Sacramento Municipal Utility District
SMUDGEO #1
Geothermal Power Plant

MASTER

FINAL REPORT

State/Federal Joint Environmental Study

California Energy Commission
in cooperation with
U.S. Department of Interior

- **Bureau of Land Management**
- **United States Geological Survey**

FEBRUARY 1981

P700-81-002

SUMMARY

APPLICANT

The Sacramento Municipal Utility District (SMUD) is a utility supply district, centered in Sacramento, which operates under the 1921 State of California Municipal Utility District Act. SMUD supplies electric power to Sacramento; it serves more than 300,000 customers in an area of more than 650 square miles, encompassing most of Sacramento County and a small portion of Placer County. In 1980 SMUD's peak demand capability was 1896 MW. This electrical power comes from three sources:

hydroelectric	649 MW
nuclear	887 MW
purchased power	360 MW

The proposed Sacramento Municipal Utility District Geothermal Power Plant (SMUDGEO #1) represents the first of a planned series of geothermal power plants by SMUD.

SMUD proposes to construct a 72 gross megawatt* geothermal power plant in the Geysers-Calistoga Known Geothermal Resource Area (KGRA). SMUDGEO #1 would be located in federal land in eastern Sonoma County, near the Lake county line. The land is administered by the Bureau of Land Management.

Two federal agencies and the California Energy Commission (CEC) have authority to review and approve construction and operation of the power plant. The federal actions addressed by this environmental analysis are (1) joint approval of the Plan of Utilization by the United States Geological Survey (USGS) Bureau of Land Management (BLM) (2) appoval of the use of the site for the power plant by the United States BLM, and (3) approval of a permit to construct and operate the power plant on public land by the USGS. If the overall proposal is found to be suitable, the Energy Commission has the authority under state law to certify the power plant for operation. The California Energy Commission, the BLM, and the USGS have combined their efforts in preparing this joint environmental study in order to assure that the environmental consequences of the proposed power plant are adequately addressed in terms of the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA).

PROJECT FEATURES

Preparation of a level site for the proposed power plant and related facilities will require alteration of approximately 10.5 acres with an additional 2.5 acres allotted to the main access road. Approximately 180,000 cubic yards of earth will be moved during cut and fill activities; however, all of the excess material will either be used as fill on the power plant site itself or on roads

*SMUD actually proposed a 72.3 MW plant, which will often be rounded to 72 throughout the text of the EIR.

MGW

and well pads within the leasehold. Thus, there will be no disposal problem with excess earth as a result of the proposed power plant.

In appearance and operation, the SMUDGEO #1 project will be essentially the same as the geothermal units currently in operation in The Geysers KGRA. The steam to run the power plant will come entirely from within the leasehold. Steam originating from nine or more wells will be piped to the power plant. The steam will drive a four flow turbine, which then turns the 72.3 MW generator, producing electricity.

After driving the turbine, the spent steam is exhausted onto a surface-type condenser located beneath the turbine. The function of the surface condenser is to transform the steam into a liquid form. The condensation of the spent steam allows the turbine to perform more efficiently. It provides a source of water to replace water lost during the operation of the cooling system, changes the steam into a form that can be easily handled, and allows a greater portion of the environmentally undesirable hydrogen sulfide to be captured with the non-condensable gases. Hydrogen sulfide in this form is more easily treated than if it is dissolved in the liquid condensate.

In order to extract heat from the spent steam so that the steam will condense, water from a storage basin in the 12-cell cooling tower is pumped to the surface condenser. The surface condenser consists of bundles of titanium tubes which provide a large surface area to make contact with the spent steam. The temperature of the water rises as it passes through the surface condenser tubes and extracts heat from the spent steam in order to condense it. The heated water is then circulated back to the cooling tower to be cooled in order to re-use it. The condensed spent steam is also sent to the cooling tower to replace water lost during the cooling cycle.

The cooling process at the cooling tower uses evaporation as part of the mechanism for cooling. The combined quantity of the circulating cooling water and the condensed steam exceeds the amount of water lost through evaporation during the cooling process. Therefore, no extra source of replacement water is required. The excess water remaining after the evaporation losses take place is returned back to the ground by piping it to a nonproductive well. Since no outside source of water is required to replenish the cooling water lost from evaporation, an initial supply has to be furnished from independent sources in order to start operating the power plant. This initial supply is approximately 1,000,000 gallons (3 acre feet). It is placed in the collecting basin at the bottom of the cooling tower. The steam supplier, Aminoil, will supply this initial start-up water. Their intention is to use condensate from nearby power plants.

A number of potentially toxic substances are contained in the incoming geothermal steam supply. Of these, hydrogen sulfide (H_2S) presents the greatest potential for adverse impacts from spent steam emissions. Unabated emissions of H_2S may produce an increasing number of localized complaints about odor and the potential for disagreeable physical reactions in sensitive public populations. Because of the current level of geothermal development at The Geysers, the cumulative effects of H_2S emissions have resulted in violations of the state standard for ambient H_2S at the populated areas nearest the proposed SMUDGEO #1 power plant, although H_2S violations have decreased in recent years.

