

## 5.0 UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS

### 5.1 HUMAN RESOURCES IMPACTED

The only possible significant unavoidable adverse effect upon the human environment resulting from the vaporization plant is the aesthetic impact of the LNG storage tanks (see section 3.1.3.7). The tanks will be the largest structures on the LNG plant site and together with the Ormond Beach Generating station will be the most prominent man-made features on the landscape. This impact, however, will be substantially mitigated by landscaping.

Construction activities at both locations will create only minor unavoidable adverse impacts. The impacts at the plant site will consist primarily of temporary detours of traffic flow due to pipeline construction and surges in heavy truck traffic during the large continuous pours of concrete. During dredging of the harbor area enclosed by the new breakwater, sand will be pumped from the seafloor to Ormond Beach, for which time use of this beach will be temporarily restricted at the west end.

### 5.2 USES PREEMPTED AND UNAVOIDABLE CHANGES

The part of the property that the proposed LNG vaporization facility will occupy is currently devoted to agricultural use. Some of this land will be taken out of production for the life of the project and will be converted to an industrial land use.

The construction of the breakwater will prohibit access to about 700 yards of beach at the extreme northern end of Ormond

Beach. However, since that beach exists only intermittently (after the biennial sand bypassing operations) and is not easily accessible to the public, its closure should have a minimal effect on beach recreation. The waterfront and beach area enclosed by the proposed berthing facility in Port Hueneme will be closed to public swimming and watersports due to ship movements.

While loss of the existing fauna due to dredging of the proposed docking facility is unavoidable, it is of low significance. Surrounding marine environments (see Section 2.2.2) are similar and not unique. The existing sandy bottom fauna will be replaced by a more diverse fish and invertebrate population.

Loss of the existing wildlife habitat is considered to be of minimal significance, as the wetland areas will not be destroyed or filled. Destruction of the agricultural area and associated fauna is unavoidable, but of low significance in that it is not a unique habitat. Clearing of the existing fields will displace most of the fauna.

If an independent seawater exchange system were used, there would be the unavoidable loss of entrained plankton through some percentage mortality during normal operation and anti-fouling prevention. There would be some incremental loss of entrained plankton over that now realized by the Ormond Beach Generating Station if water for heating was from there.

5.3

LOSS OF ENVIRONMENTAL QUALITY

Existing regulations or criteria relative to water and air quality, noise, and waste disposal will be met, and this will not lead to any unavoidable loss of environmental quality in these important environmental parameters.

6.0 RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF  
MAN'S ENVIRONMENT AND THE MAINTENANCE AND  
ENHANCEMENT OF LONG-TERM PRODUCTIVITY

This section treats two basic concepts. The first is the local short-term environmental resource commitment and project benefits within and around the LNG plant site during the facility's lifetime and a short time thereafter, during which these facilities will be dismantled. A second concept includes the long-term environmental and social effects which persist after abandonment of the site and relates to how the proposed facilities will continue to affect the human environment.

6.1 SHORT-TERM USES

The plant site is located within an area already planned for and partially developed with industrial facilities. The proposed site development is fully consistent with both the general plans for the area and the present heavy industrial uses surrounding the site. The plant will not occupy any beach front nor interfere with use of the beach for recreational purposes.

The proposed breakwater and pier are a significant addition to Port Hueneme Harbor's capability. The facility will restrict the already limited recreational use of the waterfront from the existing jetty to a point approximately 1,500 feet south.

Protection of the coastal wetlands areas (a dwindling resource in California) will be achieved by establishing a wetlands preserve on the land south of the vaporization facility (see Section 4.2). Further benefits will be achieved through

the enhancement of biological productivity and diversity by construction of the breakwater in Port Hueneme resulting in the creation of a unique habitat.

## 6.2 LONG-TERM PRODUCTIVITY

Long-term use of the harbor facilities will probably continue after this project, thus contributing to the area's productivity.

Other long-term effects are the aesthetic and recreational impact of breakwater construction upon watersport activities (swimming and surfing) in the area to be enclosed by the berthing facility. The current magnitude of these activities is very small in this area and will be more than adequately compensated for by opening the breakwater to public recreational fishing.

The abandonment of the vaporization facility may be followed by dismantling and site clearing. The land may then either be returned to its former agricultural use or maintained for continued industrial use. No long-term effect exists.

## 7.0 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

### 7.1 LAND FEATURES AND USES

Land use change resulting from the proposed action will be the transition of a portion of the property from agricultural use to industrial use for the vaporization facility. This change is consistent with the general plan for the area as well as with existing surrounding land uses (see Plate 2.3.2-1). Upon termination and abandonment of the project, it is possible that the land could revert to its former agricultural use (see Section 3.3).

Construction of the proposed berthing facility will result in a more permanent change in land use. That is, a marginal recreational beach will become part of the harbor complex. Since the berthing area will be adjacent to the existing Port Hueneme Harbor, it is compatible with present land use.

## 7.2 ENDANGERED SPECIES AND ECOSYSTEMS

No rare or endangered marine or terrestrial species are known or are likely to nest or breed at either the facility or berthing area sites. Therefore, it is improbable that any alteration of the site areas will affect any endangered species. All of the rare or endangered species which might utilize either site area are birds. The brown pelican probably feeds in the vicinity of the proposed berthing facility, and this new harbor's presence could conceivably aid the continued existence of this species through the creation of a protected feeding area.

Both the addition of landscaping in the form of trees and shrubs and the preservation of the marsh should add to the extent of use by the endangered bird species and could lead to their nesting on the property. In sum, the project's effect on local rare and endangered species would be beneficial and contains no likelihood of elimination of any of these species.

There are no existing unique habitats which might be affected by this project. However, two of the terrestrial habitats, the coastal strand and the salt marsh, are habitats which are becoming increasingly uncommon in Southern California. This project would preserve these two habitats on the property south of the LNG plant site and thereby prevent their possible elimination through either uncontrolled use (as at present) or further development. The project will have no effect on the Hueneme Submarine Canyon habitat, which, while not unique, is uncommon. The project will, on the other hand, create a unique habitat in the form of the protected, coastal, solid substrate habitat of the berthing area.

The terrestrial agricultural and coastal marsh ecosystems will be altered. The already highly altered local agricultural land will be reduced from its present volume by the addition of the LNG plant facility and its accompanying landscaping. From an ecological standpoint, the conversion of this small amount of crop land to industrial land is a neutral change, and the landscaping will resupply a missing habitat in this ecosystem in the form of trees and shrubs. The coastal marsh ecosystem will be altered by being protected from use as an uncontrolled solid waste dumping area, from vehicular traffic, and by the addition of habitat in the form of landscaping trees and shrubs at the edge of the marsh on the Hordeum grassland. All of these are seen as beneficial to the local ecosystem.

The marine ecosystem will be altered by the addition of the berthing facility. While this will not be of sufficient scale to affect the balance of the existing ecosystem, its addition is seen as producing a net benefit through the addition of solid substrate.

7.3 SOCIOECONOMIC CONSIDERATIONS

The proposed facility will not create indirect needs for resources or developments. Existing utility systems and municipal services are adequate, and the impact upon the area will not be sufficient to justify additional housing, roads, schools, or other services. As discussed in Sections 3.1 and 3.2, the proposed facility demands little from the community, yet provides an extraordinarily large economic benefit proportional to its requirements.

No historical, archaeological, or scenic areas will be destroyed.

RESOURCES LOST OR USES PREEMPTED

7.4

The proposed project calls for the use of roughly 121 acres--83 in a marine environment and 38 in an agricultural area adjacent to a developing industrial area. Any substantial undertaking necessarily precludes alternative uses of the land occupied during its life, but the extent to which the proposed action could be deemed to curtail the range of other beneficial uses must be examined by a comparison with the possible (or foreseeable) alternatives.

The marine portion of the project will consist of the construction of a breakwater adjacent to the existing harbor. In view of the existing harbor, it will not alter the use to which the immediate area has been dedicated for over 35 years, but will further restrict the already limited options for use of this area. By its nature, the harbor addition becomes an essentially permanent work. As long as it is maintained, the new basin should be a useful harbor facility.

Upon termination of the use of the berthing facility for the present project, it could readily be adapted to other similar uses and become a part of the total harbor complex. In this case it would clearly represent a continuing beneficial use.

The inland site where the vaporization and storage facilities are to be located will include a range of beneficial uses. The northerly portion will contain the required structures, tanks, and equipment, and the southerly portion will be devoted to uses beneficial to the social and biological environment.

The inland site, like the harbor site, is in an area of established land use. An industrial environment exists and is expanding. The proposed project will not alter the character of the area; it cannot therefore be regarded as a sub-optimal use of the land resource in terms of limiting its future use.

None of the structures planned for the plant site will be irremovable, and at the end of the project life, the land can be cleared and turned to other uses.

## 7.5 FINITE RESOURCES

It is impossible to determine precisely the extent to which resources may be irretrievably committed, because the value of salvage which may be available at the end of the life of the project will be governed by the technological and economic conditions which then exist. Several broad assumptions may be made, however, and estimates of the use of fuel, water, and electric energy are possible.

The principal components of the plant and marine terminal will be concrete, quarry rock, steel, and fabricated materials and equipment. These may be considered separately.

In ordinary circumstances structural concrete has a negligible salvage value; the cost of removal far exceeds its value in any secondary use such as fill material or (very rarely) recycled aggregate. Embedded reinforcing steel is sometimes recoverable, depending upon the character of the structure and the method of demolition, but its only value is as scrap.

The plant complex will contain approximately 125,000 cubic yards of concrete. The major requirements will be for: tank footings and dikes, 24,000 to 36,000 cubic yards, depending upon final design; other plant structures, 10,000 cubic yards; pier, 20,000 cubic yards; and breakwater armor, 59,300 cubic yards. No salvage or reuse should be assumed.

The breakwater will contain 241,000 cubic yards of quarry rock with a total weight of 387,000 tons in pieces weighing up to 12 tons. Salvage would not be impossible, but the structure should be regarded as permanent.

The three storage tanks will require 8,000 tons of steel plate, much of which could be recoverable and reusable; other scrap metal could be retrieved from the fabricated parts and equipment of the plant. In view of their size, the seawater and gas transmission pipelines probably would not be abandoned in place and would be removable for secondary uses. The stainless steel cryogenic lines would almost certainly be salvaged.

The expendable resources required for plant operation involve an irreversible process. These are fuel for plant and ship operation, electric energy, and water.

Ship operation creates the greatest demand for fuel. The boil-off gas will provide approximately 23 percent of the ship's fuel and the remaining 77 percent will be Bunker C fuel oil. The 14 ship fleet, required for a 1,000 MMcfd project, will use approximately 32,340,000 tons of Bunker C and  $1.73 \times 10^8$  MCF of natural gas over the 20-year life of the project.

Gas will be consumed in the plant to fire the trim heaters required to raise the temperature of the vaporized gas to the pipeline temperature level; and as fuel for the fired vaporizers used in peaking or during shut-downs of the water-warmed vaporizers. The need for this has been minimized by selection of the warmed seawater vaporization system. With a 1,000 MMcfd project, assuming that the trim heaters operate continuously and the gas-fired, peaking vaporizers 480 hours per year, they would use over the life of the project about 3,391 MMcf; 710 MMcf in the trim heaters; 2,681 MMcf in the vaporizers.

The average design electric load is 20,020 kW. At a 100 percent load factor, total consumption will exceed  $1.75 \times 10^8$  kWh per year and  $3.5 \times 10^9$  kWh over the life of the project.

Fresh water requirements are estimated at 3,100 gallons per day, half of which would flow as waste to the Oxnard municipal water treatment plant. The effluent from that plant is now discharged to the sea, but a future program for recovery and reuse may be adopted.

Other irrecoverable materials are those common to any industrial undertaking--paints, lubricants, and other expendable supplies.

In addition to the land and physical materials required for the project's facilities, the gas to be delivered may in itself be regarded as a finite resource lost, and certainly its dedication to this use will preempt its employment elsewhere.

The question of when the consumption of a natural resource creates a loss skirts the edge of philosophy. Consumption at any point in time precludes all future uses, consumption within a given area deprives potential users elsewhere, and employment for specific purposes generally excludes all others, but it is idle to examine these questions except in economic terms. Under existing socioeconomic conditions goods typically move in exchanges which maximize the utility attainable by the exchanging parties. In this case it must be presumed that the counterflow of goods and services available to the sellers of the gas will be more valuable than the gas, and conversely, that

the gas will have a higher value in its ultimate market than at the point of production.

In reaching their decision to sell, the sellers had to assess several alternatives, none of which are necessarily mutually exclusive. These could include not producing the gas (except to the extent that production was forced by the joint production of oil); flaring (a conspicuous waste when any alternative is available); use as field fuel or for repressuring; use as feedstock for a domestic petrochemical industry; or sale to others.

All of these have been evaluated, and the proposed project represents for all parties a rational purpose.

## 8.0 ALTERNATIVES TO THE PROPOSED ACTION

### 8.1 OBJECTIVE OF THE PROPOSED ACTION

The objective of the proposed project is to provide an additional annual primary gas supply to offset the decline in gas supplies from domestic sources and to provide added daily deliverability for extreme peak-day weather conditions.

Accomplishment of this objective is required if the continuing fuel needs of the 3.5 million firm gas service customers in Southern California are to be met. See Section 1.1 for supply-demand requirements.

Natural gas supplies of significant volumes must be secured as they become available and can be utilized to meet normal firm load growth. To the extent that the supply program temporarily provides more gas than the firm requirement, deliveries to interruptible users have been made. This program should be continued. No adequate alternative fuel supply system exists in Southern California which can be relied upon by the regular interruptible customers in the event of extended periods of curtailment. An overall gas supply program must also take the energy requirements of regular interruptible customers into account.

## 8.2 ALTERNATE ENERGY SOURCES

The following sections discuss possible alternate energy sources, and the alternative of decreased consumption, as parts of alternate energy plans.

Theoretical alternatives to gas service include oil, coal, nuclear power, hydropower, solar and geothermal energy. As a practical matter, however, alternate energy sources must be appraised not only in terms of energy, per se, but as energy which may be delivered and applied at the point of use. That is to say, utility (the ultimate usability of a form of energy) depends not only upon simple availability, but upon adaptability and deliverability as well.

An appraisal of alternate energy sources in these terms requires a brief examination of the way in which energy is used in Southern California and the economic considerations which control its market.

The region depends upon two major forms of stationary end-use energy--natural gas and electricity. Each of these has application to residential, commercial, and industrial purposes, and the electric generation industry in turn has been heavily dependent upon natural gas for fuel. Thus, natural gas has been the ultimate source of about 75 percent of all fixed location uses of energy. Users of every class have equipped their premises with appliances and other equipment to make use of either gas or electricity (often in combination, as in a domestic forced-air heater fired by gas and activated by electricity). Thus, the supplying utilities have constructed networks to make both gas and electricity available. The

investment by users and suppliers runs into billions of dollars. The physical structures of both the using and supplying systems could not be replaced with substitutes without the investment of additional large sums of money. In short, economics and the "public convenience and necessity," to use the key phrase in the concept of a public utility, require that these services be maintained substantially in their present form.

The sections which follow examine the utility of alternate fuel sources not only in terms of simple availability, but also in the light of these conditions of use.

### 8.2.1 Oil

One alternative to natural gas is oil. Its use in transportation (automobiles, aircraft, railroads, and shipping) gives it the largest share in the total Southern California fuel market. The transportation requirement, added to the fixed location uses of oil, makes it the source of about 45 percent of the total energy used in the region, and the demand is growing.

There are three principal limitations on oil as a substitute for natural gas (or as a substitute gas) in Southern California. They are:

1. Oil is in short supply--particularly low-sulfur oil;
2. Oil combustion increases air polluting emissions;
3. Prohibitively expensive and time-consuming measures would be necessary to convert gas use to oil use.

The circumstances surrounding the shortage of oil are well known. Declining domestic production has created a heavy demand for oil from foreign sources. Prices of foreign oil have risen at spectacular rates in the past 3 years, and the upward trend continues. The problem is complicated by the fact that environmental considerations require the use of low-sulfur oil, which is in short supply throughout the world and commands premium prices.

Further, oil is not a direct substitute for many uses of natural gas, especially in domestic and commercial appliances and process heating. Some equipment could be retrofitted to fire oil directly, but in most other applications extensive replacement would be called for and new distribution systems would have to be created. There would be an appreciable time lag to effect appliance conversion to oil.

Even if low-sulfur oil should become available in the quantities necessary for the Southern California area, combustion of low-sulfur oil would result in increased emissions of particulates, sulfur dioxide, and oxides of nitrogen over that produced by natural gas, notwithstanding the rigorous application of pollution control techniques. Table 8.2.1-I is a comparison of emissions associated with the combustion of fuel oil versus natural gas for industrial customers in SoCal's service area. This table shows clearly the net environmental benefit of using natural gas as an energy source.

Utilization of oil with existing energy distribution systems could only be accomplished by a preliminary transformation of oil to electric energy or a pipeline quality gas.

It is concluded that a substantial increase in the use of oil as a direct replacement for natural gas is uneconomical, technically unworkable, and environmentally unsatisfactory.

### 8.2.2 Coal

Burning coal directly in SoCal's service area as an alternative to gas is not feasible under current air pollution regulations and emission abatement technology. Additional environmental costs of coal usage lie in transportation and mined land reclamation. Facilities to burn coal directly do not exist in Southern California and would have to be constructed at great cost and waste of existing facilities. Consequently, direct burning of coal is not considered to be a feasible part of any alternate energy plan.

Coal may be burned indirectly as a substitute pipeline gas. Coal gasification is being planned by an affiliate of Applicant, and is discussed under Alternate Sources of Gas, Section 8.2.8.6.

