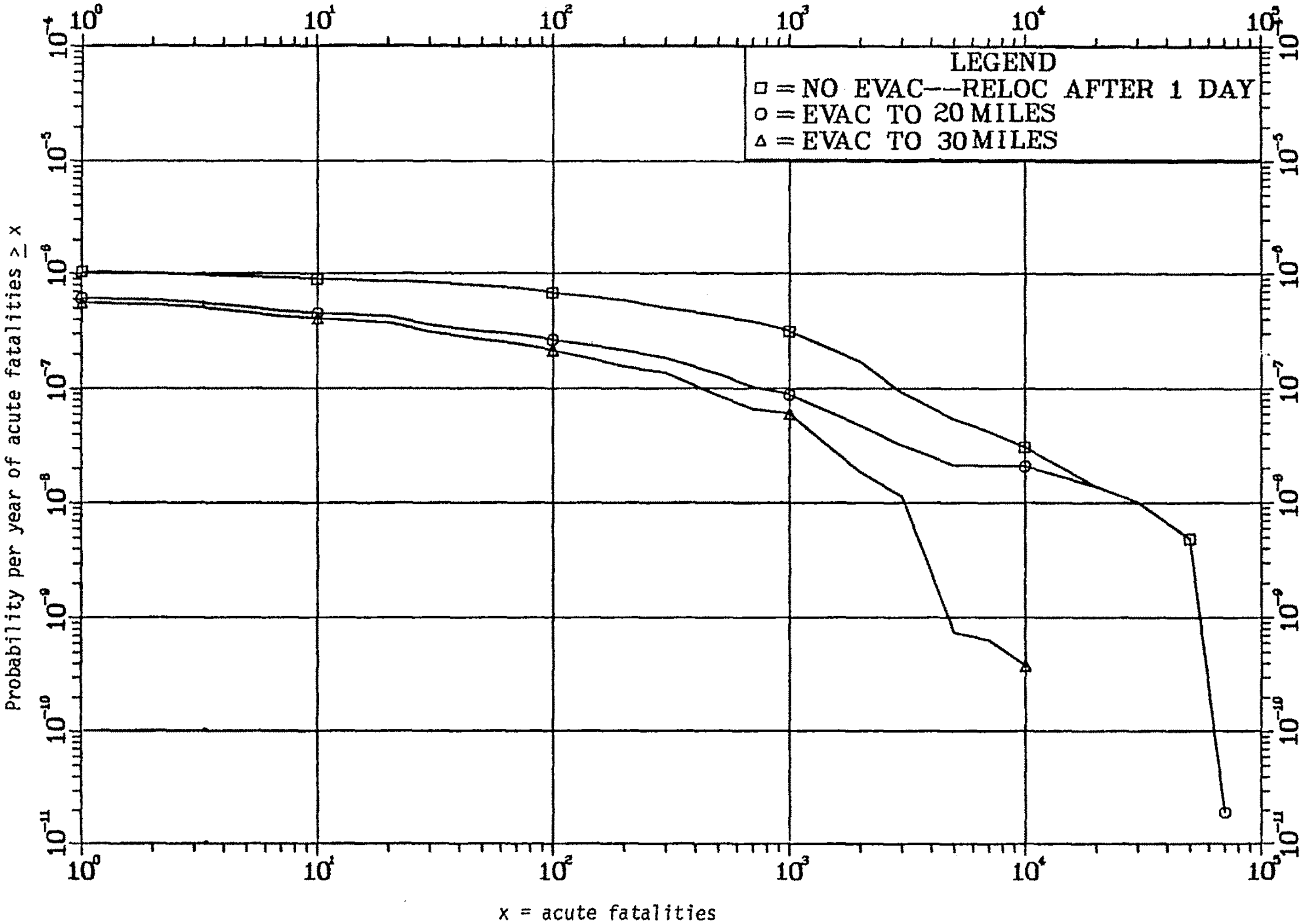


Figure F-1. Probability distribution of acute fatalities. (See Section 7.1.4.6 for discussion of uncertainties in risk estimates.)
(To change miles to kilometers, multiply by 1.6.)

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A Final Environmental Statement related to the operation of San Onofre Nuclear Generating Station, Units 2 and 3 by Southern California Edison Company, et al (Docket Nos. 50-361/362), located in San Diego, California, has been prepared by the Office of Nuclear Reactor Regulation of the Nuclear Regulatory Commission. The statement reports on the staff's review of the impact of operation of the plant. Also included are comments of state and federal government agencies on the Draft Environmental Statement and its Supplement for this project and staff responses to these comments. The NRC staff has concluded, based on a weighing of environmental, technical and other factors, that operating licenses could be granted.

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