The responsibility of determining whether a power plant will be in violation of air quality standards rests with the county Air Pollution Control Officer (APCO) who renders his opinion in the Determination of Compliance. The Northern Sonoma County APCO has determined that a contribution to an air quality violation is so likely to occur that SMUD will be required to apply Best Available Control Technology (BACT). BACT will limit the atmospheric emissions to 5 lbs/hr. Depending on the results of ambient air quality monitoring during 1982 and 1983, the allowable emission rate may be increased to 8 lbs/hr. Based on the estimated impacts SMUD does not believe that reducing the allowable emission rate from 8 lbs/hr to 5 is warranted. The application of BACT to the SMUDGEO #1 project alone is not likely to prevent air quality violations at the KGRA, since the "violation" results from the combined emissions from all the geothermal power plants in the area.

SMUD proposes to control H_2S emissions by one or more abatement systems. The primary H_2S abatement system uses a surface condenser to "partition" the H_2S in the spent steam into condensate and noncondensible gases. The noncondensible gas stream will be treated by the Stretford process, in which the hydrogen sulfide is catalytically oxidized into elemental sulfur. This sulfur can then be trucked from the site and sold or disposed in an approved Class II-1 disposal site.

In order to further reduce H_2S emissions, SMUD will employ hydrogen peroxide (H_2O_2) and catalyst with iron as a means of removing dissolved H_2S from the condensate stream.

The proposed project includes a 3,180 foot long 230 kV transmission tapline which connects to the existing PGandE 230 kV transmission line, west of the site.

PROJECT IMPACTS AND MITIGATION

Discussion of cumulative impacts in this document includes those impacts from activities occurring beyond the power plant site and outside the transmission line right-of-way. To avoid confusion, such activities, when occurring on a Federal lease, are permitted by the Federal government (USGS/BLM). Therefore, responsibility for mitigation measures for impacts from activities outside the power plant site or transmission line right-of-way rests with the Federal government (USGS/BLM). For further information, refer to applicable USGS Environmental Assessments.

Air Quality

The SMUDGEO #1 project will contribute incrementally to an existing air quality problem in the KGRA. The Northern Sonoma County Air Pollution Control District Officer (APCO), who has the responsibility of determining whether the project will comply with applicable rules and standards, issued a Determination of Compliance (DOC) for SMUDGEO #1. This determination requires SMUD to use Best Available Control Technology (BACT) to abate hydrogen sulfide (H_2S) emissions. In essence, the conditional DOC requires SMUD to use BACT to limit their H_2S emissions to 5 lbs/hour. However, SMUD will be allowed to increase this emission rate to 8 lbs/hour, if during 1982-83, SMUD's ambient air monitoring in sensitive receptor areas indicates that the ambient concentrations do not equal or exceed 22 parts per billion of H_2S. SMUDGEO's use of BACT--even at zero emissions--will not likely prevent air quality violations at the KGRA. Neither can a reduced number of violations be expected, since existing unabated power plant emissions are the major contributors to these violations, and the existing plant emissions will not be reduced significantly until 1985 and 1986 when emission reductions will be required and are expected to occur.

Emissions of potentially deleterious substances which are present in geothermal steam and/or the cooling tower plume may be carried in the air and deposited on soils, vegetation, wildlife, and populated areas. The effects of small concentrations and cumulative deposition of substances such as mercury, arsenic, boron, and radon--222 daughters are not sufficiently understood, and the significance of the impacts is unknown. Rates and amounts of emissions will be reduced by appropriate design of the cooling towers and other facilities.

Public Health

The project will contribute, albeit in relatively small amount, to existing violations of the California Ambient Air Quality Standard (CAAQS) for H_2S. Although experts do not know at this time if adverse health effects result from exposure to low levels of H_2S, the inference is that increasing H_2S concentrations will increase the possibility of public odor complaints as well as the possibility for adverse health impacts in The Geysers area. In addition, the project's emissions of nonregulated pollutants, combined with other power plant emissions, increase the possibility of adverse health impacts from these pollutants. With only scarce data on steam quality, actual emission rates, and transport of nonregulated pollutants, comparisons to suggested safe levels or proposed standards for exposure to nonregulated pollutants cannot be made with a great degree of confidence. In the face of such pervasive uncertainty and evident public concern in the project area, CEC staff recommends that SMUD be required to either conduct or participate in programs to monitor steam quality and ambient air pollutant concentrations, and to perform mass balance studies. The data base provided by these programs will aid in determining:

1. The need for further abatement of H_2S and other nonregulated pollutants in the future; and

2. The acceptability of additional power plant projects in the area.

Growth-Inducing Impacts

Geothermal development in the KGRA has induced some growth in both Lake and Sonoma counties. Roads in both counties are affected, while the public schools in Lake County have been particularly impacted by the influx of geothermal workers' families. Impacts of this type are cumulative in nature; so, while the SMUDGEO #1 proposal would contribute growth impacts to both counties, it would not be the sole source. All geothermal developments contribute to growth within the counties.

To mitigate the more drastic impacts to Lake County, SMUD offers to provide construction workers with a van pool for transportation to work in Sonoma County. Designed to provide workers with incentives to locate in Sonoma County, the proposed transportation program will shift craft union workers to the Sonoma

County side of the KGRA. SMUD will enter into an agreement with both counties regarding their proportionate share of compensation for upgrading or maintenance of county roads.