### 8.2.3 Nuclear Fuel

Because nuclear fuels are used only in the generation of electricity, their applicability is limited. Complete substitution of nuclear fuel for oil and gas used in electrical generation would only reduce the demand for fossil fuel by 12 percent in 1985 (State of California, 1972). Nuclear generation faces environmental and technological challenges and enormous capital requirements. Moreover, shortages of nuclear fuel may exist by 1981 for those generating plants now existing and under consideration because added supplies must await construction of new nuclear fuel enrichment plants.

Nuclear power cannot become available in sufficient quantity to play a significant part in an alternate energy plan within the time limits imposed by developing gas shortages.

#### 8.2.4 Hydropower and Geothermal Energy

The growth of hydropower is limited by the scarcity of available sites, and the capital and environmental costs of dam construction and reservoir inundation. Hydropower will provide a small share of future energy requirements, but cannot become a significant part of an alternate energy plan.

At present the real nature of geothermal energy and the extent to which it can be exploited is unknown. Geothermal contribution to the overall California energy demand by 1985 will be small, probably less than 3 percent. Consequently, geothermal energy does not appear to offer energy in the large quantities needed to meet the short-term gas supply problem (State of California, 1972).

#### 8.2.5 Decreased Consumption of Gas

More prudently planned use of the existing gas supplies is an alternative which has been recognized by SoCal; programs have been implemented to conserve and optimize the use of natural gas in Southern California.

Decreased consumption of gas, however, should not be considered as an alternative to the proposed project; rather, it should be viewed as an important means to curtail the wasteful use of natural gas to the extent possible.

SoCal is currently encouraging the public to conserve natural gas by reducing wasteful uses of gas. SoCal gives assistance and advice on how to operate equipment or appliances

more effectively and economically. SoCal provides appliance service to all classes of consumers to promote the most efficient use of fuel and the minimum production of air pollution. At the same time, SoCal has directed marketing efforts to inform all concerned, including architectural, engineering, and building groups, as well as commercial, industrial, and residential users, regarding the efficient use of natural gas (SoCal Application No. 53797, before the California Public Utilities Commission, January 19, 1973).

SoCal is also engaged in efforts to encourage conservation of natural gas now available. One facet of this conservation program is a research and development (R&D) program directed towards the development of more efficient gas-using devices. Most of these projects are being carried out at research agencies, universities, and manufacturing companies, allowing a high degree of flexibility and the application of specialized talent to complex problems. Almost without exception, the SoCal's R&D projects have as a goal the conservation of energy, the development of new sources of energy, and/or the reduction of air-contaminating emissions.

As a member of a group of gas and combination gas-and-electric utilities in the U.S., Canada, and Japan, SoCal is actively engaged in natural gas fuel cell research (fuel cell and other R&D projects are discussed in Statement of Harvey A. Proctor on Research, Development, and the Energy Crisis, June 1973--see Bibliography). Fuel cell power plants convert gas directly to electricity without intermediate steps found in conventional processes and require approximately one-third

less fuel while significantly reducing air contaminants. Sixty test fuel cell prototype power plants have been installed throughout the U.S.; three are in Southern California. The fuel cell concept is in the field test stage.

One area of particular interest that is being investigated is "heat pipe" technology. The characteristics of the heat pipe allow transfer of more heat than copper, with greater operating efficiency. If successful, heat pipe technology could result in development of an advanced water heater with more efficiency and service life than conventional appliances, and a vacuum furnace with double the efficiency of present industrial vacuum furnaces. An isothermal griddle, utilizing the heat pipe technology for commercial applications, has been developed, and is currently being field tested.

#### 8.2.6 Increased Storage Capacity

Between 1972 and 1974 SoCal tripled its underground storage capacity. SoCal will be able to conserve the maximum possible supply for high priority customers, and thus reduce the decline in deliverability for firm requirements under extreme peak-day conditions. System load factors will decline as the ratio of interruptible to total deliveries diminishes, resulting in the need for additional storage deliverability.

Storage is a method of load equation. With gas supply forecasts showing total availability well below average annual firm and regular interruptible requirements, no amount of storage will remedy the deficiency, and it is not an alternative to the project.

### 8.2.7 Other Alternate Energy Sources

Although fossil fuels will continue to be the dominant energy source within the time span of the proposed program, other alternate energy sources have been considered.

The prospect of energy shortages, plus the public interest in clean energy, has caused much comment on the prospect of using the sun as a source of power and heat. Results of initial investigation at the California Institute of Technology of a gas-supplemented solar energy water heater have been favorable. Additional funding by SoCal has been approved to initiate efforts directed toward the development of hardware. The time required to develop and introduce the solar water heater widely does not make it a viable alternative to the proposed LNG project. Even assuming a successful commercial solar heater, it would not significantly reduce the demand for LNG. While the supply of solar energy appears to be unlimited, there are serious obstacles to its use for other purposes in any quantity. With present technology, the physical and photochemical use of solar energy on a significant scale is not feasible. Much fundamental and sophisticated work will be required to provide a technical base for practical schemes to utilize solar energy as a major energy source.

The possibility of using hydrogen as an alternate source of energy is a fascinating concept. It could be transported by the pipeline system now used for natural gas and might be used in existing appliances after significant modifications were made to utilize this low molecular weight gas. However, at the present there is no commercial method of making

hydrogen gas for widespread fuel use. It can be made from petroleum by cracking or from water by electrolysis, but immense amounts of power are needed to produce hydrogen in quantity. It cannot be looked upon as a source of gas for public utility distribution until new sources of energy--geothermal, solar, or thermonuclear--become available for its manufacture. Major technological problems remain to be solved (National Petroleum Council, 1972; IGT, 1971).

Controlled thermonuclear fusion offers the possibility of direct conversion of thermal energy into electricity and could yield an almost infinite supply. Here too, however, technological and economic problems are so great that fusion as a practical energy source may not be commercially available before the year 2000 (National Petroleum Council, 1972).

The lack of proven commercial technology means that none of these sources is a viable substitute for the proposed LNG project.

## 8.2.8 Alternate Sources of Gas

### 8.2.8.1 Introduction

Faced with a serious supply situation, Applicant and affiliates have embarked on a program to secure gas supplies for Southern California through a plan embodying various forms of gas supply and a geographical balance of sources.

In addition to the foreign-source liquefied natural gas covered by this project, affiliates of the Applicant are considering several other possible means of increasing its supply. These include:

1. Importation of LNG from other foreign sources.
2. Delivery of natural gas from the Arctic.
3. Delivery of natural gas from Canada.
4. Shipment of LNG from south Alaska.
5. Coal gasification in northwest New Mexico to supplement the existing pipeline system.
6. Local manufacture of substitute gas from liquid hydrocarbon feed stock.
7. Increased production of natural gas within California and the adjacent federal offshore area.
8. Purchase of additional volumes of gas from its present out-of-state suppliers.

These prospective means of increasing supply complement the proposed project but are not a substitute for it. The deficiency between market requirements and dependable supplies from these proposed and SoCal's traditional sources (see Table 1.1-I) indicates an impending gas shortage of major proportions. The gas supply problems of this market are a microcosm of the national market. To serve Southern California, it will be necessary to utilize most of the gas supply options that are proposed for the nation as a whole, including all the above possibilities. It is unrealistic to speak of "alternatives" as if one project can be considered in lieu of a second, when several must be considered simultaneously as part of an overall energy plan.

#### 8.2.8.2 LNG from Foreign Sources

Projects currently under consideration call for importation of LNG from foreign sources in both the western and

eastern hemispheres. This present project proposes to import LNG from Indonesia.

In June 1972, an affiliate entered into an agreement with Magellan Petroleum (NT) Pty., Ltd., for development of the central Australian Palm Valley field. This agreement is subject to proof of sufficient reserves to support a project and government export authorization.

Efforts are underway to develop sources in Columbia, Ecuador, and Panama. At this time, no foreign sources other than Indonesia are actually available. When they do become available, they will be required in addition to, rather than as an alternative to, other available gas supply sources.

Forecast of gas supply requirements show that LNG imports to SoCal's territory are needed and its coastal location makes them feasible.

#### 8.2.8.3 Arctic Gas Via Canadian Pipelines

An affiliate of Applicant is an active member of the Gas Arctic/Northwest Project Study group, which is planning a pipeline from the North Slope of Alaska and the MacKenzie Delta of Canada through Canada to the United States. Approval of the pipeline will require action by both the United States and Canadian governments. State, provincial, and local governments will be involved in the regulation, production, and marketing operations of the project. The target date for initial deliveries is late 1978. Arctic gas is a needed supply. It is not an alternate to the proposed LNG project.

#### 8.2.8.4 Gas from Canada

An affiliate of Applicant has entered into a contract with Pan-Alberta Limited of Canada whereby it will begin receiving approximately 400 MMcfd about November 1, 1974. Although the contract terminates in 1980, it is subject to extension for a 1-year period. Deliveries of this volume are subject only to Canadian and U.S. regulatory approvals. Approximately 80 MMcfd will be sold to Northwest Pipeline Corporation and an additional approximate 214 MMcfd will be sold to El Paso Natural Gas Company for its general system use. The balance of 106 MMcfd will be delivered to Applicant's affiliate. The Pan-Alberta project reserves are needed for the Pacific Lighting system in addition to any other projects and it is not an alternative to the proposed LNG project.

#### 8.2.8.5 South Alaska LNG Project

An affiliate of Applicant is developing a project to import LNG from the Cook Inlet region of south Alaska as an early part of its expanded supply program. Negotiations are underway for proven reserves which can supply an initial 200 MMcfd. It is expected that additional reserves will be proven and dedicated, doubling that deliverability. These volumes are large enough from a physical and economic standpoint to make the south Alaska LNG project feasible, but it will not obviate the need for the proposed project.

#### 8.2.8.6 Coal Gasification

An affiliate of Applicant is undertaking one of the first modern coal gasification projects in the U.S. jointly

with a subsidiary of Texas Eastern Transmission Company. Its purpose is to offset partially the decline in deliverability of natural gas from Transwestern Pipeline Company. An application for approval of the 250 MMcfd project has been submitted to the Federal Power Commission. Hearings on this project (CP-73-211) have been initiated.

#### 8.2.8.7 SNG from Domestic and Foreign Feedstocks

Another affiliate of Applicant is evaluating a plan to convert refinery products, primarily naphtha, to substitute natural gas (SNG) at a plant within its service area. Such an SNG plant might be put on stream in less time than other supplemental supply projects and would serve to partially offset the decline in gas supply which has occurred in the past 3 years. However, to date no adequate source of a suitable feedstock has been found.

#### 8.2.8.8 Additional California and Federal Offshore Production

There are no uncommitted, proven reserves of any magnitude available to the Southern California market from either of these areas. It is not expected that local reserves of a magnitude that would eliminate the need for LNG from foreign sources will be found in the near future.

#### 8.2.8.9 Increased Deliveries from Out-of-State Suppliers

An affiliate of Applicant has entered into a joint venture exploration program with a subsidiary of Texas Eastern Transmission Corporation in an effort to discover new gas in areas adjacent to the pipeline systems of SoCal's suppliers. Some successful wells have been drilled. However, notwithstanding these efforts and the possible future relaxation of wellhead

price regulations, there is no assurance that additional proven reserves will be forthcoming in volumes sufficient to offset the decline in deliverability forecast by the pipeline companies.

El Paso Natural Gas Company is also unable to deliver its existing contractual volumes. Recognizing its declining deliverability, El Paso has applied to the Federal Power Commission for a curtailment schedule, for authorization to connect a coal gasification plant tributary to its present pipeline system, and for authorization for an LNG project from Algeria to increase its system supply.

While increasing the gas reserves of out-of-state suppliers is an important part of the balanced supply program to satisfy the requirements for gas in Southern California, it does not constitute an alternate to this project.

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TABLE 8.2.1-I

ESTIMATED EMISSIONS FROM REGULAR INTERRUPTIBLE  
CUSTOMERS WITH AND WITHOUT AN LNG PROJECT

	<u>Tons/Day</u>		
	<u>SO<sub>2</sub></u>	<u>Particulates</u>	<u>NO<sub>x</sub></u>
Fuel Oil (0.5% Sulfur)	261.5	76.5	133.5-267.0
LNG (1,000 BTU/cf)	*	*	60.0-115.0
Net benefit with LNG	261.5	76.5	73.5-152.0

\*Negligible quantities of these pollutants are emitted when burning gas.

Notes

- (a) Benefits are based on a 1,000 MMcfd LNG project.
- (b) This information is based upon emission factors and other data contained in "Compilation of Air Pollutant Emission Factors," publication No. AP-42 by the Office of Air Programs, U.S. Environment Protection Agency, February 1972.
- (c) The NO<sub>x</sub> emissions are given as a range of values because there is considerable variation in the emission rate due to the type and size of unit burning the fuel. It would probably be appropriate to use the mid-point of these values.

### 8.3 ALTERNATE SITES

#### 8.3.1 Introduction

A site selection study was conducted by others to define areas for the proposed LNG facility which would be economically feasible, operationally suitable, and environmentally acceptable. The overall study area consisted of the entire coast of Southern California from the southern boundary of Santa Barbara County to the Mexican border (Plate 8.3.1-1). Previous studies by Atlantis Scientific (1973) and Koebig & Koebig, Inc. (1971a, b) have defined several potential sites in the study area. These options were narrowed somewhat to exclude potential sites in Long Beach and Port Hueneme Harbors which are not likely to be available within the schedule of this project due to the extensive harbor construction required.

This section of the report outlines the environmental aspects of the defined sites, including physical factors, which can impinge on economics and operations. While all of the sites analyzed are acceptable, the sites adjacent to Port Hueneme Harbor and within Los Angeles Harbor are preferred.

As part of an overall energy plan, Applicant plans to construct LNG facilities adjacent to Port Hueneme Harbor and an affiliate will install facilities at Los Angeles Harbor. Current plans are that LNG from Indonesia will be received at Port Hueneme and that LNG from south Alaska will be received at Los Angeles Harbor.

### 8.3.2 Site Descriptions

The five feasible sites that were evaluated from an environmental point of view include Port Hueneme, Los Angeles Harbor, Ormond Beach, El Segundo, and Carlsbad. This section presents a brief description of the five candidate sites as shown on Plate 8.3.1-1.

The Port Hueneme site is located just outside the entrance to Port Hueneme Harbor, about 60 miles northwest of Los Angeles. A breakwater would be built adjacent to the south-east side of the entrance. The LNG ship would be berthed behind the breakwater, in a dredged berthing area. A cryogenic transfer system would deliver LNG from a pier to a storage and vaporization facility to be located about 2 miles east of the Port Hueneme Harbor entrance. The 38-acre plant site area is currently in agricultural use for one crop per year. The area around the plant site is presently zoned in part for industry and the entire plant site master-planned for industrial use. The Oxnard Municipal Treatment Plant is located immediately to the west of the plant site and the Ormond Beach Generating Station is about one mile southeast.

The Ormond Beach site utilizes the same plant location as the Port Hueneme site. The LNG off-loading site tentatively selected is approximately 2 miles southeast from the entrance to the port where a new offshore pier would be required. There is a small pier used for recreational purposes approximately one mile to the northwest. The LNG transfer lines to the plant facilities would be shorter from this pier than from Port Hueneme.

The Los Angeles Harbor site is located in the Port of Los Angeles on the south side of Terminal Island. It is a preferred site and has been proposed by Pacific Alaska LNG Company, an affiliate of Applicant, for south Alaska LNG. This site was proposed by the Port of Los Angeles in accordance with its Harbor Master Plan. The berth will lie about 2 nautical miles from Angel's Gate breakwater entrance and will have direct access to the sea. The site, which has been created from fill materials, is located in a heavily industrialized area. This site is near all the usual harbor services and facilities required for ship activities.

The El Segundo site is located on Santa Monica Bay several miles north of Los Angeles Harbor and close to extensive oil storage and shipping facilities. Several offshore moorings and submerged oil pipelines extend offshore to connect oil tankers with onshore storage. A new pier would be required for docking LNG ships. The LNG vaporization plant and storage tanks would be located about 1.5 miles from the coast at the inland boundary of the existing oil refinery.

The Carlsbad site is located in San Diego County, approximately 33 miles north of San Diego Harbor and 65 miles south of Los Angeles Harbor. A new offshore pier would be required for docking ships. The main portion of the site for storage and vaporization facilities would be located south of the city of Carlsbad and inland about 3 miles. A fossil-fueled electric generating plant (San Diego Gas and Electric Company's Encina Station) is located near the site for the new pier. The

coastline at Carlsbad is sandy and uniform and there is recreational use of nearby Agua Hedionda Lagoon.

### 8.3.3 Comparative Acceptance Criteria

A comparison of pertinent economic, operational, and environmental factors of the five candidate sites in Southern California is presented in this section. For the purpose of site selection, it was assumed that safe LNG facilities can be designed and operated at each site considered. The safety analysis and conclusions are presented in Section 3.2.8.

The site comparison included project system costs, pertinent engineering planning factors, and environmental effects. The latter are discussed in terms of physical, biological, and socioeconomic elements. These can be considered as acceptance criteria, and all are assumed to be of equal importance.

#### 8.3.3.1 Project Cost Factors

Relative cost estimates indicate that Los Angeles Harbor and El Segundo would have lower costs than Carlsbad, Port Hueneme, or Ormond Beach, all of which would require more extensive pipelines to deliver the gas to the load center. El Segundo would be more costly than Los Angeles Harbor due to the length of the LNG transfer line required. Operations cost would be greater at El Segundo due to pumping costs for LNG and seawater to overcome its greater elevation.

#### 8.3.3.2 Engineering Planning Factors

The four major factors having a significant direct or indirect bearing on final site selection are: site availability, site expansion, site convenience, and shipping delays.

