NUREG-0171

Early Site Review Report for the Sundesert Site

San Diego Gas & Electric Company

Reported by the
Office of Nuclear Reactor Regulation

Project No. 558

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U. S. Nuclear Regulatory Commission
Washington, D. C.

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February 1977

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NUREG-0171
February 10, 1977

EARLY SITE REVIEW REPORT

BY THE

OFFICE OF NUCLEAR REACTOR REGULATION

U. S. NUCLEAR REGULATORY COMMISSION

IN THE MATTER OF

SAN DIEGO GAS AND ELECTRIC COMPANY

SUNDESERT SITE

PROJECT NO. 558

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1.0 INTRODUCTION AND GENERAL DISCUSSION

1.1 Introduction

The purpose of this report is to present the Nuclear Regulatory Commission's (Commission) evaluation of several of the matters relating to the suitability of a site (Sundesert site) near Blythe, California, on which the San Diego Gas and Electric Company (applicant) proposes to build a nuclear facility, identified as the Sundesert Nuclear Plant, Units 1 and 2 (plant or facility).

The Sundesert Early Site Review Report was submitted on April 16, 1975, in support of a request by the applicant to have the Commission evaluate the suitability of the proposed site with respect to (1) demography and geography, (2) consideration of nearby industrial, military and transportation activities, (3) hydrology, including certain hydrologic design criteria, (4) geology and seismology, including seismic input criteria, and (5) site meteorology.

Initially, the applicant requested that the Sundesert Early Site Review Report be reviewed by both the Commission's staff and the Advisory Committee on Reactor Safeguards. Subsequently, in September 1975, the applicant requested that the U.S. Geological Survey also participate in the review of the report with regard to geology and seismology.

This report summarizes the results of our technical evaluation of the suitability of the proposed Sundesert site for a nuclear power plant and delineates the scope of the technical matters considered in evaluating the suitability of the site. Additional details as to the scope and bases used by the Commission's staff to evaluate the radiological safety aspects of proposed nuclear power plant sites are provided in the Nuclear Regulatory Commission's Standard Review Plan For The Review Of Safety Analysis Reports For Nuclear Power Plants, NUREG-75/087 (hereinafter also referred to as the Standard Review Plan). The Standard Review Plan is the result of many years of experience by the Commission's staff in establishing and promulgating guidance to enhance the safety of nuclear facilities and in assessing Safety Analysis Reports.

The applicant also tendered an application on December 8, 1976 for construction permits to build two light water reactors, each rated at approximately 978 electrical megawatts, on the proposed Sundesert site. The applicant submitted the Environmental Report with the application and plans on submitting the Preliminary Safety Analysis Report in March 1977. The nuclear steam supply system for each unit will be a three-loop system to be supplied by the Westinghouse Electric Corporation.

During the course of this early site review, we and our advisors, the U. S. Geological Survey, held several meetings with the applicant and visited the site on three occasions. During our evaluation of the information contained in the Sundesert Early Site Review Report, we requested the applicant to provide additional information. The additional information was provided in Amendments 1 through 12 to the Sundesert Early Site Review Report. The report and its amendments are available for public inspection at the U.S. Nuclear Regulatory Commission Public Document Room, 1717 H Street, N.W., Washington, D.C. 20555, and at the Palo Verde Valley District Library, 125 West Chanslorway, Blythe, California 92255.

A chronology of the principal actions related to our review of the Sundesert Early Site Review Report is included as Appendix A to this report. The U. S. Geological Survey's evaluation of the geology and seismology for the proposed Sundesert site is enclosed as Appendix B. The bibliography for our report is enclosed as Appendix C.

1.2 General Description of the Site

The site for the proposed Sundesert Nuclear Plant is located on the mesa in the Palo Verde Valley in the southeastern corner of Riverside County, California, as shown in Figure 1.1. It is located approximately 16 miles southwest of Blythe, California (1970 population of 7,047), and 2.5 miles west of Palo Verde, California (population less than 300). It is also approximately 50 miles north-northwest of Yuma, Arizona (1970 population of 29,007) which is the closest population center of greater than 25,000 persons. The land on the mesa is substantially controlled by the U.S. Department of Interior, Bureau of Land Management. The airspace above the site is currently overflown by low level and high level military flights.

The site is located on the mesa adjacent to the flood plain approximately two miles west of the Colorado River flood plain, as shown in Figure 1.2. The site area encompasses approximately five square miles. The Mule Mountains lie approximately five miles west of the site, and the Palo Verde Mountains lie approximately six miles southwest of the site. The ground surface ranges from approximately 350 feet above mean sea level on the east side to 400 feet above mean sea level on the west side. These elevations are 100 to 150 feet above the level of the flood plain. Groundwater level is approximately 240 feet above mean sea level.

The site is situated within the Sonoran Desert physiographic and geologic subprovince of the Basin and Range province. The geology within a 25-mile radius of the site is characterized by mountain ranges which are relatively short, irregular, and stand sharply above broad alluvial-filled basins. Rocks of the mountains vary from deformed crystalline rocks of Precambrian age to volcanic and sedimentary rocks of middle Tertiary age. Pliocene marine deposits, Pliocene to Pleistocene alluvial deposits, and Holocene alluvium fill the broad basins.

Faulting within the site area is restricted solely to the bedrock and basement complex. Thrust faulting, confined to the basement rocks, is associated with the Laramide orogeny. High-angle faults, including both strike-slip and normal faulting, postdate

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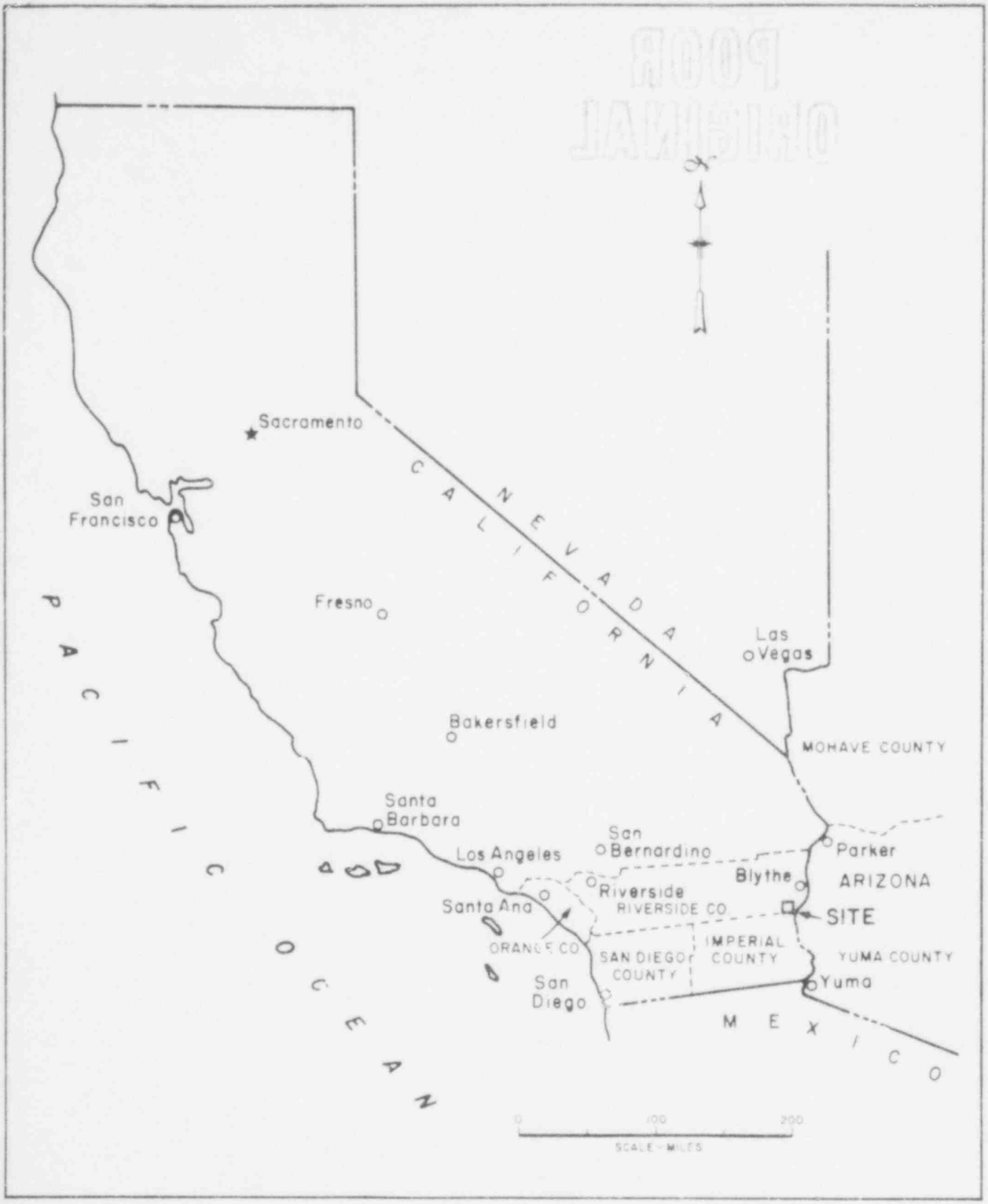

FIGURE 1.1

GENERAL SITE LOCATION SUNDESERT SITE

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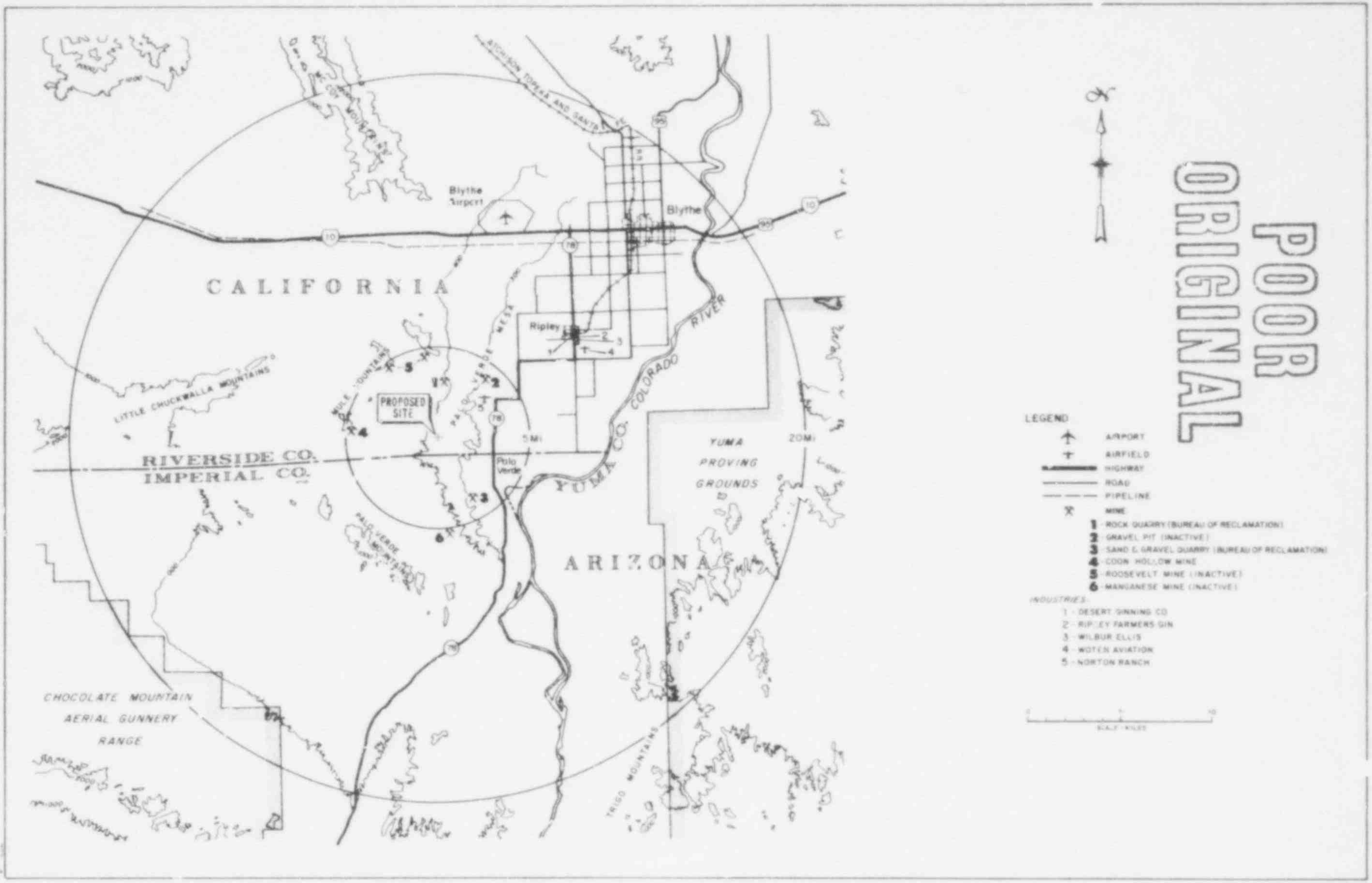

FIGURE 1.2 AREA WITHIN 20 MILES OF SITE

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the thrust faulting and disrupt both the bedrock and the basement complex. Pliocene to Holocene sediments are flat-lying and undeformed throughout the site area. The most significant tectonic structure in the vicinity of the site is the San Andreas fault system. The applicant has chosen the Sand Hills fault, which is 35 miles from the site, as the closest member of the San Andreas fault system to the site, even though the Sand Hills fault is clearly not the same kind of master through-going feature as the San Andreas system.

Foundation soils at the site consist of approximately 380 feet of dense granular soils underlain by a thick deposit of hard clay.

1.3 Identification of Agents and Contractors

The San Diego Gas and Electric Company will be responsible for the design, construction and operation of the proposed plant. At the present time the San Diego Gas and Electric Company is the only participant in the proposed Sundesert Nuclear Plant, but broader ownership may be included when the Preliminary Safety Analysis Report is submitted. The Stone and Webster Engineering Corporation has been selected as the architect-engineer and constructor for the proposed plant.

The following consultants were retained by the applicant to perform investigations and studies for the preparation of the Sundesert Early Site Review Report:

(1) Fugro, Incorporated, Consulting Engineers and Geologists

(2) EDS Nuclear, Incorporated, Consulting Engineers

(3) Bookman-Edmonston Engineering, Incorporated, Specialists in Water Resources

(4) WESTEC Services, Incorporated, Environmental Consulting Firm

1.4 Summary of Principal Review Matters

Our evaluation included a technical review of the information and data submitted by the applicant with emphasis on the following principal matters:

(1) We evaluated the exclusion area, low population zone and population density in the site environs to determine that these characteristics were in accordance with the Commission's siting criteria in 10 CFR Part 100.

(2) We evaluated the land use characteristics of the site environs and the physical characteristics of the site, including meteorology, hydrology, geology, and seismology to determine that these characteristics had been adequately described and were given appropriate consideration to determine the significant site-related parameters for the design of a nuclear plant, and that these site characteristics were also in accordance with the siting criteria in 10 CFR Part 100.