Soils

Disturbance of topographic features, soils and vegetation resulting from construction of power plant facilities, well pads, access roads and transmission lines could cause significant erosion problems. These impacts can be successfully mitigated by appropriate slope design and preparation during development of the proposed project site and steam supply field. Adequate drainage facilities will be provided under the fill areas and on the slopes to mitigate potential erosion; exposed soil surfaces will be revegetated and adequately protected prior to seasonal rains.

Water Quality

It is possible that a portion of the geothermal fluids in the cooling system could accidentally spill and result in adverse impact to surface waters. To prevent this possibility, the proposed project site will be covered with an impervious surface, and a berm surrounding the site will be constructed. The berm will be of sufficient size to contain greater than twice the maximum possible spill.

Transport of potentially toxic or harmful substances related to the H_2S abatement system(s) creates the possibility that these materials could be spilled and enter surface or ground waters. The probability of major accidental spills during transport is relatively low and can be mitigated by improved safety precautions and training.

Geology/Steam Resource

Consumptive use of geothermal steam for power generation may eventually cause a loss of pressure in the geothermal reservoir. Recent studies seem to indicate that pressures may be dropping while the rate of reservoir recharge, if any occurs, is unknown. Although a portion of the spent steam will be reinjected into the steam reservoir, this may not be sufficient to recharge the reservoir, and pressures may eventually decline. Further studies are necessary to adequately determine the rates of reservoir depletion and recharge as a possible mitigation measure.

Other cumulative impacts to which the SMUDGEO #1 proposal would contribute incrementally are induced geologic subsidence and microseismicity. Although these impacts are of no direct significance, under certain conditions they could contribute to local landslide susceptibility or fault movement. Reinjection of fluids into the steam reservoir may help to mitigate these impacts, but not enough is known to fully assess the extent of these cumulative impacts or the degree to which they can be mitigated.

Wastes

Hazardous substances stored at the power plant would be contained in appropriate vessels to ensure against accidental spills, but as a further precaution, curbs around the entire plant site and individual H_2S abatement and chemical handling areas will be sized to contain any spilled material.

SMUDGEO #1's Stretford system will produce approximately 350 cubic yards of sludge per year, and the H_2O_2 secondary abatement system may produce as much as 3.5 cy of sludge per year. SMUD has not yet contracted with any disposal sites, but available and approved disposal sites capable of handling SMUDGEO #1 wastes are located in Martinez, Middletown, and Kelseyville.

Drilling muds and liquids are to be contained in impermeable sumps during the lifetime of the well. When a well is abandoned, these muds will be tested and either removed to appropriate disposal sites if they contain any toxic/hazardous substances, or buried in the sump if there are no harmful substances. Geothermal drilling muds in The Geysers KGRA historically consist of natural soils and bentonite clays, neither considered harmful to the environment.

Biology

Removal of vegetative cover would reduce the amount of food and cover for those wildlife species which are dependent on chaparral habitat. No rare or endangered species are known to inhabit the area, but there is some evidence pointing to the presence of the fully protected ringtail. The proposed revegetation and habitat management should mitigate impacts to wildlife and may enhance the remaining habitat.

Aesthetics

The project site would not be visible from populated areas or highways in Lake County; however, remote views of the ridgetop site will be possible from areas in Sonoma County to the south and to the west-north-west of the proposed facilities. Localities capable of such remote views include Santa Rosa and portions of California Route 128 and U.S. Route 101 in the Alexander Valley. Energy Commission staff does not consider these remote viewscape effects to be significant; however, SMUD has agreed to paint the facilities in colors to reduce contrast between the facility and the natural background when viewed from a distance.

Cultural Resources

There are no known historical or cultural resources located at the SMUDGEO#1 site or within the leasehold; thus, no cultural resources will be directly impacted by this geothermal development. However, "Little Geysers," located 3/4 miles south of SMUDGEO#1 and off the leasehold, is a ceremonial site for Native Americans. CEC staff suggest establishing a buffer zone around Little Geysers to protect this cultural resource from the adverse impacts of geothermal development.

If all mitigation measures proposed by SMUD and recommended by regulatory agency staff are implemented, the proposed SMUDGEO#1 project is not expected to have a significant adverse impact on the environment.

