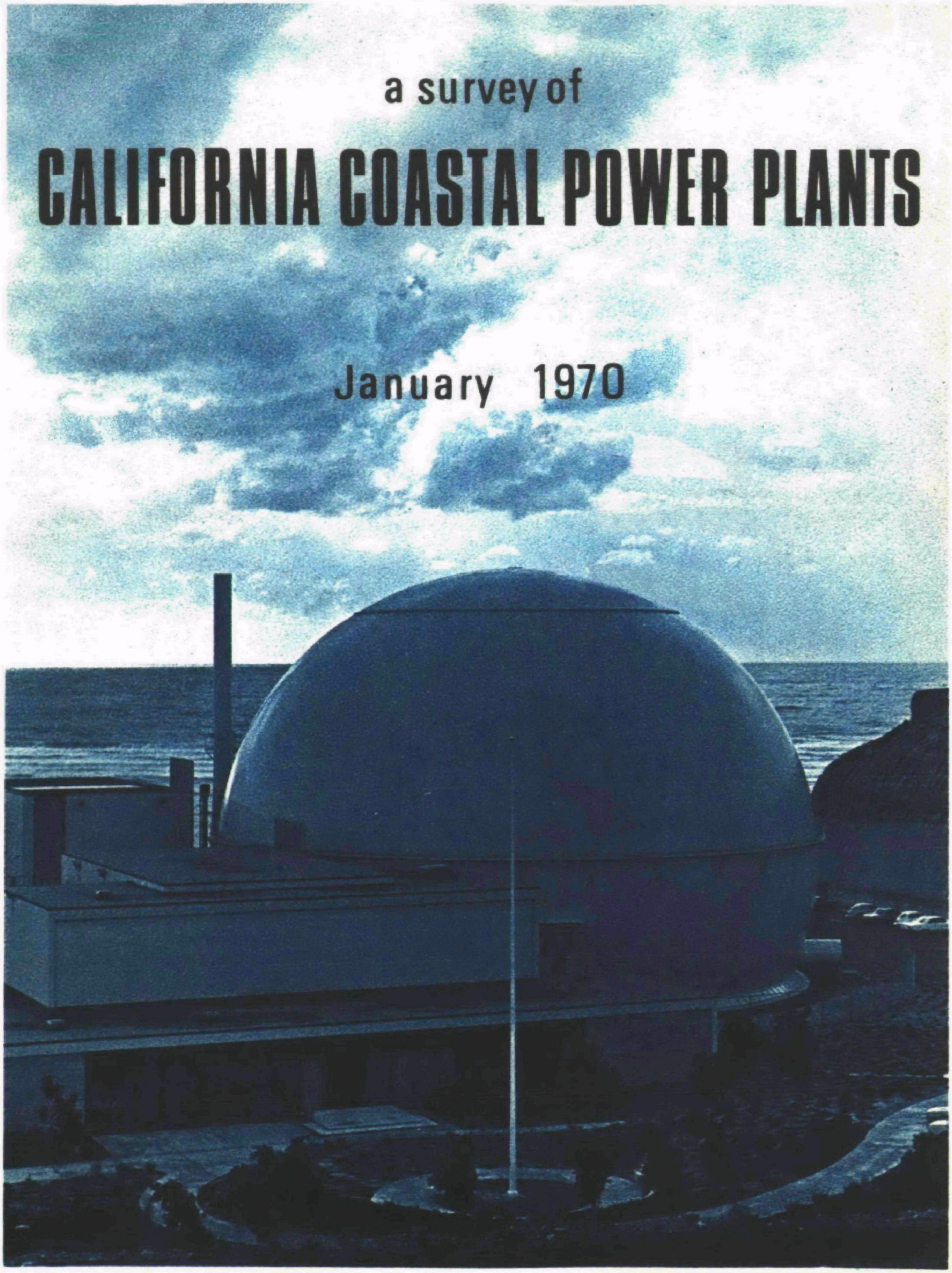
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

NORTHWEST REGIONAL OFFICE

a survey of

CALIFORNIA COASTAL POWER PLANTS

January 1970



CLEAN WATER

A SURVEY
OF
CALIFORNIA COASTAL POWER PLANTS

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INTRODUCTION

The California power plant tour is the second survey of thermal power plants by personnel of the Northwest Regional Office, Federal Water Pollution Control Administration (FWPCA). The purpose of these tours was to anticipate, from experience in other parts of the United States, the environmental impact of thermal power plants in the Northwest. In December 1968, five large inland power plants in the eastern United States were visited to observe the impact of waste heat treatment and disposal on air and water quality. The tour included two coastal power plants in California for a comparison between inland plants with cooling facilities and coastal plants with once-through sea water cooling. The Pacific Northwest Pollution Control Council published a report of the December 1968 tour titled *A Survey of Thermal Power Plant Cooling Facilities*.

The Northwest Regional Office, FWPCA, initiated the second tour in May 1969 to obtain information on the sites, operation, and environmental effects of representative coastal power plants in California. This information has direct application for developing an FWPCA policy on coastal siting of nuclear power plants in the Pacific Northwest. The purpose of this trip report is to summarize the findings of the tour participants.

The tour participants collected information on the following aspects of thermal power plant siting, design, and operation:

a. Environmental studies related to coastal power plants;

b. Condenser cooling water intakes and outfalls for large coastal plants;

c. Environmental effects of waste heat discharged to the Pacific Ocean;

d. Policies of Federal and State agencies.

The ten power plants included in the tour were selected to compare in electrical generating capacity to potential nuclear plants on the Oregon-Washington Coast and to represent a wide range of intake and outfall characteristics. The power plants visited are shown on Figure 1 (Appendix A). Nine of these plants are gas-oil fueled; San Onofre, the tenth plant, is nuclear fueled. Ten Government and research agencies involved in thermal power development were also visited.

FWPCA staff participating in the tour were Dr. Robert W. Zeller and Mr. Robert L. Rulifson of the Northwest Regional Office, and Mr. Donald Trent and Dr. Mostafa Shirazi of the Pacific Northwest Water Laboratory, Corvallis, Oregon. The tour was coordinated through the office of Mr. Paul De Falco, Director, Pacific Southwest Region, FWPCA, by Mr. Gil Hanes.

SUMMARY

Environmental Studies

In California there is no provision for regulatory agency consultation on environmental effects during preliminary site selection, a critical stage of thermal power development. After site selection, the California State Resources Agency requires pre- and post-construction field surveys. The purpose of these surveys is to (a) facilitate development of waste heat discharge requirements, and (b) document environmental changes due to heated discharges and the possible need for changes in discharge requirements.

Implementation of this procedure has not been standardized in terms of organization and conduct of the studies and interpretation and evaluation of the results. The pre-construction studies have not had a significant impact on the design and location of intake and outfall systems. For example, the Southern California Edison Company (SCE) locates open coast power plant intakes and outfalls to meet U.S. Coast Guard and Army Corps of Engineers navigation requirements rather than for the protection of environmental values.

Dr. Norman Brooks, of the California Institute of Technology, indicated that pre-construction surveys in California do not adequately define the probable distribution of heated discharges, particularly in regard to the design of outfalls. Despite extensive field surveys at the Diablo Canyon nuclear site, for example, the probable environmental impact of heated discharges from shoreline outfalls remains unclear. The lack of well-defined objectives and

established techniques for sampling and analysis makes it difficult to evaluate survey results.

Condenser Cooling Water Intakes and Outfalls

As described above, at open coastal sites Southern California Edison Company (SCE) locates intakes to meet U.S. Coast Guard and Corps of Engineers navigation requirements; SCE locates intakes at the shoreline for plants on tidal channels. Since experiencing fish kills at the Contra Costa plant, Pacific Gas & Electric Company (PG & E) has followed the recommendations of a research program and has incorporated shoreline intakes at all plants, regardless of location. The shoreline intakes reduce fish losses by avoiding the high conduit velocities associated with offshore intakes.

PG & E and SCE have also developed standard procedures for the design of intakes to minimize the losses of small fish. PG & E shoreline intakes have maximum approach and flow-through velocities of 0.5 and 1.5 ft/sec, respectively. SCE uses concrete "velocity caps" over offshore vertical intakes, effecting horizontal inflows which small fish can avoid better than they can vertical inflows.

All of the power plants visited, however, still experience intake fish kills to some extent. While the efforts to minimize fish kills caused by condenser cooling systems are welcome signs of concern, they are inadequate as general recommendations. Water intake location and design should be studied relative to the oceanographic conditions and marine biota at each site.

The power plants visited subject their cooling water intake systems to periodic heat treatment to control mussels, clams, and other incrustations. Serious fish kills have occurred at Contra Costa, El Segundo, and Huntington Beach during the periods of elevated water temperatures. Although the tonnage of fish killed has been reduced by the improvements in intake design mentioned above, heat treatment has not been an environmentally acceptable solution to cooling system incrustation problems. A means for bio-foulant control that is not a hazard to valuable marine life should be developed before completing the design of cooling water systems for new coastal power plants.

With some exceptions, PG & E uses shoreline outfalls and SCE relies on shallow, offshore locations for their outfalls. The shore-line outfalls discharge horizontally at or near the water surface. The offshore outfalls discharge vertically without the benefit of multiport or diffuser systems. Design discharge velocities range from 4 to 7 ft /sec for both kinds.

Based on temperatures at least 4°F above ambient, the heated discharge from the outfalls may affect volumes of water up to 100 acres in area and up to 15 feet thick.

As with intakes, standard procedures should not be applied to outfall location and design. Dr. Norman Brooks, of the California Institute of Technology, maintains that the technology of diffuser design permits the stipulation of local dilution requirements for off-shore outfalls. Presuming this to be true, the thermal power planner can choose to spread a small temperature increment over a large volume of water or to concentrate a large temperature increment within a small volume of water. Generalizations on design alone, however, are not particularly useful. It is the choice of alternatives that is important, and the choice should be based on the physical, oceanographic, and biological characteristics of each site.

Environmental Effects of Waste Heat Discharged to the Pacific Ocean

Surveys in the warm water zones of California coastal power plant outfalls have documented changes in the biota: there are more tropical species within the warm water zone as compared with the natural environment. The biological changes appear to be limited, however, to the zone with temperatures at least $4^{o}F$ above ambient.

There is no visible evidence that the overall changes are adverse. The lack of definitive pre- and post-construction field data, however, makes it impossible to document the exact changes that have occurred in the warm water zones or to evaluate the effects of those changes.

Policies of Federal and State Agencies

The Pacific Southwest Regional Office, FWPCA, like the Northwest Regional Office, had not established a well-defined policy on thermal power plant siting at the time of the tour.

The California State Resources Agency, the Regional Water Quality Control Boards, and the California Department of Fish and Game do not advocate numerical temperature criteria for coastal waters. They have concluded that available information is inadequate " . . . concerning the thermal requirements of marine life and the effects of natural variations in ocean temperature patterns."1/ Instead of setting numerical criteria, the temperature standards nominally limit water temperature increases to protect and enhance existing ecological conditions or to prevent overall adverse ecological effects.

The Regional Water Quality Control Boards do not officially support or oppose proposed sites, but rely upon waste heat discharge requirements to protect the marine environment during plant operation.

A lack of well-defined policies and coordination in regard to site evaluations will preclude consideration of the marine environment as a major factor in the location, design, and operation of power plants. In California one result has been documented fish kills caused by intake operation; although not necessarily adverse, biological changes have also been documented in the vicinity of the outfalls. In the Northwest the results could be seriously damaging

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1/ Lloyd R. Dunham, Recommendations on Thermal Objectives for Water Quality Control Policies on the Interstate Waters of California, Report to the State Water Resources Control Board, August 1968 (State of California Resources Agency, Department of Fish and Game, 1968), p. 4.

to the cold water fishery. To influence final site selection and plans for plant operation, Federal and State agencies must identify the data necessary to provide an adequate evaluation of the environmental effects of proposed coastal power plant sites.