(3) We evaluated the hazards to a nuclear power plant which could result from man's activities near the site environs, such as petroleum extraction, mining activity and transportation accidents to determine whether special design considerations would be required, because of these activities, for a nuclear power plant to be located on the proposed site.

During the process of performing our evaluation of the above principal matters, we have identified the additional information that we will review when the Preliminary Safety Analysis Report is submitted, to complete our detailed review of these site characteristics for a construction permit application.

2.0 SITE CHARACTERISTICS

The scope of the Sundesert early site review does not include the design parameters for a specific nuclear power plant design. This information will be provided by the applicant at at future date in the Preliminary Safety Analysis Report in accordance with the requirements of 10 CFR Part 50. However, the Sundesert Early Site Review Report and this early site review report have established an envelope of meteorological, hydrological, geological and seismological conditions for a nuclear power plant design. These conditions provide an indication, in advance of the development of a specific nuclear power plant design, of site-related design requirements for a nuclear power plant at the Sundesert site.

2.1 Geography and Demography

The 7,040 acre Sundesert site is located in the extreme southeastern portion of Riverside County, California, about 5.5 miles west of the Colorado River. The site is located on the Palo Verde Mesa, 9.5 miles southwest of Ripley, California, 16 miles southwest of Blythe, California, and 50 miles north-northwest of Yuma, Arizona. The Unit 1 containment will be centered at 33 degrees, 27 minutes, 7 seconds north latitude and at 114 degrees, 47 minutes, zero seconds west longitude. The Unit 2 containment will be located 600 feet due east of Unit 1. Figure 2.1 identifies the site location and characteristics of the area within 10 miles of the site.

The applicant has defined a site boundary and exclusion area radius of 3,200 feet as shown in Figure 2.2. The applicant proposes to acquire land (shown as Parcel No. 1 in Figure 2.2), consisting of about 6,560 acres, from the U.S. Department of Interior, Bureau of Land Management through an in-lieu property exchange. To this end, the Bureau of Land Management has designated lands, in the Coachella Valley region in California, which it is interested in acquiring by exchange. The applicant has optioned the land designated by the Bureau of Land Management for the property exchange. Based on the Bureau of Land Management's land exchange practices, the applicant will acquire 100 percent of the mineral rights in about two-thirds of the land to be acquired from the Bureau of Land Management. However, the applicant will acquire from the Bureau of Land Management 100 percent of the mineral rights in all the land within the exclusion area.

The applicant has optioned, with the exclusive right to purchase, the land shown as Parcel Nos. 2, 3, 4 and 5 in Figure 2.2. The options to purchase held by the applicant include 100 percent of the mineral rights, except for Parcel No. 2 (which is not in the exclusion area) where the optionor has reserved 50 percent of the mineral rights. An option to purchase the land shown as Parcel No. 6 in Figure 2.2 has been tendered to the owner, who declined to enter into an option agreement. The parcel is not within the exclusion area and therefore control, including mineral rights, is not required.

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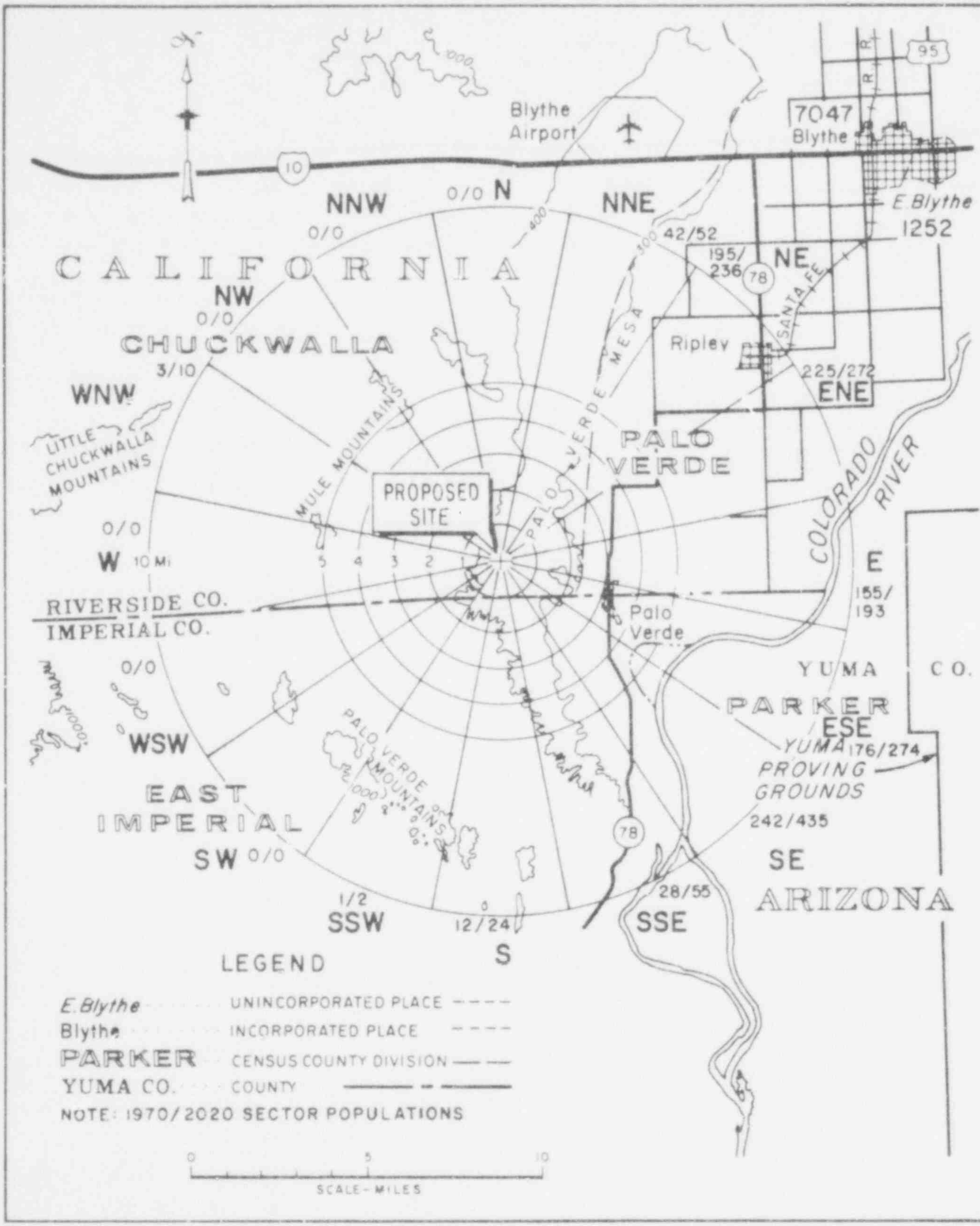

FIGURE 2.1

AREA WITHIN 10 MILES OF THE SITE

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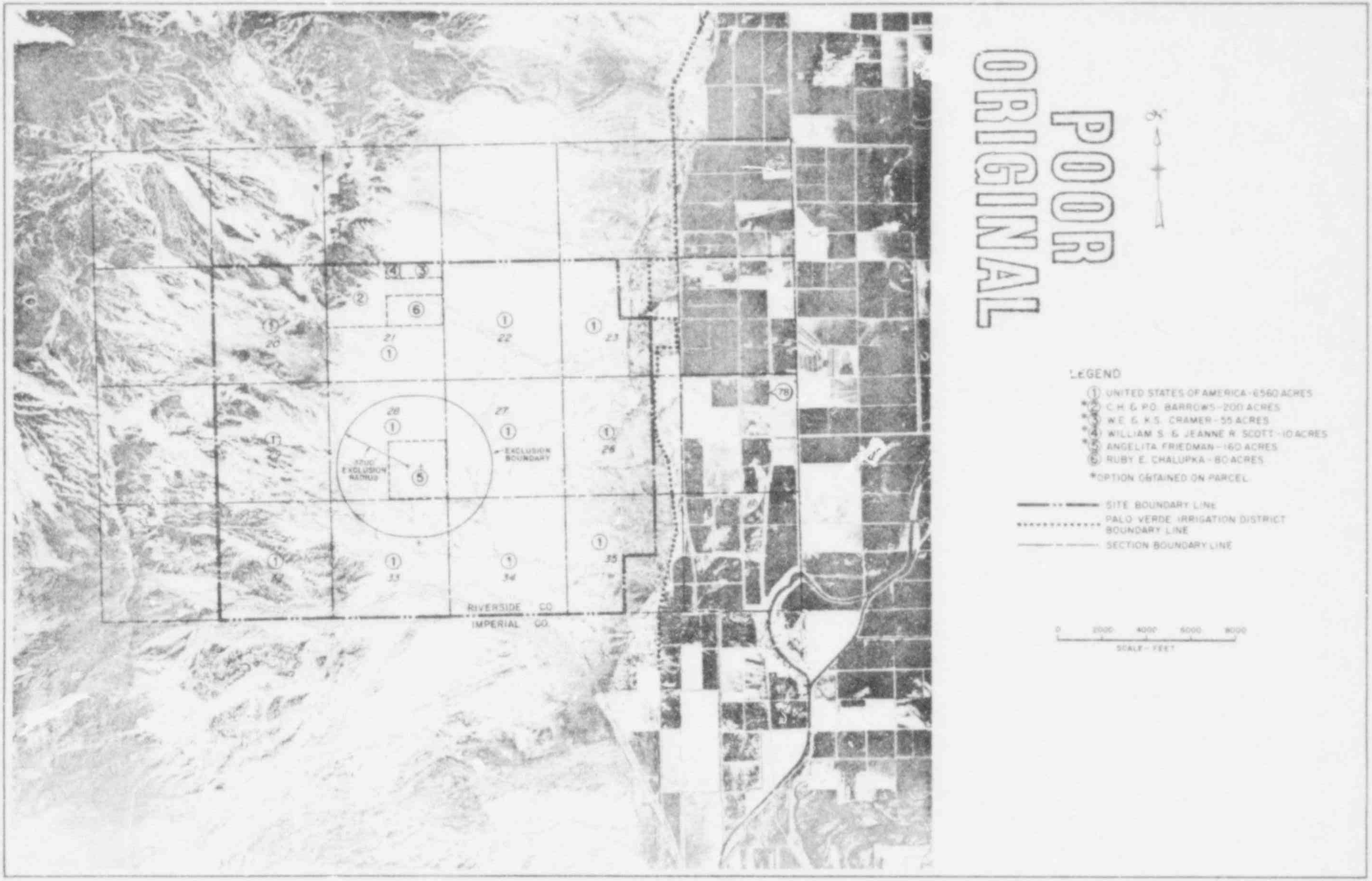

FIGURE 2.2 LAND OWNERSHIP – SUNDESERT SITE

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The applicant has specified a low population zone of three miles radius. The 1980 population within the three-mile low population zone is estimated by the applicant to be 18 persons. The 1980 population within five miles of the site is estimated to be 463 persons and within 10 miles is estimated to be 1,131 persons. The estimated cumulative population distribution within 50 miles of the site for the year 1980 is shown in Figure 2.3.

The applicant states that the population center, as defined in 10 CFR Part 100, closest to the proposed site area with a population of more than 25,000 persons, is the city of Yuma, Arizona. The 1970 population of Yuma was 29,007 and its location is approximately 50 miles south-southeast of the proposed site. Population projections do not indicate that any other area within 50 miles of the site will attain a population exceeding 25,000 by the year 2020, the approximate end-of-plant life. Therefore, the distance from the outer boundary of the three-mile low population zone proposed by the applicant is well in excess of the minimum population center distance of one-and-one-third times the low population zone radius, as required by 10 CFR Part 100.

Two distinct types of transient population are attracted to the area within a 50 mile radius of the proposed Sundesert site. The first type involves people pursuing recreational activities who visit the area primarily during the winter season. The second type involves transient farm workers employed on the area's irrigated farm lands.

Major concentrations of desert transient recreationists are located south, west, and east of the proposed site. Major concentrations of river-oriented transient recreationists occur along the Colorado River Valley extending north by northeast, to south by southeast from the site. The section of the Colorado River Valley extending to the southeast contains the largest fraction of transient recreationists. The estimated mean seasonal day recreational population within a 50-mile radius of the site is 4,952 for 1980 and 14,172 for 2020, the estimated end-of-plant life. During the lifetime of the proposed plant, however, there are no known plans for recreational activities that would result in transient recreationists within the three-mile low population zone boundary.

Agricultural areas within a 50-mile radius of the proposed Sundesert site contain more than 300,000 acres of irrigated farmlands. The 1974 peak transient work force in the area was estimated to be approximately 3,500. During the lifetime of the proposed plant, however, there are no known plans for agricultural activities that would result in transient agricultural workers within the three-mile low population zone boundary.

In accordance with 10 CFR Part 100, offsite doses from postulated design basis accidents are to be calculated at the exclusion area and the low population zone on the bases of the site meteorology, reactor thermal power level, and the safety features that are to be engineered into the nuclear power plant. Regulatory Guide 1.4 "Assumption Used for Evaluating the Potential Radiological Consequences of a Loss-of-Coolant Accident for Pressurized Water Reactors" specifies the allowable radiological consequences for the construction permit review. Since the required information for the evaluation will not be available until the Preliminary Safety Analysis Report is submitted, we are unable to conclude on these matters at this time.