SMUDGEO #1

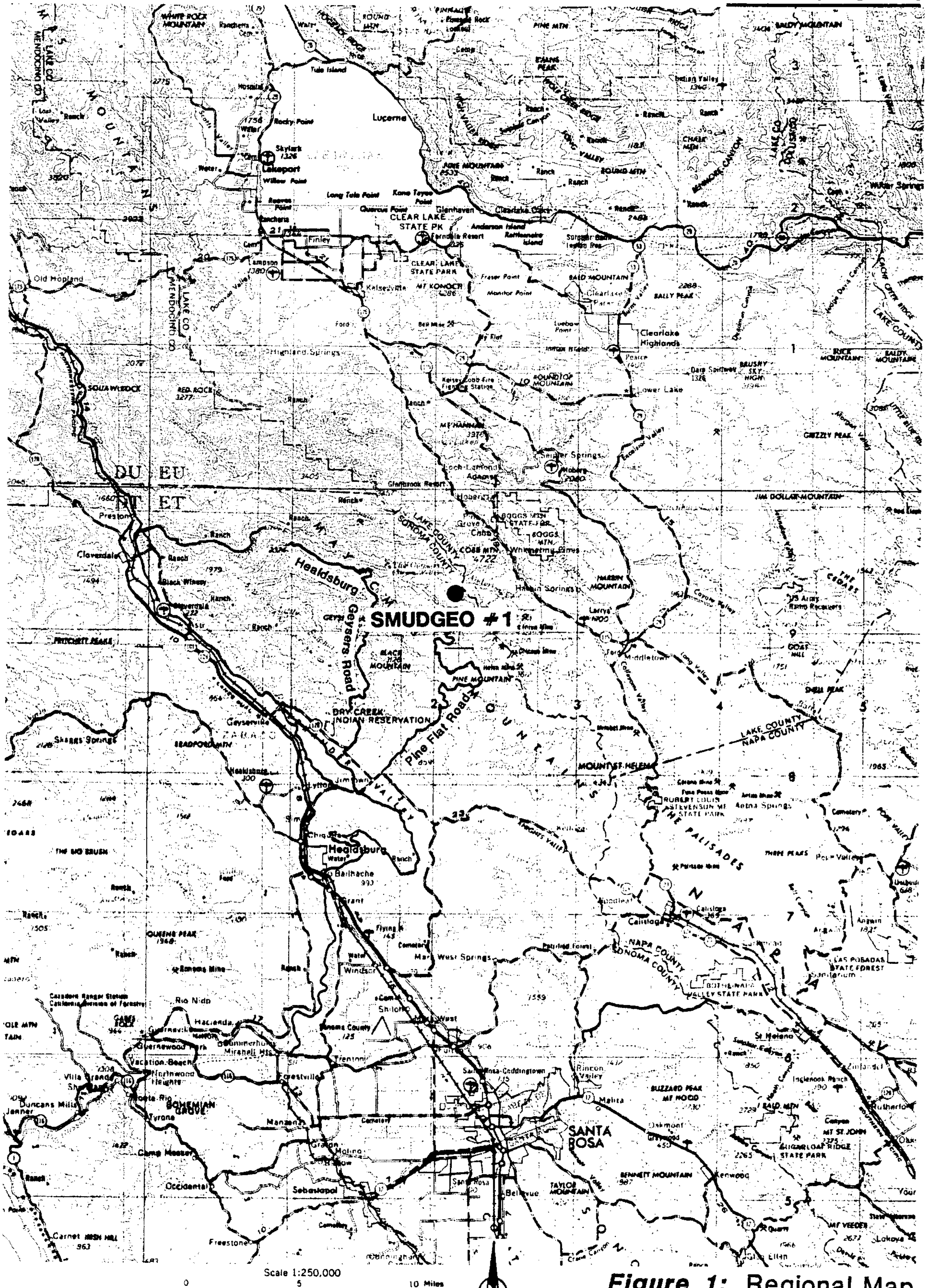


Figure 1: Regional Map

SOURCE: USGS 1:250,000 Santa Rosa and Ukiah Quads.