COASTAL POWER PLANT TOUR

The ten thermal power plants visited have several features in common that are generally described here to avoid unnecessary repetition.[1/]

First, all of the plants use a form of chlorine (usually sodium hypochlorite) as a biocide to control slime growths in their condensers. Most of the plants chlorinate for short periods of time daily at dosages that yield a small residual at the condenser outlets. It is understood that this residual usually disappears in the outfall conduits. We heard of no plants that are using chromate-based oxidants as biocides in the circulating water systems.

Second, all of the power plants subject their intake conduits to heat treatment every four to six weeks to control mussels, clams, and other incrustations. Most plants also heat-treat their outfall conduits. The use of heat as a biofoulant control agent follows the work of Fox and Corcoran in 1958.[2/] The temperature of the cooling water is raised to 105°F by reducing, and often reversing, the flow across the condensers. The temperature is

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1/ The data and discussions reported have been transcribed from notes taken during the tour.

2/ D.L. Fox and E.F. Corcoran, "Thermal and Osmotic Countermeasure Against Some Typical Marine Fouling Organisms," Corrosion, 14(3): 31-32 (1967).

held at 105°F for an hour; the entire operation requires four or five hours to permit a gradual transition from normal operating temperatures up to 105°F and then down again. At some plants (e.g., Contra Costa) Asiatic clams must be physically cleaned from the intake conduits.

Third, it is common practice to discharge through the outfall lines the debris screened from the cooling water intakes. Other wastes, such as brine from evaporators, are also discharged through the outfall lines. Justification seems to rest upon large dilution ratios.

Finally, several of the power plants have comminutors that operate in conjuction with the intake screens. Some biologists think that the discharges of ground-up fish may explain the attraction of sport fish to the affected outfalls.

The following is a day-by-day presentation of the visits the tour group made and a summary of the discussions.

APRIL 28, 1969

Central Valley Regional Water Quality Control Board
Sacramento, California

The Regional Water Quality Control Boards compile data and hold hearings to develop waste discharge permit requirements for proposed thermal power plants. The California State Resources Agency is the major policy development and coordinating agency for thermal power plants, but the Regional Water Quality Control Boards (entities within the Resources Agency) are the focal point for State agency involvement. In effect, the Regional Water Quality Control Boards serve as "sounding boards" for each proposed plant.

After initial field studies of one or two years' duration, power companies file with the Regional Water Quality Board a pre-construction report on environmental conditions and plant specifications. The Regional Water Quality Board sets waste discharge requirements on the basis of the power company report, the results of special hearings, and the information furnished by other agencies. The requirements can be appealed to the State Resources Agency and from there to the courts.

The Regional Water Quality Control Boards do not officially support or oppose a proposed site, but specify the waste discharge requirements to be met by the power company at each site. The Regional Boards can modify discharge requirements after they are in effect and have the authority to shut down plants under extreme circumstances.

California State Resources Agency
Sacramento, California

A Power Plant Siting Committee has been organized in California to promote a unified approach to consideration of thermal power development and siting. Mr. Paul Clifton heads the multi-agency committee. Members include the Department of Public Health, the State Lands Division, the State Air Resources Control Boards, and the Resources Agency (which comprises the Departments of Fish and Game, Parks and Recreation, Water Resources, Conservation, Harbors and Watercraft, and the Regional Water Quality Control Boards).

In addition to the pre-construction surveys of physical and biological conditions, the Regional Water Quality Control Boards require at least one year of post-construction surveys to establish the distribution of the discharged cooling water and its effects on the marine biota. The power company can conduct the surveys or can contract commercially for the services. Although the State Resources Agency, the Department of Fish and Game, and the Regional Water Quality Control Board examine the data, the ecological field studies have not had well-defined objectives and techniques for analysis and interpretation. The Department of Fish and Game can conduct studies which may have an impact on the discharge requirements set by the Regional Water Quality Board. The Regional Water Quality Boards can also conduct special studies: the Central Valley Board, for example, has a staff of fourteen engineers, with six available for field studies.

The State Resources Agency is not planning major policy or administrative changes relative to thermal power plants. The agency is planning, however, to require more study data than the power companies are presently supplying.

The State Resources Agency includes the State Water Resources Control Board, which is the State agency responsible for water quality standards.

California Department of Fish and Game
Sacramento, California

Specific aspects of thermal power plant biological studies were discussed at the offices of the Department of Fish and Game.

A study of particular interest concerns the impact of temperature changes on *Neomysis* (opossum shrimp). Mr. Harold (Pete) Chadwick is in charge of these studies for the Department of Fish and Game in cooperation with Pacific Gas & Electric Company. *Neomysis* is the principal food item for striped bass and its center of abundance is at Collinsville, California, where the Montezuma Nuclear Plant will be built. Although preliminary results are available, this study is still under way.

The Fish and Game biologists felt that there is little possibility for the occurrence of thermal blocks which would affect juvenile fish, including salmon, at the Contra Costa and Pittsburg Power Plants.

APRIL 29, 1969

San Francisco Bay Regional Water Quality Control Board
Oakland, California

The development of water quality criteria for the Bay-Delta system was summarized for the tour group. The San Francisco Bay hydraulic model, located at the U.S. Army Corps of Engineers, Sausalito, has been extended up the Delta for temperature regime studies relative to the new generating units for the Pittsburg Plant. The Pittsburg Plant is the first thermal power plant for which the San Francisco Bay Water Quality Board set discharge requirements. Based upon experience at the Pittsburg Plant, the Board plans to examine the waste discharge requirements for the new Montezuma plant more closely. The requirements for the pre-construction field study at the Montezuma site were not completely established at the time of our visit.

Contra Costa Power Plant
Pacific Gas & Electric Company
Antioch, California

The Contra Costa Power Plant is located on the San Joaquin River above its confluence with the Sacramento River near Antioch, California.

Pacific Gas & Electric Company (PG & E) has experienced problems with the cooling water intake design on units one through five at the Contra Costa Plant. Cooling water for units one, two, and three is pumped through a headworks 400 feet offshore to traveling screens onshore. A fish collection system was incorporated to "remove fish too large for screen passage and too small to swim back out of the conduit." 3/ Early operating experience showed a considerable problem with fish kills due to impingement on the

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3/ J.R. Adams, Thermal Effects and Other Considerations at Steam Electric Plants, (Pacific Gas and Electric Company, August 20, 1968), p. 34.

traveling screens. "Biologists estimated that up to 20,000,000 small bass might be killed each year by the cooling water system." 4/ Through a cooperative research program of PG & E California Department of Fish and Game, and the Bechtel Corporation, a successful fish bypass system was developed so that the power plant could continue in operation. Other results of this research included a recommendation that future PG & E intake screens be designed with approach and flow-through velocities of less than 0.5 ft/sec and 1.5 ft/sec, respectively. It was also concluded that juvenile fish (striped bass and king salmon) have an excellent chance of surviving the thermal shock of passage through the power plant condensers with a temperature difference of 16°F and transit time of 3 to 5 minutes.

Because of the experience with units one through five, Contra Costa units six and seven have been built with shoreline intakes to avoid the high conduit velocities associated with offshore intakes.

Intake water quality for the Contra Costa Power Plant is generally good, although turbidities are high. The annual range of intake water temperature is from 45 to 74°F. Salinity averages about one part per thousand with 4000 to 10,000 cfs fresh water flow during the summer months. Estimated tidal discharges range from 120,000 to 150,000 cfs.

4/ *Ibid.*

Cooling water for Contra Costa is discharged to the San Joaquin River; the discharge channel for units six and seven is shown in Figure 2. Discharge velocities average 2.5 ft/sec. Figure 2 also shows the San Joaquin River upstream from Contra Costa. Tidal velocities in this reach of the San Joaquin River, 30 miles upstream from San Francisco, average 1.4 knots during both ebb and flow tides.

The PG & E biologists and engineers have conducted infrared aerial surveys at Contra Costa and other sites since 1963. Early surveys were made with a Barnes Radiometer installed in a small Cessna aircraft. Two boats collected water temperature samples during the overflight for instrument calibration.

PG & E scientists are now conducting their aerial temperature surveys with a thermal mapper. This infrared mapper has a 120^{o} field of vision and yields imagery maps on which "gray scale" intensities indicate surface temperatures. The infrared signals are simultaneously converted to temperatures and stored on magnetic tapes. Isotherms are subsequently plotted on the imagery maps. This system still requires boats for ground control.

From the discussions with PG & E and State agency biologists, and the tour of Contra Costa, the tour participants concluded that power plant operation does not appear to adversely affect the San Joaquin River delta biota. This area supports an extensive sport fishery for both the king salmon and striped bass. Maintenance of this fishery is important to P G & E as well as the Department of Fish and Game and is a major reason for promoting ecological impact studies in the San Joaquin River delta.

<u>April 30, 1969</u>

Pittsburg Power Plant
Pacific Gas & Electric Company
Pittsburg, California

The Pittsburg power plant (Fig. 3) is located on the San Joaquin River at the confluence of the Sacramento River.

Because of the problems with offshore intakes at Contra Costa, the Pittsburg plant incorporates shoreline intakes as seen in Figure 3. Approach velocities to the screens are less than 0.5 ft/sec, with flow-through velocities less than 1.5 ft/sec. Consequently, fish mortality problems have not been as severe here as during the first years of Contra Costa operations.

Slides of Pittsburg, Morro Bay, and Humboldt Bay thermal studies were shown to the tour group. Of special interest were the slides showing computer-calculated isotherms superimposed on thermal imagery maps as described during the Contra Costa discussions. Rhodamine B dye studies have been conducted to indicate dispersion characteristics. A PG & E biologist told the tour group that the dye dispersion and temperature dispersion rates are poorly correlated with radionuclide dispersion. Boat surveys with bathythermographs and thermistor probes were conducted to obtain temperature profiles with depth.

The field surveys conducted at the 1320 megawatt (MW) Pittsburg Plant were briefly summarized. Averages of five infrared aerial surveys showed that 15 acres was the maximum area of water surface covered by a 10^{o}F increase over ambient water temperature. The area enclosed by a 4^{o}F temperature difference was 74 acres. Temperature cross-sections at Pittsburg, taken at slack tide, showed that the temperature anomaly decreases to zero within 2600 feet of the shoreline outfalls. The warm water layer within this area is largely confined to the top 3 feet. Outfall velocities at Pittsburg are 7 ft/sec.

Tidal velocities at the Pittsburg Plant average 2.2 knots compared to 1.4 knots at Contra Costa. Tidal excursions average 5 or 6 miles and may exceed 10 miles. Salinity at Pittsburg is about four parts per thousand compared to one part per thousand at Contra Costa.

Again, present information indicates there are no apparent adverse effects on the aquatic environment. As at Contra Costa, local sport fishermen favor the turbulent areas in the vicinity of the power plant outfalls.

Diablo Canyon Nuclear Site
Pacific Gas & Electric Company
San Luis Obispo, California

Although not included in the itinerary, the discussion at Pittsburg included references to the Diablo Canyon nuclear site located in a cove on the central California coastline near San Luis Obispo. Both physical and biological field studies have been conducted by PG & E and State agency scientists.

PG & E has made temperature distribution predictions for Diablo Canyon based on data extrapolated from similar coastal sites, tank model studies, and mathematical relationships. Onsite dye and current measurement studies have also provided input to these predictions. A PG & E biologist estimated that the warm water effects will be limited to 40-50 acres around the outfall and within 15 feet of the water surface for up to 3000 MW output. This is equivalent to saying that the warm water will be confined to the cove in which the plant will be built.

Both warm water and cold water flora and fauna species have been identified at Diablo Canyon. The most noticeable predicted effect of warm water discharges on the biota will be the inhibition of bull kelp within the cove. A California Fish and Game biologist commented that rays and leopard sharks may be attracted to the outfall.

The mixed comments of several information sources indicated that the actual impact of Diablo Canyon nuclear power development on the local environment is still unclear. Studies are continuing.