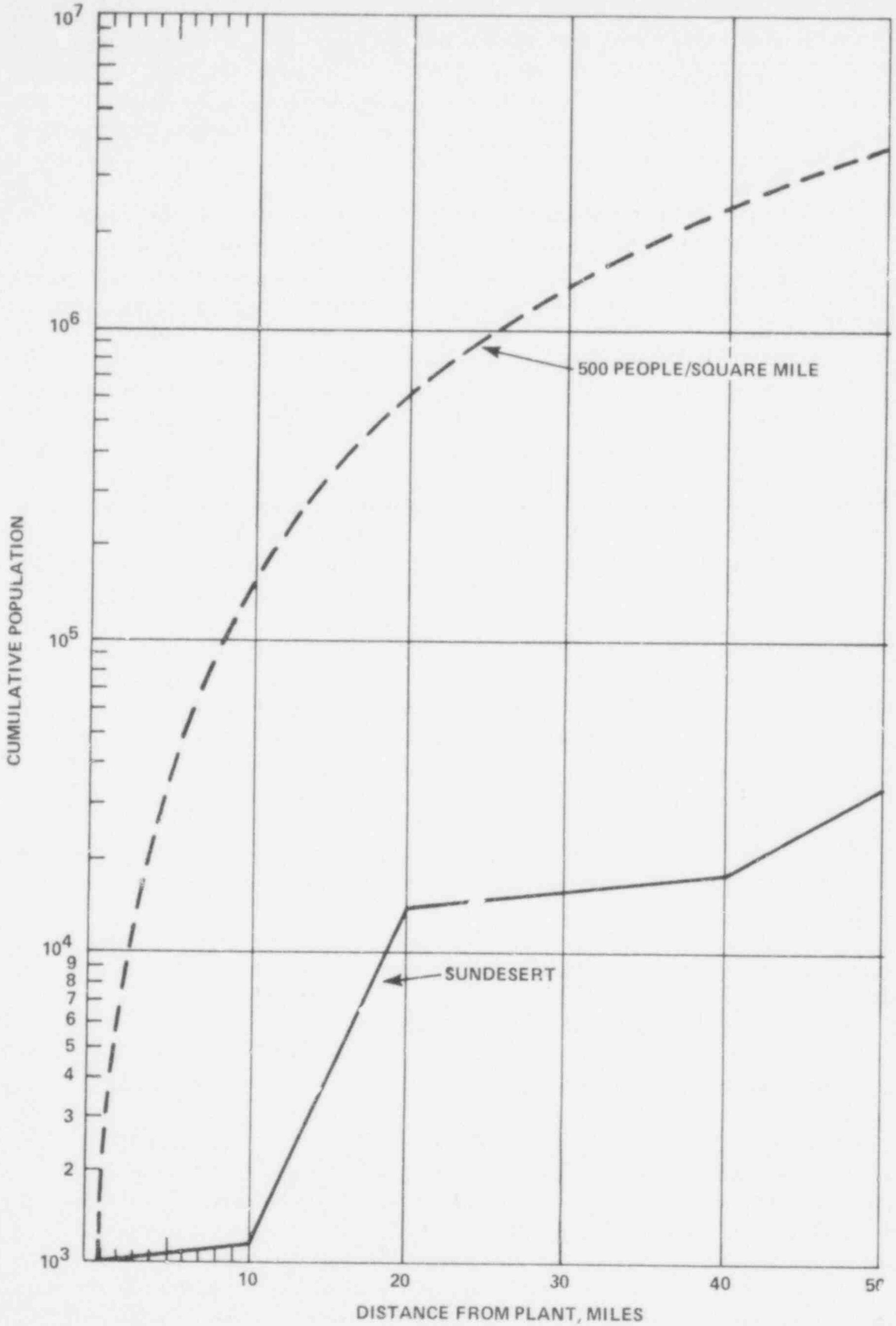

FIGURE 2.3

CUMULATIVE POPULATION DISTRIBUTION (1980)

However, based on past experience, we have found that a minimum exclusion area distance of 640 meters (0.4 mile), and a low population zone distance of 4800 meters (three miles), even with unfavorable atmospheric dispersion characteristics, usually provides assurance that engineered safety features can be provided to maintain calculated doses from postulated accidents within the guidelines of 10 CFR Part 100. This will be verified during our review of the Preliminary Safety Analysis Report when the design features of the plant are available.

The practicability of evacuation, as an emergency protective measure, of persons within and beyond the low population zone is performed during the review of the applicant's proposed emergency plans. The emergency plans are evaluated to determine that they meet the requirements of the Commission's emergency planning criteria in Appendix E to 10 CFR Part 50. Since the proposed emergency plans will not be available until the Preliminary Safety Analysis Report is submitted, we are unable to conclude on this matter at this time.

However, based on past experience, we have found that appropriate emergency plans can be developed for the expected population levels in the vicinity of the site. The practicability of evacuation, as an emergency protective measure, of persons within and beyond the low population zone will be verified during our review of the proposed emergency plans after the Preliminary Safety Analysis Report is submitted.

On the basis of the 10 CFR Part 100 definitions of the exclusion area, low population zone, and population center, we conclude that exclusion area, low population zone, and population center distances for the proposed Sundesert site can meet the requirements of 10 CFR Part 100. The following areas will be verified during our review of the Preliminary Safety Analysis Report in order for us to complete our evaluation of site geography and demography.

(1) The ability of the exclusion area boundary to meet the dose limitation guidelines of 10 CFR Part 100 in the event of a postulated accident.

(2) The practicability of evacuation, as an emergency protective measure, of persons within and beyond the low population zone.

2.2 Nearby Industrial, Transportation, and Military Facilities

There are no industrial facilities, pipelines, railroads, or commercial or military airports within five miles of the site. The nearest of these facilities is an industrial area located in Ripley, 9.5 miles northeast of the site; a small airfield also in Ripley, nine miles northeast of the site; and two 30-inch natural gas pipelines, rated at a pressure of 807 pounds per square inch, which parallel Interstate Highway 10 about 10.5 miles north of the site. There is also a smaller natural gas distribution line, located one mile south of the two major lines, with a two-to-four inch varying diameter and rated at a pressure of 30-40 pounds per square inch. There is a private airstrip about three miles northeast of the site on the Norton Ranch with two Cessna 411s based at this field. None of these facilities would have the potential for adversely affecting the safe operation of the proposed plant.

There are six mines within five miles of the site: Coon Hollow Mine, a "rock-hound" mine located five miles west of the site; a sand and gravel quarry located four miles southeast of the site, and a rock quarry located three miles north of the site, both operated by the Bureau of Reclamation; Roosevelt Mine, an inactive gold mine located 4.5 miles north by northeast of the site; and an inactive manganese mine located five miles south of the site. None of these mines would have the potential for adversely affecting the safe operation of the proposed plant.

The nearest Highway is California State Highway 78, a north-south two-lane road connecting Blythe and Brawley, located about 3.25 miles east of the site. Because of the distance of this road to the site, no type of transportation accident on the road would have the potential for adversely affecting the safe operation of the proposed plant.

The only major waterway near the site is the Colorado River, which is 5.5 miles southeast of the site at its closest point. The river is dammed north of the site at Parker Dam and south of the site at Imperial Dam. No locks exist at these dams, and thus there is no commercial shipping on this portion of the river. Since there are no hazardous materials transported on this section of the river, there would be no impact on the safe operation of the proposed plant.

The airspace above the site vicinity may be conveniently divided into three general vertical levels: below 1,500 feet, between 1,500 and 18,000 feet, and above 18,000 feet. This airspace is virtually bounded, to the east and west by large areas restricted to military aviation, and by major east-west aerial routes that cross through the region over Blythe to the north and Yuma to the south. Within this area, airspace below 1,500 feet is currently used by local general aviation and military low level training routes. A line connecting navigation aids operated by the Federal Aviation Administration near Blythe and Yuma passes 3.5 miles east of the site, and defines Federal Airway V135. Above 18,000 feet there is a traffic pattern associated with a military base to the south of Yuma.

The applicant has submitted an analysis, using an acceptable method of estimation, which concluded that the risk of aircraft impact from present traffic on the low level military training routes, where they are now located, is less than 4×10^{-8} per year per unit. By agreement between the Nuclear Regulatory Commission and the Department of Defense, however, a directive exists (Department of Defense, Flight Information Publication, AP/1B) that such military training routes be moved prior to reactor operation, such that they are clear of nuclear power plants. The clearance specified is sufficient so that accidents that might occur involving aircraft flying those routes could not credibly be expected to impact these plants.

Crashes are extremely rare for aircraft while flying in traffic separation schemes of Federal airways. Domestic air carriers have accumulated only one occurrence of such an accident in 2×10^{10} revenue miles. Miles flown by all other aircraft in Federal airways is unknown, but we may take ten times the domestic air carrier crash rate as a conservative estimate of the total crash rate for all airway traffic, which computes to an accident rate of 5×10^{-10} per aircraft mile. If it is further assumed that 30,000 flights per year occur along Federal Airway V135 (about twice the current traffic), and that crash impacts are restricted to a ten-mile wide corridor, then an impact rate of 2×10^{-8} per year per unit is predicted for flights in this airway. Because of this low impact rate, we conclude that the proposed site is suitable for the construction of a nuclear power plant without the need for special design considerations for postulated commercial aircraft accidents in Federal Airway V135.

About 1,400 military flights per year, some fraction of which carry live ordnance, overfly the site at altitudes in excess of 18,000 feet. Overall training mission loss rates for aircraft of the general type used in this traffic are about 5×10^{-8} per mile. However, a search of Department of Defense records for the years 1965-1975 shows that no military crashes in the Yuma-Blythe corridor were recorded during that period. Again assuming a 10-mile wide impact corridor, the present traffic leads to an estimated impact rate of 10^{-7} per year per unit for these military flights. The centerline for this flight path, the Yuma Marine Corps Air Station Standard Instrument Departure, passes about one mile from the proposed site. Hence, it would be conservative to assume a one-mile wide impact corridor, yielding a conservative impact rate estimate of 10^{-6} per year per unit for the flights. The criteria to be satisfied for excluding, as a design basis, the capability to mitigate the consequences of a postulated accident involving a nuclear power plant, are (1) an accident frequency of about 10^{-7} per year per unit or less, as determined by the most realistic estimate available, and (2) an accident frequency of less than about 10^{-6} per year per unit, as determined by conservative estimates. As demonstrated in the above analyses, the proposed site for the plant meets these criteria for military flight accidents. It should be noted that military regulations, applicable to an aircraft in the Standard Instrument Departure flight path which became unairworthy, would require the pilot to direct the aircraft towards the Yuma Proving Grounds to the east or toward the Chocolate Mountain Gunnery Range to the west, prior to abandonment. At an altitude in excess of 18,000 feet, sufficient glide path is available to perform this maneuver. Therefore, both of the above estimates contain an additional unquantifiable conservatism.

We conclude that, with the current military traffic estimates, the proposed site is suitable for the construction of a nuclear power plant without the need for special design considerations for military aircraft impact. To provide against any future changes in military aviation risk over the service life of any plant at the proposed site, we will require that the applicant obtain an agreement for relocation of the present Yuma Marine Corps Air Station Standard Instrument Departure route north of Yuma to assure that after a plant on this site is ready for operation, no aircraft carrying live ordnance will overfly within five miles of the site.

The nature and extent of the other activities at nearby industrial, transportation, and military facilities have been evaluated and we conclude that currently, with regard to these considerations, there are not activities in the vicinity of the Sundesert site which have the potential for adversely affecting safety-related structures of any nuclear power plant which may be proposed for the Sundesert site nor which would require special design considerations for any plant proposed for the site.

2.3 Meteorology

Information concerning the atmospheric dispersion characteristics of a proposed nuclear power plant site is required in order that a determination may be made that postulated accidental, as well as routine operational, releases of radioactive materials are within Commission guidelines. Furthermore, regional and local climatological information, including extremes of climate and severe weather occurrences which may affect the safe design and siting of a nuclear plant at a proposed site, is required to assure that safety-related plant design and operating bases are within Commission guidelines. The design basis meteorological characteristics of a proposed site are determined by the Commission staff's evaluation of meteorological information in accordance with the procedures presented in Sections 2.3.1 through 2.3.5 of the Standard Review Plan.

2.3.1 Regional Meteorology

The southeastern corner of California, which includes the proposed site, is typified by a desert-type climate. Summers are long and hot with afternoon temperatures averaging 100 degrees Fahrenheit from June into September. Moist air from the Gulf of Lower California is drawn into the area resulting in higher humidities than would normally be expected to occur in a desert climate. Winds from the south-southeast prevail during the summer months and from the north-northeast during the winter months.

Temperatures may be expected to reach 90 degrees Fahrenheit or higher, on about 169 days a year, 32 degrees Fahrenheit or lower on about three days a year and would not be expected to fall to zero during an average year. Annual average relative humidity is 30 percent.

Local thunderstorm activity is responsible for most of the severe weather activity in this region.

No tornadoes were reported during the period 1955 through 1967 within a one degree latitude-longitude square containing the site. During the same time interval, storms with winds of 58 miles per hour or greater were reported on two days. The "fastest mile" wind speed reported at Yuma, Arizona (about 50 miles south-southeast of the site) during the 24-year period ending in 1974 was 60 miles per hour (August 1973). Thunderstorms in Yuma may be expected to occur on approximately seven days on an annual average. Climatic records indicate that icing is not a problem in this area.

Design and operating bases for tornados and sustained fastest mile wind speeds have not yet been determined for the Sundesert plant. We will require that these values be provided in the Preliminary Safety Analysis Report.

2.3.2 Local Meteorology

Long-term weather records from Yuma, Arizona, show that an extreme maximum temperature of 116 degrees Fahrenheit occurred in June 1974 and an extreme minimum temperature of 24 degrees Fahrenheit occurred in January 1971. Annual temperature extremes of 123 degrees Fahrenheit (September 1970) and 22 degrees Fahrenheit (January 1937) have been recorded elsewhere in the site area. Maximum 24-hour precipitation, totalling 2.42 inches, was recorded at Yuma in September 1963. For other areas in the locality of the site, a 24-hour maximum precipitation of 4.01 inches was reported in August 1909. Maximum 24-hour snowfall recorded in Yuma is a trace. The area has an average of one day a year with heavy fog (visibility reduced to one-fourth mile or less).

Wind data collected at the 33-foot level of the onsite meteorological tower during the period of June to November 1975 show predominant wind flow was from the southwest with a frequency of 13 percent. Winds from the east-southeast were least frequent, occurring 2.5 percent of the time during that period.

2.3.3 Onsite Meteorological Measurements Program

The onsite meteorological tower for the Sundesert site became operational in June 1975. Measurements have and are being made from an instrumented 260-foot high tower. Wind speed and direction are measured at the 33-foot, 190-foot, and 260-foot levels on the tower. The vertical temperature gradients are determined by measurements between the 33-foot and 190-foot levels, and between the 33-foot and 260-foot levels. The dew point is measured at the 33-foot level. The meteorological measurements program conforms to the recommendations of Regulatory Guide 1.23, "Onsite Meteorological Programs."

The applicant has provided six months of onsite data for the period of June 1, 1975 through November 30, 1975. We will require that the applicant provide one full year of representative onsite meteorological data, with at least a 90 percent recovery for each set of data, in the Preliminary Safety Analysis Report.

2.3.4 Diffusion Estimates

A preliminary analysis was conducted of the onsite data submitted for the period June 1, 1975 through November 30, 1975, using a straight-line Gaussian model and desert dispersion parameters. This evaluation indicated that dispersion at the Sundesert site, during the indicated six month period, is comparable to another site in the area (Palo Verde, Nuclear Generating Station, Units 1-3, Docket Nos. STN 50-523, STN 50-529 and STN 50-530) which has previously been evaluated. However, data in the Sundesert analysis included only two seasons, winter and spring, when dispersion is expected to be relatively good at the site. Therefore, we will reevaluate the site dispersion characteristics when a full year of representative onsite meteorological data is submitted with the Preliminary Safety Analysis Report.

2.3.5 Conclusions

Based on our review of the meteorological information presented by the applicant, we conclude that the meteorology for the area will not preclude a favorable finding with regard to site suitability. We also conclude that the onsite meteorological measurements program is being conducted in a manner that is consistent with the recommendations of Regulatory Guide 1.23. The following additional information will be reviewed during the review of the Preliminary Safety Analysis Report to complete our evaluation of the site meteorology:

(1) Design and operating bases for tornadoes and "fastest mile" wind speeds for the Sundesert plant.