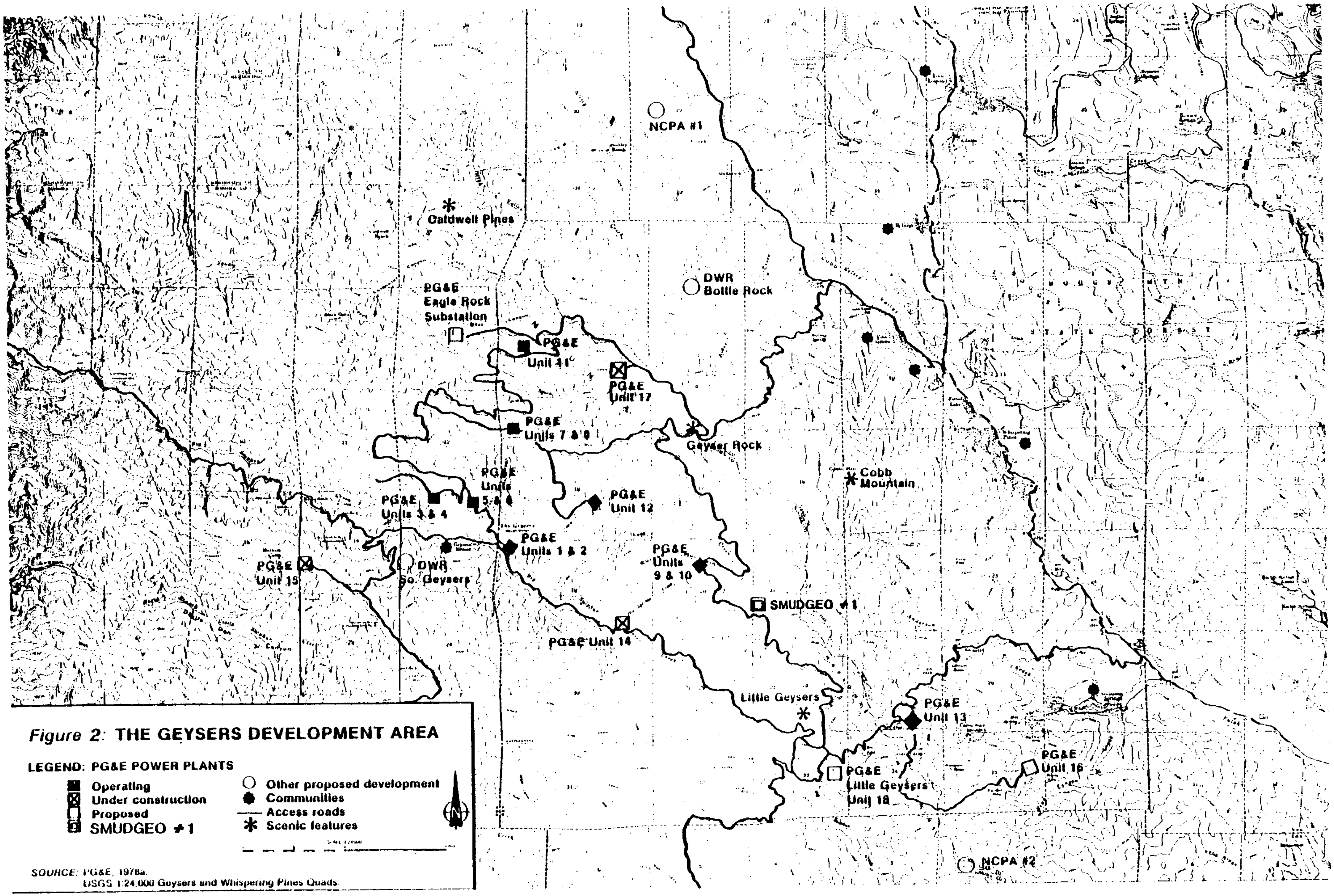


Figure 2: **THE GEYSERS DEVELOPMENT AREA**

SOURCE: PG&E, 1978a.
USGS 1:24,000 Geysers and Whispering Pines Quads

SMUDGEO #1

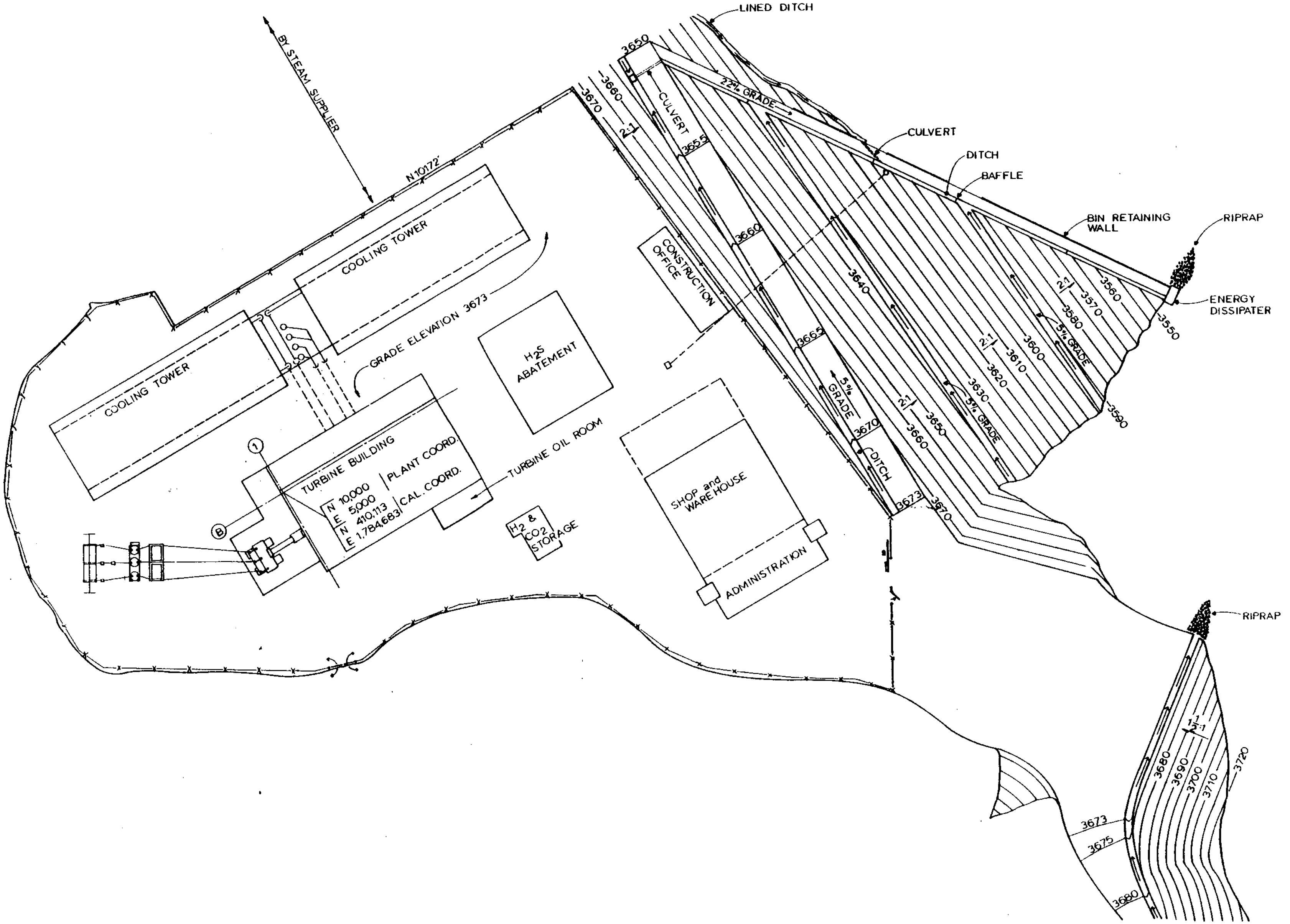


FIGURE 3: Plant Layout

Sacramento Municipal Utility District

SMUDGEO #1

Geothermal Power Plant

DRAFT

Joint Environmental Study

Prepared by
California Energy Commission
1111 Howe Avenue
Sacramento, CA 95825

in cooperation with

U.S. Department of Interior
Bureau of Land Management
555 Leslie Street
Ukiah, CA 95842

U.S. Department of Interior
Geological Survey
2465 E. Bayshore Road
Palo Alto, CA 94303

CONTENTS

	Page
SUMMARY	i
CONTENTS	xi
LIST OF FIGURES	xiii
LIST OF TABLES	xv
I. INTRODUCTION	1
II. PROJECT DESCRIPTION	3
OBJECTIVES	3
NEED	3
APPLICANT	3
OVERVIEW	5
HISTORY	5
LOCATION	6
FEATURES	6
STEAM SUPPLY WELLS AND PIPELINES	7
WATER SUPPLY	7
III. ENVIRONMENTAL SETTING, IMPACTS AND MITIGATION MEASURES	8
GEOLOGY	8
SOILS	17
BIOLOGY	21
WATER QUALITY	37

CONTENTS (continued)

	Page
HYDROLOGY	46
NOISE	49
CULTURAL RESOURCES	63
TRANSPORTATION	65
LAND USE	74
AESTHETICS	78
WASTE MANAGEMENT	80
AIR QUALITY	86
PUBLIC HEALTH AND SAFETY	137
IV. PROJECT ALTERNATIVES	155
V. GROWTH INDUCING IMPACTS	164
VI. SUMMARY OF ENVIRONMENTAL CONSEQUENCES	170
UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS	170
IRREVERSIBLE ENVIRONMENTAL CHANGES AND IRRETRIEVABLE COMMITMENTS OF ENERGY AND MATERIALS	176
THE RELATIONSHIP BETWEEN LOCAL SHORT-TERM USE OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY: CUMULATIVE IMPACTS	178
BIBLIOGRAPHY	183
AGENCIES AND PERSONS CONTACTED	201
GLOSSARY	203
APPENDICES	
A. IMPACT MATRICES	208
B. POTENTIAL HEALTH EFFECTS OF GEOTHERMAL POLLUTANTS	251
C. ASSUMPTIONS FOR PUBLIC HEALTH CUMULATIVE IMPACT ANALYSIS	257