Site availability is expressed in terms of the availability of the site property and the degree of property control possible. The Los Angeles Harbor site was proposed by the Port of Los Angeles, and it is expected that very little difficulty would be encountered in completing negotiations to lease an appropriate parcel of land for the project. The Port Hueneme berthing site would be available from the Oxnard Harbor district. At Port Hueneme and Ormond Beach, land for the LNG storage and vaporization plant has been acquired. The El Segundo site is located in an area already heavily industrialized; no problems would be expected. The Plant site at Carlsbad is underdeveloped at the present time. The Port Hueneme site would require dredging, and construction of a breakwater and trestle. The Ormond Beach, El Segundo, and Carlsbad sites would require pier construction from the open shoreline.

Another significant consideration in site selection involves the ability of the site area to accommodate future project expansion. All sites are adequate in this respect.

Site convenience favors locating at existing harbors for ship operations and near other industrial facilities for plant operations. For instance, the Los Angeles Harbor site has some advantages in proximity to the goods and services required for ship operation, as it is near a major center of commercial activity. During construction, the ready availability of a labor pool and construction services would tend to keep costs in line and facilitate orderly and timely project development. Port Hueneme shares some of these advantages. Carlsbad is the least desirable from this standpoint.

At El Segundo, the existing industrialization, especially the refinery complex, may represent a lesser site convenience factor. This would be due to the extensive existing underground pipelines which would significantly interfere with installation of an LNG transfer and seawater exchange system. In addition to this dense substructure, the route is heavily traveled.

At Ormond Beach, El Segundo, and Carlsbad, there would be relatively more shipping delays due to weather exposure of open coast piers. However, little down time would be expected at any site under general Southern California weather conditions. This factor is essentially economic in nature, although there are also safety considerations.

The Los Angeles and Port Hueneme sites are preferred with respect to engineering planning factors, primarily because the shelter from open seas would minimize shipping delays.

#### 8.3.3.3 Environmental Factors

Environmental factor criteria are divided into three categories: physical, biological, and socioeconomic.

##### Physical Impacts

Potential earthquake effects at Los Angeles Harbor and El Segundo would require more detailed foundation and design consideration than at the other three sites.

In terms of the acreage required, each of the sites would have approximately the same requirements for storage and vaporization facilities. Port Hueneme, El Segundo, and Carlsbad would require cryogenic pipeline rights-of-way outside the site properties themselves. Port Hueneme, Ormond Beach, and

Carlsbad would require substantial additional gas pipelines to connect the plants to the transmission system. At the El Segundo site, the pipeline connecting the facility with the gas distribution system would be less than one-half mile long, and at Los Angeles Harbor, about 3 miles long, both principally along public streets. The connector line from Los Angeles Harbor would cross the inner harbor channel as it leaves Terminal Island. At the Carlsbad site, the estimated length of the connecting pipeline is about 25 miles, about equally divided between public and private rights-of-way.

Relatively few short-term problems in meeting water quality standards during construction would be expected at Port Hueneme, Ormond Beach, El Segundo, and Carlsbad. The Los Angeles Harbor site may encounter more significant problems because of the required dredging and landfill operations. None of the candidate sites would be expected to present any significant water quality problems from a long-term standpoint.

#### Biological Impacts

The Carlsbad connector gas pipeline would probably involve the most significant amount of wildlife habitat and species disruption in view of its length and the terrain crossed. Although the pipeline would be underground, construction roads would be built and later become maintenance roads for the portion of pipeline installed in private rights-of-way. Their existence and use would continue to have some impact on the affected ecosystem. The Port Hueneme and Ormond Beach sites would require about 12.2 miles of gas pipeline, largely along public streets; little biological impact would be anticipated.

Construction of an LNG facility would entail disruption of wildlife species inhabiting or using the site or its environs. It is reasonable to assume that biota in the construction laydown areas, roadways, and parking areas would be destroyed by construction. At the Los Angeles Harbor and El Segundo sites, this would not be a significant factor since the on-site terrestrial biota is sparse. At the other sites, however, the effects of construction would be more significant.

Construction of a breakwater at Port Hueneme would add solid substrate to the ship berthing site. This would increase diversity and productivity in the area. The biological impact of effluents and other water circulation effects would be negligible at all five sites with proper design of the cold water system. There would be no cooled seawater discharge into the ocean under normal operating conditions at the Port Hueneme or Ormond Beach vaporization plant site. Instead, warmed seawater available from the Ormond Beach Generating Station would be cooled.

#### Socioeconomic Impacts

An important factor in this evaluation is aesthetics. At the Los Angeles Harbor site, relatively little impact would result, since the present visual setting is heavily industrialized. There would be more significant impact at the Port Hueneme/Ormond Beach plant site, primarily because the LNG storage tanks would be on level terrain without other large structures immediately adjacent. This potential impact would be lessened, though, because the area is already lightly industrialized and the tanks

would be within a mile of a larger installation, the Ormond Beach Generating Station. The protected berth just outside the existing Port Hueneme Harbor entrance would extend from the coast, but would be consistent with the present harbor setting. At the Ormond Beach site, the existence of a 7,000-foot pier out from the shoreline would represent significant intrusion on the relatively open coastline (the existing recreational pier extends only a short distance from shore) and, while it would not be highly visible from onshore locations, its presence would still constitute an environmental impact of some significance. An LNG facility located at the El Segundo site would be compatible with current refinery and tank-farm surroundings. Effects of the pier would be similar to those at Ormond Beach. The Carlsbad site would also afford a significant visual impact. The offshore pier would be visible from U.S. Highway 101; the pier and associated breakwater would definitely intrude on the existing coastline character of the site. The storage tanks and vaporization facilities would be located about 3 miles inland and would have a minimal visual impact.

In terms of land-use conversion, the Los Angeles Harbor, El Segundo, and Port Hueneme breakwater sites are already industrial. The others are currently in agricultural use or are fallow, although in the case of Port Hueneme/Ormond Beach, the area is planned for manufacturing use.

There would not be any significant recreational impact associated with construction at the Los Angeles Harbor site. At Port Hueneme Harbor, a portion of a narrow beach, also used for

biennial deposition of bypassed sand, would no longer be available to the public. The breakwater would have some small effect upon recreational boat traffic from Port Hueneme and Channel Islands Harbors. At the other three sites, there would be some inconvenience caused by a pier. The exact nature of this inconvenience would depend on current and expected recreational offshore traffic. It is estimated that this would be greater at El Segundo due to the tanker traffic plus considerable recreational boating traffic near the site. Recreational impact at the Carlsbad site would probably be somewhat less, since it is estimated that the amount of nearshore recreational vessel traffic is fairly low.

#### 8.3.3.4 Separate LNG Terminal for Imports

An alternate plan of providing a single LNG terminal for all imports, from all sources, was considered. This project, however, is planned to have an independent LNG terminal separate from the proposed Los Angeles Harbor terminal. This will provide a major operating advantage in terms of diversity of sources.

This significantly reduces the possibility that any one gas supply source will be so large that a mechanical failure could mean a major disruption in service to a large number of firm customers.

Reliable utility service over a large geographical area such as served by SoCal requires that major sources of supply be delivered into the system at separate points rather than at a single location.

### 8.3.3.5 Summary

No data have been developed in the above analysis to indicate that any of the five sites should be eliminated from further consideration. Each has advantages and disadvantages; it becomes a matter of judgment, therefore, in determining which is the most acceptable site.

The Port Hueneme site is favorable in terms of both engineering planning factors and environmental effects and is considered a preferred site. However, more construction activities would be required, including dredging, construction of a new breakwater and pier to handle the LNG ships, and a 2-mile-long LNG transfer system.

The Los Angeles Harbor site was also identified as a preferred location although there could be a short-term impact associated with the dredge and fill operation. However, this has been selected by the Pacific Alaska LNG Company for its LNG marine terminal and vaporization facilities. Consequently, in order to provide the operating flexibility of multiple sources of supply into SoCal's gas pipeline grid, Port Hueneme becomes a more desirable site than Los Angeles Harbor for importing LNG from a new source.

An important factor in preference of these two sites is that they are associated with existing commercial harbors. This fact makes them attractive in terms of operations factors due to nearby services and, more importantly, protected waters which will minimize delays in offloading. The harbor sites are also desirable from an environmental point of view since the sites are compatible with surrounding land use and aesthetics.

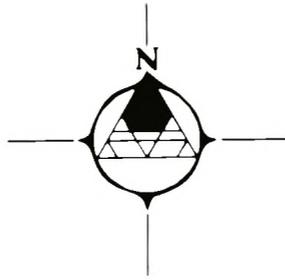
The Ormond Beach, El Segundo, and Carlsbad sites were judged less attractive than Port Hueneme because of factors discussed in previous paragraphs, including potential delays and aesthetic impact. Also, considerable costs and difficulty in installation are anticipated for an LNG transfer and seawater systems at El Segundo.

Based on the factors described above, Applicant selected the Port Hueneme berthing facility and vaporization plant as the most acceptable alternative of those considered for the Indonesia project.

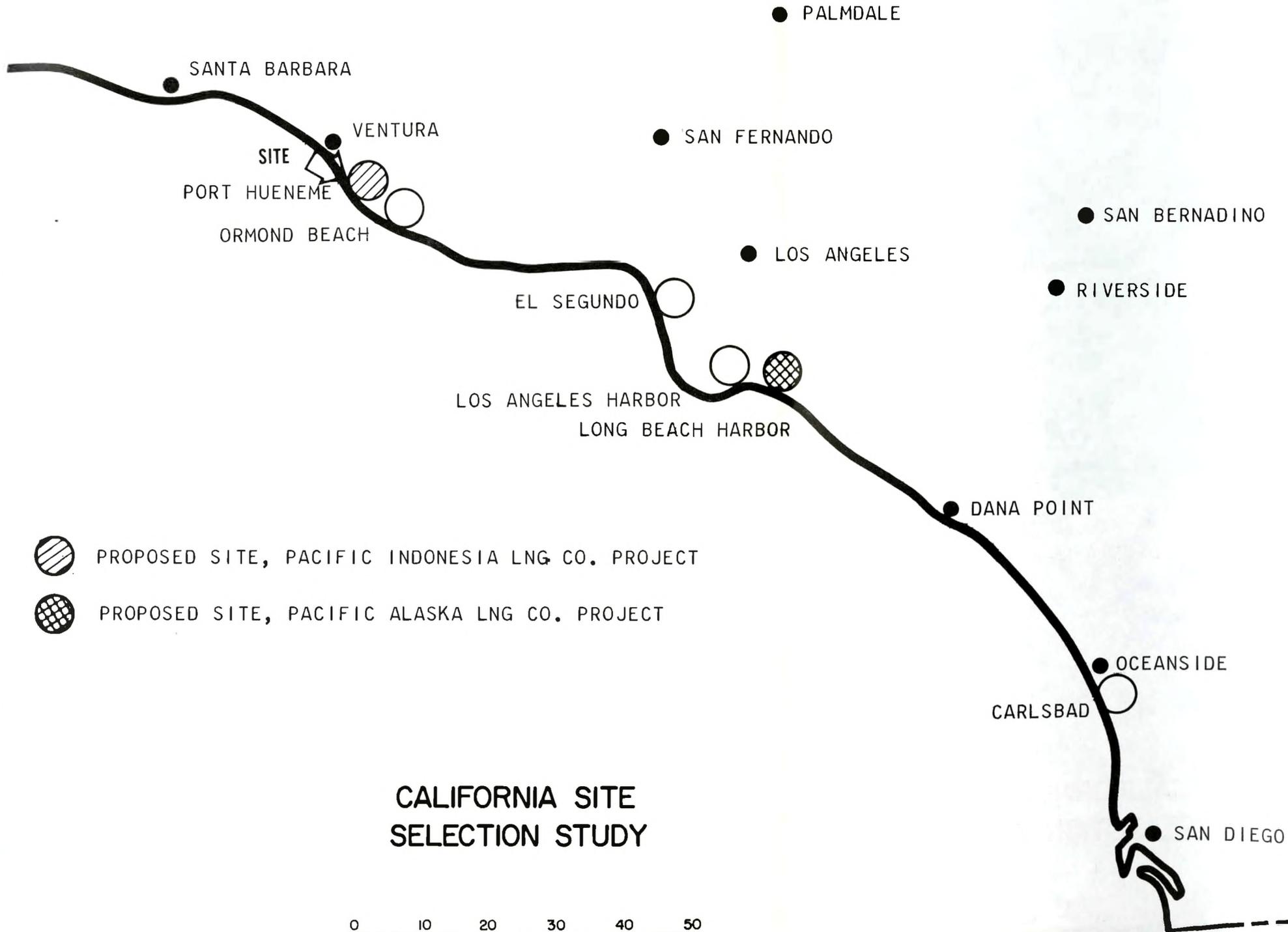
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- \*Koebig & Koebig, Inc., 1971a, Site Selection Analysis, LNG Marine Terminal, May.
- \*Koebig & Koebig, Inc., 1971b, Site Selection Analysis, LNG Marine Terminal, September.



SERVICE AREA MAP  
SOUTHERN CALIFORNIA GAS CO.  
(retail and wholesale)



● PALM SPRINGS



-  PROPOSED SITE, PACIFIC INDONESIA LNG CO. PROJECT
-  PROPOSED SITE, PACIFIC ALASKA LNG CO. PROJECT

### CALIFORNIA SITE SELECTION STUDY



CALIFORNIA  
MEXICO

8.4

DESIGNS, PROCESSES, AND OPERATIONS

Alternate facility designs and operations were considered for the following four systems:

1. Berthing and Mooring
2. LNG Transfer System
3. LNG Storage
4. Vaporization Systems

8.4.1 Berthing and Mooring

Three alternatives were considered for the berthing and mooring system. The first was to construct a pier on the open coast. This would require a shorter LNG transfer system by being closer to the vaporization site, but could interfere with public recreation and would have a greater visual impact. The open coast pier would also be more exposed to severe weather and sea conditions.

The second alternative was to utilize the existing protected facilities at Port Hueneme Harbor. Extensive development of the harbor, including removal of some existing facilities, would be required to provide an adequate stopping distance for the LNG ships and maneuvering space for other vessels. Further, it would not be possible to accomplish the necessary harbor modifications by the time these improvements would be necessary.

A third alternative was construction of a new protected berth adjacent to the Port Hueneme Harbor. This solution is a compromise including the attractive features from the other two alternatives. These facilities would be on the exposed coast but protected by a new breakwater. Deep-water access is provided by a natural submarine canyon and littoral drift

processes would not be altered by placement of the berthing facilities adjacent to the existing harbor. Because of its nearness to the existing harbor, aesthetic and land-use features are compatible. The LNG would be transferred to the vaporization site by a cryogenic piping system of length equivalent to that needed if the existing harbor were used.

#### 8.4.2 LNG Transfer System

Two designs and two routes were considered for the LNG transfer system. The two designs concerned locating the transfer line above or below ground. The above-ground system would be less expensive and such pipelines are constructed relatively routinely. However, this would present an obstruction to surface traffic and be exposed to potential damage. The underground system will require special engineering development, such as heat tracers to prevent freezing of the soil around the line, but would not be visible or obstruct traffic after construction. The underground system is also less susceptible to damage from impacts.

The two routes considered for the LNG transfer line are discussed in Section 1.4. One follows the Ventura County Railroad right-of-way from the breakwater to the vaporization site. The other parallels the beach from the breakwater to Euclid Avenue, then runs north and east to the vaporization site.

Construction and maintenance of the transfer line, if it were placed near the beach, would result in some disruption of beach activities; however, the route is aligned in a dedicated road. Construction and maintenance operations

of the line mostly within the railroad right-of-way will have the least environmental impact.

#### 8.4.3 LNG Storage Systems

A study was conducted to determine the optimum number of LNG storage tanks that would result in a total storage capacity of 1,650,000 barrels. Four layouts were made, varying from three tanks of 550,000 barrels capacity each to six tanks of 275,000 barrels capacity each. Tank data for the various tanks considered follows:

<u>Capacity</u> (Barrels)	<u>Quantity</u>	<u>Diameter</u> (Feet)	<u>Height</u> (Feet)
550,000	3	252	102
412,500	4	230	90
330,000	5	216	82
275,000	6	204	76

Environmental, engineering, and economic factors were considered in selecting the tank system and layout. On an overall basis of these factors, it was concluded that the three-tank alternative was the most desirable. Three tanks are the best choice from engineering and economic perspectives. There are positive and negative environmental aspects to this decision.

Greater environmental impacts would result from more than three tanks due to more land used and increased volume of excavation. Any increase in the number of tanks beyond three would result in placing the other tanks on a location of known poor soil requiring greater excavation and imported soils. Increasing the number of tanks to six (2 rows of three), would result in an infringement on the adjoining salt marsh which is to be preserved as a natural habitat. The need to use more

material resources to build more tanks represents an additional indirect environmental impact. The amount of materials required increases rapidly as the number of tanks increases. Approximately 30 percent more of both nickel and carbon steel would be required to construct the "six-tank" layout. However, the higher tanks needed for the three-unit option will increase their visual impact on the surrounding area. In view of this, design of the tanks will be a more expensive low-profile configuration; tank layout has been moved off the line-of-sight of a major thoroughfare; and landscape design has been based upon the tank height and location.

Both construction and operating costs will increase appreciably as the number of tanks increases. As the tank surface area increases, the amount of material required, the amount of welding and of nondestructive testing of welds, foundation forming, materials, and excavation, and the number of primary submerged pumps, piping, and controls all increase. The amount of labor required to construct the storage portion of the facility would also increase substantially for more tanks.

Construction time estimates indicate that a minimum of one additional year would have to be added to the facility construction period to construct six tanks as opposed to three.

A careful weighing of these benefits versus disadvantages revealed that the small visual benefit was not sufficient to overcome the disadvantages of increased construction cost, material and time, and greater land used which would be sustained by increasing the number of tanks.