(2) Diffusion estimates for the site based on one full year of representative onsite data.

2.4 Hydrology

2.4.1 Hydrologic Description

The proposed site for the Sundesert Nuclear Plant is located approximately 5.5 miles west of the Colorado River on the Palo Verde Mesa overlooking the Colorado River Flood Plain known locally as the Palo Verde Valley. The proposed plant grade will be approximately 375 feet above mean sea level. The Colorado River in the vicinity of the site is about 150 feet below the proposed plant grade.

The site is located within the Colorado River drainage basin of which approximately 182,000 square miles are upstream of the site. Numerous dams for water supply, irrigation, power and flood control are located upstream of the site. The two largest and most significant ones are Glen Canyon Dam and Hoover Dam.

Colorado River water below Hoover Dam is committed to water users in Southern California, Arizona and Mexico. Diversions are presently made at Parker Dam, Headgate Rock Dam, Palo Verde Dam, Imperial Dam, and Morelos Dam. Major future diversions are planned for the U.S. Bureau of Reclamation's Central Arizona Project.

The local 7.5 square-mile drainage basin, within the Colorado River drainage basin, to the west and upstream of the site is characteristic of desert area basins. It consists of very steep, barren mountains with many canyons terminating in alluvial fans. These fans then merge forming a bajada that is crossed with numerous dry channels. The proposed site, located about five miles from the Mule Mountains, is on this alluvial plain and is crossed by many distributary channels.

The site is subject to flooding originating in the local 7.5 square-mile drainage basin. Although there are no records of floods at the site, records for similar areas in the southwest show that they are subject to rare but very intense precipitation that causes flooding. However, it is not unusual for several years to go by without any runoff.

Groundwater at the site is directly related to the Colorado River level. The water table has been lowered only in the area of intense well development to the north on the Palo Verde Mesa (northwest of the town of Blythe, California).

2.4.2 Flood Potential

The applicant has evaluated the flood potential at the site due to (1) postulated dam failures, (2) the probable maximum flood on the Colorado River, and (3) the probable maximum precipitation on the local drainage basin.

Although there are numerous dams upstream of the proposed Sundesert site, there are only two major structures whose failure could adversely affect the plant. These are Glen Canyon Dam, located near the Arizona-Utah border about 500 miles upstream, and Hoover Dam, located about 150 miles to the north on the Arizona-Nevada border.

The applicant concludes that plant grade at the site will be above the maximum water level that could be reached by the failure of any of the dams on the Colorado River, including the Glen Canyon and Hoover Dams, because the site is about 150 feet above the flood plain for these postulated failures, and because of the large amount of storage available in the flood plain. We have performed an independent water level computation for these postulated failures and concur with the applicant's conclusion.

The applicant has also evaluated the effects of a probable maximum flood on the Colorado River and has concluded that such a flood would not result in the design basis flood level for the proposed site. We concur with the applicant's conclusion since the flood control storage available for the Colorado River would reduce the probable maximum flood discharge to a value that is less than the discharge that would result from a postulated dam failure.

The applicant has determined the probable maximum precipitation on the local drainage basin using the methods defined by the National Oceanic and Atmospheric Administration in "Probable Maximum Thunderstorm Estimates for the Southwest States." The applicant then used this probable maximum precipitation to calculate that the runoff from the local drainage basin could reach 33,000 cubic feet per second. We have performed an independent analysis of this postulated event and concur with the applicant's value of estimated runoff from the local drainage basin.

We conclude that the probable maximum flood analysis for the site meets the recommendations of Regulatory Guide 1.59, "Design Basis Floods for Nuclear Power Plants." However, the applicant has not yet determined the method of protection for the proposed plant from the runoff that would result from the probable maximum precipitation on the local drainage basin. We will require that this information be provided in the Preliminary Safety Analysis Report. We will evaluate both the analysis of the water level resulting from this postulated flood and the proposed flood protection for the site during our review of the Preliminary Safety Analysis Report.

2.4.3 Cooling Water

Although the plant cooling water requirements have not been finalized, the applicant estimates that approximately 17,000 acre-feet per year will be used for each unit. The applicant proposes to supply the approximately 17,000 acre-feet per year for Unit No. 1 (an average flow of 23.5 cubic feet per second) with irrigation return water, which is relatively high in salt content, from the Palo Verde Irrigation District's outfall drain by pumping it up to the site. This water is the remainder of irrigation water obtained upstream from the Colorado River and which would be returned to the Colorado River downstream. In order to maintain the water allotment for the downstream users, the applicant has acquired 17,000 acre-feet per year from the Metropolitan Water District of Southern California's allotment to the California coastal plain which it obtains via the Colorado River aqueduct. Instead of actually acquiring it, this amount of additional water, having a lower salt content than the irrigation return water, will be allowed to pass through Parker Dam down the Colorado River.

For Unit No. 2, the applicant proposes to reduce the irrigation allotment of the applicant's farm lands within the Palo Verde Irrigation District by a sufficient amount to provide the 17,000 acre-feet per year needed for makeup. The applicant states that the plant makeup water system, including the proposed pumping facilities in the Colorado River flood plain, will not be safety-related.

2.4.4 Low Water Considerations

Makeup water for normal plant operation and cooldown will be supplied from the Colorado River. The ability to safely shutdown the plant is not related to the probable minimum flow rate and level resulting from the most severe drought on the Colorado River since the ultimate heat sink design will not rely on this source of water during postulated accidents.

However, the applicant has not yet defined the ultimate heat sink design for the proposed plant. As a result, an evaluation of the ability of the ultimate heat sink design to provide adequate cooling for a minimum of 30 days under the most severe environmental conditions has not been performed. We will require that this analysis be included in the Preliminary Safety Analysis Report.

2.4.5 Groundwater

The water table at the site is directly related to the Colorado River, which is approximately 150 feet below the surface. The only areas of extensive groundwater use are near Blythe, where domestic water is derived from wells, and on the Palo Verde Mesa to the northwest of Blythe, where extensive use is made of wells for irrigation.

The nearest irrigation well to the site is on the Palo Verde Mesa about 10 miles to the north. The nearest domestic well is three miles east of the site in the town of Palo Verde.

The evaluation of the resultant contamination of ground or surface water due to postulated accidental releases of liquid effluents from the plant will be performed during our review of the Preliminary Safety Analysis Report when the design features of the plant are available. However, we expect that the resultant contamination from these releases would be below 10 CFR Part 20 limits because (1) the existing ground water level is about 150 feet below the surface, (2) the nearest domestic well is three miles from the site, and (3) the nearest downstream surface water user (Imperial Dam) is about 50 miles away.

2.4.6 Conclusions

Based on our review of the hydrological information presented by the applicant, we conclude that, subject to establishing the requirements for the ultimate heat sink, the hydrology for the area will not preclude a favorable finding with regard to site suitability. We also conclude that the probable maximum flood analysis for the site meets the recommendations of Regulatory Guide 1.59. The following additional information will be reviewed during the review of the Preliminary Safety Analysis Report in order for us to complete our evaluation of the site hydrology:

(1) The proposed flood protection for the site from the runoff that would result from the probable maximum precipitation on the local 7.5 square-mile drainage basin.

(2) The ability of the ultimate heat sink design to provide adequate cooling for 30 days under the most severe environmental conditions.

(3) The resultant contamination of ground or surface water due to postulated accidental releases of liquid effluents.

2.5 Geology and Seismology

Our review of the Sundesert Early Site Review Report addressed the safety-related geologic aspects of the proposed site, including the geologic history of the region through analysis of physiographic, lithologic, stratigraphic and tectonic settings, and the subregional and site specific geology and seismology, and seismic design basis. In addition to reviewing data submitted by the applicant, we visited the site and its environs on three occasions. During those visits we examined the regional geology, bedrock exposures, and excavated trenches. We also conferred with local geologists, the applicant's consultants, geologists from the California Division of

Mines and Geology, and with our advisors, the U.S. Geological Survey. The U.S. Geological Survey evaluation is attached as Appendix B to this report. The main effort in reviewing this site was to resolve specific site and regional geological and seismological issues which could pose a potential hazard to the safe operation of a nuclear power plant at this location and/or impacted on the seismic design for the proposed plant.

These issues were (1) capability of several subregional faults, (2) potential for local surface faulting, (3) definition of regional tectonic environment of the site, and (4) determination of the safe shutdown earthquake.

2.5.1 Regional Geology

The Sundesert site is located in the Sonoran Desert subprovince of the Basin and Range geologic and physiographic province. Basin and Range type structural geology and the San Andreas fault system (including subparallel major fault zones with similar characteristics) provide the distinguishing geologic characteristics of site region. Within 200 miles of the site are located parts of the Great Basin and Mexican Highlands Transition zone subprovinces and parts of the Colorado River Plateau, Salton Trough-Gulf of California, Peninsula Ranges, and Transverse Ranges provinces. The Sonoran Desert province includes the Mojave Desert of California and the Gila Desert of northwestern Mexico. This province is characterized by subdued mountain ranges, usually less than 4000 feet in elevation, trending northwest, north and northeast. This subdued relief suggests a relatively stable crust.

The Basin and Range geologic province was involved in several orogenic events ranging in age from Precambrian to Tertiary. The most recent diastrophism to affect the site region was the Laramaide orogeny which began in late Cretaceous and continued into Tertiary time. A good description of the orogeny during the Tertiary time is presented by the applicant on pages 2.5-46 and 2.5-47 of the Early Site Review Report under the heading Late Tertiary. Igneous activity, including volcanism and plutonism, was widespread in the Sonoran Desert and Mexican Highland-Transition Zone during the Mesozoic. Volcanism occurred in the Central Sonoran Desert Region, the Western Mojave, the Colorado Plateau, and the Salton Trough during Quaternary time. Continued crustal spreading along the San Andreas fault system is evidenced by extensive Quaternary and Holocene fault displacement which can be related to movement of the Pacific Plate relative to the North American Plate.

The San Andreas fault system is the tectonic first order feature in Western North America. The closest approach of this system to the site is approximately 40 miles. The San Jacinto, Whittier, Elsinore, Garlock, and the Death Valley-Furnace Creek fault zones are approximately 75, 80, 170, and 200 miles, respectively, from the site. Quaternary deformation is continuing in some areas of the site region. As a result, a number of active fault zones can be found in the region. All of the active faults within the 200 miles radius of the site are not discussed here due to the dominant influence of the San Andreas fault zone and some smaller faults closer to the site on the determination of the safe shutdown earthquake.

The geologic evolution and tectonic implications of the San Andreas fault system have been discussed extensively by many authors. In these discussions, only its relationship to the site area is addressed. The San Andreas fault system is approximately 700 miles long and extends from the Mendocino Escarpment to the Gulf of California. In Central California, the fault is basically a single, linear break displaying right lateral strike-slip displacement. Further to the southeast, the San Andreas fault has several elements. Still further to the south, the San Andreas zone appears to terminate. As the applicant describes, "At the south end of the Salton Sea, the San Andreas Fault appears to terminate at an active spreading center, transferring motion within the San Andreas system to the Imperial and San Jacinto faults." Although the Sand Hills and Algodones faults lie along the projection of the San Andreas ' 't southeastward from the Salton Sea, they do not appear to be active elements of the present San Andreas fault system. However, the applicant has conservatively assumed the Sand Hills fault to be the element of the San Andreas fault system closest to the site.

Numerous small faults were found in the site region. The applicant conducted an intensive geologic investigation of all such features which were identified. None of the faults within 50 miles of the site, with the exception of those of the San Andreas fault system, have been associated with historic seismicity, although some show geologic evidence of Quaternary displacement. The Chuckwalla Mountain, Salton Creek and Sheep Hole faults and the Blythe Graben are considered to be capable faults. In addition to these faults, extensive investigations were conducted by the applicant along the Lost Trigo fault and in the Chocolate Mountains which lie adjacent to and northeast of the Salton trough and San Andreas fault zone.

The Chuckwalla Mountain faults trend northwest for several miles. The closest approach of the faults to the site is about 25 miles and they are identified primarily as linears which parallel stream drainages. One of the linears aligns with an east-west trending fault which juxtaposes indurated Tertiary deposits with interbedded clay, silt, and sand deposits. Overlying younger alluvial fan surfaces and deposits appear undisturbed, but field relationships are not definitive enough to preclude Quaternary faulting.

The east-west trending Salton Creek fault separates the Orocopia Mountains from the Chocolate Mountains and is marked by a major change in geology between the two areas. Tertiary alluvial deposits are offset by the fault which has a mapped length of 12 miles and is located 38 miles from the site.

The Sheep Hole fault, which trends northeast along the Sheep Hole Mountains, disrupts Quaternary formations. Extension of this fault to the southeast is based on gravity data. A few earthquakes have been located near the northern end of this fault. Its length is about 40 miles and its closest approach to the site is 41 miles.

The Blythe Graben is a set of two parallel normal faults spaced about 300 feet apart. It is a small arcuate structure which strikes approximately northwest, has a

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traceable length of 3-1/2 miles, and is 22 miles northeast of the site. The faults of the Graben offset Quaternary units and last movements most likely occurred between 6,000 and 30,000 years ago. At present, the graben can be seen as a topographic depression in the alluvial surface. This structure is located to the southwest of the Big Maria Mountains and on strike with the general trend of the structural front of both the Big Maria and Little Maria mountains.

The Blythe Graben coincides with a steep gravity gradient along the Little Maria and Big Maria mountains. Although available data are inadequate to establish a direct structural relationship between the gravity gradient and the Blythe Graben, the coincidence of strike and location require that it be assumed that such a relationship exists. This gradient and another parallel to it, about four and a half to seven miles southeast of it (22 and 15 miles respectively from the site), are interpreted as faults with large vertical separation. These faults would delineate a northwest trending subsurface basin approximately coincident with McCoy wash.

To the southeast in the Dome Rock Mountains (approximately 30 miles from the site) are several northwest-trending faults which indicate separation up to two miles. These faults do not appear to disturb Plio-Pleistocene alluvial fan materials. The steep gravity gradients noted in McCoy wash do not cut the dome Rock mountains. To the northwest, faulting was observed only in the older Tertiary fanglomerate, based on field reconnaissance and inspection of aerial photographs of the Palen Pass area, but no capable faulting was found.

The Lost Trigo fault zone is a zone approximately 1,000 to 2,000 feet wide containing numerous small faults, some of which are en echelon and others indicating dips both to the east and west. This zone has a general north-south strike, has been traced for seven and a half miles and is located 15 miles southeast of the proposed Sundesert site along the western margin of the Dome Rock mountains. Geologic evidence indicated that this fault is not capable. The fault exposed in Hart Mine wash offsets the Pliocene Bouse Formation, a Plio-Pleistocene alluvial fan deposit, and a Plio-Pleistocene fluvial deposit but is crosscut by an alluvial fan deposit which is middle Pleistocene in age (estimated to be 500,000 to 1,000,000 years old).