D. COMMENTS AND RESPONSES TO COMMENTS ON THE DRAFT JES	259
AUTHORS	301

LIST OF FIGURES

Figure		Page
1.	Regional Map	vii
2.	Geysers Development Area	viii
3.	Plant Layout	ix
4.	Geologic Map of Geysers	9
5.	Cross Section through the Geysers	10
6.	Regional Quaternary Faults	11
7.	Habitat Map	22
8.	Leasehold Development	23
9.	Noise Estimates Site Preparation	50
10.	Noise Estimates Plant Operation	51
11.	Access Road	72
11.5	Roads	73
12.	Leasehold Evaluation	76
13.	Transmission Corridor Geology Map	77
14.	SMUD/DWR Monitoring Locations	88
15.	SRI-2 Wind Rose (Socrates Mine Road)	92
16.	SRI-6 Wind Rose (Anderson Springs)	93
17.	SMUD-1 Wind Rose (SMUD 1)	94
18.	Distribution of H_2S Hourly Average at or Above 30 ppb	99
19.	Distribution of H_2S Hourly Average at or Above 30 ppb (concluded)	100
20.	SRI-2 H_2S Sampling	101
21.	H_2S Sampling - Anderson Springs	102
22.	H_2S Sampling - Anderson Springs	103
23.	Equivalent H_2S Isopleths for Limited Mixing -- 1150' Tracer Release	120
24.	Equivalent H_2S Isopleths for Limited Mixing -- 1150' Model Simulation	121

Figure		Page
25.	Equivalent H_2S Isopleths for Limited Mixing -- 350' Tracer Release	122
26.	Equivalent H_2S Isopleths for Limited Mixing -- 350' Model Simulation	123
27.	Predicted 1984 Worst Case H_2S Concentrations Due to SMUDGEO #1 Emissions	125
28.	Predicted and Observed H_2S Concentrations (ppb) for 28 July 1976	128
29.	Predicted and Observed H_2S Concentrations (ppb) for 28 July 1976 - Concluded	129
30.	Predicted 1984 Ground Level H_2S Concentrations Due to PGandE and NCPA 1 Emissions	131
31.	Predicted 1984 Ground Level H_2S Concentrations Due to DWR Bottle Rock and South Geysers Emissions	132
32.	Estimated Construction Personnel Geysers KGRA 1976-1982	167