<u>May 1, 1969</u>

Moss Landing Power Plant
Pacific Gas & Electric Company
Monterey County, California

The Moss Landing Power Plant is located in Moss Landing Harbor north of Monterey, near Castroville, California. Cooling water for the power plant is pumped from the harbor. At 2086 MW rated capacity, Moss Landing is one of the largest operating plants in the world. As with the other plants, the facilities do not operate continuously at rated capacity. This is because these plants must provide for both "peak" and "base load" requirements. In fact, annual load factors (total production for the year over production at capacity) for these plants will average only 60 to 70 percent. During August and December, the peak production months in southern California, the plants may operate at capacity for several days at a time. When we visited Moss Landing, power production was at 400 MW to 500 MW, about a minimum level for this facility.

Water quality in Moss Landing Harbor is generally satisfactory as a condenser cooling water supply. Although the power plant cooling water is not discharged to the harbor, wastes from the adjacent Kaiser Industries' chemical processing plants are discharged to the south end of the harbor. The only problem with intake water quality is an occasional, unidentified incrustation on the intakes. Intake temperatures range annually from 50 to 60°F and average 55°F.

Cooling water discharges are divided, with units one through five going to Elkhorn Slough, one arm of the harbor, and units six and seven going through conduits under the harbor and discharging 800 feet offshore. Figure 4 shows the shoreline discharge structure for units one through five. The surface foam evident in the photograph is a common phenomenon of unknown origin. There is no evidence of recirculation between the Elkhorn Slough discharge and the intakes located in the main harbor. Elkhorn Slough is about 15 feet deep, several hundred yards wide, and 7 or 8 miles long. There is, reportedly, a striped bass fishery in the slough.

The offshore outfall for units six and seven is in 55 feet of water with the outfall opening 40 feet below the surface. Discharge velocity averages 5 ft/sec from the 12 foot diameter pipe.

The only reported complaints of environmental impact at Moss Landing concern the visible nitrogen dioxide vapors from the power plant chimneys. The familiar commentary was heard about sport fishermen congregating in the vicinity of the power plant outfalls.

PG & E began a three year, pre- and post-operational, oceanographic study in 1966 to determine the impact on the marine environment of heated discharges from units six and seven. Details of the study design are reported in Thermal Effects and Other Considerations at Steam Electric Plants by J. R. Adams, PG & E. The studies have attempted to establish a physical and biological baseline upon which to judge effects of cooling water discharges. Water temperatures, salinity, current velocities, dissolved oxygen concentrations, and weather data have been taken regularly at predetermined grid locations in the vicinity of the outfall. Rhodamine B dye studies have also helped to determine dispersion characteristics. These data have been supplemented by continuous records of weather data at a shore-based station near the plant. Benthos samples taken during the studies have been screened, counted, weighed and identified. There has not been sufficient time since units six and seven went into commercial operation to document changes, if any, in the benthic fauna.

<u>May 2, 1969</u>

Morro Bay Power Plant
Pacific Gas & Electric Company
Morro Bay, California

The Morro Bay facility is entirely enclosed, has a well-equipped visitors center, and is very clean--factors which create a favorable impression upon visitors.

Cooling water for the power plant is pumped from Morro Bay Harbor. Mean water depth at the shoreline intakes is 26 feet. Bars, screens and pumps are located in the intake building shown at the harbor's edge in Figure 5. Morro Bay Rock is seen in the background. Intake temperatures average 56°F with an annual range of 50 to 60°F.

The heated cooling water is discharged to a canal along the north face of Morro Bay Rock into Estero Bay.

With the high spring runoff in 1969, hydroelectric production in the PG & E system was above average and thermal electric production was below average; Morro Bay was running well below capacity.

As at the other plants visited, the discussion on the environmental impact of heated discharges from Morro Bay yielded no specific complaints. Sport fishermen get good catches of striped bass, kelp bass, and perch adjacent to the outfall (Figure 6). California Fish and Game personnel report a good population of pismo clams on the beach north of Morro Rock during the last five years of power plant operation.

Temperature and dye studies at Morro Bay indicate that warm water from the power plant covers about 100 acres within which surface temperatures are at least 4°F higher than ambient ocean temperatures. The surface area contained within a 9°F difference is less than 10 acres.

Dr. Wheeler North, of the California Institute of Technology, has done biological studies for PG & E. at Morro Bay. His findings show a reduction in numbers and densities of plant and animal species in a transitional zone which extends approximately 200 meters from the terminus of the discharge canal.

Specially conducted studies have shown no drop in dissolved oxygen concentration across the power plant condensers, although percent saturations will vary with the water temperature.

<u>May 3, 1969</u>

El Segundo Power Plant
Southern California Edison
El Segundo, California

El Segundo is located near the Los Angeles International Airport on the open coastline. Figure 7 shows El Segundo as seen from the beach north of the plant area.

The intake and outfall conduits are side by side, with the intakes located one half mile offshore and the outfalls about 2100 feet offshore. No specific studies were conducted to locate the intake and outfall structures. Colder water is available farther out, but not within economical reach. The outfalls were placed to meet navigation requirements of the U.S. Coast Guard and Corps of Engineers.

The El Segundo intakes now have velocity caps to induce peripheral inflow currents. The velocity caps have reduced fish mortalities in the intakes from 272 tons during the year preceding installation to 15 tons the following year.

The intake temperatures at El Segundo range annually from 50 to 70°F. Although the temperature increase across the condensers is 20 to 24°F when the units operate at capacity, during normal operation the temperature increases are much less. As at most of the plants visited, recirculation water flow to individual operating units is fixed even though electrical generation fluctuates. Since these large thermal plants normally run at reduced loads, it is not surprising that actual temperature increases across the condensers may be only 14 to 15°F. During October 1968, for example, average intake and outfall temperatures were 58 and 72°F, respectively, with a 14°F increase across the condensers.

No pre-construction studies were required for units one and two which were placed on line in 1955. Pre-construction studies and 2 years of operational studies were required, however, for units three and four, which went on line in 1964. Monthly surveys at four points near the outfall included measurements of temperature, dissolved oxygen and light transmission (Secci Disk). Daily samples for temperature, pH, oil and grease were collected in the outfall. Twenty-four hour discharge composite samples were also run quarterly for cadmium, chrome, copper, cyanide, nickel, phenols, zinc, and biochemical oxygen demand (BOD).

In-plant sampling has continued with monthly measurements of temperature, pH, dissolved oxygen, oil and grease, turbidity, and BOD taken in both intake and discharge conduits. The water samples are collected by plant personnel and analyses are conducted commercially.

The following are three sets of temperature and dissolved oxygen data from the operational field surveys at El Segundo. Temperatures were taken at the intake, the outfall, the water surface above the outfall, and at the water surface and 10 feet below the surface 300 feet north, south, east, and west of the outfall. Dissolved oxygen was measured in addition to temperature, at the 300-foot locations:

Location	Temp./D. O. (°F/ppm)		
	Set #1	Set #2	Set #3
Intake (ambient)	56	57	68
Outfall	77	75	91
Outfall surface	66	--	--
300 North-Surface	62/8.31	62/9.55	74/8.43
300 North 10'	61/8.98	62/9.93	73/8.59
300 East-Surface	60/8.60	60/9.38	73/7.55
300 East 10'	58/9.45	58/10.0	71/7.45
300 South-Surface	59/8.99	59/9.10	73/7.60
300 South 10'	57/9.77	58/10.0	72/8.02
300 West-Surface	61/8.85	59/9.45	77/7.75
300 West 10'	60/9.98	58/10.0	72/8.28

These data show that the temperature increase across the condensers is reduced by half by mixing between the outfall and the water surface. A temperature increase of 4 or 5°F is still evident 300 feet from the outfall. At El Segundo, this means that water temperature elevations greater than 4°F are contained within an area of about two acres. There is no apparent dissolved oxygen problem in the vicinity of the outfall.

There have been no specific complaints about effects on the heated discharges on the marine environment. As elsewhere, sport fishermen are attracted to the outfall area. Occasionally charter boats will stop near the outfall for bonito if the action on colder water species has been slow.

<u>May 5, 1969</u>

Los Angeles Regional Water Quality Control Board
Los Angeles, California

In general, the San Gabriel River is the dividing line between the Los Angeles and Riverside Regions. The line zigzags, however, and both the Haynes and Alamitos plants are within the Los Angeles Region.

The Los Angeles Board is modifying California's water quality standards within the area excepted from the Interior Secretary's approval, which includes the estuaries from the San Gabriel River to Rincon Point (near Carpinteria) and the Los Angeles Harbor. The exception emphasis was placed on Los Angeles Harbor.

The Regional Board has initiated field studies at the Redondo Generating Station to revise discharge requirements. Redondo had a year of pre-construction field studies. Oceanographic Services, Inc., is working on the Redondo Beach studies, and the Regional Board is cooperating with the Department of Fish and Game.

Southern California Edison (SCE) has contracted with Marine Advisers for pre-construction field studies at the Ormond Beach power plant site south of Ventura. The Regional Board considered discharge requirements for the site during its May, 1969, meeting. By the 1971 completion date for Ormond Beach, there will be about 3 years of pre-construction data. Mr. John Day of Los Angeles and Mr. Charles Turner, Department of Fish and Game, have been working with the Board on structuring these studies.

Pre-construction data will be required at all new power plant sites. Monitoring programs will be required at existing plants to determine necessary discharge requirement changes. For example, if a maximum allowable temperature were established for the San Gabriel River, this might require revision of the discharge requirements for the Haynes and Alamitos Plants.

California Institute of Technology
Pasadena, California

The tour group met with Dr. J. W. McKee, Dr. Norman Brooks, and Dr. Wheeler North. Both Dr. McKee and Dr. North prefer coastal sites for thermal power plants over inland sites, from an environmental point of view.

Dr. North has been engaged in biological effects studies at Morro Bay, Diablo Canyon, and San Onofre. He is also studying biotic changes in the San Gabriel River. At Morro Bay Dr. North found that the abundance and diversity of plant and animal species were affected by the heated effluent in a "transitional zone" which extended approximately 200 meters from the terminus of the discharge canal. Densities and numbers of plant and animal species were reduced in the transitional zone, probably due to substantial temperature fluctuations. It was not possible to evaluate the factors involved in a greater effect upon flora than fauna. "The change from an impoverished condition typical of the transitional region to the luxurious cover of the normal region occurred rather abruptly within a horizontal distance of about 10 meters." 5/

At the Diablo Canyon nuclear site, Dr. North predicts the possible disappearance of all cold water species within the immediate cove. To avoid this change, Dr. North suggests constructing a deep offshore outfall. PG & E has rejected the suggestion on the basis of costs as compared with a shoreline outfall. The Department of Fish and Game is attempting to evaluate the extent and value of probable biotic changes in the Diablo Canyon cove.

5/ Wheeler J. North, "Biological Effects of a Heated Water Discharge at Morro Bay, California," paper presented at VI International Seaweed Symposium, Madrid, Spain, September 1968 (La Jolla, Calif.: California Institute of Technology, W.M. Keck Engineering Laboratories), p.9.

Dr. Brooks maintains that the technology of diffuser design permits the stipulation of any dilution required. The thermal power planner can choose to spread a small temperature increment over a large water volume or to concentrate a large temperature increment within a small volume. Waste heat can be stored below the thermocline or added to the surface layer for faster dissipation to the atmosphere.

Temperature stratification in the nearshore waters of southern California is extremely stable during the summer months and may be present during the winter months as well. This stratification inhibits the rise of deep outfall waste discharge plumes to the water surface. The effluent from the Orange County waste treatment plant is expected to emerge at the water's surface only 15 to 30 days per year.

Dr. Brooks noted that the Tennessee Valley Authority's Brown's Ferry Plant on Wheeler Reservoir will be the first large prototype incorporating multi-port diffusers for diluation of waste heat-- 4300 cfs at capacity, with a temperature elevation of 25°F. Hydraulic model studies of the plume dispersion patterns are being conducted at MIT, Cambridge, Massachusetts; the diffuser characteristics are being studied by TVA at Norris, Tennessee.