The Chocolate Mountains of California are immediately adjacent to and east of the Imperial Valley-Salton Trough and San Andreas Fault System. To the north and south of this range are the Orocopia and Cargo Muchaco Mountains, respectively. Previous mapping of this area, the Salton Sea Sheet, Geologic Map of California (Jennings, 1967) and the Preliminary Fault and Geologic Map of California (Jennings, 1967) indicated the presence of numerous northwest-southwest and some east-west trending faults. Some of the northwesterly trending faults were inferred to be continuous for tens of kilometers. Some faults were shown to offset Quaternary units. Because of the proximity to the San Andreas fault system, the potential existence of a large throughgoing northwest trending fault which might be directly related to the San Andreas system and closer to the site than the Sand Hills fault, was assessed.

The geology of the Chocolate Mountains is not well known partly due to limitations on ground and aerial access to large areas of the Chocolate Mountain Aerial Gunnery Range, which is an active military practice range. In order to obtain more detailed mapping of this area, the applicant undertook a reconnaissance geologic mapping study utilizing newly acquired Landsat imagery and black and white aerial photographs. This reconnaissance study was supplemented by ground field checks and extensive consultation with numerous experts on the geology of this region. As a result, the applicant has been able to generate a new updated map of this area. As a result of our review of this updated mapping, we conclude that the northwest trending Tertiary or Quaternay faults in the Chocolate Mountains region southeast of the Salton Creek fault are discontinuous structures which cannot be directly related to the presently active San Andreas fault zone. Although there is evidence for the existence of some small capable faults along Salton Creek and on the western flank of the Chocolate Mountains, they have no influence on the determination of the safe shutdown earthquake for the Sundesert site.

2.5.2 Tectonic Province and Regional Tectonics

The proposed Sundesert site is located in the Basin and Range tectonic province. As described by Eardley (1962), this province is characterized by an extensional stress regime which has resulted in block faulting with the mountains and intervening alluvium-filled valleys corresponding to up-lifted and down-dropped blocks respectively. Throughout much of the province, the faults which mark the boundary between the up-lifted and down-dropped blocks are now buried under alluvium eroded from the receding mountain fronts which makes their identification difficult.

The main tectonic event responsible for the development of the Basin and Range structure began in middle-Miocene time and continued into Pleistocene time (Eardley, 1962). However, a tensional stress regime conducive to strike-slip and/or normal faulting apparently persists to the present time in some parts of the province. The Sonoran Desert region of the Basin and Range province, in which the Sundesert site is located, is characterized by broad and deep alluvial valleys and low-altitude mountains which are considered to be evidence that the area has experienced relatively little orogenic activity since the earlier stages of Basin and Range development.

Northwest-trending right-lateral strike-slip deformation and northeast-trending left-lateral strike-slip deformation appear to be present in many parts of the western and southern portions of the Basin and Range province. Most of this deformation was apparently initiated in Miocene time and is contemporaneous with the tectonic activity generally thought to be responsible for the formation of the typical Basin and Range structural pattern (Hamilton and Myers, 1966). A limited number of earthquake focal mechanisms, displacements observed in historical surface faulting and observations of strain accumulation indicate that the present stress regime in the western and southern portions of the Basin and Range province corresponds to extension oriented northwest-southeast to east-west.

If strike-slip faulting is the dominant mode of tectonic activity in the western and southern portions of the Basin and Range province, recent faulting could be more difficult to recognize than if normal faulting is dominant. However, if dip-slip displacement accompanies strike-slip movement, as is expected for most faults in the region, recognition of recent faulting would be facilitated.

Several faults have been identified by geologic investigation in the general vicinity of the site. As discussed in Section 2.5.1 of this report, some of these faults, such as the Chuckwalla Mountain fault, the Salton Creek fault, and the Blythe Graben, show geologic evidence of Quaternary fault displacement which is regarded as indicative that these faults are capable. However, the Chuckwalla Mountain fault, Salton Creek fault, and Blythe Graben are not recognized to have associated seismicity. The nearest of these faults to the Sundesert site is the Blythe Graben approximately 22 miles north of the site.

West and southwest of the site the tectonics are more strictly controlled by the interaction between the Pacific and North American plates. This interaction mainly is represented by right-lateral strike-slip movement along faults in the San Andreas fault system, associated high seismicity, and relatively recent (Quaternary) surface displacement. The southeast portion of the San Andreas fault system, where the fault system has its closest approach to the Sundesert site, splays into several strands which are in most areas buried under thick alluvium in the Salton Trough. As noted in Section 2.5.1 of this report, the applicant has indicated that the San Andreas fault appears to terminate in an active spreading center at the south end of the Salton Sea which transfers motion within the system to more active strands further west in the Salton Trough. This spreading center would align with, and represents a continuation of, a series of such centers linked by transform faults which have been described further south in the Gulf of California (Atwater, 1970 and Anderson, 1971).

The existence of a spreading center and multiple stranding of the San Andreas fault system in the Salton Trough tend to distinguish this region from areas further to the northwest where most activity is confined to a much narrower zone and where the largest earthquakes have occurred.

Within and bounding the Salton Trough, several northwest trending fault strands are recognized including principally the Imperial, Calipatria, Brawley, Superstition Mountain, Superstition Hills, and San Jacinto faults and, closer to the site, the San Andreas, Algodones, and Sand Hills faults. Based on seismicity, the most active of these appear to be the San Jacinto fault and the Imperial fault.

Northwest of the site, the Mojave Block is identified as an area bounded by the Garlock fault, part of the San Andreas fault, the eastern Transverse Ranges, and on the east by a less well-defined boundary, the Soda-Avawatz fault zone (Garfunkel, 1974). The Mojave Block includes several northwest-trending, right-lateral, strike-slip faults which have undergone displacement in Quaternary time, such as the Helendale fault, the Lockhart fault, the Lenwood fault, the Camp Rock fault, the West Calico fault, the Pisgah fault, and the Blackwater fault. These faults apparently do not represent through-going structures and do not extend beyond the boundaries of the Mojave Block. Garfunkel (1974) suggested that this faulting has been produced by a distortion of the overall shape of the Mojave Block to accommodate lateral variations in crustal spreading between the area east and the area southwest of the Mojave Block. Because seismicity and faulting in the Mojave Block is lower in magnitude and rate of activity than in the San Andreas fault system, and because the Mojave Block comes no closer to the site than the San Andreas fault system, the largest earthquakes associated with the San Andreas fault system are expected to produce larger ground motions at the site than earthquakes in the Mojave Block.

2.5.3 Site Geology

The proposed site is located in the western part of the Palo Verde Valley on the Palo Verde Mesa west of the Colorado River in Eastern California. The site is flanked on the west by the Mule Mountains, to the south by the Palo Verde Mountains, and on the east by the Colorado River and the Dome Rock Mountains. To the north of the site is the continuation of the Palo Verde Valley and Mesa. In the site area (five mile radius), the Palo Verde Mesa is composed of a series of broad, gently sloping alluvial fans and fluvial terraces which slope 40 feet per mile to the east. The proposed site is situated on an alluvial fan surface and partly on a flat surface of the 70-foot terrace, one of two terraces above the present Colorado River level.

A north-south trending linear wash exists along the Pebble Terrace part of the Palo Verde Mesa. Reconnaissance geologic mapping by the California Division of Mines and Geology noted this lineation as a fault, but trenching of this feature revealed undisturbed sedimentary strata across the trend of the lineation. The lineation is due to a difference in erosion rate of the fluvial material and, therefore, is not a fault.

The section underlying the site has been investigated directly by borings and surface mapping and indirectly to basement rock, by gravity and magnetic analyses, by seismic refraction and by projections of units from surface mapping. The subsurface investigation program included 51 drill holes with depths from 140 feet to 900 feet. Thirty-four of these drill holes were used for geological investigation while the others were used for foundation engineering assessment. Subsurface continuity of strata was based on correlation of drill logs and geophysical data, such as radiation logging, resistivity and potential measurements.

The section beneath the site area consists of Cretaceous plutonic and metamorphic basement rocks, overlain by Tertiary volcanic and fanglomeratic bedrock. These units are overlain by the Bouse Formation which is a Pliocene Marine sediment. Surficial deposits at the site are Pliocene-Pleistocene alluvial deposits of the Colorado River, and Holocene alluvial and fluvial deposits and eolian sands.

Structure contour and isopach maps developed for the site area did not indicate the presence of any faulted stratigraphic units. Good correlations can be made in the site area using seven units, a silt lens, and four intra-unit clay horizons. To the east and southeast, correlation becomes more difficult as the alluvial fan pinches out. Lateral variation within the units is common even over short distances so correlation of detailed sub-units is not feasible. Elevation charges are to be noted but no consistent anomalies are evident.

The applicant's seismic refraction survey, and gravity and magnetic surveys indicated no evidence of faulting. Displacement of sediments caused by vertical or lateral faulting could create sharp breaks or discontinuities to appear on the profiles, isometric drawings, and structure contour and isopach maps. The absence of such discontinuities is strong supportive evidence that there is no faulting beneath the site. No evidence of ground subsidence has been noted in the site area. There is no petroleum extraction and no mining activity or other man made activities which would have any effect on the site.

2.5.4 Surface Faulting

We have found no evidence to indicate that a potential exists for surface faulting at the site. The closest known capable fault is the Blythe Graben which is located 22 miles from the site and is discussed in Section 2.5.1 of this report.

2.5.5 Regional Seismicity

The Sundesert site is located in an area of the Basin and Range province which apparently has experienced a relatively low level of historical seismic activity. It must be recognized, however, that the historical record in this area is short compared to most areas of the United States, and that the population density in much of the Sonoran Desert area has historically been very low and remains low. A limited instrumental detection capability for earthquakes in this area has existed since the earliest seismograph stations were established in southern California in the late 1920's. The applicant estimates that the instrumented detection threshold since 1945, for earthquakes with epicenters in this area, is about magnitude 4. (The size of earthquakes in the Western United States is typically classified by the units of magnitude on the Richter scale.) This detection and location capability has improved substantially in the past few years with installation of a dense seismograph network in the eastern Mojave desert, such that the current threshold level in the area is estimated to be as low as magnitude 1.0.

Much of the earthquake activity in the Basin and Range province is concentrated near its eastern and western margins as evidenced by the earthquake epicenters along the Wasatch Front and those in western Nevada and extending southward into California just to the east of the Sierra Nevada batholith.

Comparable zones of high seismicity are not apparent in the southern portion of the Basin and Range province in which the site is located. Exclusive of the Fort Yuma earthquake, which is discussed in detail below, the earthquake reported nearest to the site occurred in 1943 about 30 miles southwest of the site and has an estimated magnitude from 4 to 4.5. The earthquakes reported nearest to the site, which are of magnitude 6 and greater, were associated with the San Andreas fault system which approaches the site no closer than 35 miles. The largest earthquake in the historical record associated with

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these southern splays of the San Andreas fault system was the Imperial Valley earthquake of 1940, which had a magnitude of 7.1 and occurred on the Imperial fault approximately 60 miles southwest of the site.

During the course of our review, several questions were raised regarding an earthquake which occurred in the vicinity of Fort Yuma in 1852. Because this earthquake occurred so early in the history of southern California at a time when the area was virtually undeveloped, detailed information regarding this earthquake was not easily attainable. The main questions raised were with regard to the date, location, and structural association of the Fort Yuma earthquake. Conflicting reports regarding these points exist in the published accounts for this earthquake. This is a problem which is generally encountered when one attempts to obtain information about earthquakes which occurred in a region prior to or during its early development. Specific information to unequivocally determine the location of such an earthquake and demonstrate its structural association is usually not available.

In this case, the applicant conducted a careful literature search and was able to identify the primary sources for the published reports on this earthquake. These sources consisted of diaries kept by two military officers stationed at Fort Yuma, a report published in 1861 on the Colorado River expedition of 1857 and 1858 (Ives, 1861), and two newspaper accounts of effects felt at large distances. In addition to the literature search on the Fort Yuma earthquake, the applicant investigated reports of similar phenomena observed during more recent earthquakes in this area of the San Andreas fault system, such as the 1940 Imperial Valley earthquake, two earthquakes in 1915 and one in 1934 located in the Salton Trough. The applicant argued that geyser activity, ground cracking and liquefaction, which occurred southwest of Fort Yuma during the 1852 earthquake, should be regarded as the primary indicator of proximity to the epicenter. The applicant further contended that the rock fall at Chimney Peak (Picacho Peak), which occurred at the time of the earthquake, should be discounted because the weathered condition of the Peak made it susceptible to rock falls at relatively low levels of motion.

As a result of analysis of data gathered in the literature search and consideration of the history of earthquake activity in this area, the applicant concluded that:

(1) The Fort Yuma earthquake occurred on November 29, 1852 at approximately noon.

(2) The epicenter of the earthquake was located in the Salton Trough.

(3) The magnitude of the earthquake is estimated to have been between 6 and 7.

As a result of our review of data on the Fort Yuma earthquake and knowledge of seismicity and tectonics in the area, we have concluded that:

(1) The date for the Fort Yuma earthquake determined by the applicant is accurate.

(2) It is reasonable to assume that the Fort Yuma earthquake was associated with structures of the San Andreas fault system.

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(3) The Fort Yuma earthquake was probably no larger than other earthquakes which have occurred in this area of the San Andreas fault system.

Besides the arguments provided by the applicant cited above, the prime data supporting these conclusions are (1) the relatively high seismicity in the Salton Trough and virtual absence of seismicity to the northeast of this area, (2) the existence of several faults with Quaternary displacement within the Salton Trough and relative scarcity of evidence for recent fault displacement to the northeast of this area, and (3) the existence of major, plate bounding faults in the Salton Trough and lack of similar features to the northeast of this area.

2.5.6 Design Basis Earthquakes

As already noted in Section 2.5.5 of this report, the historical record of seismic activity in the southern portion of the Basin and Range province is poor. Because of this, it is necessary to rely primarily on the recognition of active faulting in establishing the safe shutdown earthquake for the Sundesert site.

The majority of earthquakes which have occurred in the Basin and Range province can be reasonably associated with mapped faulting. In particular, what was probably the largest earthquake in the province, the Owens Valley earthquake of 1872, produced surface ruptures at the time of the earthquake (Slemmons, 1967 and Bonilla, 1967). Many of the other large earthquakes in the province, such as the 1887 earthquake in Sonora, Mexico, the 1915 earthquake in Pleasant Valley, Nevada, and the 1954 earthquakes at Fairview Peak and Dixie Valley, Nevada, also are reported to have produced surface displacements. Because of this association between earthquake activity and faulting, according to the criteria of Appendix A of 10 CFR Part 100 it is not necessary to assume that earthquakes in the Basin and Range province can occur closer to the site than the faults with which they can be reasonably associated.