LIST OF TABLES

Table		Page
1	Characteristics of Selected Quaternary Faults in the Geysers Region	12
2	Water Quality of Big Sulphur Creek at Points Below Cobb Creek and Calm Creek Influences	44
3	Water Quality Monitoring, October 1979 of SMUDGEO #1 Project Area	45
4	Existing Noise Environment During Quiet Conditions, Location 8	53
5	Ambient Sound Levels in dBA	54
6	A-weighted Sound Levels, dBA of Typical Noises in Various Environments	55
7	Noise Levels Due to Geothermal Development and Operation Activities	56
8	Projected Construction Equipment Use	57
9	Estimated Worst Case Noise Levels and Minimum Measured Background Levels	58
10	Estimated Construction Traffic Noise	60
11	Monthly Average Ambient Temperatures in Project Area	89
12	Noncondensible Gases and Solids in Steam	97
13	Distribution of H_2S Hourly Averages	104
14	Condensate Treatment Removal Efficiencies to Meet 50 g/GMWh	113
15	Number of Days per Month that Adverse Meteorological Regimes Occur at The Geysers	118
16	Peak Concentrations Due to SMUDGEO #1	119
17	Peak Predicted and Observed H_2S Concentrations for Seven Stations	130
18	Population Distribution in The Geysers KGRA	139
19	Ambient Air Quality Standards	141
20	Suggested Levels for Nonregulated Pollutants in Ambient Air	144
21	Nonregulated Pollutant Impacts from SMUDGEO #1 Power Plant	148

I. INTRODUCTION

On February 19, 1980, the Sacramento Municipal Utility District (SMUD) filed an Application for Certification (AFC) with the California Energy Commission (CEC) to construct and operate SMUDGEO #1 geothermal power plant. SMUD's proposed power plant will have a net normal operating capacity of approximately 72 MW. It is scheduled for operation in December 1983, provided that construction begins in spring 1981. SMUD has indicated that the power plant would be operational for about 30 years (80-AFC-1).

This Joint Environmental Study (JES) is constructed to address environmental concerns according to the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA). The purpose of this study is to discuss and to allow the public an opportunity to comment on the environmental impacts which would be caused by the proposed 72 MW geothermal power plant. The project would be located in eastern Sonoma County within The Geysers-Calistoga Known Geothermal Resource Area.

This environmental study identifies the significant effects of the project on the environment, it identifies alternatives to the project, and indicates the manner in which environmental effects can be mitigated or avoided. A significant effect on the environment is a substantial or potentially substantial change in the environment.

The JES is not meant to present a conclusion regarding the overall acceptability of the project. The Energy Commission will use this study, in combination with other materials, to determine whether, and under what conditions, the project should be approved.

The staff of the Energy Commission, hereafter referred to as "staff," prepared this JES in accordance with the NEPA and the CEQA, the State EIR Guidelines, and the Energy Commission's regulations to implement CEQA. Information was used from both published and unpublished sources. The primary document the staff used was SMUD's AFC. The staff collected other information from the AFC proceedings (80-AFC-1), from federal, state, and local agencies, and from private groups or individuals. Although much of the information presented in this JES was originally provided by SMUD, the staff examined it for its reasonableness and technical accuracy and conducted its own independent verification. The analysis of the environmental impacts and the determination of their significance were conducted by and are the responsibility of the staff.

SMUDGEO #1 would be located on Federal land in eastern Sonoma County, near the Lake County line. The land is administered by the Bureau of Land Management (BLM). Two Federal agencies and the California Energy Commission have authority to review and approve construction and operation of the power plant. The Federal actions addressed by this environmental analysis are (1) approval of the Plan of Utilization by the United States Geological Survey (USGS) and (2) approval of the use of the site for the power plant by BLM. If the overall proposal is found to be suitable, the Energy Commission has the authority under state law to certify the power plant for operation. The Energy Commission, BLM, and USGS have combined their efforts in preparing this JES in order to assure that the environmental consequences of the proposed power plant are adequately addressed in terms of NEPA and CEQA.

The sections that follow discuss (1) the project as proposed by the utility (Project Description); (2) the environment in the vicinity of the project as it exists before the commencement of the project, from both a local and regional perspective (Environmental Setting); (3) the adverse consequences of the project, any significant environmental effects which cannot be avoided, and any mitigation measures to minimize significant effects (Impacts and Mitigations); (4) the potential feasible alternatives to the proposed project (Alternatives); (5) the significant unavoidable, irreversible, and long-term environmental impacts (Unavoidable Adverse Impacts); and (6) the Growth Inducing Impacts.

An interdisciplinary team of environmental analysts of the Engineering and Environmental Division of the Energy Commission prepared this JES. Specific staff are recognized under "Authors."

This Joint Environmental Study was prepared by the California Energy Commission (CEC) in cooperation with the United States Geological Survey (USGS) and the Bureau of Land Management (BLM). In the absence of any major problems in the Final JES, these two federal agencies will stipulate to the joint effort once the final comment period is closed.