Dr. Brooks thinks that the data collected at existing plants and proposed sites are not comprehensive enough to define the distribution of waste heat discharges, either beneath the thermocline or at the surface.

May 6, 1969

Santa Ana Regional Water Quality Control Board
Riverside, California

Personnel of the Santa Ana Water Quality Board told the tour group that with no fresh water inflow during the summer months the water quality of the San Gabriel River is improved by the hydraulic flushing action induced by the 3500 cfs combined discharge from the Haynes and Alamitos power plants. Reduced upstream waste loadings have also contributed to improved water quality. Further improvement of the San Gabriel is possible, however, and is being studied.

Although there are no apparent problems, there is little information available on the environmental effects of heated discharges at the Huntington Beach Power Plant.

The Los Angeles Metropolitan Water District (MWD), the United States Department of the Interior, and private power companies have been studying a proposal for a combination power desalting plant near Sunset Beach. However, with rapidly increasing costs, only MVD and USDI (Office of Saline Water) are still seriously considering the suggestion.

California Department of Fish and Game
Terminal Island
Long Beach, California

The Department of Fish and Game is conducting studies at the

Redondo Generating Station and the San Onofre Nuclear Generating Station.

The Redondo Beach Studies have revealed few harmful effects of heated discharges on the biota. The kelp beds, which are sensitive to heat, have been adversely affected. There have also been changes in the number and variety of marine species, and the warm water fishery has been enhanced.

Similarly, less than one year of operational studies at San Onofre shows no major environmental effects. High flows in the San Mateo River have reportedly caused more change in biota than the warmed water from San Onofre.

The pre- and post-construction studies, such as those being done by Marine Advisers for Southern California Edison, are not effectively coordinated with the Department of Fish and Game at the working level. Consequently, it is possible for pre- and post-construction studies to meet State policy requirements without yielding the most useful product. The Department's biological surveys at San Onofre are being conducted at the request of the San Diego Regional Water Quality Board to provide an independent check on the studies being done by Marine Advisers. Marine Advisers have only recently hired a full time biologist, at the suggestion of the State. Previously, biota analyses were done under a sub-contract by graduate students at the Scripps Institution of Oceanography.

The Department of Fish and Game's biological studies at Redondo Beach are being conducted on their own initiative, but are financed by SCE.

In any case, biological sampling and analysis techniques have not been standardized in California, or anywhere else. It is to be expected that independent biological surveys by different groups will yield varying results, because of differences in the techniques employed and in the ability and judgment of the investigators.

A staff member of the Department told the tour group that heat treating intakes and outfalls invariably kills fish under the present mode of operations. We agreed that serious study should concentrate on control of biofoulants by means that are not destructive to fish.

Redondo Generating Station
Redondo Beach, California

Figure 8 shows the Redondo Generating Station adjacent to King Harbor. The Redondo Plant has six older generating units (1949, 1954-57) that are operated at annual load factors of 40 percent or less; two new units (1967) are operated at annual load factors of 90 percent.

Originally two intake and outfall conduits outside the harbor served units one through four and two conduits inside the harbor served units five and six. Currently, the two conduits inside the harbor are intakes for units one through six and the conduits outside the harbor are outfalls for units one through six. The outfall for units seven and eight is inside the harbor, 300 feet from the shore. The intake for units seven and eight is located at the harbor entrance. During past years at Redondo Beach, large numbers of fish trapped in the conduits have been killed by high temperatures during heat treatment operations.

The Redondo Generating Station provides warm water from the discharge lines for units five and six or seven and eight for the large municipal swimming pond in Figure 8. Water for the pond is supplied continuously during the five- or six-month swimming season.

The Redondo Beach Harbor (King Harbor) contains berthing for 1400 boats and is a popular fishing location. The levee, which runs northward from the harbor entrance, is pervious except along the east-west section at the north end of the harbor where it is impervious to protect moorings from the surging of high seas. Except at the north end where the water tends to become "stale", water quality in the harbor is satisfactory because of tidal flushing. The sport fishery inside the harbor is primarily Pacific bonito. The tour group observed large schools of bonito; the fish were so numerous, in fact, that most of the fish caught were "snagged" by anglers. The relation between the presence of bonito and the location of the harbor outfall was not established.

Southern California Edison has financed temperature surveys within the harbor since December 1965. Bio-assays are also run on material scraped from growth panels located in the harbor. Although there are insufficient temperature data from outside the harbor for exact comparisons, the temperatures within the harbor are reportedly slightly higher than ambient ocean temperatures. The data collected for SCE have not been interpretively compiled, but they are available for examination. The Department of Fish and Game also conducted surveys from January through December, 1968.

The tour participants were impressed by the apparent lack of environmental effects due to heated discharges. Extensive pre- and post-construction field data are not available, however, to document what changes have occurred within the harbor.

May 7, 1969

Haynes Steam Plant
Los Angeles Department of Water and Power
Long Beach, California

The Haynes and Alamitos power plants are located on opposite banks of the San Gabriel River. Both stations withdraw condenser cooling water from Alamitos Bay and discharge the heated water to the San Gabriel River. This is apparently an excellent arrangement because it provides hydraulic flushing action for Alamitos Bay, Los Cerritos Channel, and the San Gabriel River.

It also physically separates the intake water supply from the receiving water, minimizing the possibility of recirculation of the heated cooling water.

The Haynes Steam Plant (Figure 9) is a relatively new plant and operates at an annual load factor greater than the system average of 62 percent. Figures 10-13 show the unique water intake system for the Haynes plant. The initial intake area (Figure 10) is in the Long Beach Marina. The intake acts as a giant vacuum cleaner for the marina: debris accumulates on the intake bars and is collected at routine intervals. The cooling water flows from the intake through 1200 foot conduits under the San Gabriel River and discharges to an open channel from the outfall shown in Figure 11. Figure 12 shows the San Gabriel River on the right, flowing away from the plant, and the Haynes cooling water channel on the left, flowing towards the plant. The plant's intake pumps and screens are located on this channel; Figure 13 shows the intake structure for unit one.

Intake water temperatures range from 55 to 72°F. Except for a "red tide" in 1962, intake water quality has been good. Red tides are heavy blooms of red-colored, dinoflagellate algae. High dissolved oxygen production occurs during the bloom generation stage. During degeneration and decomposition, the oxygen resources are depleted and sulfide concentrations increase rapidly. The resulting conditions are seriously adverse to most indigenous biota. During the 1962 red tide, dead biota clogged the stationary intake screens for units one and two at the Haynes plant. These units were temporarily shut down as a result. The bloom was not limited to the local area but extended along the coastline for several miles.

Although damaging to normal biota and plant operations, the probability for an occurrence of a red tide is not significant.

The Los Angeles Department of Water and Power is conducting monthly surveys at the Haynes Steam Plant. Data on temperature, dissolved oxygen (DO), pH, and biochemical oxygen demand are collected at the intakes and outfalls; data on temperature, DO, and pH are collected in Long Beach Marina and at two points in the San Gabriel River. The Department also checks for filamentous green algae on the intake channel surface and controls it with chlorine when necessary.

In a documented memo on the San Gabriel River, prepared in January 1967 for Los Angeles Water Quality Control Board hearings the Department of Water and Power concluded:

> To sum up biological conditions in the tidal prism, it is evident that many marine forms find a suitable environment here, and were it not for an occasional scouring by flood waters . . . , or a natural disaster such as a "Red Tide", all these forms would survive and flourish.

A Department of Fish and Game survey along the coast south of the San Gabriel River in 1966 failed to document a concentration of round stingrays that had been reported. They did find that ecological conditions were improved over earlier surveys in 1952 and 1954, but conditions were still less than optimum.

Public attitude toward the Haynes Steam Plant is neutral or favorable. Early complaints on stack emissions ceased when the plant began to use ashless fuels low in sulfur.

Alamitos Steam Station
Southern California Edison Company
Long Beach, California

The Alamitos plant was first visited in December, 1968. A detailed description of Alamitos can be found in Thermal Power Plant Cooling Facilities, Northwest Pollution Control Council, April, 1969. Figure 14 shows the Alamitos Plant and its surface discharge into the San Gabriel River.

The item of real interest on this visit was the new 132 MW, gas turbine (jet engine) generator unit. This unit was installed expressly for power peaking capability, it can go from "cold-standby" to full load in 3 minutes. Conventional steam turbine generators may take several hours before reaching full power from cold-standby.

The new unit includes 8 Pratt & Whitney aircraft type engines, 4 Worthington expander turbines, and 1 generator. The unit was tested for several months and made operational in June, 1969.

Although the gas turbine generator requires 16,000 BTU/KWH, no heat is discharged to a receiving steam. A gas turbine generator has also been installed at the Huntington Beach Generating station. These gas turbine units require overhauling every 4000 hours at a cost of $40,000 each; consequently, they are not practical for continuous duty. There appear to be no insurmountable problems, however, in modifying gas turbines for continuous use.

<u>May 8, 1969</u>

Huntington Beach Generating Station
Southern California
Edison Company
Huntington Beach, California

The Huntington Beach Generating Station (Figure 15) is located on the open coast near Los Angeles.

Huntington Beach, although not very old, is currently operating at an annual load factor of 37.5 percent. Some of the generating units remain on standby most of the time.

As mentioned above, a gas turbine generating unit, rated at 162 MW, has been installed here. Unfortunately, the tour group missed the testing schedule for the gas turbines at both Alamitos and Huntington Beach. We were especially curious about the noise level of eight jet engines in a closed building. Evidently, with efficient soundproofing systems very little noise is heard outside the building.

Huntington Beach has one intake and one outfall conduit, each about a half mile long. As mentioned earlier, the outfall was designed to meet USACE and USCG navigation requirements. The outfall discharges vertically 25 feet below the water surface in a total depth of 40 feet. Nearshore currents are seasonably about 70 percent downcoast and 30 percent upcoast. The vertical intake opens 20 feet below the water surface and is equipped with a velocity cap.

There have been no pre- or post-construction field surveys conducted at Huntington Beach to document environmental effects. There have been no oomplaints, however, which is somewhat remarkable considering the proximity of the plant to Huntington State Beach. The power plant is across the highway from 2.4 miles of State-owned swimming beach. This highly developed beach area is extremely popular and is a money-making business (75¢ per car) for the California Department of Parks and Recreation. Apparently, the power plant, recreationists, and homeowners are getting along very well at Huntington Beach.

The only problem described to the tour group related to difficulties with cooling water intake screens. Stationary screens that had to be cleaned manually were installed initially at Huntington Beach. During heat treatments these screens had to be cleaned too often to remove the dead fish. In march, 1961, the screens had to be cleaned every shift; an average of 3600 pounds of dead fish was removed each time. Travelling screens have since been installed and are more satisfactory from the standpoint of fish kills and maintenance.

May 8, 1969

San Diego Regional Water Quality Control Board
San Diego, California

Since San Onofre was the first power plant in the San Diego Region to be subject to waste discharge requirements, there was considerable local interest in the Board Hearings conducted to set the discharge requirements. The prime subject of discussion at the Hearings was thermal effects.

Water Quality Control Board personnel agreed with the Department of Fish and Game staff in regard to the conduct of biological monitoring surveys at San Onofre. SCE has contracted with Marine Advisers for operational field studies and the Regional Board has requested California Fish and Game to conduct independent surveys. The latest conclusion of California Fish and Game is that biological effects, if any, have been negligible. The surveys will be repeated in two years.

The studies conducted by Marine Advisers meet the State monitoring requirements but do not necessarily provide useful data for evaluating environmental changes at San Onofre. It is difficult to make judgments from the data as presented.

May 9, 1969

San Onofre Nuclear Generating Station
Southern California Edison Company
San Diego Gas & Electric Company
San Clemente, California

San Onofre, the last power plant in the tour, is shown in Figure 16. San Onofre was also a repeat visit from the December 1968 tour.

San Onofre was designed as a base load unit and will be operating at an annual load factor of 80 to 90 percent for the first 10 years. The proposed Diablo Canyon nuclear generating station will be designed to follow load cycles rather than to operate continuously at rated capacity.