In connection with our geology and seismology review of the Palo Verde nuclear power plant site, it was determined that the largest earthquake in the Basin and Range tectonic province, which could not reasonably be associated with faulting, had a magnitude of 4. The applicant for the Sundesert site has conservatively assumed a magnitude 5 earthquake could occur near the site, at a distance of five miles, in establishing the safe shutdown earthquake.

Except for the Sundesert site area and a few other scattered areas, only reconnaissance geologic mapping has been conducted throughout much of southeastern California and most of the western half of the State of Arizona. The applicant has conducted state-of-the-art geologic investigations in the vicinity of the site. Based on the applicant's investigations and the results of reconnaissance mapping in the region, the fault nearest the site which is considered to be capable is the Blythe Graben, 22 miles from the site. As discussed in Section 2.5.1 of this report, the Blythe Graben has a traceable length of three and a half miles but can be inferred to be longer based on gravity measurements. Based on interpretation of the gravity data, the Blythe Graben has been inferred to be on the northeast side of a structural trough about 25 miles in length, whose southwest side is about 15 miles northwest of the site. Though the southwest side of the structural trough may be inferred to be related in the mechanism of its origin to the northeast side, the southwest side has not been assumed to be capable because of the lack of evidence of Quaternary fault displacement on the southwest side of the trough. The applicant assumed a magnitude 6.5 earthquake could occur on the Blythe Graben 22 miles from the site. Given the relatively short length (approximately 25 miles) of the structure and lacking evidence of associated seismicity, the applicant's assessment appears conservative when compared to existing correlations between earthquake magnitude and fault length.

Capable faulting is known to exist in the area of the San Andreas fault system southwest of the site. The San Andreas fault system extends from the Gulf of California on the southeast to Cape Mendocino on the northwest, a distance of about 700 miles. The length of the southern San Andreas fault system from the bend near the Garlock fault to the Gulf of California is about 300 miles. The southern part of the system has several splays.

The largest earthquake which has occurred on the San Andreas fault system was the 1906 San Francisco earthquake with an estimated magnitude of 8.3. An earthquake of estimated magnitude 8 occurred in 1857 at Fort Tejon near the intersection of the Garlock fault and the San Andreas fault, producing surface displacements north and south of this intersection. This earthquake has been associated with the northern portion of the San Andreas fault system since the geologic characteristics of the fault system near this intersection and the characteristics of the Fort Tejon earthquake are more representative of those associated with the northern San Andreas fault system. The largest earthquakes on the southern San Andreas fault system were slightly larger than magnitude 7. These include the 1915 Baja California earthquake, the 1934 Baja California earthquake, and the 1940 Imperial Valley earthquake, all of magnitude 7.1, and the 1903 Baja California earthquake listed as magnitude 7 plus. The fault strands in the San Andreas fault system closest to the site are about 35 miles to the southwest in the Salton Trough. The applicant assumed a magnitude 8.5 earthquake could occur on these structures 35 miles from the site. This assumed earthquake is larger than any reported for California. Based on relations between magnitude and length of surface fault rupture during earthquakes, a magnitude 8.5 corresponds to a surface rupture length of about 300 miles. Based on these considerations, an earthquake producing surface rupture along the entire length of the southern San Andreas fault system; i.e., from the Gulf of California to the bend near the Garlock fault, could reasonably be expected not to exceed magnitude 8.5.

Considering that (1) earthquakes in the historical record for the southern San Andreas fault system have not had magnitudes exceeding about 7.1, (2) the largest earthquake in the historical record anywhere on the San Andreas fault system had a magnitude of 8.3, (3) total offset in the San Andreas fault system may be distributed over multiple strands in the southern San Andreas system, and (4) the more active strands within the Salton Trough are further to the southwest, the assumption of a magnitude 8.5 earthquake on northeast strands of the San Andreas fault system 35 miles from the site appears conservative.

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The applicant has proposed to use the response spectra defined in Regulatory Guide 1.60, "Design Response Spectra for Nuclear Power Plants," to define the characteristics of the safe shutdown earthquake. Our evaluation of the proposed design response spectra is presented in Section 3.7.1 of this report. The horizontal response spectra are to be normalized to 0.35g, and the vertical response spectra are to be normalized to 0.23g. Several different scenarios were evaluated in assessing the adequacy of a horizontal acceleration level of 0.35g for the safe shutdown earthquake:

(1) A magnitude 5.0 earthquake was assumed to occur near the site, beyond the region of intense geologic investigations conducted within five miles of the site. Based on empirical relations between magnitude, epicentral distance, and acceleration, the peak acceleration due to this earthquake would be expected to be between about 0.07g and 0.15g.

(2) Historical earthquakes associated with mapped faulting in the Basin and Range province were assumed to occur on those faults at their closest mapped positions to the Sundesert site. All such earthquakes had magnitudes less than 8.3, the estimated magnitude of the Owens Valley earthquake of 1872, and the associated faults are sufficiently distant from the site so that the peak accelerations resulting at the site from such earthquakes would be expected to be less than 0.35g.

(3) A magnitude 6.5 earthquake, associated with the Blythe Graben, was assumed to occur 22 miles from the site. The peak accelerations calculated from acceleration-magnitude-distance relationships for this event are between about 0.1g and 0.25g.

(4) A magnitude 8.5 earthquake, associated with the San Andreas fault, was assumed to occur 35 miles from the site. Peak accelerations for this event calculated from acceleration-magnitude-distance relationships are between about 0.19g and 0.35g.

(5) Effects at the site due to potential earthquakes in the Mojave Block were also considered. As discussed in Section 2.5.2 of this report, peak accelerations at the Sundesert site from earthquakes in the Mojave Block are expected to be less than that for earthquakes associated with the San Andreas fault system.

Therefore, the horizontal acceleration level proposed for the safe shutdown earthquake is as great as, or greater than, the peak accelerations which would be expected to result at the site due to any of the postulated earthquakes.

Trifunac and Brady (1975) developed empirical relationships between earthquake intensity and peak acceleration for both horizontal and vertical components of motion. By a comparison of the relationship for peak horizontal acceleration to the relationship for peak vertical acceleration, the peak vertical acceleration is seen to be somewhat less than two-thirds the peak horizontal acceleration. Based on this comparison, the vertical acceleration level of 0.23g proposed for the safe shutdown earthquake is as

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great as the peak vertical acceleration which would be expected to occur at the site from an earthquake producing a peak horizontal acceleration of 0.35g, i.e., a magnitude 8.5 earthquake occurring 35 miles from the site.

Therefore, we conclude that the applicant's proposed horizontal and vertical acceleration values of 0.35g and 0.23g, respectively, for the safe shutdown earthquake are acceptable for the Sundesert site.

As an additional check on the adequacy of the proposed safe shutdown earthquake, the applicant developed response spectra from strong motion time histories for four earthquakes recorded at firm-soil sites thought to be most representative of the conditions at the Sundesert site. For each of the earthquakes; i.e., the 1952 Kern County earthquake recorded at Taft, the 1940 Imperial Valley earthquake recorded at El Centro, the 1933 Long Beach earthquake recorded at Vernon, and the 1971 San Fernando earthquake recorded at Whittier Narrows, the horizontal and vertical components of strong motion were scaled using acceleration-magnitude-distance relationships. The response spectra were determined and compared to the response spectra in Regulatory Guide 1.60 scaled to 0.35g (horizontal) and 0.23g (vertical). In general, the response spectra in Regulatory Guide 1.60 envelope the response spectra for the real earthquake records with the exception of the El Centro spectra which slightly exceed the spectra in Regulatory Guide 1.60 at a few frequencies.

The vibratory ground acceleration values for the operating basis earthquake, which are taken to be one-half the vibratory ground acceleration for the safe shutdown earthquake, are consistent with the guidelines of Appendix A of 10 CFR Part 100. Therefore, we find them acceptable.

2.5.7 Conclusions

Based on our review of the geology and seismology for the proposed Sundesert site, we conclude that (1) there are no geological structures that would tend to localize earthquakes in the immediate vicinity of the site or cause surface faulting at the site, (2) there are no known geologic features at the site which could represent a potential hazard due to solution activity and/or subsidence, and (3) the seismic design bases are appropriately conservative for the earthquake potential at the site. Therefore, we conclude that the proposed Sundesert site is acceptable with regard to geology and seismology considerations.

3.0 DESIGN CRITERIA FOR STRUCTURES, COMPONENTS, EQUIPMENT, AND SYSTEMS

3.7 Seismic Design

3.7.1 Seismic Input

The seismic design response spectra to be applied in the design of seismic Category I structures, components, equipment, and systems comply with the recommendations of Regulatory Guide 1.60, "Design Response Spectra for Nuclear Power Plants." The specific percentage of critical damping values to be used in the seismic analysis of seismic Category I structures, components, equipment and systems are in conformance with Regulatory Guide 1.61, "Damping Values for Seismic Analysis of Nuclear Power Plants."

The synthetic time history to be used for seismic design of seismic Category I plant structures, components, equipment, and systems will be adjusted in amplitude and frequency content to obtain response spectra that envelop the response spectra specified for the site.

Conformance with the recommendations of Regulatory Guides 1.60 and 1.61 assures that the seismic inputs to seismic Category I structures, components, equipment, and systems are adequately defined so as to form a conservative basis for the design of such structures, components, equipment and systems to withstand seismic loadings.

We conclude, therefore, that the seismic input criteria are acceptable.

18.0 REVIEW BY THE ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

The Sundesert Early Site Review Report is expected to be reviewed by the Advisory Committee on Reactor Safeguards. We intend to issue a supplement to our early site review report after the Committee's report to the Commission, relative to their review, is available. The supplement will append a copy of the Committee's report and will address comments made by the Committee, and will also describe steps taken by the Commission's staff to resolve any issue raised as a result of the Committee's review.

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21.0 CONCLUSIONS

Based on our evaluation of the site characteristics presented in the Sundesert Early Site Review Report, we have reached the following conclusions, subject to the applicant establishing the requirements for the ultimate heat sink (Section 2.4.6), with regard to these site characteristics.

(1) The applicant has described, analyzed and evaluated the proposed Sundesert site to establish the acceptability of the site for the construction and operation of a nuclear power plant. This description and our evaluation have included a definition of site parameters which we would find to be acceptable for a nuclear power plant at the proposed Sundesert site.

(2) On the basis of the foregoing, we conclude that the Sundesert site is acceptable under the guidelines of 10 CFR Part 100 for the construction and operation of nuclear power plant of the general type and size being proposed for the Sundesert site.

APPENDIX A

CHRONOLOGY OF THE LIMITED EARLY SITE REVIEW FOR SUNDESERT SITE

October 29, 1974	Meeting with representatives of San Diego Gas & Electric Company (applicant) and its consultants to discuss plans for the proposed Sundesert Nuclear Plant and an early site review.
March 4-5, 1975	Site visit by Commission staff, applicant and its consultants to inspect geologic features.
April 16, 1975	Submittal of a 4-volume Early Site Review Report for review by the Commission.
May 27, 1975	Letter to applicant advising that the Early Site Review Report is acceptable for continued review and requesting additional information on exclusion area control, regional and site area land use, population projections, turbine-generator missiles, and statistical independence of three earthquake components.
June 12, 1975	Letter to applicant transmitting a review schedule for the Early Site Review Report.
June 13, 1975	Letter to applicant requesting additional information on geology, seismology, and soils structure interaction analysis.
June 25, 1975	Submittal of Amendment No. 1 to the Early Site Review Report, consisting of responses to request for information dated 5/27/75.
July 23, 1975	Letter to applicant requesting a description of aircraft activities in the vicinity of the site, and recalculation of the probable maximum flood.
July 25, 1975	Submittal of Amendment No. 2 to the Early Site Review Report, consisting of responses to request for information dated 6/13/75.
July 30, 1975	Meeting with applicant to discuss round one questions and general progress of the review.

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August 11, 1975	Submittal of Amendment No. 3 to the Early Site Review Report, consisting of additional responses to 5/2[illegible]/75 request for information.
August 20, 1975	Letter to applicant requesting additional geological information.
August 22, 1975	Submittal of Amendment No. 4 to the Early Site Review Report, consisting of responses to request for information dated 7/2[illegible]/75 with the exception of information on aircraft activities.
August 27, 1975	Meeting with applicant to discuss its response on aircraft activities in the vicinity of the site; applicant's decision to request U.S. Geological Survey participation in the review; and hydrology question 321.1.
September 12, 1975	Submittal of Amendment No. 5 to the Early Site Review Report, consisting of responses to request for information dated 8/20/75.
September 19, 1975	Meeting with applicant, its consultants and U.S. Geological Survey to discuss seismology and geology of the proposed site.
September 30, 1975	Submittal of Amendment No. 6 to the Early Site Review Report, consisting of responses to request for information on all aircraft activities in the vicinity of proposed site.
October 7, 1975	Meeting with applicant to discuss antitrust matters.
October 15, 1975	Letter to applicant requesting additional information on meteorological data reduction technique and on faulting.
November 3, 1975	Submittal of Amendment No. 7 to the Early Site Review Report, consisting of responses to request for information dated 10/15/75.
December 2-4, 1975	Meeting with applicant, its consultants, U.S. Geological Survey and the California Energy Commission to discuss hydrology, geology and seismology and to inspect the site.
January 16, 1976	Letter to applicant requesting additional geological information.
January 28, 1976	Submittal of Amendment No. 8 to the Early Site Review Report, consisting of revisions to the analysis of local flooding, as a result of 12/2-3/75 meetings.
February 9, 1976	Letter to applicant requesting additional geological information.

March 1, 1976	Submittal of Amendment No. 9 to the Early Site Review Report, consisting of partial responses to request for information dated 1/16/76.
March 2, 1976	Meeting with applicant and its contractors to discuss the status of the site review.
March 11, 1976	Letter to applicant forwarding U.S. Geological Survey draft report on the geological review of the site.
March 18, 1976	Letter from applicant submitting first six months of onsite meteorological data.
April 7, 1976	Letter to applicant transmitting a revised review schedule.
April 9-11, 1976	Meeting with applicant to discuss geology and to inspect areas where extensive geologic studies have been conducted in response to Commission and U.S. Geological Survey questions.
April 20, 1976	Submittal of Amendment No. 10 to the Early Site Review Report, consisting of responses to requests for information dated 1/16/76 and 2/9/76 addressing geotechnical aspects of site.
May 20, 1976	Meeting with applicant, its consultants, U.S. Geological Survey, and California Division of Mines and Geology to discuss the geology and seismology of the site environs.
June 8, 1976	Letter to applicant transmitting staff position on aircraft impact risks.
June 15, 1976	Letter to applicant transmitting a revised review schedule.
July 7, 1976	Letter from applicant requesting reconsideration of our position on aircraft impact risks as it pertains to applicant's agreement with U.S. Marine Corps.
July 14, 1976	Submittal of Amendment No. 11 to the Early Site Review Report, consisting of responses to all questions posed at the 5/20/76 meeting.
July 21, 1976	Meeting with applicant to discuss the acceptability of incorporating the Site Report by reference into the construction permit application.
August 4, 1976	Letter to applicant forwarding the revised staff position on aircraft impact risks.