#### 8.4.4 Vaporization Systems

Three alternate approaches for vaporizing the LNG were considered. The first system would utilize gas-fired vaporizers while the other two would use ocean water as a heat exchange source. The gas-fired vaporizers, while producing at 1,000 MMcfd, would consume  $5.82 \times 10^{12}$  BTU per year. This is 1.4 percent of the total annual vaporized gas to be produced at the facility. Use of seawater as a heat source will result in a smaller release of oxides of nitrogen into the air than would the use of fired vaporizers.

One seawater heat exchange system would obtain water via a direct intake from, and discharge into, the ocean. The direct intake and outfall would require construction of two pipelines of 9 and 5.5 feet in diameter and 2,100 and 6,000 feet in length, respectively. The system would discharge cooled seawater with a temperature depression of about 6° F below ambient. A diffuser may be required at the outfall to disperse the cooler water.

The second seawater source is the preferred one. It will utilize warmed seawater available from the Ormond Beach Generating Station.

The supply and return lines for an exchange with the Generating Station would be 48 inches in diameter, about 1,700 yards in length, and constructed onshore in one trench.

Three significant advantages will be realized by combining with the existing Ormond Beach Generating Station system. The first advantage is that the offshore intake and outfall have already been constructed and will cause no additional mechanical

disruption of the marine environment. The second advantage is that the water obtained from the power plant will be above ambient ocean temperature. Therefore, both the LNG plant and the power plant effluents will be closer to ambient ocean temperature. Finally, this alternative will require less use of trim heaters to raise the natural gas to pipeline temperature. This reduces both consumption of natural gas and emissions to the atmosphere.

8.5 NO ACTION8.5.1 Effects on Energy Supply

No action in the present matter would have a near-term critical impact upon the fuel and energy supply available to Applicant's affiliate, SoCal. Applicant will serve, directly or indirectly, 3.5 million retail gas customers, some of whom have had supplies progressively curtailed over recent years, beginning with the lower priority classifications--a constraint which will, in the absence of this project, reach the firm service groups by 1979 on an average-year basis. The detail of the restrictions appears in Table 1.1-I and is discussed more completely in Section 1.1.

The significance of the proposed project may be seen in a summary of the data in Table 1.1-I. Total firm requirements are estimated to grow on an annual average-year basis from 582 billion cubic feet in 1973 to 653 billion in 1983, an annual growth rate of 1.2 percent. Interruptible requirements, over the same period, will grow from 849 to 1,258 billion, or an annual growth rate of 4.0 percent. The present sources without new supplies will drop from 956 to 437 billion, a decline of 46 percent.

In view of the discussions in Sections 8.1 and 8.2, which demonstrate the impracticality of substitutes for gas service in Southern California, the theoretical alternative of "no action" can be seen to be no alternative at all.

There is a direct positive correlation between energy use and the other measures of economic activity and well-being in every urban industrial society. The causal relationships are

largely reciprocal, but an effort to "back down" the energy curve would have severe social consequences.

#### 8.5.2 Probable Land Use Without LNG Project

The proposed site of the project consists of two parcels--one on the coast at the entrance to the existing commercial harbor, and a second one roughly one-half mile inland and about 2 miles east of the harbor entrance in a transitional agricultural area which has been partially zoned for industrial use. The harbor-mouth parcel is bounded on the shore side by a rock seawall. The land behind the seawall is occupied by the U.S. Navy Civil Engineering Testing Laboratory. Transitory beach conditions caused by biennial dredging spoil disposal on the ocean side of the wall preclude any permanent recreational use.

A beach used for public recreation and crossed by a small pier used for sport fishing lies southeast of the proposed ship berthing site (see Plate 1.2-2). The project will not interfere with the use of this beach. The beach is bounded on the shore side in part by an area zoned for and containing newly-developed multiple housing and in part by a transitional agricultural area planned for heavy industry.

The inland site where the storage tanks, vaporization equipment, and pumps will be located lies in county territory, currently zoned agricultural, but adjacent to industrial use. This pattern of industrial use is developing steadily and is expected to continue whether the site is used for the proposed LNG facilities or not. The salt marsh on the site is master-planned for industrial use, but will be preserved and not developed under this project.

The current land use plan represents a logical assessment of the value of the land. As discussed in Section 2.1, the topography, soil, and geology of the land, plus the proximity of railway, highway, drainage and wastewater treatment facilities, and the other industrial plants, make this a logical site for an industrial plant in the future if this project does not occupy it.

#### BIBLIOGRAPHY 8.5

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\*Statistical Abstract of the United States, 1972, pp. 647, 658, 659.

## 9.0 PERMITS AND COMPLIANCE WITH OTHER REGULATIONS AND CODES

### 9.1 PERMITS

The permits and approvals required from federal, regional, state, and local government agencies for the Port Hueneme LNG project are listed in Table 9.1-I. Issuance of these permits requires compliance with the codes and regulations applicable to the construction, maintenance, and operation of the Port Hueneme LNG facility.

#### 9.1.1 Authorities Consulted

##### 9.1.1.1 State Lands Commission

The State Lands Commission was contacted and application was made for an offshore drilling permit to obtain samples from submerged lands. The permit was granted.

##### 9.1.1.2 South Central Coastal Zone Commission

The South Central Coastal Zone Commission was consulted and applications for offshore and onshore borings were completed. Approval by the South Central Coastal Zone Commission was given. Two conditions were attached to the offshore permit:

- "1. Applicant shall make data obtained pursuant to this Permit available to any interested member of the public at the principal place of business of the Southern California Gas Company. Such data shall include the basic raw data acquired during field work and any interpretation thereof or conclusions drawn therefrom by technical staff of Applicant's consultants or Applicant's own personnel.
- "2. Applicant or Applicant's subsidiary Southern California Gas Company, shall notice all members of the public requesting such notice the time, date and place, and subject matter of any public hearing to be held concerning the proposed port and re-gassifying facility at or near Port Hueneme Harbor."

9.1.2 Dates of Approval

Dates of approval for the three permits were:

State Lands Commission - October 25, 1973

South Central Coastal Zone Commission (onshore) -  
September 26, 1973

South Central Coastal Zone Commission (offshore) -  
October 31, 1973

FEDERAL, STATE, AND LOCAL PERMITS AND APPROVALS  
FOR PORT HUENEME LNG PROJECT

<u>Agency</u>	<u>Permits or Approvals</u>
<u>Federal</u>	
1. Environmental Protection Agency	Review and approval of Environmental Impact Statements.  Discretionary review and approval of responsibilities delegated by EPA to State agencies for control of air and water pollution.
2. Corps of Engineers, Department of the Army	Permits to construct pier and breakwater in navigable waters.  Permit to discharge or deposit dredging spoils into navigable waters.
3. Federal Aviation Administration, Department of Transportation	Determination that the plant facilities will not be a hazard to air navigation.
4. U.S. Coast Guard, Department of Transportation	Approval of control requirements for transferring liquid cargoes on waterfront facilities.
5. Occupational Safety and Health Administration, Department of Labor	Approval of the facility construction and operation for compliance with OSHA regulations for general safety of workers.
6. Commanding Officer, United States Naval Construction Battalion Center, City of Port Hueneme	Determination that marine facilities do not interfere with military operations at Port Hueneme.
<u>State</u>	
1. California Coastal Zone Commission	Permit for soil test borings. Permit for plant siting. Permit for construction.
2. California Regional Water Quality Control Board (Region 4, Los Angeles)	Discharge permits for dredging, construction dewatering, and hydrostatic testing.
3. Division of Industrial Safety, State of California	Industrial safety permits (excavation and buildings) and Cal OSHA.
4. Division of Highways, State of California	Roadway arrangements and entrance.
5. Oxnard Harbor District, State of California	Port Warden approval of fire and safety equipment and design of dock.
<u>County</u>	
1. Ventura County Air Pollution Control District	Construction and operating permits for LNG storage tanks, gas-fired vaporizers, and other plant equipment.
2. Ventura County Flood Control District	Approval of storm and flood control measures.
3. Ventura County Building and Safety Department	Building permits. Grading permits.
4. Ventura County Planning Department	Zoning changes. Special use permit.
5. Ventura County Fire Department	Construction permit--tanks. Approval of fire protection systems for marine facilities, storage, and vaporization facilities.
<u>City</u>	
1. Building and Safety Department, City of Oxnard	Building permits--LNG transfer and seawater exchange lines.
2. City of Oxnard Planning Department	Use permit.
3. City of Oxnard Fire Department	Approval of LNG Transfer Line Leak detection system.
4. City of Port Hueneme Building and Safety Department	Building permits--LNG Transfer Lines and Marine Facilities.
5. City of Port Hueneme Planning Department	Use permit.

9.2 COMPLIANCE WITH HEALTH AND SAFETY  
REGULATIONS AND CODES

The governmental regulations and codes concerning health and safety which are applicable to the Port Hueneme LNG project are given in Table 9.2-I. Some of these agencies have been listed in Table 9.1-I and are repeated here as their regulations are pertinent.

9.2.1 Authorities Consulted

The following agencies were contacted regarding the above-mentioned regulations:

1. Environmental Protection Agency (San Francisco)
2. California Air Resources Board
3. Ventura County Air Pollution Control District
4. Los Angeles Regional Water Quality Control Board
5. U.S. Army Corp of Engineers
6. Department of Public Health (State of California)
7. Oxnard City Fire Department
8. Ventura County Fire Department

9.2.2 Procedures to be Followed

Procedures outlined by the agencies having health and safety regulations (see Table 9.2-I) will be followed.

### 9.3 COMPLIANCE WITH OTHER REGULATIONS AND CODES

Table 9.3-I lists other organizations with regulations and codes which may be relevant to the Port Hueneme LNG project. These are primarily design and construction codes, some of which are also listed in Tables 9.1-I and 9.2-I. Since it is difficult to completely separate design from safety, the major ones are repeated here.

The Port Hueneme LNG project covering the LNG ship berthing facilities, LNG transfer lines, storage tanks, vaporization facilities, and all auxiliary facilities will be designed, constructed, and operated in compliance with all applicable standards, codes, regulations, and specifications.

All required permits, certificates, licenses, and approvals will be applied for, obtained, and complied with.

TABLE 9.2-I

HEALTH AND SAFETY CODES AND REGULATIONS

<u>Agency</u>	<u>Codes or Regulations</u>
<u>Federal</u>	
1. Occupational Safety and Health Administration (OSHA)	Regulations governing safety of workers.
2. U.S. Public Health Service	Vessel sanitation systems, rat-proofing, and ship fumigation.
3. Office of Pipeline Safety, Department of Transportation	Federal safety standards for transport of natural or other gas by pipeline.
4. National Fire Codes	Relevant sections.
5. U.S. Coast Guard	Port and sea safety, life saving and fire fighting equipment codes.
6. Environmental Protection Agency	Air and water pollution controls.
<u>State</u>	
1. State Division of Industrial Safety (Cal. OSHA)	California OSHA regulations for safety of workers.
2. State of California Oxnard Harbor District	Fire and Safety regulations.
3. California Regional Water Quality Control Board	Water pollution controls.
<u>Local</u>	
1. Ventura County Fire Department	Fire Protection Systems.
2. Ventura County Building & Safety Department	Safety Regulations.
3. Ventura County Air Pollution Control Board	Air Pollution Controls.
4. City of Oxnard Fire Department	Approval of fire safety equipment.
5. City of Oxnard Building and Safety Department	Safety Regulations.
6. City of Port Hueneme, Building and Safety Department	Safety Regulations.
<u>Other</u>	
1. National Fire Protection Agency	#59A Standard for Production, Storage, and Handling of LNG. #30 Flammable and Combustible Liquids.
2. American Petroleum Institute	2510A - "Design and Construction of LNG Installations at Petroleum Terminals, Gas Processing Plants, Refineries, and Other Industrial Plants." 620/Q - "Recommended Rules for Design and Construction of Large Welded, Low-pressure Storage Tanks for LNG."

TABLE 9.3-I

OTHER AGENICES AND REGULATIONS

1. American Concrete Institute (Building Code Requirements for Reinforced Concrete).
2. American Institute of Steel Construction.
3. American National Standards Institute (ANSI) (B31.3-1966), B31.4-1971, B31.4a-1972 and Z225.1).
4. American Petroleum Institute (RP 500C and 2534).
5. American Society of Mechanical Engineers (ASME) (Boiler and Pressure Vessel Code).
6. American Society of Testing Materials (ASTM) (A-353-64, A-553-64, and others).
7. American Welding Society.
8. Concrete Reinforcing Steel Institute.
9. Hydraulic Institute Standards (HIS).
10. Institute of Electrical and Electronic Engineers.
11. Instrument Society of America (ISA).
12. Insulated Power Cable Engineers Association.
13. National Electrical Code.
14. National Electrical Manufacturers Association.
15. Underwriters Laboratory (where applicable).
16. U.S. Department of Agriculture.
17. U.S. Maritime Administration.

## 9.4 SPECIAL CASES

### 9.4.1 Liquified Natural Gas Facilities

The Port Hueneme LNG storage and vaporization facility including the off-loading pier, transfer lines and other ancillary facilities, will be designed to meet all applicable current standards, codes, regulations and specifications. Additionally, the design specifications will incorporate features which will exceed current standards to provide increased operational reliability, decreased maintenance requirements and improved systems for protection of the facility from accidents. Increased protection of the facility from mal-operation, accidents, etc., will have the dual benefit of also providing increased protection for operating personnel and public safety and health.

#### 9.4.1.1 LNG Ships

Current plans call for propulsion by a steam-driven turbine from a boiler fired by both natural gas and oil. The dual fuel boiler capability allows the ship to utilize the boil-off from the LNG cargo as fuel in the boilers. This boil-off will not exceed 0.14 percent per day of maximum cargo capacity. The delivered volumes of LNG will be about 95 percent of the ship's maximum cargo capacity.

Each ship will have a double hull. The cargo will be carried in five freestanding aluminum tanks insulated from the ship's inner hull with approximately 12 inches of foam and an inert atmosphere under positive pressure. Each tank will also be subdivided by a liquid-tight longitudinal bulkhead.

The relative ductility and higher impact strength at cryogenic temperatures of aluminum are an additional safety

feature. The interior hull also acts as a secondary barrier against possible cargo leakage.

In addition to characteristics already described, the LNG ships proposed for this project will have several unique features designed to enhance safe operation along the Indonesia to California route. Bow thrusters are included in the design of the proposed vessels to allow greater low-speed maneuverability. These thrusters will be mounted to provide added lateral thrust and will increase the ship's turning ability. The ships will also have twin screws which will provide high-speed maneuverability.

Critical navigation and communication systems will include both long and short wave-length radars, radio direction finders, LORAN (Type A and C), fathometers, bridge-to-bridge radio telephones, long range radio equipment, computerized collision avoidance plotting systems, gyrocompasses, and depth sounding equipment.

Fire prevention and mitigation systems will include:

1. Spacing of equipment to separate possible sources of leaks from sources of ignition.
2. Remote-controlled, automatic block valves and check valves to isolate major sections of LNG piping to minimize escape of LNG in case of line leakage or rupture.
3. Pushbutton and automatic stopping of LNG pumps.
4. Relief valves to protect tanks, equipment, and piping from rupture caused by pressure buildup from exposure to fire or other causes of over-pressure.
5. Installation of leak and fire detection instrumentation in strategic locations for monitoring by ship's personnel.

6. Installation of dry chemical fire extinguishing systems at strategic locations.
7. Installation of fire water systems at strategic locations.
8. Emergency power for ship's lighting, communications, and monitoring systems.
9. Emergency alarms and warning systems and redundancy of key equipment.

Single-man mooring hooks will be used on all dolphins which can be released, even if mooring lines are taut. Each mooring hook, or cluster of hooks, will have a motor-driven capstan to assist in the handling of the mooring lines. The four breasting dolphins will have energy-absorbing fenders against which the LNG ships will be moored.

In the event of a spill in or near the port, the Fire Department and Port Authority will be notified immediately. The Fire Department's, Harbor's, and Company's fire protection equipment will be mobilized as necessary to minimize the extent of the hazard. Water spray will be used to direct the vapors away from land and away from ignition sources, and also to warm the vapors and cause them to rise rather than spread out. Aircraft will be warned away, since the area of greatest potential flammability is in their normal altitude of operation.

As in the case of any comparable situation involving chemicals, evacuation will be ordered by the appropriate authorities in the remotely possible situation where it is necessary, and sources of ignition will also be turned off as may be necessary.

#### 9.4.1.2 Storage Tanks and Transfer Lines

##### Storage Tanks

The three storage tanks will be of double-walled steel construction. The inner tank wall will be 9 percent nickel steel, a proven material for storage of LNG at  $-260^{\circ}$  F. The outer tank wall will be constructed of carbon steel. For aesthetic and other reasons, the tanks will be a low-profile design, measuring approximately 240 feet in diameter and approximately 109 feet above finished grade. A concrete dike will be constructed around each tank, extending 6 inches above the top head seam of the tank walls. The tanks and concrete dikes will be painted a subdued color compatible with their surroundings and will be located on the plant site so as to offer minimal visual impact from off-site points of visibility. The inner walls of the dikes will also be insulated. Between the inner tank and the outer carbon steel tank wall, an insulating annulus of Perlite will be provided. This material is an expanded volcanic glass that will not burn and is the most commonly used insulation in cryogenic systems. The base of the storage tanks will be insulated with foamed glass or styrofoam, both non-flammable insulation materials.

##### Transfer Lines

The design for the underground LNG transfer system calls for stainless steel LNG lines insulated with polyurethane foam, covered with a protective barrier of nonflammable glass-reinforced epoxy. The insulation will not be fixed to the lines so that the lines will be free to slide within their insulation

covers. The two 30-inch LNG lines and the one 12-inch vapor return line will be supported in common pipe guides which maintain the horizontal and vertical position of the pipes but allow for longitudinal movement (See Plate 1.4.1-3). The entire underground system will be installed at least 4 feet below ground surface. All support and anchor structures for the underground lines will be of steel-reinforced concrete (see Plate 1.4.1-4). These heavy concrete supports will also provide a "neutral buoyancy effect," preventing the lines from rising to the surface if groundwater should rise above the lines. Covered standpipes rising from the supports to above grade will permit checking of the pipelines for any changes in location.