According to schedule, SCE will begin refueling during the summer of 1970 by removing the center fuel cells, moving the intermediate and peripheral cells inward, and placing new fuel cells in the vacated periphery. In the future, one-third of the cells will be replaced annually; five weeks are required to complete the refueling operation.

Data from Huntington Beach temperature surveys were used for preliminary evaluation of the probable distribution of discharged cooling water from San Onofre. By extrapolation it was estimated that an increase of $1^{o}F$ above ambient temperature would be confined within half a mile radius. The operational studies by Marine Advisers over a period of about 9 months show that the San Onofre thermal plume has about the same configuration as at Huntington

Beach but is of considerably less areal extent. Marine Advisers had completed an infrared aerial survey just before our visit.

The final summary of pre-operational data on San Onofre is complete and is being reviewed for publication. An annual report with the first year's operational data is also nearing completion.

Bureau of Commercial Fisheries
Fishery-Oceanographic Center
La Jolla, California

The Fishery-Oceanographic Center is not involved in activities closely related to the usual objectives of coastal siting studies. Most of the Center's work relates directly to the preservation and enhancement of the offshore fishery; they do very little nearshore research or surveys. The tour group was impressed with the Center's facilities for analytical, laboratory, and pilot plant research.

Scripps Institute of Oceanography
University of California
La Jolla, California

The Scripps Institution is not directly involved in thermal power plant environmental impact studies. There are no immediate plans to initiate formal relationships with groups that are involved in such studies. Scripps is organized around long range, continuing research programs. Short term specialized study requests are not regularly accepted. The scientists at Scripps are, however, individually interested in the objectives and problems of coastal power plant studies.

BIBLIOGRAPHY

Adams, J.R., Thermal Effects and Other Considerations at Steam Electric Plants. Pacific Gas and Electric Co., August 20, 1968.

Dunham, Lloyd R., Recommendations on Thermal Objectives for Water Quality Control Policies on the Interstate Waters of California. Report to the State Water Resources Control Board, August 1968. State of California Resources Agency, Department of Fish and Game.

Fox, D.L., and Corcoran, E.F., "Thermal and Osmotic Countermeasure Against Some Typical Marine Fouling Organisms," Corrosion, 14(3), 1967.

North, Wheeler J., "Biological Effects of a Heated Water Discharge at Morro Bay, California," paper presented at VI International Seaweed Symposium, Madrid, Spain, September 1968. LaJolla, California: California Institute of Technology, W.M. Keck Engineering Laboratories.

APPENDIX A

MAP AND PHOTOGRAPHS

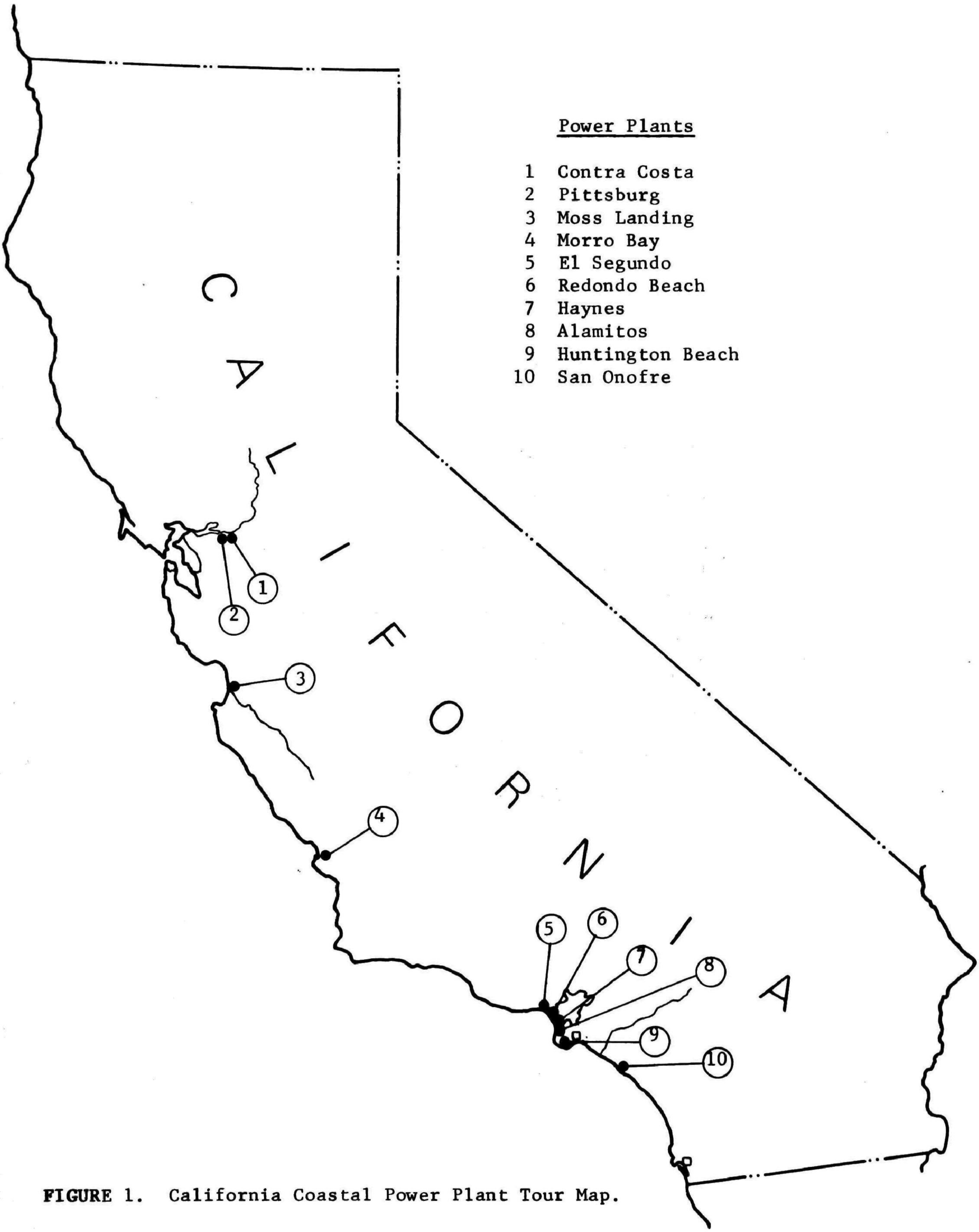

FIGURE 1. California Coastal Power Plant Tour Map.

FIGURE 2. San Joaquin River and Contra Costa discharge canal for units 6 and 7.

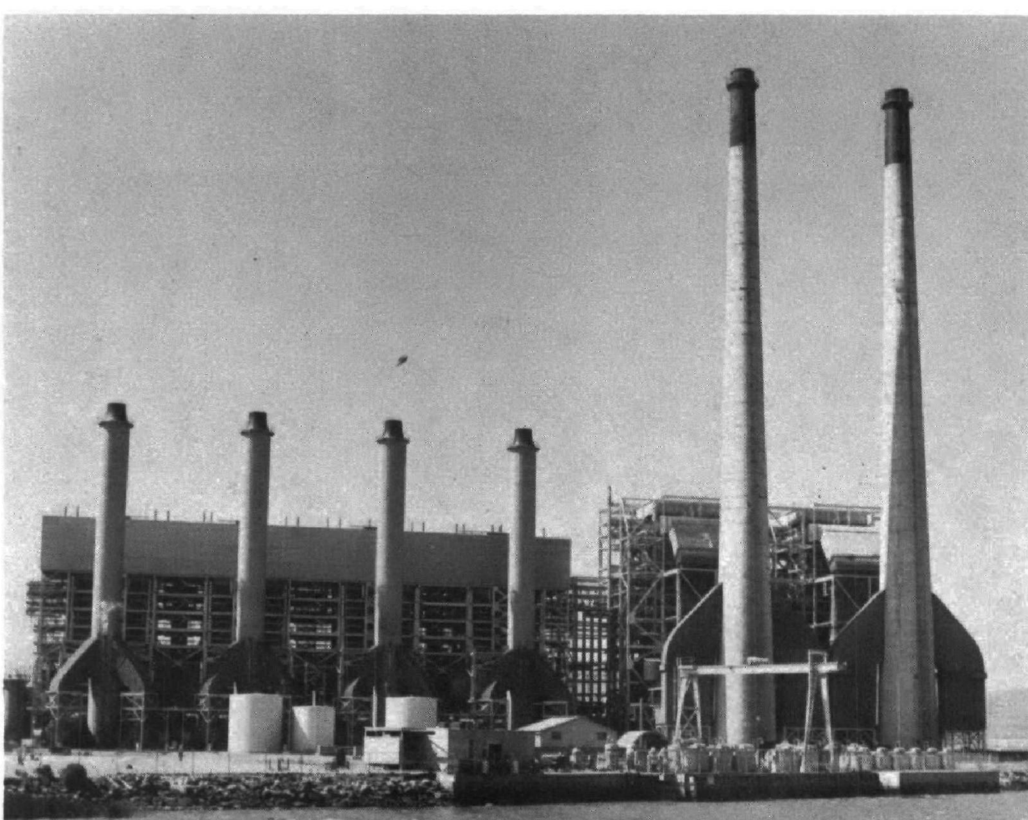

FIGURE 3. Pittsburg Power Plant on Suisun Bay. The shoreline intakes can be seen in the right foreground.

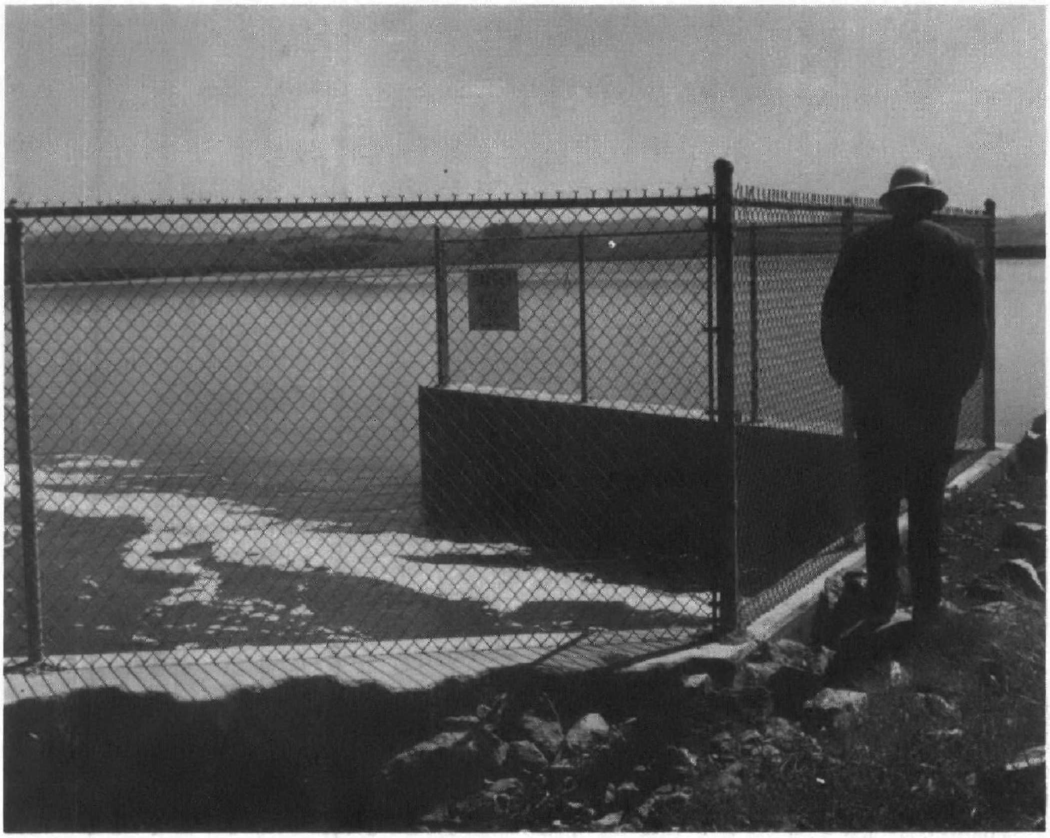

FIGURE 4. Moss Landing Power Plant shoreline discharge structure for units 1 through 5. The outfall discharges to Elkhorn Slough. The surface foam is a common phenomenon of unknown origin.