August 31, 1976	Letter to applicant forwarding corrected revised staff position on aircraft impact risks.
October 20, 1976	Meeting with applicant, its consultants and U. S. Geological Survey to discuss "Status of Review" report prepared by The U. S. Geological Survey on Sundesert.
November 2, 1976	Letter from applicant regarding the Sundesert seismic design response spectra.
November 10, 1976	Letter to applicant requesting additional information concerning the 1852 Fort Yuma Earthquake and transmitting the "Status of Review" report by the U. S. Geological Survey.
November 18, 1976	Submittal of Amendment No. 12 to the Early Site Review Report, consisting of responses to request for additional information dated 11/10/76.
December 9, 1976	Letter to applicant concerning Sundesert seismic design response spectra.
December 15, 1976	Meeting with applicant, its consultants and U. S. Geological Survey to discuss Amendment No. 12 to the Early Site Review Report concerning the 1852 Fort Yuma Earthquake.
December 29, 1976	Letter from applicant transmitting Errata to Amendment No. 12 of the Early Site Review Report.

United States Department of the Interior

GEOLOGICAL SURVEY
RESTON, VIRGINIA 22092

In Reply Refer To:
Mail Stop 905

JAN 19 1977

RECEIVED 1/25/77 U.S. NUCLEAR REGULATORY COMMISSION Mail Section

Mr. Benard C. Rusche
Director of the Office of Nuclear
Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Rusche:

Transmitted herewith, in response to a request by your staff, is a review of the geologic and seismologic data relevant to the Sundesert Nuclear Plant, Units 1 and 2, (NRC Docket No. 558) as presented in the Early Site Review Reports and Amendments.

This review was prepared by W. J. Carr, D. D. Dickey, M. G. Hopper, and S. R. Brockman.

We have no objections to your making this review part of the public record.

Sincerely yours,

Henry W Coulter
Acting Director

Enclosure

AMERICAN REVOLUTION BICENTENNIAL 1776-1976

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San Diego Gas & Electric Company
Sundesert Nuclear Plant, Units 1 and 2
Riverside County, California
NRC Project 558

The U.S. Geological Survey hereby provides a review of the geology and seismology of the Sundesert site and surrounding region as presented in the Early Site Review Report (ESRR), Volumes 1 through 4 and Amendments 2, 5, 7, 10, 11, and 12. In addition, the Geological Survey has participated in three field examinations (December 1974, December 1975, and April 1976) of the Sundesert site area in company with representatives of the applicant and with several geologists of the California Division of Mines and Geology. We also attended two conferences on the Sundesert site in Denver, Colorado, and examined several trenches near Blythe, California, which were dug across the Blythe graben, the only known capable fault in the area.

Geology

During the past several years the reviewers have been mapping in detail the Vidal area about 50 miles (80 km) northeast of the Sundesert site. This area is also adjacent to the Colorado River and is similar geologically. Much of the initial work by consultants for the power companies, in particular Southern California Edison Company, was done for a proposed nuclear generating station near Vidal west of Parker, Arizona. On the basis of the similarity of the two areas, and our work in the Vidal site region, which has led to a general familiarity with regional geologic problems, plus our review of the Vidal site ESRR, it is reasonable to extrapolate this experience to the Sundesert site.

The Geological Survey reviewers concur with the general geologic conclusions reached by consultants for the applicant, San Diego Gas & Electric Company, but, as in the case of the Vidal site, we disagree with some aspects of the stratigraphy and tectonic history of the region, as presented in the ESRR. These structural and stratigraphic problems are not easily resolved with existing techniques, and as most of them involve the pre-Quaternary history of the area, probably are not critical to site safety. These problems will be discussed below.

The Sundesert reactor site is located about 15 miles (24 km) southwest of Blythe, California, about 4 miles (6 km) west of the Colorado River, and lies within the Sonoran Physiographic and geologic subprovince of the Basin and Range Province. Geologically, the site is on an old Colorado River terrace that is locally veneered with younger alluvium and underlain by Plio-Pleistocene sands and silts, largely Colorado River deposits, and clays, silts, and sands of the Bouse Formation of late Pliocene age. Bedrock in the adjacent Mule and Palo Verde Mountains consists of metamorphosed volcanic and sedimentary rocks and granitic plutons of Mesozoic age, overlain unconformably by mafic to silicic lavas, tuffs, volcaniclastic rocks, and fanglomerate of middle Tertiary age.

Late Cenozoic deposits of the site area have been divided by the consultants to the power company into seven units, the oldest of which are probably of Pliocene age. In addition, three Holocene units are distinguished on the large-scale geologic site maps. The younger Colorado River deposits are overlain in the immediate site area (about a square mile (3 km^2) by a thin veneer of Recent alluvium (probably less than about 10,000 years old), so that drill hole information and geophysical measurements have been heavily relied upon to substantiate claims of unfaulted deposits beneath and adjacent to the site. Within a 2-mile (3 km) radius of the site only about 50 percent of the surface area is mapped as older than Holocene. The rapidly changing, largely fluvial character of the deposits above the Bouse Formation makes correlation by means of drill hole sampling difficult. Therefore, the evidence is largely geophysical--in-hole logging and surface seismic, gravity, and magnetic surveys. The substantial data acquired provide an adequate basis to demonstrate that large capable faults are not present in the immediate site area. However, it is our position that capable faults of perhaps as much as 10 feet (3 meters) of vertical displacement cannot be completely ruled out in the immediate site area. The assumed absence of such small capable faults at the site is predicated partly on their probable absence in the surrounding area.

Dating of the deposits of critical age, chiefly those of middle Pleistocene age, has been accomplished in part by extrapolation from the Vidal area where earlier work established a relative sequence of deposits based on geomorphic and soil development, supplemented by U-Th dating of caliche. Magnetostratigraphy of the fine-grained river deposits and a few supplemental dates from the Blythe-Sundesert site area seem to adequately support the extrapolation. The reviewers feel that the correlations between Quaternary units at Vidal and Sundesert areas are reasonable, although reservations expressed on the dating problem for Vidal (Carr and Dickey, 1976) apply also to the Sundesert site: basically that the older Pleistocene units in particular are not precisely dated. At and near the Sundesert site very few faults have been found in rocks younger than the Tertiary volcanic rocks (approximately 15-30 m.y.). One of the few, the Lost Trigo fault, does not appear to offset rocks younger than the Bouse Formation. The only capable fault found near either Vidal or Sundesert is the Blythe graben about 20 miles (32 km) north of the Sundesert site. It is topographically expressed and clearly offsets unit Qfc, which, on the basis of soils and U-Th dating, is thought to be between 50,000 and 200,000 years old. U-Th dates from similar deposits in the Vidal area averaged about 80,000 years. The apparent relative scarcity of post-volcanic faulting in the Sundesert area as compared with the Vidal area can be reasonably explained by the lesser aerial exposure of the Bouse Formation and Pleistocene units in the Sundesert area.

Although the Vidal and Sundesert areas are quite similar geologically, there are several fundamental differences which help to maintain a relative perspective of the structural setting:

(1) The Sundesert area lies in a region of relatively much stronger geophysical anomalies, both magnetic and gravity; the Vidal region is characterized by very weak geophysical anomalies with diverse trends and very few steep gradients that might indicate buried

large faults, whereas the Blythe-Sundesert area has several strong gravity gradients, as pointed out in the ESRR. The reviewers believe these gradients are best explained by faulting that probably involves late Pliocene age or possibly even early Pleistocene age deposits.

(2) The Sundesert site is only about 35 miles (56 km) from the nearest seismically active areas to the southwest--twice as close as Vidal.

(3) Mountain ranges in the Blythe area tend to be distinctly more linear than those in the Vidal-Parker area, including some definite northwest trends; this linearity suggests younger faulting than in the Vidal region, but such faulting, if present, may not necessarily be capable.

(4) The Vidal site region has an areally greater proportion of exposed critical dating units (Q2 or Qfc and older), so that establishment of the absence of active faulting seems to be on a slightly firmer basis than at Sundesert.

(5) The structural style of the Sundesert-Blythe area appears to differ somewhat from that of the Vidal-Parker area in that the latter is characterized by a major low-angle detachment fault of Tertiary age, and the structural grain of northwest-trending faults developed in the upper plate of that fault seems to be largely extensional and dip slip in character, whereas such a detachment fault has not been recognized in the Sundesert-Blythe area, and the northwest-trending faults, particularly in Arizona, seem to have a greater component of strike-slip displacement.

It should be pointed out that much of the area in the Trigo Mountains on the Arizona side of the Colorado River within 25 miles (40 km) of the Sundesert site has received little geologic study by the applicant. Thus, it represents a geologic "blindspot" in the site region.

In the reviewers' opinion, the most important site safety consideration at Sundesert is the character and recency of faulting (1) along the northwest side of the Mule Mountains, (2) along the northeast side of the McCoy Mountains, and (3) along the southwest side of the Big Maria Mountains. These locations are discussed below.

(1) An extremely steep linear gravity gradient is present along the northwest side of the Mule Mountains, indicating a steep contact and sharp density contrast between the bedrock of the hills and the valley fill, which is probably Bouse Formation and fine-grained Colorado River deposits. The evidence tends to support the conclusion that the gravity defined scarp is not an active fault. The mountain front is not strikingly linear and the buried scarp is not very close to the mountain front, and although much of the trace of the fault is buried by Holocene deposits, several small areas of Pleistocene alluvium apparently are not faulted.

(2) A linear gravity gradient along the northeast side of the McCoy Mountains 10-25 miles (16-40 km) north of the site is less pronounced but similar to the gradient along the Mule Mountains in that it lies a mile or so (about 2 km) from the mountain front. According to the applicant,

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photo study of the area has revealed no evidence of faulting in what appear to be largely Pleistocene age alluvial deposits along the northeast flanks of the range. Existing information, therefore, seems to indicate that neither the Mule Mountains nor the McCoy Mountains frontal faults are a site safety problem. However, two things should be pointed out with respect to possible faulting in that area; first, Nicholls Warm Springs, a warm water well near the Blythe airport, is located almost precisely at the projected junction of the two faults just discussed, but according to available information, the water from this well is only very slightly warmer than that from some other wells in the general vicinity of Blythe; second, a low drainage divide exists in the area between the McCoy and Mule Mountains. With a few exceptions, all alluvium-filled valleys that lie between ranges immediately west of the Colorado River and between Las Vegas and Yuma drain into the Colorado River. Just west of the Colorado River drainage system are several closed, internally drained depressions--the Salton Sea, Ford Dry Lake, Rice-Danby dry lakes, and an unnamed dry lake about 10 miles (16 km) southwest of Boulder City. Ford Dry Lake lies a few miles northwest of the Mule Mountains. These closed depressions relatively near the Colorado River drainage are regarded by the reviewers as sensitive indicators of possible Quaternary fault activity.

(3) The McCoy Wash area southwest of the Big Maria Mountains is the site of a pronounced negative gravity anomaly elongated northwest-southeast parallel to the fronts of the Big Maria and McCoy Mountains.

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A 3 1/2-mile-long (5 1/2 km) capable fault, called the Blythe graben in the ESRR, has been identified which coincides closely with the northeast side of the anomaly. Consultants for the applicant have been reluctant to directly relate the Blythe graben to a subsurface structure defined by the gravity gradient, whereas it seems very reasonable, almost compelling, to do so. It is significant to the reviewers that this elongate linear gravity anomaly is the only one known to cross the present Colorado River Valley between Needles and Yuma. Furthermore, it is on line with northwest-trending faults mapped by the applicant in the Dome Rock Mountains east of Blythe, and with a major gravity low west of the Kofa Mountains in Arizona. Even though the mapping in the Dome Rock Mountains indicated no faulting of Pleistocene deposits, this does not preclude such offsets in the Blythe-McCoy Wash area. The applicant attempts to show that the Bouse Formation is not at greatly different altitudes in wells in the Blythe-McCoy Wash area, but the reviewers believe that the well logs on which the conclusions are based are not adequate to eliminate the possibility of important structural displacement of the Bouse in this area.

The Blythe graben cuts alluvium possibly as young as 50,000 years; rough scarp slope angles measured by the reviewers suggest an age of between 100,000 and 1,000,000 years, using curves developed by R. E. Wallace of the U.S. Geological Survey. Very recently the reviewers detected an additional small, short fault scarp with a northwest trend about 4 miles (6 km) southeast of the previously noted Blythe fault, and about 8 miles (13 km) north of Blythe. Although the two faults have the same trend and general relation to the Big Maria Mountains and the gravity-topographic trough, the Blythe graben has a curved trace and therefore the two do not quite line up. On the basis of aerial photo inspection the newly discovered fault appears to cut alluvial deposits of the same age as the much more pronounced Blythe graben. The two separate scarps could have been produced by two or more earthquakes, however. We believe the discovery of the small additional fault strengthens the argument that the entire northeast side of McCoy Wash structural trough should be considered a capable fault zone.

It is our opinion that the Blythe-McCoy Wash gravity anomaly suggests that a major structural through extends from east of the Colorado River northwestward about 25 miles (40 km). The nearest approach of the southwest side of this structural trough to the Sundesert site is about 15 miles (24 km). The northeast, possibly active side, which coincides with the scarps in alluvium, lies from 20 to 23 miles (32-37 km) from the site.

The applicant has used a design earthquake of magnitude 8.5 located 35 miles (56 km) southwest of the Sand Hills fault, the nearest possibly active major strand of the San Andreas system. On the basis of our inspection of the applicant's geologic work in the Chocolate Mountains area, we believe this to be a conservative assumption. Helicopter surveillance and examination of high-quality areal photographs revealed no large capable faults in the area between the site and the Sand Hills fault. Several small scarps, some probably as young as 10,000 years, were seen on the southwest side of the Chocolate Mountains 30=40 miles (48-64 km) from the site. These active faults appear to be part of the en echelon frontal fault system between the Chocolate Mountains and Salton trough, and though individually short (1 mile (1 1/2 km) or less) they probably form a zone that extends for many miles along the southwest side of the mountains. There is no evidence to suggest that these small faults are part of the San Andreas system, nor are any faults seen within the Chocolate Mountains active strands of the San Andreas. The Sand Hills fault is completely buried southeast of the Salton Sea.

In summary, the Geological Survey reviewers believe that the applicant has done a good job of investigating the geology of the region with the possible exception of the Trigo Mountains area in Arizona. Concerns about northeastward extent of active faults of the San Andreas system in the Chocolate Mountains area, and the eastward extent of east-trending faults of the Pinto Mountain, Blue Cut, Salton Creek system seem to be adequately resolved. Ages of the alluvial Pleistocene units, though not precise, are probably well enough known under the present state-of-the-art.