The 12-inch vapor return line from the storage tanks to the ships will be relatively warm so that an uninsulated, carbon steel pipe with a corrosion-resistant coating can be used. Plate 9.4-1 shows the arrangement of the lines within the pipe trench.

#### 9.4.1.3 Vaporization Facility

At a 1,000 MMcfd rate the facility will use 10 warm-water base load vaporizers to vaporize the LNG. In addition, five gas-fired peak-shaving vaporizers will be used to meet peak demands. Gas-fired trim heaters will be used to raise the temperature of the water-vaporized gas to 50° F prior to metering, odorizing, and delivery to the gas transmission system.

The amount of heat that must be transferred into and absorbed by the LNG during vaporization is called the "vaporization duty." The total vaporization duty to yield

1,000 MMcfd delivered to the pipeline at 50° F and about 800 psig is about 680 MM BTU/Hr. The preferred alternate for this project is planned to be a seawater exchange system with the Edison Generating Station. The required supply will be 89,430 gpm. The warm water supply and return system pumps and lines have been designed to handle 98,400 gpm or 10 percent more than the normal requirement. The system utilizes a total of 23,340 BHP in pumps, of which 7,780 BHP is in standby pumps. Both the supply and the return lines will be 48 inches in diameter, about 6,000 feet long, and they will be routed as shown on Plate 1.2-2.

Submerged cryogenic pumps will transfer LNG from the storage tanks to booster pumps at 70 psig. The booster pumps will then raise the LNG pressure to about 850 psig for transfer to the ten warm water base-load vaporization facilities. Ten base-load, warm water vaporizers will be constructed.

The gas-fired peak shaving vaporizers will utilize submerged-combustion hot water baths with a thermal efficiency of 96 percent. The fuel requirement will be 318.4 MM BTU/hr, and it is estimated that these vaporizers will only be in use about 480 hours per year.

The water of combustion from these units will condense in water baths resulting in a water overflow of about 10,000 gallons per day or 7 gallons per minute during use. This water will have a pH of about 5.5, due to dissolved carbon dioxide, and will be returned to the sea with the 89,430 gpm of water from the base-load vaporizers.

#### 9.4.1.4 General Design Features

General items which will be included in the plant design are:

1. Placing sources of ignition in a normal up-wind position from possible sources of leaks and spacing of equipment to separate sources of leaks and ignition.
2. Grading of the area to minimize potential spill damage and maximize spill containment control. Separate drainage which does not connect with the public sewers.
3. Grading to facilitate storm runoff drainage.
4. Battery and emergency generator electric power supply to critical lighting and instrumentation in case of power failure.
5. Loading arms capable of accommodating differential movement between the ship and the dock in all directions.
6. Remote controlled, automatic block and check valves to isolate sections of LNG piping to minimize escape of LNG in case of major line leakage or rupture.
7. Pushbutton and automatic stopping of LNG pumps, vaporizers, and other equipment.
8. Fail-safe closure of control valves.
9. Design and selection of materials to prevent collapse or bursting of LNG-containing structures, pipes, and equipment exposed to fire.
10. Relief valves to protect tanks, equipment, and piping from rupture caused by pressure buildup from exposure to fire or other causes of overpressure.

Lightning protection will be provided by grounding metal objects. Non-metallic structures such as the concrete tank dike will be protected by means of grounded lightning points. When venting of gas occurs for maintenance purposes, it will be vented from an elevated relief stack.

#### 9.4.1.5 Construction Procedures

A quality control program will be in effect to assure that all construction practices, materials, and equipment are in accordance with all regulations and codes as well as good construction practices. The objective of the quality control program is to provide surveillance and documentation necessary to assure the owner, the engineer, and the regulatory authorities that all steps associated with design, procurement, and construction have met the design specifications and that fabrication and construction are in compliance with the applicable codes and regulations, as well as with engineering specifications and drawings. To achieve this objective, a quality control program must establish procedures for monitoring all phases of the project from design through fabrication, installation, testing, and final acceptance. The procedures in this case will govern the specification of dimensions and operating characteristics, as well as life and reliability objectives, and engineering and manufacturing costs.

Prior to construction, the potential contractors and subcontractors must be qualified under appropriate codes and must guarantee compliance with the quality control program.

During the construction phase, a test program will be carried out to include the following:

All materials will be tested to insure that they have the required physical properties, metallurgical analysis, and high-low temperature performance specified. Heat and/or plate tests will be performed as required. All materials and

equipment will be inspected for damage or surface defects.

All shop and field dimensions will be checked to determine compliance with drawings and specifications.

All welding will be done according to welding procedures specifically prepared for the specific materials and applications for which the weld was made. Inspection will include radiography, ultrasonic testing, dye penetrant and vacuum box testing as specified in the procedures.

Test piles will be driven and loaded according to established pile testing practices.

All concrete specifications will include test procedures in accordance with provisions of the American Concrete Institute (ACI).

All piping and pressure vessels will be hydrostatically proof-tested according to the applicable codes and regulations.

Selected piping and vessels will be pneumatically tested according to the appropriate codes and regulations. The outer shell of the LNG storage tanks will be pneumatically tested, and the inner tank will be tested both hydrostatically and pneumatically.

During the construction and commissioning phases, all equipment will be functionally and operationally checked out and tested. This will include shop and field individual testing as well as testing of installed elements of larger systems. As part of the maintenance and loss control programs, equipment will be periodically retested.

Operating equipment and systems will be performance tested to assure product quantities and qualities or specifications

are met and that utility consumption does not exceed design.

#### 9.4.1.6 Operation

The startup and operation of this facility will be by selected personnel who will have received thorough training in all phases of operation and maintenance from the start of construction, through startup and checkout of all systems. Startup planning activities, which provide an opportunity for training, will result in an organization which will have seen the facility's parts and pieces put into operation. This participation supplements formal class training and demonstrates the interrelationship of the various items of equipment and their location and disposition. It also introduces the operating personnel to the equipment and its control at the very beginning of its operating life. Applicant will conduct formal training programs, using material developed by the Institute of Gas Technology and the American Petroleum Institute.

Training of operating personnel will begin during the construction period. Suitable aids will be utilized with training procedures; plant personnel will participate during startup and use the test and startup activities as a final part of their training activity.

Operator training will occur in several distinct phases, i.e., basic training in LNG fundamentals, plant training including startup, emergency training, and continuing training for reinforcing and updating competence.

#### 9.4.1.7 General Safety

The primary safety emphasis in LNG storage and handling is on the protection of the surrounding neighborhood, plant personnel, and the plant facility. LNG facilities are industrially safe provided proper precautions are observed and plant personnel are adequately trained.

Familiarity with the nature of the plant process at each stage is required of all personnel. This includes equipment operating characteristics, piping and instrumentation systems, and interaction of all plant systems. The essential aspects of this information will be reflected in the operating and safety procedures developed for the facility. Safety procedures will recognize the low temperature and combustible nature of LNG, the fire-protection capabilities, and the fire-control characteristics of the various systems.

The cleaning, purging, cool down, startup, and testing activities will be planned for each individual facility component after study of its flow plan and piping and instrumentation layout.

The possible personnel hazards involved in the handling and storage of LNG are frostbite and asphyxiation. No liquid will be released during normal operations. Protective clothing and self-contained breathing apparatus will be used if work is required where the oxygen concentration in the atmosphere is below about 15 percent.

Adequate safety rules will be established and strictly enforced. The safety program will include training, inspection,

and maintenance programs, as well as the use of vapor detection systems, alarms, and personnel protective devices.

All personnel will wear hard hats and safety glasses in operating areas at all times. Where exposure to cold equipment, vapors, and liquid can occur, personnel will be equipped with special clothing, including gloves, face shields, and footwear. Special clothing is in general use in the cryogenic industry.

The plant equipment will be specified for the lowest feasible noise levels. The individual noise levels of the equipment at 5-foot distances will range from 70 to 85 dBA, which will satisfy the Federal Occupational Safety and Health Act (OSHA) requirements of 90 dBA for 8-hour exposures for plant workers.

#### 9.4.1.8 Fire Protection System

Sound engineering and thorough training of plant personnel can reduce the possibility of gas escape and greatly reduce the consequence of any release which may occur. A safety philosophy with primary emphasis on quality design and construction will be strictly followed.

Good safety practice requires that flammables be reliably contained; that small leaks which may occur during storage, transfer, and processing be contained; that means for control of fire be provided; and that in no case may leaks or fire endanger neighboring properties.

The recommendations for equipment design, spacing, grading, diking, drainage, etc., as found in the latest issue of NFPA 59A, "Storage and Handling of LNG, 1972," and API

standard 2510A "Design and Construction of LNG Installations at Petroleum Terminals, Natural Gas Processing Plants, Refineries, and Other Industrial Plants" will be followed.

The design of the fire-prevention system will be developed in cooperation with the local fire department. Suitable safety rules and operating techniques will be established and firmly administered, and plant personnel will receive thorough training in fire prevention. Cooperation in the training of local fire department personnel will be offered. The factors which will influence the fire protection system design include the plant location, local fire standards and requirements, site configuration, availability of water, separation distances, and consideration of maximum potential fire size.

Codes, standards, and guidelines cover fire-protection requirements for LNG plants. Specific fire protection requirements fall under the jurisdiction of the local fire department. The current NFPA Standard, issued in 1972, comprehensively covers the design and operation of LNG facilities and has been adopted into federal law by the Department of Transportation. Currently applicable specific codes and standards are listed in Table 9.4.1-I.

A flammable gas detection system will be installed with stations throughout the facility. Detectors will be located near pump and compressor stations, fired vaporizers, and within the process area and will sound a warning if they sense unusual levels of methane. Critical areas will contain several sensors which can initiate shutdowns of the compressors,

pumps, and vaporizers in the area at the detection of dangerous levels of gas. Portable gas and oxygen indicators will be provided for personnel safety.

Dry chemical, foam, and water spray fire fighting systems will be provided at the vaporization plant. The characteristics of these systems are discussed in Section 3.2.8.2.

#### 9.4.1.9 Safety Regulations and Codes

The LNG facility design and installation will include adherence to all applicable codes and standards during all phases of engineering, specification, construction, testing, operation, and maintenance. When put into operation, this facility will be safe in terms of its ability to properly perform assigned functions during both normal and abnormal operating conditions.

Prime consideration is given to methods and materials used, techniques of design and fabrication, containment of spillage, relief of all closed systems, fire protection, and personnel protection. These have been addressed in detail in previous portions of this section.

In addition to the codes and regulations listed in Tables 9.1-I and 9.2-I, there are specific codes which have been established to assure that LNG be reliably contained, transferred, and processed. These are listed in Table 9.4.1-I.

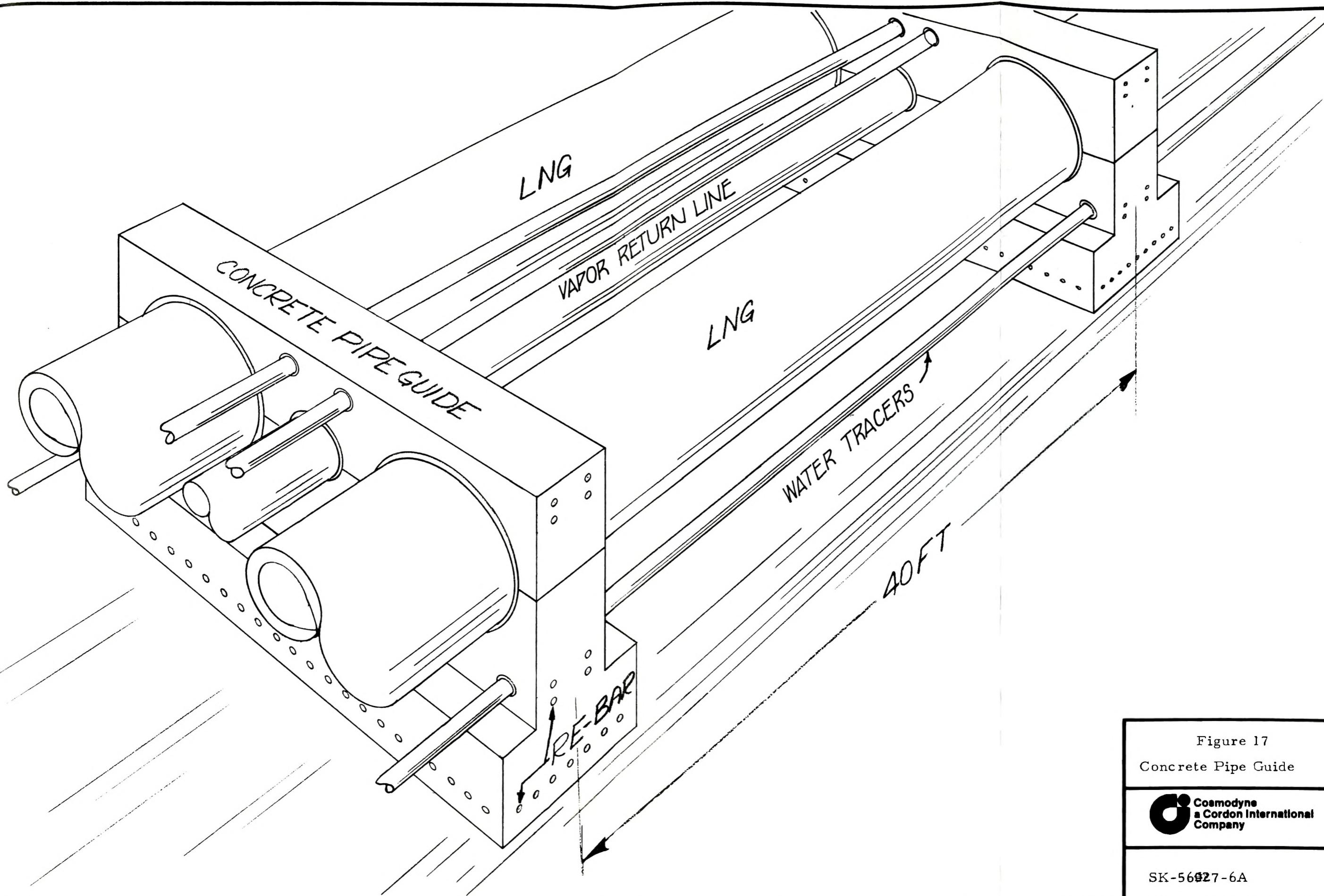


Figure 17  
Concrete Pipe Guide



SK-5627-6A

TABLE 9.4.1-I

CODES AND REGULATIONS FOR LNG FACILITIES

American National Standards Institute	Piping Code B31.3.
American Petroleum Institute	<p>a) 2510A - "Design and Construction of LNG Installations at Petroleum Terminals, Natural Gas Processing Plants, Refineries, and other Industrial Plants."</p> <p>b) 620/Q - "Recommended Rules for Design and Construction of Large Welded, Low-Pressure Storage Tanks: Low-Pressure Storage Tanks for Liquefied Natural Gas."</p>
American Society of Mechanical Engineers	Boiler and Pressure Vessel Code.
American Society for Testing and Material	A-353-64 and A-553-65 covering requirements for the low alloy steel known as "9% Nickel" which will be used for construction of the inner tank.
Department of Transportation Regulations U.S. Coast Guard Standards	<p>33 CFR 6.14-1</p> <p>33 CFR 124.14</p> <p>33 CFR 126</p> <p>46 CFR Subchapter D</p> <p>49 CFR 192</p>
National Fire Protection Association	<p>59A - (1972) "Standard for the Production, Storage and Handling of Liquefied Natural Gas (LNG)" (Adopted by DOT).</p> <p>30 - "Flammable and Combustible Liquids."</p>

## 10.0 SOURCES OF INFORMATION

### 10.1 PUBLIC HEARINGS

No public hearings to obtain authority for construction of the proposed project were held. However, three permit application hearings for the purpose of obtaining authorization to gather geotechnical and environmental data were held. The permits were obtained (see Section 9.1.1.2).

### 10.2 OTHER SOURCES

#### 10.2.1 Meetings with Governmental and Other Entities

##### 10.2.1.1 Federal Agencies

##### United States Geological Survey (USGS)

A meeting with the USGS and Dames & Moore personnel was held on September 24, 1973, in Menlo Park, California. The FPC may request that the USGS review the EIR. Messrs. E. Rimnitz, R. Campbell, S. Wolf, B. Rowland, P. Barnes, and D. McCallough of the USGS were in attendance.

USGS comments emphasized public safety and geological hazards and suggested that this is of greater concern to them than environmental impact. No environmental conclusions resulted from this meeting.

##### 10.2.1.2 State Agencies

##### California Department of Fish and Game (CDFG)

The meeting with Lt. Hank Hoover, Game Warden with CDFG, concerned the use of the LNG site area by recreationalists and wildlife. No environmental conclusions were obtained from this meeting.

### 10.2.1.3 Local Governmental Agencies

#### County of Ventura

Dames & Moore held meetings with Messrs. F. Dokken, T. Collart, and P. Wack of the County Planning Department, G. Peters of the Department of Agriculture, and Captain R. Crawford, Bureau of Fire Prevention. Discussion topics included:

1. projected population growth of Ventura County;
2. crop production on the site; and
3. the impact of the proposed berthing facility on the fire department.

As a result of these meetings, the following environment conclusions were made:

1. The proposed marine facilities should be capable of accommodating fire vehicles.
2. These facilities should be at least 24 feet wide for this capability, and
3. The Ventura County Fire Department may require a new 1,000 pound dry chemical fire protection system to serve this project.