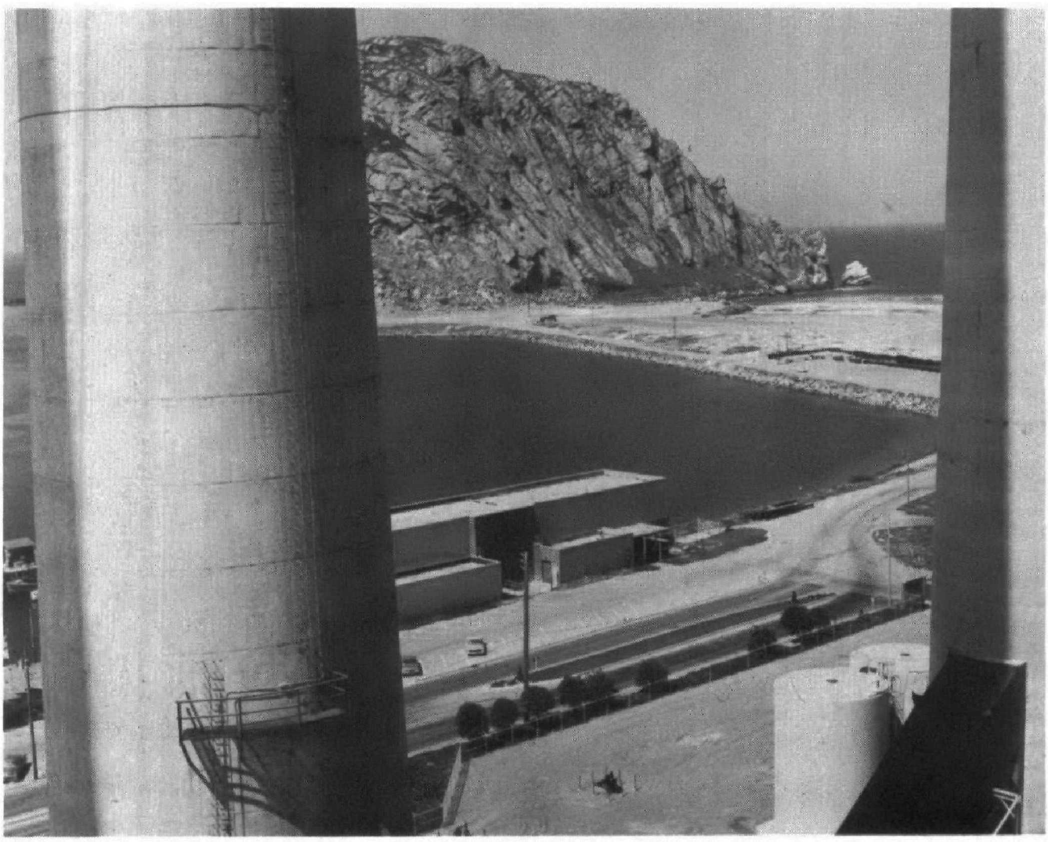

FIGURE 5. Morro Bay Power Plant intake structure in foreground and outfall channel along side Morro Rock.

FIGURE 6. Fisherman with ocean perch at Morro Bay outfall channel.

FIGURE 7. El Segundo Power Plant, El Segundo, California

FIGURE 8. Redondo Power Plant adjacent to King Harbor. During the six month swimming season the plant supplies warm water for the municipal swimming pond in the foreground.

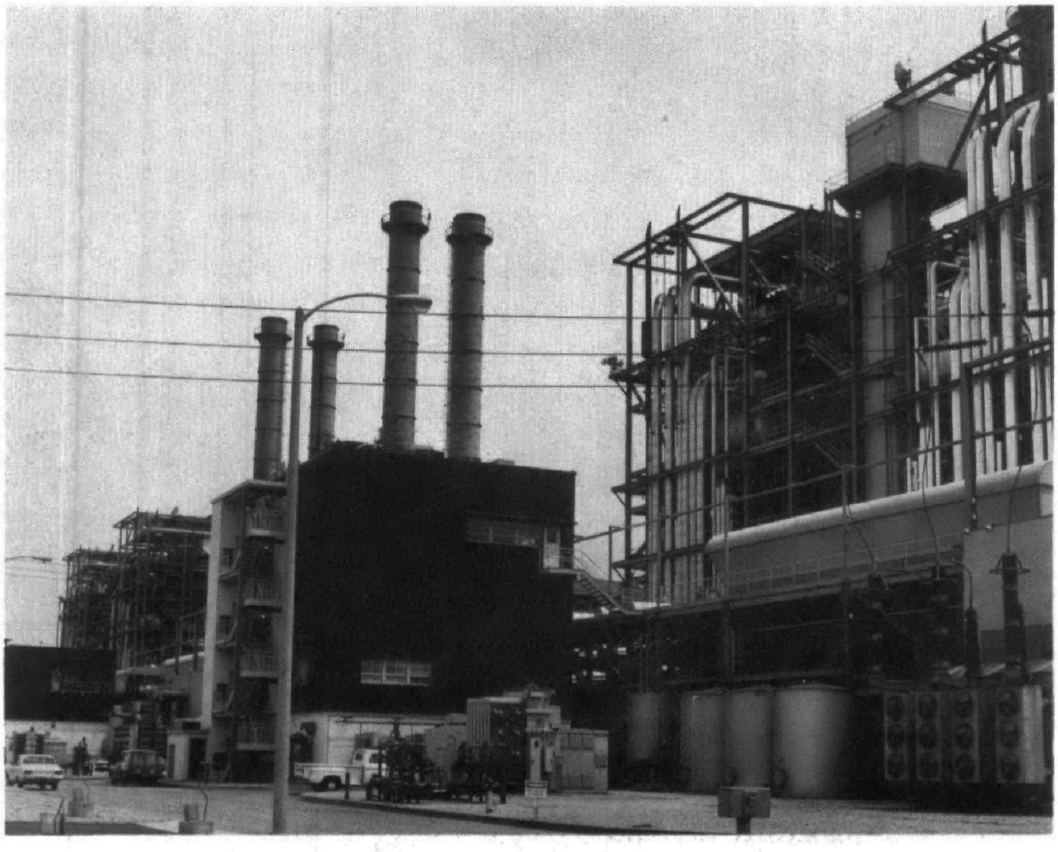

FIGURE 9. Haynes Steam Plant, Long Beach, California

FIGURE 10. Haynes Steam Plant initial cooling water intake Long Beach Marina.

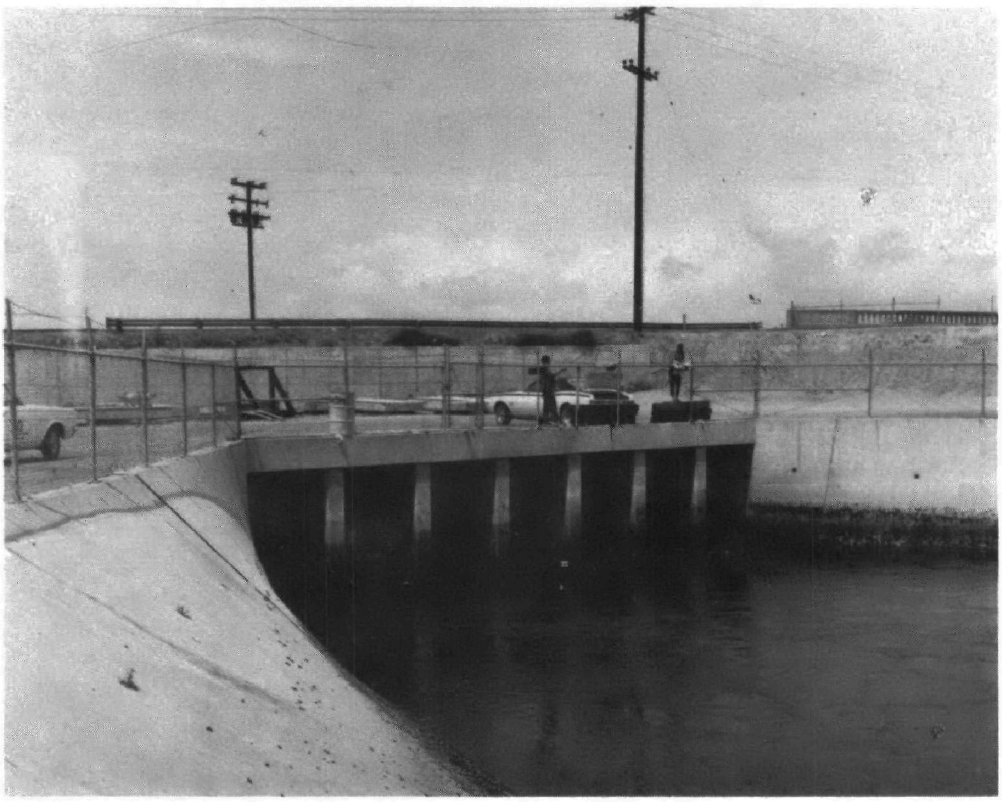

FIGURE 11. Discharge from Haynes Power Plant intake tunnel to intake channel. The tunnel, which travels under the San Gabriel River, connects the intake channel to the Long Beach Marina where water is initially withdrawn for cooling.

FIGURE 12. The Haynes Power Plant intake channel is on the left. Water in the channel is pumped under the San Gabriel River on the left from the Long Beach Marina.

FIGURE 13. The Haynes Power Plant intake structure for unit 1, located on intake channel.

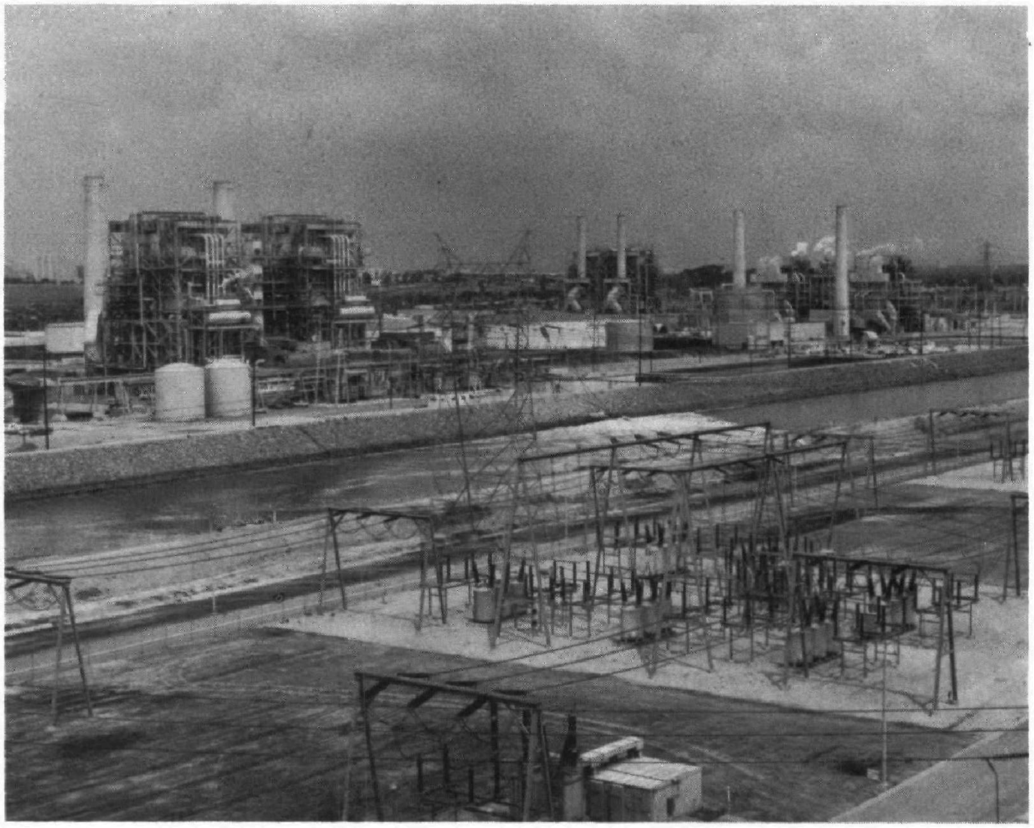

FIGURE 14. Alamitos Steam Station, Long Beach, California. Note discharge into San Gabriel River.