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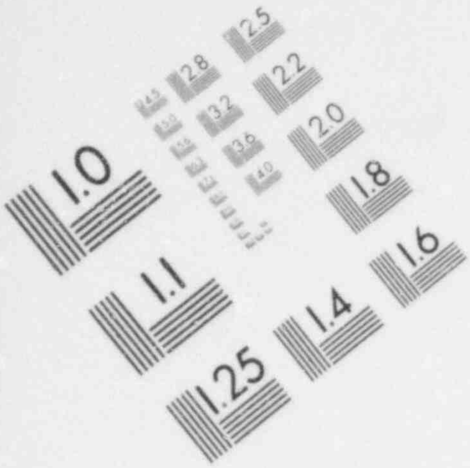
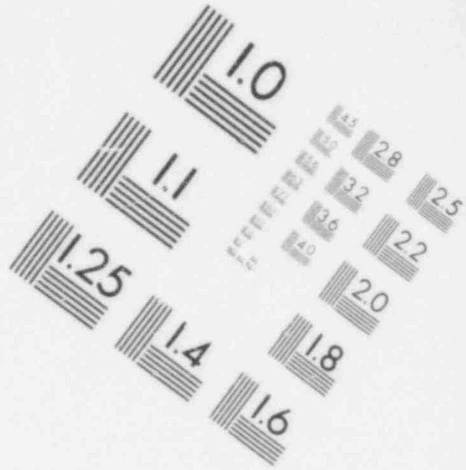
Seismology

Introduction

The investigations contained in the seismology section and amendments 1-12 of the Sundesert ESRR have been reviewed by the U.S. Geological Survey and have been found satisfactory. Earlier problems concerning the Blythe Graben and the 1852 Fort Yuma earthquake have been resolved.

There are no known large historic earthquakes within the immediate area of the site. The applicant's Safe Shutdown Earthquake (SSE) acceleration value of 0.35 g at the site was obtained by assuming a magnitude 8.5 earthquake on the nearest approach of the San Andreas fault system (that is, on the Sand Hills/Algodones fault) about 56 km (35 mi) southwest of the site. Most of the historic seismic activity in the southern California area has occurred on the San Jacinto and Imperial faults, west of the San Andreas fault system. The only historic magnitude 8 earthquakes on the San Andreas fault system in southern California is the 1857 Fort Tejon earthquake, which occurred north of the Sand Hills/Algodones fault and propagated southward to within about 240 km (150 mi) of the site (Saint-Amand and others, 1963, Fig. 5). In the absence of strong motion data from seismograms recorded within 100 km (62 mi) of a magnitude 8 1/2 event, attenuation relations developed by Schnabel and Seed (1973), Housner (1965), and Donovan (1973) were used to scale real earthquake response spectra from smaller earthquakes recorded at sites with soil characteristics similar to the Sundesert site and of comparable epicentral distances.





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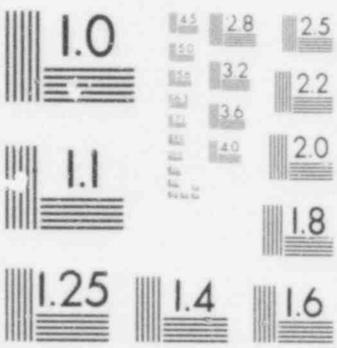

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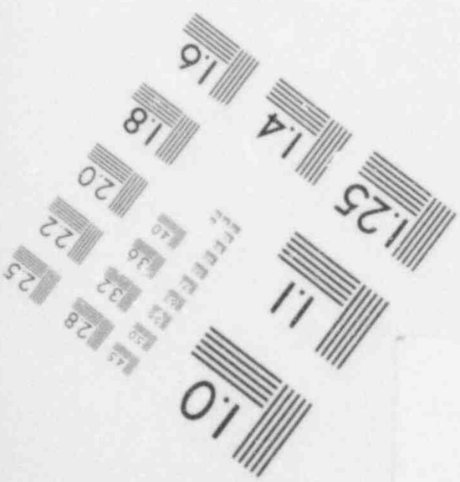
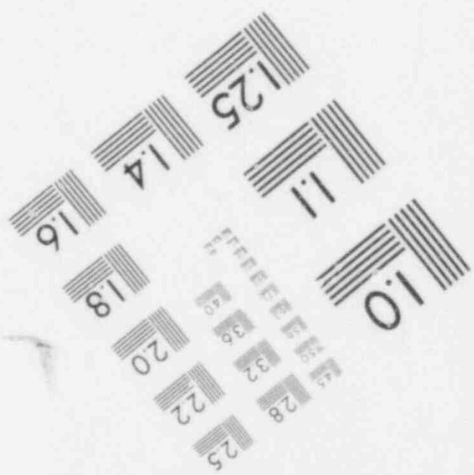
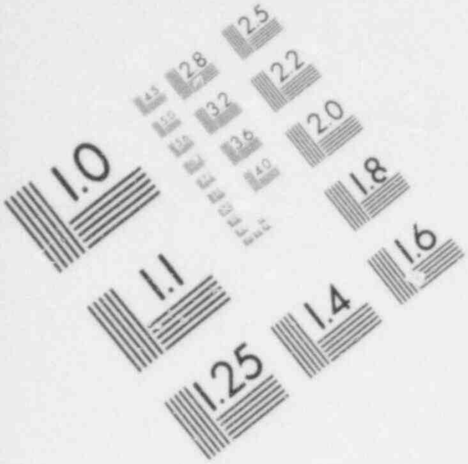






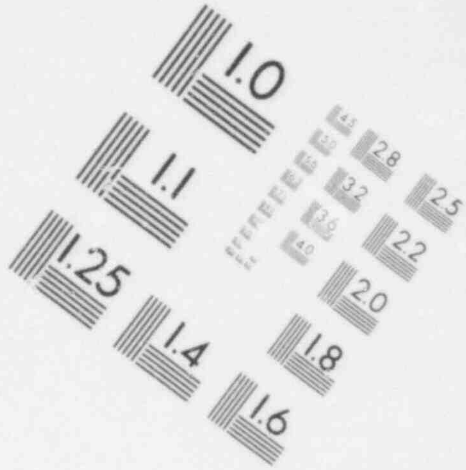
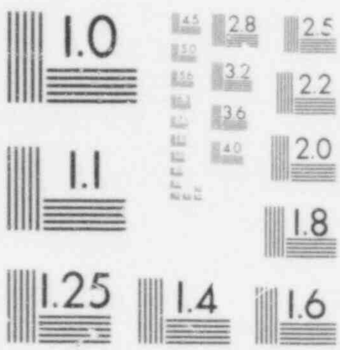
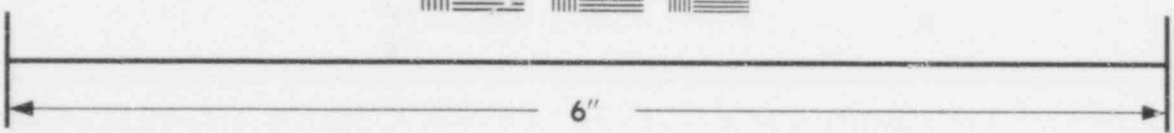
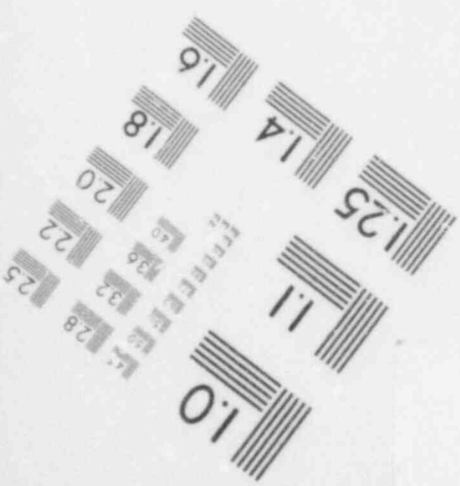
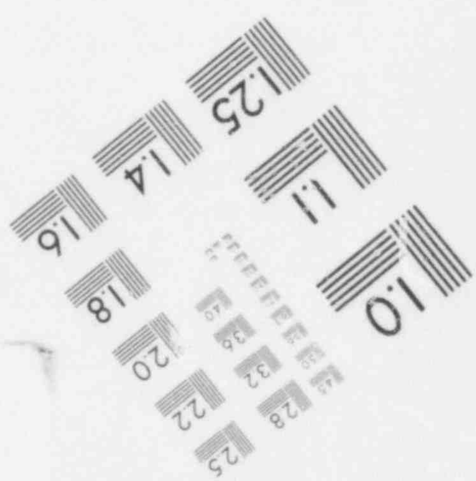


IMAGE EVALUATION
TEST TARGET (MT-3)









Blythe Graben (Zone D)

The applicant has divided the area within 320 km (220 mi) of the site into six seismic zones identified as Zones A, A1, B, C. D, and E. They determined that a San Andreas (Zone A) earthquake, as discussed above, would generate an acceleration of 0.35 g at the site (Zone D), which would be significantly greater than those acclerations produced by earthquakes occurring in the other five zones. However, one possible exception to this might have been an event on the structure described in the ESRR as the "Blythe Graben," which is in the same zone as the site. The applicant has mapped the Graben for 5.6 km (3.5 mi) along the southwest flank of the Big Maria Mountains, 35 km (22 mi) north of the site. Because a pronounced gravity anomaly coincides with the Graben, the applicant has assumed a maximum fault length of 31 km (19 mi) (the applicant's interpreted length of the anomaly) at a distance of 35 km (22 mi) from the site. From this the applicant derived a fault-rupture length of 14 to 24 km (9-15 mi) and a magnitude 6.5 earthquake, resulting in 0.23 g at the site (sections 2.5.2.8.8, P. 2.5-124 and 2.5.2.9.5, P. 2.5-128). The USGS reviewer of the site geology reports found an additional short fault scarp 6 km (4 mi) to the southeast and states that "The Blythe-McCoy wash gravity anomaly suggests that a major structural trough extends from east of the Colorado River northwestward about 40 km (25 mi)." This trough comes within 24 km (15 mi) of the Sundesert site. Based on the foregoing, we have assumed that an earthquake associated with the Graben is likely to generate accelerations at the site less than those from the applicant's postulated San Andreas event.

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The applicant notes that "no historic or recorded epicenters can be associated with the Blythe Graben" (P. 2.5-124). However, two very small earthquakes of about magnitude 1 recorded by the eastern Mojave seismic net in May 1976 (G. Fuis, U.S. Geol. Survey, Oral Commun.) are located at approximately lat. 34° north and long. 115° west as a point about 40 km (25 mi) north 50° west of the "Blythe Graben." These microearthquakes represent the only seismic activity detected in the region in two years of recording. Although these two epicenters have been located generally on strike with the northwest extension of this structure, it is not possible to conclude that they are associated with it because the structure is not known to exist in that vicinity. The recorded first motions of the two events are inconclusive (G. Fuis, Oral Commun.); thus, it is not possible to discuss their focal mechanisms relative to the strike or sense of motion of the Graben.

November 29, 1852, Fort Yuma Earthquake

Amentment 12 to the ESRR contains the applicant's justification for the removal of the 1852 Fort Yuma earthquake from seismic Zone D (the site zone) and its relocation in seismic Zone A (the San Andreas fault system). Their research seems to support such a move. Confusion about the date of the shock has been resolved satisfactorily and questions about the location, felt area, and magnitude of the event have been adequately discussed.

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Date

The date of the earthquake has now been established as November 29, 1852. This is based on two sources, first on the diaries of Major Heintzelman and Lieutenant Sweeny of Fort Yuma which record an earthquake on November 29, but do not mention an earlier shock, and second on accounts in the San Diego Herald Newspaper. The applicant has traced the various other dates back to their original sources and has provided convincing evidence that the earthquake that was felt at Fort Yuma occurred on November 29, 1852.

Location

The location of the earthquake is not precisely established, but enough evidence has been submitted to justify the applicant's removal of the earthquake from seismic Zone D, where it has traditionally been placed, and relocated in seismic Zone A. Although it would be difficult to assign intensities to many of the reports available, and although there are too few reports available to make an isoseismal map, nevertheless it seems evident that the highest known intensities did occur in the vicinity of the Colorado River along some 100 km (62 mi) of the river from the Fort southwestward (that is, within the San Andreas fault system, seismic Zone A). The earthquake and several of its aftershocks were felt west of the Fort at San Diego and Vallecito. Evidence is presented that the earthquake probably was not felt at San Bernardino, northwest of the Fort. North of the Fort there was a rockslide at Chimney Peak. East of the Fort there were no felt reports because the area was largely uninhabited; however, the diaries of

Heintzelman and Sweeny contain no accounts of the earthquake reported by travelers passing through Fort Yuma from the east. Southwest of the Fort several reports were obtained describing lurching, liquefaction, changes in the course of the Colorado River and unusual activity at a mud volcano in northern Baja California. The applicant has compared these effects with the effects of modern earthquakes in this area and concluded that the epicenter was most likely in the Salton Trough southwest of Fort Yuma. Although the reviewers do not concede that the epicenter was necessarily within the boundaries suggested by the applicant (an area of approximately 3500 sq. km (1400 sq. mi) centered about 50 km (31 mi) southwest of Yuma and shown in Fig. 2.5P-6), we do agree that the evidence presented in Appendix 2.5P and at the meeting with the applicant on December 15, 1976, does indicate that the epicenter of the 1852 Fort Yuma earthquake was within the applicant's seismic Zone A rather than seismic Zone D.

Felt Area

The earthquake is now known to have been felt from San Diego to Fort Yuma and from Picacho Peak to the mouth of the Colorado River. Because the land was largely uninhabited, it is impossible to tell how far beyond these points the felt area might have extended. The establishment of the correct date for the earthquake, the applicant's search of existing records in the United States and Mexico, and the tracing of the various accounts back to their original sources have eliminated felt reports from far outside the Colorado River-San Diego area.

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Magnitude

The magnitude of the earthquake has been estimated by the applicant to be between 6 and 7. This seems reasonable and conservative to us based on both the kind of felt reports that the applicant has found and on the probable size of the felt area. In any case the magnitude of this event was certainly less than the magnitude 8 1/2 event the applicant has already assumed on the eastern edge of seismic Zone A, and therefore does not affect the SSE at the site.

Zone B

Zone B apparently has been created by the applicant by drawing a semicircle around a group of small faults and epicenters in Zone D along the extension of the San Andreas fault system southeast of the site. No persuasive arguments, either seismologic or physiographic, have been presented for excluding this group of earthquakes from Zone D. In any case, assuming the largest event in Zone B to be a random event in Zone D (that is, 8 km (5 mi) from the site) would not alter the SSE for this site.

Conclusion

We find the applicant's investigation of the seismicity of the area to be adequate. Their derived SSE of 0.35 g at the site seems sufficient for the assumed magnitude 8 1/2 earthquake on the Sand Hills/Algodones segment of the San Andreas fault system. It is recommended that the acceleration value of 0.35 g at the ground surface be used as the zero-period acceleration in the development of the appropriate design response spectrum as described in AEC Regulatory Guide 1.60, Revision 1, December, 1973.

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APPENDIX C

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