#### City of Oxnard

Dames & Moore held meetings with Messrs. R. Byers, Economic Development Office and L. Hayes, Oxnard Traffic Engineer, to discuss general economic characteristics of the City of Oxnard and the scheduling and routing of construction vehicles through this area.

Conclusions reached at this meeting were:

1. Continuous concrete pours will require a substantial number of heavy trucks through Oxnard; and

2. Several alternative routings from ready mix plants through the city should be utilized to avoid traffic concentrations and damage to roads.

Separate meetings were held with Messrs. J. Faulconer, City Manager's Office, and Bennett of the Planning Department.

These meetings yielded information on present and projected financial and population growth of the City of Oxnard. No environmental conclusions resulted from these meetings.

In a meeting with Chief R. Owens of the Oxnard Police Department and Captain Brooks, Fire Chiefs H. Gustafson, and A. Koog of the Oxnard Fire Department, the impact of the proposed project on their respective departments was discussed.

Environmental conclusions resulting from this meeting were:

1. That an emergency communications system direct to the Oxnard Fire Department would be desirable;
2. These departments must have additional access points to the vaporization site. Two would be preferable.

City financial data and utility layouts, design, and access were discussed in a meeting with Messrs. S. Roberts, City Finance Director, and J. Mima, Assistant Public Works Director. The following suggestions were made during this meeting:

1. The feasibility of Applicant acquiring the three parcels of land south of McWane Boulevard.
2. At least one additional access road to the site is necessary. It may be desirable to construct a new road from McWane to the beach for recreational purposes.

3. Safety aspects of the vaporization plant layout.
4. Improvement of the Oxnard Industrial Drain.

#### City of Port Hueneme

Discussion in a meeting with Director H. Wright, City of Port Hueneme Planning and Development Department centered around the recreational land use of the site and surrounding vicinity. Mr. Wright suggested that the breakwater be constructed to shelter the entire Port Hueneme beach area, thus allowing construction of a marina for recreational boating.

In a separate meeting with Finance Director J. Hickerson, Lt. J. Smith, Port Hueneme Police Department; Director J. Duffy, Public Works Department and Mr. W. Moranda, Chief Administrative Officer, the impact of the proposed project on the Police Department, existing public utilities, and sand pumping program was discussed.

Environmental concerns included the impact on the beach sand and existing pumping program.

#### 10.2.1.4 Nongovernmental Meetings

Meetings with Messrs. C. O'Hara, Ventura County Railway Company, S. Merryman, Ventura County Building and Construction Trades Council, and B. Coultas, Southern California Edison Company, covered the impact of the proposed construction and operation on the railroad, labor market, and electrical capacity of the Oxnard area.

Baseline information was gathered during meetings with Dr. G. Cianko of the Oxnard Municipal Sewage Treatment Plant and Mr. E. Millan, Oxnard Harbor District. Documentation

of baseline environmental conditions, including marine coliform bacteria counts and the present condition of the past facilities, was gathered.

### 10.2.2 Studies Conducted

In order to compile environmental data for this report, an extensive literature review was conducted. In addition, six field studies were conducted. They were:

1. Soils (Section 2.1.3).
2. Biology (Sections 2.2.1 and 2.2.2).
3. Aesthetics (Section 3.2.1.3).
4. Noise (Section 2.4.3.2).
5. Dredging (Section 2.1.2.3).
6. Water Quality (Section 2.4.3.4).

The analysis and report text for Section 3.2.8, Accidents and Catastrophes, and related subjects in all other sections, was prepared and written by Applicant.

### 10.2.3 Consultants

#### 10.2.3.1 Dames & Moore Personnel

Following are the professional biographies of key Dames & Moore personnel who participated in this project.

MANAGEMENTN.F. Yaghoubian, Management

Jack Yaghoubian, a Dames & Moore partner, under whose supervision this report was prepared, has been involved primarily with environmental studies for the last four years. He has been in charge of numerous environmental studies and reports for large projects on the West Coast and in the southwest United States. Mr. Yaghoubian is also Director of the Gas Market for the firm. In this capacity he participates in final review of all projects in the field of gas production, transport and storage.

Projects in which Mr. Yaghoubian has been involved include: the Cholla Power Plant for Arizona Public service, the Navajo and Kaiperowitz Power Plants for the Salt River Project, the Gaviota to Avila gas and oil pipeline for Exxon, the Santa Ynez Treating Facilities Unit for Exxon, the South Alaska LNG Project for Pacific Alaska LNG Company, and several projects of a similar nature.

Mr. Yaghoubian has a Bachelor of Science degree in civil engineering from the University of Illinois (1961) and a postgraduate degree from The Netherlands (1964). Part of his graduate work included a study of comprehensive environmental planning for the large reclaimed land areas (polders) in the North Sea of The Netherlands.

He is a registered civil engineer in California, Florida, Colorado, Pennsylvania, and Illinois.

Jerry C. Wilson, Marine Environmental Studies and Geology

Before becoming Project Manager for this report, Jerry Wilson planned and participated in numerous projects involving the marine environment. He has also conducted many onshore and offshore geological and engineering investigations. Environmental studies concerning these disciplines are a primary interest of Mr. Wilson. He has managed environmental impact reports for two major LNG facilities including marine and onshore installations. He was a team leader on an environmental report for a major pipeline project in California. He has also investigated environmental considerations for dredging projects in Los Angeles Harbor and Delaware Bay, and conducted water quality monitoring during maintenance dredging operations. In addition, he has participated in an inventory of the physical and land-use characteristics along the entire California coastline as part of a national shoreline study for the U.S. Army Corps of Engineers.

Mr. Wilson has conducted marine geological and oceanographic surveys from on and under the ocean. Such projects have included selecting the location of intake and discharge structures for a power plant in Western Australia, investigating sea caves below a proposed construction site in California, and mapping an offshore fault at Amchitka Island in the Aleutians for study during an atomic test. He utilized a two-man submarine in mapping the route for the new deep Honolulu Sanitary Outfall.

A Registered Geologist and Engineering Geologist in California, Mr. Wilson has a Bachelor of Arts degree in geology from Occidental College and a Master of Arts degree in marine geology from the University of Southern California. He is a Certified SCUBA Diving Instructor and a member of the Geological Society of America. As an affiliate member of the ASCE, he is a member of their Committee on Oceanographic and Hydrographic Surveying and Charting.

Ian C. Macfarlane, Marine Environmental Studies

Assistant Project Manager for this report, Ian Macfarlane has experience with the coastal, harbor, and foundation engineering aspects of marine projects. Presently he is specializing in environmental work related to dredging operations. He has done bathymetric mapping and current studies in San Francisco Bay, and water quality evaluations for dredging and spoil disposal activities in Puget Sound and Southern California. He authored water quality and environmental impact reports for dredging projects in Washington and later gave expert witness court testimony on a littoral drift case. In addition to performing numerous diving surveys, Mr. Macfarlane has conducted environmental pre-dredging investigations and has participated in the preparation of environmental impact reports for other LNG facilities.

Mr. Macfarlane received a Bachelor of Science degree in geology from California State University at Northridge and a Master of Science degree from the University of California. His academic background includes many courses in marine geology, coastal engineering, oceanography, and marine biology as well as undergraduate studies in electronics. He also was given a research grant by the University of California to build sediment sampling and recovery equipment which he designed.

Robert D. Shanman, Acoustics and Seismology

Project Coordinator Bob Shanman has brought his knowledge of acoustics as well as his general engineering background to this project. He has performed noise surveys and participated in environmental acoustics studies for a number of environmental reports for proposed LNG and SPG facilities. Mr. Shanman's experience in earthquake engineering has involved him in the development of design earthquakes based on geological and historical seismic data, and statistical and modeling analyses. Projects have included studies for nuclear power plants, hospitals, dams, and other facilities, which have required the development of recurrence data, response spectra, and time histories for the sites.

As an Assistant Development Engineer at the University of California, Los Angeles, he was involved in forced vibration studies and mathematical modeling of the San Onofre Nuclear Generating Station, and the ambient testing of structures damaged by the San Fernando earthquake. He also has experience in civil and structural engineering, and as an applications analyst for scientific computer programs.

Both his Bachelor and Master of Science degrees in engineering were received from the University of California, Los Angeles. He is presently studying the development of new techniques and procedures in acoustical engineering at UCLA. He has authored and co-authored five published papers concerning forced vibration studies and analyses of large buildings and nuclear power plants.

William M. Greenslade, Environmental Studies

An associate with Dames & Moore, Bill Greenslade has participated in several comprehensive environmental investigations for proposed nuclear power plant sites, and has been a principal investigator in the areas of geology, groundwater hydrology, and mineral resources. For three years he was involved in a substantial number of the firm's groundwater investigations, becoming familiar with hydrogeologic conditions over much of the United States and Spain. More recently, Mr. Greenslade has served as project director and reviewer for a number of comprehensive environmental reports which include identification of the physical, chemical and biological characteristics of various site environs, review of facility design, impact evaluation, alternative considerations, and cost-benefit analyses. He maintains contact with various governmental agencies, keeps informed on environmental regulatory requirements, and has given expert testimony in this field.

Mr. Greenslade received his Bachelor of Science degree in geological engineering and his Master of Science degree in hydrology from the Mackay School of Mines at the University of Nevada. His graduate work was supported by a research assistantship from the Desert Research Institute Center for Water Resources Research. He is a member of the International Association of Engineering Geologists, American Water Resources Association and the National Water Well Association.

BIOLOGICAL SCIENCESThomas B. Scanland, Marine Ecology

Tom Scanland has been involved in many investigations which include siting surveys, preconstruction environmental planning and environmental baseline studies. He has been responsible for the design, supervision and operation of sampling programs and the subsequent analysis and presentation of generated data. He is knowledgeable in the fields of statistics, physical, and chemical oceanography. Recently he has participated in predredging site selection for a municipal outfall in Alaska, the impact analysis of a dredging and pipeline installation in California, and an analysis of impacts of military operations involving dredging, quarrying and spoil disposal in the Marshall Islands. He has conducted analyses of marine environmental effects from construction and operation of nuclear generating stations, and the potential beneficial uses of dredge spoil and sand disposal from onshore grading and beach replenishment.

Dr. Scanland received his Bachelor of Science degree from California State University at San Diego, a Master of Science degree from Florida State University, and a Ph.D. from the Scripps Institution of Oceanography. He has lectured at California State University at San Diego and the Scripps Institution of Oceanography. He is a member of the Ecological Society of America, the American Association for the Advancement of Science, and the Marine Biological Association of the United Kingdom. He also is a qualified SCUBA diver, having logged over a thousand hours.

David W. Valentine, Marine Biology

Dave Valentine's major field of interest is the study of marine fish populations as they respond to environmental stress from chlorinated hydrocarbons, heavy metals, oils, heated effluents, and domestic and industrial effluents. He is familiar with trace contaminate detection techniques, and has performed assays for chlorinated hydrocarbons and heavy metals using gas chromatography and atomic absorption spectroscopy. Having conducted field work in California for several years, he is also qualified in performing terrestrial surveys.

Dr. Valentine received his B.A. in biology from the University of California at Santa Barbara. An M.S. in population biology and a Ph.D. in ecology were awarded him by the University of California at San Diego.

Bruce A. Wales, Environmental Biology

Bruce Wales has had a great deal of specific Life Sciences experience in the fields of agriculture, plant ecology, botany, bioclimatology, environmental measurement, meteorology, and agronomy. He has directed research dealing with chaparral revegetation after fire, the pattern and establishment of plants on coastal sand dunes, and the ecological effects of the advection of sea salt aerosol far inland. He has served as biological consultant to a large petroleum company and has managed environmental work for them. He has also conducted biological studies for several multidisciplined environmental reports. He is a Major in the U.S. Air Force Reserve, and has consulted with the U.S.A.F. on air pollution damage to vegetation and the management of biotic communities along with planned development of U.S.A.F. facilities.

Dr. Wales received his B.S. degree in agriculture from Rutgers University in 1959 and graduated from the Air Force Institute of Technology meteorology program at Texas A&M University in 1960. His M.S. degree in agricultural meteorology and Ph.D. in plant ecology were earned at Rutgers, where he later taught. He has authored several professional articles and is affiliated with the Ecological Society of America, the American Meteorological Society, the Soil Conservation Society of America, and the American Association for the Advancement of Science.

Leray A. deWit, Marine Biology

Having participated in onboard marine geological and oceanographic research throughout central California, Ray deWit has gained experience in the intraspecific relationships of marine and estuaries organisms, their food habits, and systematics. In particular, he has done food habit, parasite and population studies on sharks in the San Francisco Bay, research concerning the Environmental Protection Agency's dumping site near Savannah, Georgia, biology management for an environmental impact report in the Los Angeles area, and a number of diving surveys in both Northern and Southern California.

Mr. deWit received his B.A. and M.A. degrees in biology from California State University at San Jose, where he was a graduate teaching assistant. He has also taught marine biology on a floating marine research vessel for the Marine Ecological Institute in Redwood City, California. He is a certified SCUBA diver and is affiliated with the International Oceanographic Foundation.

G. Frederick Shanholtzer, Terrestrial Biology

Wetlands and terrestrial ecology are the primary interest of Fred Shanholtzer. He is particularly qualified in applying aerial photographic remote sensing to ecological studies. Dr. Shanholtzer has managed the terrestrial biology for the Rochester Gas & Electric Corporation's Sterling Power Project, involving alternate site, safety analysis, and environmental impact reports for a proposed power generating station. As a research associate at the University of Georgia Marine Institute, he participated in the Ecological Survey of the Coastal Region of Georgia for the U.S. Department of the Interior, researched salt marsh-vertebrate relationships, and performed remote sensing studies of an estuarine watershed.

Dr. Shanholtzer received his B.A. in biology from Hope College, his M.S. from Florida State University, and his Ph.D. from the University of Georgia. He has published and presented a number of scientific papers, and given a special seminar presentation, "Salt Marsh Ecology - An Integrated Approach."

AIR SCIENCESFrederick M. Kessler, Engineering Acoustics

Fred Kessler has been engaged in many aspects of the engineering profession for over 18 years. For the past 12 years, he has been engaged in noise control engineering in the areas of product noise abatement, muffler research, and environmental acoustics. As Vice President and Manager of Engineering Acoustics at Lewis S. Goodfriend and Associates, he directed and consulted on such projects as the Environmental Protection Agency's "Report to the President and Congress on Noises," particularly the supportive document, "Noise from Industrial Plants." Recently he has directed a study for the Bureau of Noise Abatement of the City of New York entitled "Construction Site and Equipment Noise in New York City" and the environmental noise survey for Rochester Gas and Electric's Sterling Power Project. He was also instrumental in the development of a recommended practice for construction site noise measurements which utilizes a novel noise sampling technique.

Dr. Kessler holds a Bachelor of Mechanical Engineering degree from the City University of the City of New York, and M.S. and Ph.D. degrees in electrical engineering from Rutgers University. He has written several publications on noise control engineering. He is a member of the Acoustical Society of America, the IEEE, the Institute of Noise Control Engineering and the SAE Vehicle Sound Level Committee, and is chairman of the SAE ad hoc Committee on Construction Site Noise Measurement.

John D. Walsh, Senior Meteorologist

For more than 15 years, John Walsh has participated in meteorology and air pollution studies, particularly those concerning nuclear power plant siting. He has also been a principal investigator for several classified projects dealing with atmospheric biological warfare defense systems. For six years, Mr. Walsh was a senior meteorologist in New York State's air pollution control agency, involved in all air quality survey work for the state. He organized the state's first air pollution alert system and contributed to the development of New York State's air pollution control program. He also provided support for reactor operations and planning for the Brookhaven National Laboratory, where he participated in micro- and mesometeorological studies relating to diffusion and atmospheric turbulence.

Mr. Walsh graduated from New York University with a degree in meteorology. He has since done part-time graduate work in physics, mathematics and meteorology at Hofstra College, the State University of New York, and the University of Maryland. He is the author and co-author of over 40 reports, technical documents and papers. He is a founding member of the International Association for Pollution Control, a professional member of the American Meteorology Society, and a member of the Air Pollution Control Association and American Nuclear Society.

Stanley R. Kozlowski, Meteorology

Stan Kozlowski has participated in or directed meteorological and population studies for numerous Safety Analysis Reports, site selection studies, and environmental impact reports. These reports were determinations of the climatological conditions of the site areas along with evaluations of the climatic influences upon proposed facilities and evaluations of the climatic diffusive capability of the atmosphere. He has assisted in the development of techniques for evaluating meteorological influences on cooling towers for large power plants, and has developed many computer programs for the calculation of vent stack designs, cooling tower orientation, nuclear diffusion studies and man-rem (radiological) studies. He has also assisted with chemical air quality and air pollution laboratory work for the Salt River Project's large Navajo Generating Station.

Mr. Kozlowski has a Bachelor of Science degree in geography and science from the University of Buffalo in New York. He has done graduate work at the University of Oklahoma as part of a U.S. Air Force training program, and has been a meteorological instructor for Air Force pilots.

Edwin M. Roberts, Air Quality and Chemistry

As a firm specialist in environmental investigations for the power industry, Ed Roberts is responsible for the assessment of air quality programs. He has testified before the Federal Power Commission as an expert witness and has assisted legal counsel in technical matters involving environmental affairs. He has also conducted Preliminary Safety Analysis Reports for nuclear power plant monitoring studies and in-ground water chemistry. Dr. Roberts directed the meteorological studies for the Navajo Generating Station and the Salt River Project environmental reports, and for a fossil fuel power station for the Florida Power and Light Company. He holds a patent based on earlier research on the characterization and analysis of catalyst poisons in crude oil.

Dr. Roberts received a Bachelor of Science degree from West Texas State College, with a major in chemistry and a minor in mathematics. John Hopkins University awarded him his Ph.D. in chemistry. He has published 12 papers in the fields of chemistry and physics, and is a member of the American Chemical Society.