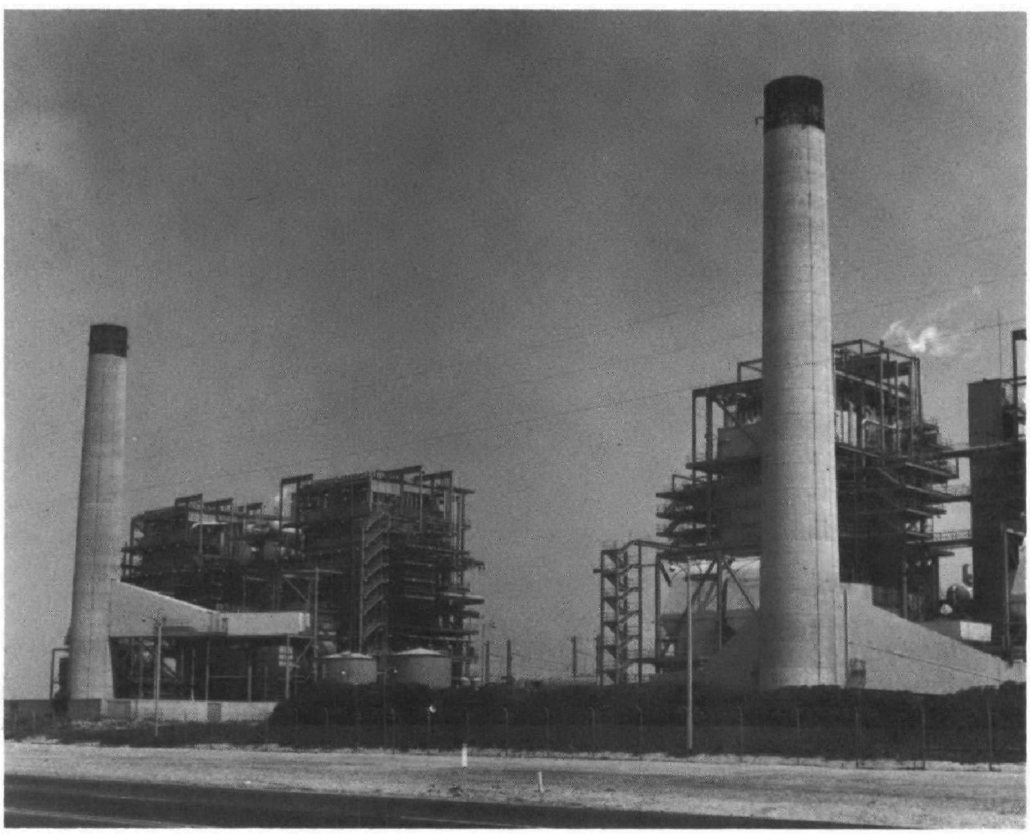

FIGURE 15. Units 1 through 4, Huntington Beach Power Plant, Huntington Beach, California.

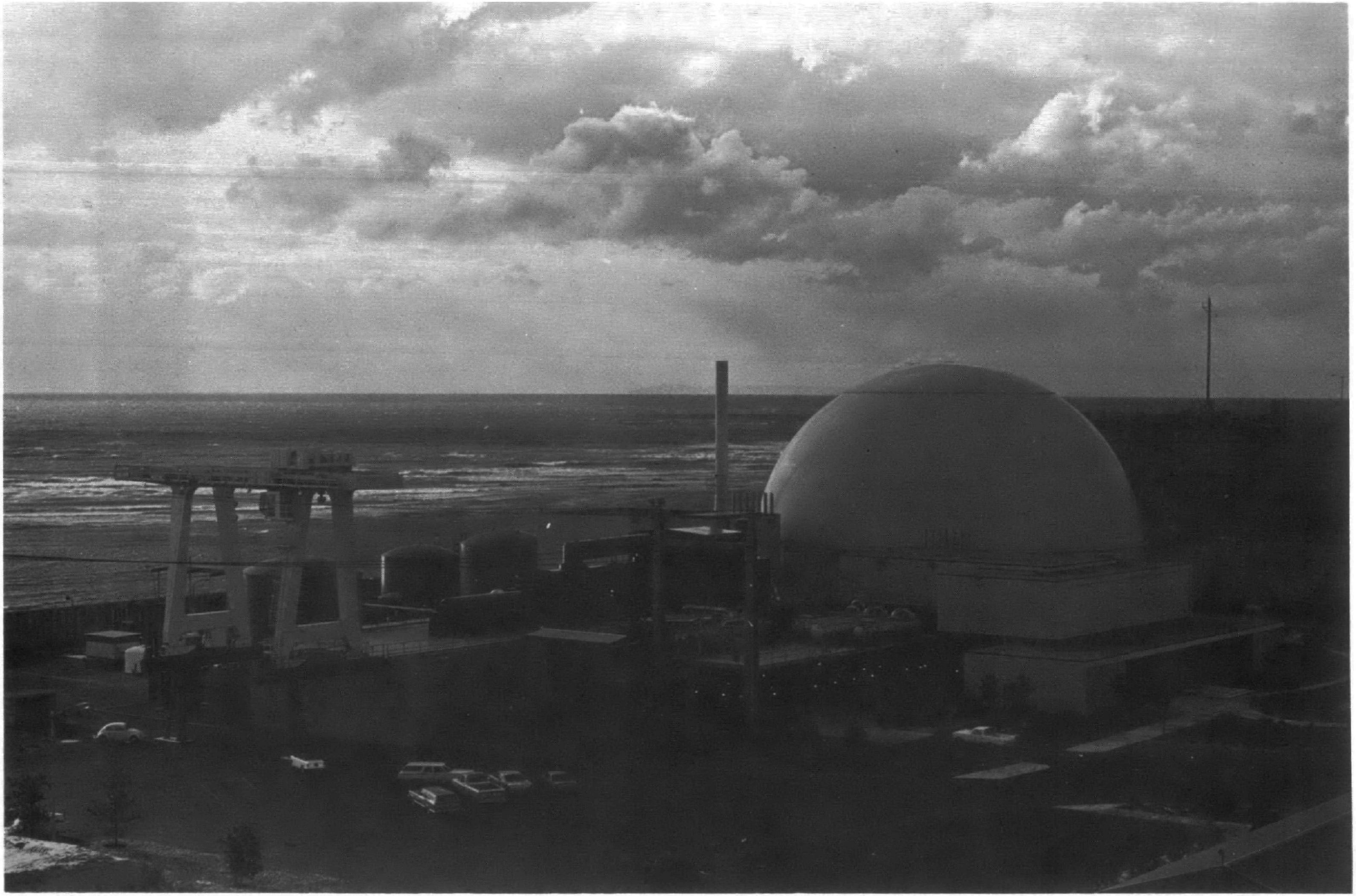

FIGURE 16. San Onofre Nuclear Power Plant about halfway between Los Angeles and San Diego. Sea water for cooling is pumped through intake and discharge lines extending offshore.

APPENDIX B

Power Plant Data

1. Contra Costa Power Plant

a. Location-Antioch, California
b. Owner-Pacific Gas & Electric Company
c. Date(s) in operation-1951, 1953, 1964
d. Generator Capacity
   (1) Capacities:

Units	1,2,3	300 MW
	4,5	200 MW
	6,7	660 MW
	Total=	1160 MW

e. Turbine Steam Data (psig/degree F/degree F)

Units 1,2,3	1405/950/-
4,5	1500/1000/1000
6,7	2400/1050/1000

f. Heat rates-(not given)
g. Fuel-oil or gas (quantities not given)--usually burn natural gas for air quality control.
h. Condenser Cooling Water Reg'ts.-680,000gpm (total)
   (1) Source-San Joaquin R.-just above confluence with Sacramento R.
   (2) Intake(s)
       Location 1-5--offshore
                6,7--shoreline
       Size (not given)
       Screens 1-5--"travelling"
               6,7--"travelling" with approach velocity of 0.5 fps and flow-thru velocity of 1.5 fps.
   (3) Water treatment
       (a) Chlorination for slime control--½ hr. every 24 hrs. to 0.5 ppm residual at condensers
       (b) Heat treatment (plus physical cleaning for asiatic clam control in the intake conduits for units 1-5)
   (4) Cooling water discharge
       (a) ΔT=18 degrees Fahrenheit (design, at capacity)
       (b) Outfalls--shoreline to outfall channels into the Sacramento R.

2. Pittsburg Power Plant

a. Location-Pittsburg, California
b. Owner-Pacific Gas & Electric Company
c. Date(s) in operation-1954, 1960, 1961
d. Generator Capacity

Units 1-4	165 ea	660 MW
5,6	330 ea	660 MW
	Total	1320 MW

e. Turbine Steam Data (psig/degrees F/degrees F)

Units 1-4	1800/1000/1000
5,6	2400/1050/1000

f. Heat rates-(not given)
g. Fuel-Natural gas for air quality control; oil in winter when gas supplies are short: (12,400,000 cu. ft. 3/hr. of gas or 84,000 gal/hr of fuel oil.)
h. Condenser cooling water reg'ts.--555,000 gpm (or 1240 cfs) total according to brochure. Operating engineer gave 1600 cfs as acutual maximum.
   (1) Source--San Joaquin R. near confluence with Sacramento, but downstream of Contra Costa Plant
   (2) Intake(s)
   shoreline structure with bars, screens, & pumps in one facility

   screens: 0.5 fps approach velocity
   1.5 fps flow through velocity

   (3) Water Treatment
   Chlorination and heat treatment as at Contra Costa

   (4) Cooling water discharge
   (a) ΔT=18 degrees Fahrenheit at max. load
   12 degrees Fahrenheit at 990 MW
   (b) Outfall-shoreline to Suison Bay

Note: Unit #7 scheduled to go on line in 1972 with new intakes and outfall west of present facilities.

3. Moss Landing Power Plant

a. Location-Castorville, California (Monterey Co.)
b. Owner-Pacific Gas & Electric Co.
c. Date(s) in operation-1950, 1952, 1967, 1968
d. Generating Capacity

Units 1-3	114 ea	342 MW
4,5	122 ea	244 MW
6,7	750 ea	1500 MW
	Total =	2086 MW

e. Turbine Steam Data (psig/degrees F/degrees F)

Units 1,2,3	1300/950/--	
4,5	1450/1000/1000	
6,7	3675/1000/1000	Note: "supercritical"

f. Heat Rates (BTU/KWH)

1-5	9500 with gas fuel
6,7	8700 with gas fuel

g. Fuel-18,950,000 cubic feet of natural gas/hour or 162,500 gal. of fuel oil/hour
h. Condenser cooling water reqts.

Units 1,2,3	80,600 gpm each	241,800
4,5	46,400 gpm each	92,800
6,7	300,000 gpm each	600,000
	Total =	934,600 gpm

(1) Source-Shoreline intakes in Moss Landing Harbor
Pumps and screens for units 1-5 in a separate structure.
Pumps and screens for 6 and 7 in same structure as intakes.

(2) Intakes--(see above)

(3) Water Treatment-Chlorinate to 0.5 ppm at condenser inlet for 2.5 hrs. once each week, on units 1-5. Chlorinate to 10 ppm at condenser inlet for 10 min. once each day on units 6,7. Heat treat for mussel control on units 6,7 once each week; raise temperatures to 105 degrees Fahrenheit for 2 to 4 hrs.