William W. Hildreth, Geology, Meteorology, Oceanography

With a broad academic background in three environmental fields and over 25 years of professional experience, Bill Hildreth is qualified to identify, investigate and analyze problems related to the interaction of the environment with man and his activities. Dr. Hildreth's experience includes positions in teaching, research, and management, with 15 years dedicated to the application of meteorology and oceanography to offshore oil exploration and aerospace problems. He has spent five years of specialization in the remote sensing of the environment, which includes the physics of radiative transfer, the scattering and reflection of solar radiation, the phenomenology of targets and backgrounds, and the relationship of atmospheric, ocean and earth properties to the interpretation of electro-optical data obtained with remote sensors. Before joining Dames & Moore, he was Director of Environmental Science and Phenomenology for ECOM Corporation, where his duties included meteorological and air quality studies for environmental impact reports.

Dr. Hildreth has a B.S. in geology from the University of New Hampshire, and M.S. in meteorology from the Massachusetts Institute of Technology, and a Ph.D. in oceanography and meteorology from Texas A&M University. He has written numerous technical publications and belongs to the American Meteorological Society, the Marine Technology Society, the Instrument Society of America, and the Institute of Environmental Sciences.

A. Roger Greenway, Meteorology

Recently Roger Greenway has been applying his micrometeorological and air quality skills to the environmental analyses of nuclear and fossil-fuel power plants, and cooling towers. Former experience was gained as an Environmental/Systems Analyst at the U.S. Air Force Environmental Technical Application Center (ETAC) in Washington, D.C. As project officer there, he served as consultant in environmental assessments of design and operation of existing facilities and new construction starts. Electric power plants, fuel disposal facilities, and missile launch operations were primary projects. Mr. Greenway's duties included project definition and management of programs, reduction of data, modeling and evaluating effluent dispersion patterns, preparation of assessment reports, and recommendations of design and operational restraints.

A Bachelor of Science degree with honors in meteorology was awarded Mr. Greenway by Rutgers University. He also received a Master of Science degree in meteorology with an air pollution control minor from Rutgers. He has authored several technical papers and journal articles, and belongs to the American Meteorological Society, the Air Pollution Control Association and the American Geophysical Union.

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EARTH SCIENCESJeffrey R. Keaton, Geological Engineering

Jeff Keaton has assisted with the site evaluation studies for several dams, nuclear power plants, hospitals, refineries and industrial sites. During these studies, he has performed geologic mapping and supervised exploratory borings. He has also been involved with soil and rock sample collection, laboratory testing, engineering analyses, and report preparation. Mr. Keaton has served as project engineer for both the site evaluation of a proposed industrial park in central California and the site selection along the entire coastline of California for a nuclear power plant.

Mr. Keaton received a Bachelor of Science degree with honors in geological engineering from the University of Arizona and subsequently received a Master of Science degree in soil mechanics from the University of California at Los Angeles. He is a member of ASCE, the Association of Engineering Geologists, and the American Institute of Mining, Metallurgical and Petroleum Engineers.

David J. Leeds, Seismology

For more than 25 years, Dave Leeds has conducted field investigations of most of the major U.S. and foreign earthquakes. His travels have permitted him to study the epicentral areas of many major earthquakes which have occurred in the last two centuries. He is on the roster for UNESCO Earthquake Investigation Missions and has received research grants from the California State Division of Architecture for selecting optimum locations for strong-motion earthquake recorders. He was a member of the UNESCO Reconnaissance team which traveled to the site of the 1968 Khorassan, Iran earthquake, and a team captain for the EERI investigation of the 1972 Managua earthquake. In recognition of his contributions in the field of vibration analysis and seismology, Mr. Leeds has received a commendation from the Director of the Carnegie Institute of Washington.

Mr. Leeds received his BA in geology from the University of Texas, spent seven years as an exploration geophysicist, and nine years as a lecturer and research engineer at the University of California at Los Angeles. As a geophysicist for the U.S. Coast and Geodetic Survey, he was in charge of the Los Angeles office of the Seismological Field Survey. In this capacity he investigated strong-motion earthquakes and was responsible for seismograph stations throughout Southern California and Nevada. Throughout his career, Mr. Leeds has had project responsibility for a number of seismic and vibration investigations, including numerous earthquake investigations for nuclear power plants and ambient background observations at nearly 400 sites in the western U.S. He is a member and officer of many professional organizations and has published many papers in his field.

Larry T. Murdock, Soils and Foundation Engineering

As a project manager on numerous soils and foundation investigations for a variety of industrial, commercial and port developments, Larry Murdock has been involved in environmental studies for the siting of nuclear and fossil fuel power plants in Washington, Florida and Arizona. One of these projects entailed the preparation of a comprehensive environmental report for a large coal-fired generating plant, a coal mine to supply the plant; and a 200-mile transmission line. Another coal project Mr. Murdock managed was a complex slope stability and groundwater control study for a large open pit coal mine in Wyoming. He has also managed several feasibility and design studies for earth and tailings dams in Utah, Idaho, and Spain.

Mr. Murdock has a Bachelor of Science degree in civil engineering from the University of Utah. He is a member of ASCE and a registered civil engineer in California, Utah, and Washington.

William J. Attwooll, Soils and Foundation Engineering

Specializing in engineering management, Bill Attwooll has considerable experience in soils, foundation engineering, and design. He recently designed and managed the three-year soils and foundation work Dames & Moore performed for Walt Disney World in Florida. This entailed working with various specialists in preparing reports and solving unique engineering problems, such as the foundation design for a five-mile monorail and the grouting of several incipient sinkholes. Mr. Attwooll has also participated in many other projects, including the design of a gypsum tailings dam in British Columbia, the design of foundations for a rocket launch tower at Vandenberg Air Force Base, and an investigation of the damage to pipelines and tanks from the 1971 San Fernando earthquake.

Mr. Attwooll is a member of ASCE and a registered professional engineer in California. He has a BES degree in civil engineering from Brigham Young University and an MSE degree from Arizona State.

Michael F. Donnelly, Environmental Geology

Mike Donnelly has extensive experience with environmental projects which includes the management of light environmental impact reports in California. He has also been the principal investigator for two preliminary safety analysis reports for nuclear reactor sites. During six years with the U.S. Geological Survey, Dr. Donnelly mapped over 1,500 square miles of a previously unmapped area of Sonora, Mexico and performed extensive laboratory studies of rock found there. He also has three years of field exploration experience, including regional appraisal, detailed reconnaissance and target area investigations, and the mapping of approximately 2,000 square miles of both crystalline and sedimentary terrain. He has conducted core-drilling and electric-logging programs, and geophysical and geochemical exploration surveys. Other work has included data retrieval, preparation and analysis, and the evaluation and translation of geologic data in follow-up feasibility studies.

After receiving a Bachelor of Science in geology with a minor in mathematics from California State University at Los Angeles, Dr. Donnelly went on to Stanford University to receive his Ph.D. His doctoral program there included remote sensing of the environment (photographic, radar and thermal infrared interpretation) as it is used in the assessment, surveillance monitoring and control of environmental pollution.

Stephen L. Ryland, Seismology and Geophysics

Steve Ryland has a strong background in seismology, field geophysics, structural geology and tectonics, and geomorphology. He has acted as an assistant instructor in geology and geophysics at both the University of Missouri at Columbia and the California Institute of Technology. He has done summer work for the National Center for Earthquake Research of the U.S. Geological Survey, and been a research assistant at the Seismological Laboratory at Caltech. He has also worked for Geophysical Systems Corporation, a manufacturer of seismic instrumentation for the petroleum industry.

Mr. Ryland obtained his B.S. degree with honors in geology at the University of Missouri at Columbia in 1970. On a grant from the National Science Foundation, he conducted the first gravity and magnetic surveys of the Galapagos Islands. He received an M.S. degree in geophysics from the University of Missouri in 1971, and an M.S. degree in seismology from the California Institute of Technology in 1973.

David L. South, Engineering Geology

During his association with Dames & Moore, Dave South has been involved with site evaluation studies for several nuclear power plants, subdivisions, refineries and industrial sites. These studies have included geologic mapping, seismic exploration, supervision of exploratory borings, soil and rock sample collections, laboratory testing, field testing of hydrologic conditions and report preparation. Mr. South has had extensive experience in collecting soil and rock samples during preliminary site evaluations for several nuclear power plants throughout the United States, as well as supervising water pressure testing for reservoir evaluation and assisting in seismic exploration at these sites. Most recently, he has undertaken geologic evaluation of several proposed sites for a conventional power plant. This work has included both field mapping and writing of the report.

Mr. South received a Master of Science degree from the University of Arizona in 1972, where he specialized in mining and engineering geology. He received his Bachelor of Science degree in geological engineering from the Colorado School of Mines in 1969.

J. Russell Mount, Hydrology and Groundwater Geology

Russ Mount's professional experience has involved a variety of groundwater and surface water activities. He has performed numerous groundwater investigations which include the design of dewatering systems for deep excavations, drainage of saturated soils, and seawater encroachment studies in coastal aquifers. His surface water hydrology experience has included runoff and flood stage analyses, evaporation pond design, and water supply evaluations. He has also analyzed the environmental impact of existing and proposed projects as related to percolation and runoff. When employed by the U.S. Geological Survey, Mr. Mount was responsible for evaluating available groundwater supplies and analyzing thermal and dispersion characteristics of streams as part of a comprehensive plan for water and related land resources of the Puget Sound region. As a geologist with the Texas Water Development Board, he directed groundwater studies associated with the formulation of a statewide water plan for the next 50 years.

Mr. Mount has a Bachelor of Science degree in geological engineering from the Colorado School of Mines and a Master of Science degree in geology from Texas Technological College. He has also completed courses in mathematics and engineering hydraulics at the University of Texas. He is a licensed professional geologist in California and a member of ASCE.

R. Sage Murphy, Water Quality

Sage Murphy specializes in waste treatment and disposal problems of all kinds. He has been a consultant on water supply and waste disposal problems for nearly all the major petroleum companies on Alaska's North Slope, as well as the pulp and paper industry in Alaska and Saskatchewan, Canada. Dr. Murphy has held the position of Chief of the Environmental Engineering Section of the Arctic Health Research Center in Anchorage for the U.S. Public Health Service, where he was responsible for supervising and conducting research concerned with water supply and waste disposal in remote Alaskan villages. He has taught senior and graduate courses in sanitary and environmental health engineering at the University of Alaska, Fairbanks, and became head of the Department of Environmental Health Engineering and Director of the school's Institute of Water Resources. He also has experience with waste treatment for ocean disposal systems and oceanographic studies for planning outfall locations for the forest products industry in Northern California.

Dr. Murphy has Bachelor and Master of Science degrees in civil engineering from Southern Methodist University. He was awarded his Ph.D. in sanitary engineering from Pennsylvania State University. He has published numerous articles and research reports, and has co-edited one book. In addition to holding membership in ASCE and a number of specialty organizations, he is on two international committees concerned with waste disposal.

Thomas K. Wheeler, Geology and Hydrology

Prior to joining Dames & Moore as a hydrologist, Tom Wheeler was employed by Desert Research Institute, Water Resources Division, in Reno. Mr. Wheeler was involved with initial field studies of hydrologic basin delineation, spring and phreatophyte mapping for the institute at a Nevada Test Site project, and performed field chemical analyses and statistical analyses of data for a large regional flow system. He has participated in snowmelt and precipitation estimation, analysis of weather records, evaluation of evapotranspiration processes, and all segments related to water budget studies of river basins, hydrograph analysis, determination of basin yields, and flood and drought studies. His application of statistical methods to hydrology include frequency distributions for planning, correlogram analysis, nonparametric procedures and selected time series techniques. He also is experienced in the use of digital computers for hydrologic studies.

In addition to this background in surface water hydrology, Mr. Wheeler is experienced in relating surface water characteristics to groundwater flow systems and geochemical processes. He received a Bachelor of Science degree in geology from the University of Wisconsin in Madison and a Master of Science degree in geological engineering with a minor in hydrology from the University of Nevada in Reno. He is a member of the American Geophysical Union and the Sierra Club.

Barry Berdahl, Water Quality

Before joining Dames & Moore, Barry Berdahl worked for the Environmental Protection Agency in New York on the preparation and review of water basin plans, the upgrading of water quality standards, data handling, computerization and analysis, and contract liaisons. In addition to general water quality, he is particularly qualified in the fields of microbiology and water system modeling.

Dr. Berdahl has a Bachelor of Arts degree in premedical studies at John Hopkins University. His M.A. and Ph.D. degrees were awarded by Rutgers in environmental science. He received a Federal Pollution Water Control Administration EPA fellowship and a U.S. Public Health Service training grant. His doctoral thesis dealt with bacteria in activated sludge.

SOCIAL SCIENCESGuido Z. Zengals, Senior Planner

With over 15 years of professional experience as planner, consultant and architect, Guido Zengals' experience encompasses a broad spectrum of land use and major site and facilities planning, as well as architectural design and environment-related problem solving. While with the National Engineering Science Company, he gained valuable experience in oceanography related systems, wave-tank design, structural design, and design of various instrumentation systems. He holds a patent on a miniature ocean wave and current generator capable of simulating over 50 physical sea phenomena. While with Theodore Barry and Associates, Mr. Zengals was responsible for management of the firm's planning, architecture and engineering activities, land use feasibility and site search work, and all major space planning and building systems activities.

Mr. Zengals has a Bachelor of Architecture degree from the University of Southern California. He has done graduate studies in land use, planning, and real estate development at U.S.C. and the University of California at Los Angeles. He is a registered architect in California.

Joyce Herman, Environmental Planning

Joyce Herman has more than ten years experience in urban planning, with emphasis on the interface between people and the physical urban environment. Mrs. Herman has participated in environmental impact reports for marinas and harbors, municipal water systems, quarries, industrial parks, and large-scale multi-use redevelopment areas. In addition, she prepared the evaluation of the environmental consequences of a long-range general plan for a large area in Monterey County which proposed significant changes in the natural environment. She has designed and managed an urban planning field survey for the Public Health service. She also participated in a project studying the subjective noise reaction of residents near freeways as compared to objective noise measurements.

In addition to environmental work, Mrs. Herman has helped to develop and apply computer graphic techniques for the input and output of spatially-related planning data. A project for the Highway Research Board studied the 20-year impact of the developing Los Angeles freeway system on changing land use and population distribution. Another project for the Los Angeles County Local Agency Formation Commission used computer graphic techniques to facilitate the evaluation of alternative incorporation and annexation proposals.

Mrs. Herman has a Bachelor of Arts degree in geography from the University of California at Los Angeles, a Master of Science degree in city and regional planning from the University of Southern California, and a diploma for study in computer graphics from U.S.C. She is affiliated with the Urban and Regional Information Systems Association, the Southern California Research Coordinating Committee, and the Research Committee of the Los Angeles Chamber of Commerce.

Carl A. Carlson, Aesthetics and Environmental Geology

Carl Carlson's capabilities include computer modeling of geologic processes, regional assessment of geological risks, land use and population studies, visual impact analysis, and systematic analysis of general environmental problems, all with special emphasis on coastal zone projects. He has developed a technique to quantify the visual impact of proposed industrial facilities on scenic and residential areas, which has been used to assess the impact of a number of industrial projects. His experience with environmental studies includes those dealing with the siting of power plants in California's coastal zone and impact reports for power plants, transmission lines, and industrial port facilities.

Mr. Carlson has a Bachelor of Science degree in environmental geology from Stanford University, and was one of the first in his field to receive a formal degree in the systematic analysis of environmental problems.

Thomas R. Soper, Socioeconomics, Geology

Tom Soper has recently been involved primarily with land-use planning and socio-economic analyses. He has participated in site evaluations and environmental studies, as well as various geological investigations. In addition to working on the aesthetics, demography and land-use portions of these reports, he has played a major part in planning recreational development for the U.S. Army Corps of Engineers at a California reservoir.

Mr. Soper has Bachelor of Arts degrees in geology and geography from the University of California at Santa Barbara. While attending school, he worked on a three-year study of land-use change in California's Central Valley for NASA. He was also involved in an evaluation of landslide danger zones in Santa Barbara County. During this period he co-authored several technical reports dealing with remote sensing and land use.

Leslie W. Senger, Social Sciences

As a geographer in the Dames & Moore Santa Barbara office, Leslie Senger concentrates on environmental problems related to the social sciences. Prior to joining Dames & Moore, Dr. Senger held a position as Research Geographer at the University of California at Santa Barbara. He was primarily responsible for organizing and directing a research group associated with the National Aeronautics and Space Administration's space program. The research program was directed towards earth sciences investigations, land use, agriculture, regional change detection, and California coastal zone data base construction. As part of this work, he has lectured to personnel from state and county agencies on applications of space technology to resource management. He has also been a participant in a contract with the U.S. Coast Guard to evaluate the efficiency of a containment device for oil spill clean-up on the high seas.

Dr. Senger received his Bachelor of Arts, Master of Arts, and Ph.D. degrees in geography from the University of California at Los Angeles. His dissertation concerned the impact of the California State Water Project on agricultural development in the San Joaquin Valley. He is author on numerous papers and reports related to remote sensing technology, land use and environmental problems; he is also co-editor of a forthcoming book, Remote Sensing: Techniques for Environmental Analysis. He is a member of the American Society of Photogrammetry and the American Association for the Advancement of Science.

OCEAN SCIENCESLeland E. Fausak, Geological Oceanography

The academic and professional experience of Lee Fausak has emphasized nearshore hydrology and sedimentary processes. He has conducted research concerning the development of predictive models for beach changes and the use of artificial means to inhibit beach erosion. His efforts in the field of environmental coastal pollution have included the development of a classification system to evaluate pollutant levels, the study of natural submarine seepage, the investigation of oil/water behavior and its particular effect on dissolved oxygen content, and the evaluation of thermal effects from coastal industrial and power generating facilities. Mr. Fausak has also conducted several offshore and coastal geophysical diving surveys.