(4) Cooling water Discharge
Units 1-5 to Elkhorn Slough (shoreline discharge)
Units 6,7 to Pacific Ocean about 800 feet from shore (12 feet, conduit, vertical outlet, no diffuser, 40 feet below surface).

4. Morro Bay Power Plant

a. Location-Morro Bay, California
b. Owner-Pacific Gas & Electric Company
c. Date(s) in operation - 1956, 1963
d. Generating capacity

Units 1,2	170 each		340 MW
3,4	345 each		690 MW
		Total =	1030 MW

e. Turbine steam data (psig/degrees F/degrees F)

Units 1,2	1800/1000/1000
3,4	2400/1050/1000

f. Heat water - 9000 to 9500 BTU/KWH
g. Condenser cooling water reqts

Units 1,2	49,000 gpm each pump;	98,000 x 2 =	196,000gpm
3,4	73,000 gpm each pump;	146,000 x 2 =	292,000gpm
		Total =	488,000gpm

(1) Source-Morro Bay Harbor
(2) Intake(s)
Shoreline with pumps & screens in same structure
(3) Water treatment
Chlorinate for slime control
Heat treat for mussel control; temperatures increased to 105 degrees Fahrenheit for 3 to 4 hours in intake lines once a month and in outfalls every 6 months.
(4) Cooling water discharge
(a) ΔT=20 degrees Fahrenheit (design) At operating levels, of power production measured ΔT's have averaged 12 to 15 degrees Fahrenheit.
(b) Outfall at base of Morro Bay Rock into Estero Bay

5. El Segundo Power Plant

a. Location-El Segundo, California
b. Owner-Southern California Edison
c. Date(s) in operation-1955, 1964
d. Generating Capacity

Units 1,2	175 each	350 MW
3,4	335 each	670 MW
	Total =	1020 MW

e. Turbine Steam data (psig/degrees F/degrees F)
   Units 1,2 1850/1000/1000
   3,4 2400/1050/1000
f. Heat rates-Units 1,2 9500 BTU/KWH
   3,4 9100 to 9200 BTU/KWH
g. Fuel-Gas most of the year
   Oil when gas is in short supply.
h. Condenser cooling water reqts.

Units 1,2	36,000/pump	72,000 x 2 =	144,000 gpm
3,4	70,000/pump	140,000 x 2 =	280,000 gpm
		Total =	424,000 gpm

(1) Source-Pacific Ocean
(2) Intake(s)-Units 1,2; Two 10 ft. ID conduits 2600 ft. long, vertical risers with velocity caps, 20 ft. from intake to surface. Units 3,4; two 12 ID conduits, 2580 ft. long, vertical risers with velocity caps, 20 ft. from intake to surface.
(3) Water treatment-
   Chlorinate intakes once per day for 2 hrs. for slime and mussel control.
   Heat treat by flow reversal; hold temperature at 105 degrees Fahrenheit for 1 hour; black mussel control.
(4) Cooling water discharge
   (a) ΔT = 22 to 24 degrees Fahrenheit
   (b) Outfall offshore-
      Units 1,2: 2-10 ft. ID conduits
      2100 ft. long
      Disch. vertically; 20 ft below surface.
      V_{out} = 4.1 fps
      3,4: 2-12 ft. ID conduits
      2070 ft. long
      Disch. vertically; 20 ft. below surface.
      V_{out} = 5.2 fps

6. Redondo Generating Station

   a. Location-Redondo Beach, California
   b. Owner(s)-Southern California Edison Company
   c. Date(s) in operation-1949, 1954-57, 1967
   d. Generating Capacity

Units 1-4	70 to 78 MW each	302 MW
5,6	175 each	350 MW
7,8	480 each	960 MW
	Total =	1612 MW

   e. Turbine steam data (psig/degrees F/degrees F)

Units 1-4	850/900/-
5,6	1850/1000/1000
7,8	3500/1000/1000

   f. Heat rates-(not given)
   g. Fuel-oil or gas
   h. Condenser cooling water req'ts.

Units 1-4	8 pumps	175,000 gpm
5,6	4 pumps	150,000 gpm
7,8	4 pumps	468,000 gpm
	Total =	794,000 gpm

   (1) Source-Redondo Beach Harbor
   (2) Intakes
      Units 1-6: 2-10 ft. ID conduits
      2100 and 2300 ft. long
      Units 7,8: 1-14 ft. ID conduit with intake at mouth of yacht harbor.
      All intakes with vertical risers and velocity caps.
   (3) Water treatment
      (a) Use sodium hypochlorite for slime control; twice per day to 0.5-1.0 ppm at outlet of condensers for 20 min.
      (b) Heat treat every 5 to 6 weeks by raising temperatures to 105 degrees Fahrenehit and holding for 1 hr. 20 min.
   (4) Cooling water discharge
      (a) Design ΔT-Units 1-6: 20 degrees Fahrenheit
      7,8: 18 degrees Fahrenheit
      (b) Outfalls
         Units 1-6: 2-10 ft. ID conduits
         1800 and 2000 ft. long just north of yacht harbor.
         Disch. vertically; no diffusers.
         Units 7,8: 1-14 ft. ID conduit
         About 300 ft. offshore, inside yacht harbor.
         Disch. vertically; no diffusers.
         Located in approx. 16 ft. of water.

7. Haynes Steam Plant

a. Location-Los Angeles Co. near Seal Beach, California
b. Owner-Los Angeles Department of Water and Power
c. Date(s) in operation-1 unit per year from 1962 thru 1967.
d. Generating Capacity

Units 1-4	230 each		920 MW
5,6	330 each		660 MW
		Total =	1580 MW

e. Turbine steam data (psig/degrees F/degrees F)

Units 1-4	2000/1000/1000	
5,6	3500/1000/1025/1050	(Note: supercritical and double reheat)

f. Heat rates-Values for December 1968 for all 6 units averaged 8820 BTU/KWH at a thermal efficiency of 38.7%.
g. Fuel-Natural gas except when in short supply when low sulfur (<0.5%) oil is used. (eg: Burned 800,000 barrels of oil and 1,800,000 MCF of natural gas in December 1968)
h. Condenser cooling water req'ts.

Units 1-4 2 pumps/unit at 48,000 gpm each:
192,000 x 2 = 384,000 gpm
5,6 2 pumps/unit at 80,000 gpm each:
160,000 x 2 = 320,000 gpm
+384,000 gpm
Total = 704,000 gpm

(1) Source-Long Beach Marina
(2) Intakes-Seven intake lines (7 ft. 3 in. square, 1200 ft. long)
From Marina shoreline, under San Gabriel River and Pacific Coast Highway, into an open channel. "Grizzly" openings on intakes flared to reduce approach velocities.
Screens and pumps adjacent to power plant. Units 1,2 have stationary screens; 3-6 travelling screen.
(3) Water treatment
Heat treat (intake lines from open channel to plant) every six weeks (105 degrees Fahrenheit for 1 hour); intake lines only; outfall lines warm enough so problems minor
Chlorinate units 3-6, 3 times per day to 0.35 ppm residual on outlet side of condenser for 55 min.
No chlor. on units 1,2
Shut off flows through intake lines (from Marina to open channel) for anaerobic control of mussels, clams, bryozoa, etc.
Note: Use "Amertap" rubber balls in unit 1 and 2 condensers instead of chlorination.

7. Haynes Steam Plant (cont.)

(4) Cooling water discharge

(a) Design ΔT = 18 to 20 degrees Fahrenheit

(b) Outfalls-Submerged, shoreline outfalls into San Gabriel River (3-7 ft. diam. pipes).

8. Alamitos Steam Station

a. Location-Long Beach, California
b. Owner-Southern California Edison Co.
c. Date(s) in operation-1956-57; 1961-62; 1966; 1969
d. Generating Capacity

Units 1,2	175 ea	350 MW		
3,4	320 ea	640 MW		
5,6	480 ea	960 MW		
7	132	132 MW	(gas turbine, peaking)	
	Total =	2082 MW		

e. Turbine steam data (psig/degrees F/ degrees F)

Units 1,2	2180/1000/1000
3,4	2560/1050/1000
5,6	3599/1000/1000
7	(not applicable)

f. Heat Rates (BTU/KWH)-The average station heat rate for units 1-6 is 9270. For unit 7, the heat rate will be about 16,000.
g. Fuel:Natural gas or oil (low sulfur and negligible ash) for units 1-6; kerosene & additives (JP-5 jet fuel) for gas turbine
h. Condenser cooling water req'ts. (Unit 7 not applicable)

Units 1,2	144,000gpm
3,4	270,000gpm
5,6	468,000gpm
Total	882,000gpm

(1) Source-Long Beach Marina via Los Cerritos Channel
(2) Intakes-Two intakes on the Low Cerritos Channel, one for units 1-4 and one for units 5 and 6.
(3) Water Treament-(not given)
(4) Cooling water discharge
   (a) Δ T= 15 degrees Fahrenheit (reported, not monitored)
   (b) Outfalls-Surface, shoreline outfalls into San Gabriel River

9. Huntington Beach Power Plant

a. Location-Huntington Beach, California

b. Owner-Southern California Edison Co.

c. Date(s) in operation-1958, 1961, 1969 (Note that the 1969 unit is a gas turbine peaking facility)

d. Generating Capacity

Units 1,2,3	215 each	645 MW
4	225 each	225 MW
5	162 each	162 MW
	Totals=	1032 MW

e. Turbine steam data (psig/degrees F/ degrees F)

Units 1,2,3,4	2400/1050/1000
5	(not applicable)

f. Heat rates

Units 1-4 9100 BTU/KWH average at capacity
5 15000 BTU/KWH average at capacity

g. Fuel-Units 1-4: Natural gas except when in short supply when low sulfur (< 0.5%) oil is used. Gas consumption averages 80,000 MCF/day.
Unit 5: JP-5 (jet fuel which is kerosene plus additives for clean burning characteristics).

h. Condenser cooling water req'ts.

Units 1-4: 2 pumps/unit at 44,000gpm each
Total = 352,000gpm
5: None

(1) Source-Pacific Ocean

(2) Intake-One 14ft. ID conduit 2480 long (from screen well). Vertical riser with velocity cap. 20 ft. from intake to surface (at mean lower low water)

(3) Water treatment
Chlorinate (sodium hypochlorite) twice per day to 0.1 ppm at condenser outlet for 15 to 30 min.
Heat treat intake and outfall conduits every 5 to 6 weeks; 105 degrees Fahrenheit for 1 hour.

(4) Cooling water discharge

(a) ΔT=15 degrees Fahrenheit; more or less, depending upon "load"

(b) Outfall-one 14ft ID conduit, 2180 ft long
Discharge vertically with 25ft of water from outlet to surface in 40 ft. of water total.
(ie: 15ft. riser) No diffuser.

10. San Onofre Nuclear Generating Station

a. Location-4 mi. SE of San Clemente, California; within Camp Pendelton

b. Owner(s) -Southern California Edison Co.
-San Diego Gas & Electric Co.

c. Date in operation-1968

d. Generating Capacity
450 MW from 1 unit

e. Turbine Steam data-(psig/degrees F/ Degrees F)
680/500/- (no reheat)

f. Heat rate-10,000 BTU/KWH

g. Fuel-nuclear (72 tons of slightly enriched uranium dioxide)

h. Condenser cooling water req'ts. - 350,000gpm

(1) Source-Pacific Ocean

(2) Intake-Single intake 3200 ft. offshore and 15 ft. below the water surface; equipped with a velocity cap. Located in 30 ft. of water.

(3) Water treatment
Chlorinated for slime control at pumpwell
Heat treat to 105 degrees Fahrenheit for 1 hour every 5 to 6 weeks (both intake and outfall) for control of black mussels, barnacles, etc.
Note that San Onofre has a travelling trash rack, a rather unique design for thermal power plants. Maintenance savings are significant.

(4) Cooling water discharge-Single 12 ft. ID outfall, 2600 ft. offshore and 15 ft. below the water surface. Located in 30 ft. of water.

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