Mr. Fausak received a Bachelor of Arts degree in geology from the University of California at Santa Barbara and a Master of Science degree in oceanography from Virginia Institute of Marine Science of the University of Virginia. He holds membership in several professional societies, including the American Geophysical Union, the Marine Technology Society, the International Oceanographic Foundation, and the American Shore and Beach Preservation Association.

Kenneth H. Knesel, Jr., Field Engineering

As a Senior Field Engineer, Ken Knesel manages all field and construction inspection operations for the Dames & Moore Los Angeles office. He has over 22 years of drafting, surveying, and civil engineering experience. He has managed field engineering work for projects in Cook Inlet, South Korea, the Persian Gulf, and Bagdad, as well as throughout the continental United States. During the course of his career, Mr. Knesel has developed special expertise in marine, dredging, and offshore foundation investigations.

Mr. Knesel has an A.A. degree in civil engineering, and has completed various courses in soil mechanics and related subjects at the University of Southern California and the University of California at Los Angeles. He has lectured at the Los Angeles Trade Technical College and is a regular guest lecturer for the UCLA short course, "Foundation Engineering in the Marine Environment," which is presented under the auspices of the Naval Postgraduate School in Monterey, California. He is a member of ASCE and ASTM.

Alan A. Allen, Oceanography

Al Allen's oceanography experience includes coastal planning and management, underwater surveying and monitoring, manned underwater systems, and basic and applied research in marine oil pollution. Mr. Allen has served in several research efforts involving the detection and monitoring of pollutants with airborne remote sensing systems. He has directed a field survey and evaluation of thermal dispersion characteristics associated with an offshore waste-water discharge to Santa Monica Bay. He has also served as an expert witness during the completion of numerous oil pollution experiments in the Gulf of Mexico. He has developed new techniques for the measurement of oil film thickness, and directed field investigations on the magnitude and extent of pollution from natural oil seeps off Southern California.

After receiving a B.A. in physics and math from Washington and Jefferson College in Washington, Pennsylvania, Mr. Allen continued with graduate and undergraduate studies in physics, coastal engineering, environmental pollution, and physical and biological oceanography at the University of Maryland, University of California, and University of Southern California. While employed by Marconsult, Inc., he established their Environmental Sciences Department. His oil pollution activities led to consulting requests from the U.S. Geological Survey, the U.S. Coast Guard and the Environmental Protection Agency. As a member of the technical staff for General Research Corporation in Santa Barbara, he was involved with nuclear weapons effects, ballistic missile defense systems, undersea-antisubmarine warfare, and environmental pollution. Results of his research on the 1969 Santa Barbara oil spill were presented by Mr. Allen during his expert witness testimony at legal investigations of the spill's impact on the environment.

Richard Dornhelm, Coastal Engineering

The design of marine outfall systems for the disposal of waste and thermal discharges is the special expertise of Richard Dornhelm. He has performed preliminary feasibility studies for the marine disposal of a combined industrial park waste, cannery waste, domestic sewage and power plant cooling water effluent. He has designed a submarine outfall for refinery waste, hydraulic model experiments used to study the mixing of cooling water effluents from power plants, and a digital computer model to simulate the hydrodynamic behavior and waste dispersion characteristics of a one-dimensional estuary.

A joint project sponsored by the Geological Survey and Port Authority of Israel was initiated and directed by Mr. Dornhelm which included the engineering analysis of accumulated hydrographic data at Ashdod Port to determine the quantity and cause of sand movement around the port. Bathymetric charts were prepared and marine observations were processed. The effect of the port structures in disrupting the unimpeded sand transport in the region and the effect of the sand movement on the operation of the port were determined.

Mr. Dornhelm received his Bachelor of Engineering degree in civil engineering from Cooper Union. He also holds a Master of Science degree in sanitary engineering from Cornell University and a Master of Engineering degree in coastal engineering from the University of California.

James A. Hendrickson, Systems Engineering

Jim Hendrickson has applied his knowledge of numerical techniques to the solution of many coastal engineering and hydrodynamic problems. Recently his efforts were turned to analyzing the effects of cold water discharge into receiving waters. His analyses involved the study of thermal distributions and cold water mixing, including the design of outfall diffusers to minimize the environmental impact of the cold water. He has also developed computer programs to study hurricane storm surges, monochromatic wave refraction and transformation of a directional wave spectra, moving from deep to shoaling waters. The computer programs Dr. Hendrickson has developed on the interaction of large moored terminal buoys with wind and waves are now used to analyze and design the mooring for supertanker terminals.

Dr. Hendrickson received his Bachelor of Science, Master of Science, and Ph.D. degrees from the California Institute of Technology. He is a consultant to the State of California for preparation and grading of test documents concerning state registration of professional engineers. He is a member of the Marine Technology Society and the Sierra Club.

Roger S. Schlueter, Oceanography

In 1968, Roger Schlueter became a member of the technical staff at General Research Corporation of Santa Barbara, where his primary duties were concerned with large-scale systems analysis, using the techniques of computer simulation. After the 1969 Santa Barbara oil spill, however, Dr. Schlueter focused his energies on oceanography and oil pollution in the marine environment. In addition to participating with the U.S. Geological Survey and the University of California at Santa Barbara in a study of oil films using remote sensing techniques, he has performed diving surveys in the Santa Barbara Channel and an investigation of natural oil seeps in Santa Monica Bay. More recently he has been doing mathematical modeling in connection with atmospheric dispersion and studying pollutant transport in estuaries.

Dr. Schlueter received a B.S. in engineering science from Purdue University. Both his M.S. and Ph.D. were awarded in the same field from the California Institute of Technology.

Francis J. Gremse, Coastal Engineering

Frank Gremse's coastal engineering activities have involved studies related to hurricane storm surge, wave generation, flood levels, shore protection design, and sediment transport. He has worked on safety analysis reports for nuclear power plants and an environmental impact statement for beach improvement work in Hawaii, where he supervised the field program for the collection and reduction of baseline physical oceanographic data for the EIS. In addition, he has helped design sewage treatment facilities.

Mr. Gremse has a Bachelor of Science degree in civil engineering from Merrimack College, an EIT certificate from the State of Massachusetts, and a Master of Science degree in ocean engineering from the University of Hawaii.

### 10.2.3.2 Outside Consultants

#### Milton R. Beychok

Mr. Milton R. Beychok is an environmental advisor to Dames & Moore. He is a graduate of Texas A&M with a B.S. in Chemical Engineering and has nearly 30 years of experience in the petroleum/petrochemical field. Until recently, Mr. Beychok was associated with Fluor Engineers and Constructors where he was Manager of Environmental Engineering. In this capacity, he was responsible for all aspects of environmental engineering, supervising the development and writing of environmental impact statements for a number of major projects.

Mr. Beychok has been involved with both LNG and SNG projects and, as manager of Process Engineering at Fluor, he directed the process design of refineries, as well as individual refining processes.

Mr. Beychok is the author of many articles in the fields of his expertise. His book Aqueous Wastes from Petroleum and Petrochemical Plants, has become widely used as a reference for refinery and petrochemical plant waste water treatment. He holds professional engineering registration in the states of Texas and California, and is serving as a Research Grant Reviewer for the U.S. Environmental Protection Agency. Mr. Beychok has also served as a member of the California Regional Water Quality Control Board for Los Angeles.

#### Kenneth Y. Chen

Since 1970, Dr. Kenneth Y. Chen has been an Assistant Professor for the Department of Civil Engineering and the Environmental Engineering Program at the University of Southern California. From 1968 to 1970, he was a trainee in the Federal Water Quality Administration of the U.S. Department of Interior. As an independent consultant, Dr. Chen specializes in water pollution. He has particular experience with marine sediments, gas chromatography, trace metals, wastewater and storm drain effluents, and the catalytic effects of specific water contaminants. He is also a consultant to Region IX of the Environmental Protection Agency concerning dredge spoil disposal criteria and chemical testing techniques.

Dr. Chen obtained his B.S. degree in civil engineering from the National Taiwan University in 1963. He received an M.S. degree in sanitary engineering from the University of Rhode Island in 1966. From 1966 to 1968, he was a Teaching Fellow in the Division of Engineering and Applied Physics at the Harvard University. Harvard awarded him his Ph.D. in environmental science and engineering in 1970. His doctoral degree involved a major in environmental chemistry with minors in environmental microbiology and water resources engineering. Dr. Chen has published over 15 technical papers in his field. He belongs to the American Chemical Society, the American Society of Civil Engineers, the American Society of Limnology and Oceanography, the Water Pollution Control Federation and the Association of Environmental Engineering Professors.

Jim W. Dole

Dr. Jim Dole is a Professor of Biology at California State University at Northridge, where he has been employed since 1963. A specialist in animal ecology and behavior, Dr. Dole has taught both basic and advanced classes at the University in population ecology, animal behavior, and invertebrate zoology. Dr. Dole's major field of interest is studying the ecology and behavior of animals, especially the lower terrestrial vertebrates. He has authored or coauthored many papers in various scientific journals, including Ecology, American Midland Naturalist, Copeia, Herpetologica, and the Carribean Journal of Science. He is the author of a general ecology laboratory manual used by the ecology classes at California State University. He has received two research grants from the National Science Foundation and several others from the California State University, Northridge, Foundation.

Dr. Dole is familiar with the major ecological communities of Southern California, having conducted field work and research in them for more than 10 years. He has also had considerable field experience with other ecological regions of the Americas, including a year in the tropics in Venezuela. He is familiar with the utilization of standard ecological sampling techniques and is qualified to perform terrestrial surveys and field analyses.

Dr. Dole received his B.A. degree in the field of biology from Arizona State University, Tempe, and his M.S. and Ph.D. in zoology from the University of Michigan. He is affiliated with the Ecological Society of America, American Society of Ichthyologists and Herpetologists, Animal Behavior Society, Southwestern Association of Naturalists, and the American Association for the Advancement of Science.

George F. Fisler

Dr. George Fisler is a Professor of Biology at California State University, Northridge, where he has been employed since 1964. He has taught ecologically-oriented undergraduate and graduate courses in ornithology and mammalogy since 1962. He is also a Research Associate with the Los Angeles County Museum of Natural History.

Dr. Fisler's area of research is the behavior, ecology, and systematics of birds and mammals. He has field research experience in many areas of the United States, particularly Michigan, Oregon, and California, and has traveled extensively in many other states. He has also studied in Puerto Rico and Costa Rica. His research and travels have resulted in scientific articles being published in such journals as Ecology, Condor, Journal of Mammalogy, Canadian Journal of Zoology, and the American Midland Naturalist.

Dr. Fisler received his Bachelor of Science and Master of Science degrees from Michigan State University and holds a Ph.D. from the University of California, Berkeley, where his major fields were ecology, systematics, and plant distribution. He has been a Research Zoologist with the University of California Hastings Natural History Reservation, Carmel Valley, an Assistant Professor at Portland State University, and a Visiting Professor of Biology at the University of Puerto Rico. He is currently a member of the Ecological Society of America, British Ecologist Society, and other professional organizations.

John Koeller

Mr. Koeller possesses 14 years of experience in the area of demographic studies, industrial site location, and economic feasibility and impact. Mr. Koeller holds a B.A. and M.A. in Industrial Engineering from the University of Southern California. He is a registered professional engineer, a Senior Member of the American Institute of Industrial Engineers, and a member of the Urban Land Institute.

Lindvall, Richter and Associates

Lindvall, Richter and Associates is a consulting firm designed to advise on all earthquake-related phases of major construction and building projects. The firm's founders are Dr. Eric Lindvall, Dean Emeritus of Engineering, and Dr. Charles Richter, Professor Emeritus of Seismology, both of the California Institute of Technology. Incorporating expertise in seismology, geology, soils engineering, hydraulics, and dynamic analysis as they relate to earthquakes, the firm provides general consulting services to engineering profession.

Marine Ecological Consultants

Marine Ecological Consultants is a consulting firm operating out of Del Mar, California. Marine monitoring surveys, ecological impact analyses and taxonomic identification services are their principal areas of expertise. They have participated in the preparation of many environmental impact statements in the western United States. Recent work includes the marine biological studies for a proposed LNG facility, thermal effects studies for power generating plants in Mandalay, San Onofre, Scattergood and Pearl Harbor, and baseline inventories and dredging effect studies in the Marshall Islands. In addition, they have taken part in a number of environmental impact reports for oil pipelines.

Rudolf Mattoni

Dr. Mattoni is founder and General Director of Agri-Science Laboratories. He is Chief Executive Officer and directs technical activities in biochemistry. Most recent research activities involve heavy metal and pesticide translocation in micro-organisms.

Dr. Mattoni served as general manager of NUS's Biological Systems Division and was Principal Investigator on the NASA Biosatellite Experiment to determine weightlessness and radiation effects on bacteria-virus systems.

At North American Aviation, Dr. Mattoni managed three research projects including principal investigation of the Biosatellite experiment; the company-funded project on photosynthetic conversion of wastes (industrial photosynthesis), (later funded by USPHS), and a basic investigation of algal genetics for the U.S. Air Force.

He has supervised a study on personal hygiene and sanitation in spacecraft for the Air Force. Dr. Mattoni has taught and done research in genetics and ecology. He has authored over 60 papers and reports, including the chapter on "Algal Genetics" in Algae, Man, and the Environment. Dr. Mattoni received his B.S., M.S., and Ph.D. in zoology from the University of California.

Agri-Science Laboratories, Inc. is an AOCs laboratory, a licensed cottonseed chemical lab, and an FDA drug chemist lab. They are also USDA certified meat chemists, and approved by the State of California for water bacteriology, chemistry and bioassays.

Paul Meyers

Mr. Meyers is a Teaching Assistant in Botany and Plant Taxonomy at the University of California, Santa Barbara. He has been a teaching assistant and lecturer at this University since 1969.

Mr. Meyers' experience is in the field of terrestrial plant ecology and taxonomy. He received his B.A. in botany at Whitman College and his M.A. at the University of California, Santa Barbara.

Eugene B. Nebeker

Dr. Nebeker is President of Scientific Associates, Inc. He received his Ph.D. in Chemical and Nuclear Engineering in 1965; his M.S. in Chemical Engineering in 1960 from the California Institute of Technology. His B.S. in Chemical Engineering was obtained at Stanford University in 1959. He currently directs the development of an oil-spill skimmer under Coast Guard contract DOT-CG-22878-A, a follow-on effort to earlier feasibility work. Other current technical interest include natural oil spill dispersal and a novel application of water jets to rock mining.

From 1965 to 1969, Dr. Nebeker was employed with North American Rockwell Corporation. Two years were spent with the Autonetics Division in air and water pollution problems. He was proposal engineer on several proposal activities and responsible for design and testing of a prototype bioluminescent chemical detector for the Air Force. The preceding two years he was technical specialist in the Rocketdyne Division where his work related to fluid mechanics and heat transfer. Specific problem areas included propellant orientation under zero gravity, cool down and bubble formation in cryogenic transfer lines in reduced-gravity environments, dilution of liquid oxygen, propellant by pressurant nitrogen gas, and liquid hydrogen density profiles at supercritical pressures.

Between 1960 and 1965, he worked towards his doctorate at Cal-Tech, performing theoretical and experimental research on irreversible thermodynamics. Dr. Nebeker is a member of the American Institute of Chemical Engineers, the American Chemical Society, and the American Institute of Aeronautics and Astronautics. He is a registered chemical engineer in California and Texas. He has published technical papers in physical chemistry, chemical kinetics, thermo-dynamics and transport phenomena.

Andrew Starrett

Andrew Starrett is a Professor of Biology at the California State University at Northridge. He is also a Research Associate at the Los Angeles County Museum of Natural History. Dr. Starrett's main research focus has been on the systematics, morphology, distribution, and ecology of mammals. His most recent field activities have been mainly in the Pacific coastal states and Costa Rica, although he has traveled throughout North and Middle America.

During his recent sabbatical, Dr. Starrett served as Chairman of the Los Angeles County Environmental Resource Committee, which compiled an extensive report on the natural habitats and areas of ecological significance of the county for the Los Angeles County Regional Planning Commission. He also participated in providing baseline and impact information for several city and county departmental studies and in evaluating environmental impact studies for the Los Angeles County Regional Planning Department.

Dr. Starrett received his B.A. from the University of Connecticut and an M.A. and Ph.D. from the University of Michigan. He has held a number of research grants and authored over 20 scientific publications. He belongs to the Southern California Academy of Sciences (President in 1971 and 1972), the American Society of Mammalogists, the Society of Systematic Zoology, the Society for the Study of Evolution, the Association for Tropical Biology, and other professional organizations.

Westwood Research, Inc.

Westwood Research, Inc. is an independent California Corporation formed in 1965. The firm provides contract research and consulting services to business, industry, and government both in the United States and abroad. The professional staff offers expertise in economics, financial analysis, development planning, operations research, systems analysis, and management consulting. Specialized capabilities of the firm include economic and technical feasibility evaluations, demand forecasting and market analysis, facilities and systems planning studies, benefit-cost evaluations, and systems cost and effectiveness studies. The senior staff has had significant experience in the development of evidence and testimony relating to a diversity of public policy and economic concerns, such as route and rate matters, tax policies, antitrust proceedings, and labor arbitrations.

The major fields of activity of Westwood Research are economic feasibility and financial analysis, energy and mineral economics, program planning and evaluation, regional economics and development planning, and transportation research and consulting.

10.2.4 Bibliography

A bibliography is included at the end of each section of the report where applicable. References cited within the text are denoted by an asterisk in the bibliography.

10.3 SUPPORTIVE REPORTS

No separate publications or reports have been made nor will result from information compiled for this report.