The depth of analysis of environmental effects is "in proportion to their severity and probability of occurrence" (Section 15140(e) State EIR Guidelines). Effects the staff considered insignificant are discussed in Appendix A, entitled Impacts Matrices. Appendix A focuses on potentially significant impacts and documents why insignificant impacts were identified as such. Effects the staff classified as unresolved or potentially significant in the Impacts Matrix are addressed in Chapter III "Environmental Setting, Impacts and Mitigation Measures."

A 20-day public review will follow the release of the Final JES. Staff encourages comments on the JES, both with regard to substance of its content, and to the clarity of its discussion.

Where changes have been made in the wording of the Final JES as compared with the Draft version, the changed portions are underlined and marked in the right-hand margin.

Written comments should be submitted to:

Valerie Campbell
California Energy Commission
1111 Howe Avenue, MS-32
Sacramento, CA 95825
(916) 920-7504

II. PROJECT DESCRIPTION

OBJECTIVES

The Sacramento Municipal Utility District proposes to construct and operate the SMUDGEO #1 geothermal steam power plant to provide an economic and nonfossil fuel source of 72 MW gross electrical generation.

NEED

The California Energy Commission's Geothermal Policy Report, dated March 22, 1978, recognizes geothermal energy as a preferred technology for meeting electric power needs because (1) the geothermal resource is indigenous to California; (2) its development offers a stimulus to the state's economy; (3) the environmental impacts and power plant technology for dry steam resources are well understood; (4) geothermal power plants are relatively small (50 - 110 MW) and thus enable greater system reliability and flexibility; and (5) geothermal power plants may be planned and constructed in a shorter time frame than power plants using fossil or nuclear fuel.

In its 1979 Biennial Report, the California Energy Commission indicated that generation alternatives such as geothermal should be expanded because of their reliability and more stable costs. In the 1979 Biennial Report, the California Energy Commission declared, "We will continue to certify the maximum number of geothermal sites and facilities that demonstrate reasonably mitigable environmental impacts and that meet existing air and water quality standards. Any facility that meets these criteria will be deemed needed." (CEC, 1979) According to the AFC, the SMUDGEO #1 project would meet these criteria.

SMUD proposes SMUDGEO #1 as the first in a planned series of geothermal power plants. Denial of the project will impede their efforts to diversify power sources and gain greater reliability. If the project is not approved, SMUD will rely on mandatory conservation measures until they can bring other power plants on line to meet growing energy demands.

APPLICANT

Economics

SMUD's construction cost estimate is about $800 per kilowatt for geothermal steam capacity (1979 dollars). The estimated 1983 in-service cost is between $980-$1,045 per kW (SMUD's and CEC staff estimates, respectively). The expected cost for the life of the geothermal plant is 7.7-8.0 cents per kWh of energy generation (based on SMUD's and CEC cost assumptions, respectively). This compares with a levelized cost of new coal plant generation of 9.6 cents per kWh, for the same time period--1983-2010.

This means that geothermal generation for SMUD is less costly than new coal-fired generation (8.0 cents versus 9.6 cents) but slightly more expensive than SMUD's systemwide cost of generating electricity (8.0 cents versus 6.6 cents).

Financing

The estimated 1983 in-service capital cost of the SMUDGEO #1 project is between $53.9 million and $57.5 million (SMUD's and CEC staff estimates respectively).

SMUD will finance SMUDGEO#1 out of District's cash flow. These funds are generated from internal sources, retained earnings and depreciation, and from sales of revenue bonds.

OVERVIEW

In The Geysers KGRA (Figure 2), a typical geothermal development area contains steam wells, well pads, access roads, steam supply pipelines, a power plant, and transmission lines connecting the power plant with the intended electricity service area. In most cases, the land or leasehold where the steam wells and power plant are located is owned by private individuals or the Federal government. The land is then leased to a steam developer who supplies the steam to an electrical utility company. The steam supplier is also responsible for disposing of or reinjecting any steam condensate generated by the power plant.

Aminoil U.S.A., Inc. (Aminoil) is the steam supplier for the SMUDGEO #1 project. Both the power plant site and geothermal steam field are located entirely on a Federal leasehold, where the Federal Government is responsible for environmental documentation. Aminoil currently plans to contain the steam transmission pipelines entirely within the Federal leasehold. Permitting authority for activities on these private lands rests with local government agencies. For further information regarding activities on the Federal leasehold, refer to U.S.G.S., Environmental Assessment(s) Nos. 14, 130-9, 136-80.

Pacific Gas and Electric Company (PGandE) currently operates 15 geothermal power plants in The Geysers KGRA equalling a total installed electric capacity of 908 MW. PGandE units 17 and 18 are under construction and are scheduled for operation in 1982. These PGandE plants will each have 110 MW of installed capacity. Also, the Northern California Power Agency (NCPA) has a 110 MW plant currently under construction, which is scheduled for operation in 1983. Completion of the currently certified power plants will bring the total installed electric capacity of the KGRA to 1,238 MW by 1982.

Power plants which are proposed but not yet certified by CEC are SMUDGEO #1 (72 MW), Department of Water Resources, Bottle Rock (55 MW), DWR South Geysers (55 MW), and PGandE Unit 16 (110 MW). If these plants are all certified and constructed on schedule, they will bring the total installed capacity at the KGRA to 1,530 MW by 1986. Projections for maximum development of the KGRA* indicate a maximum installation of 2,700 MW of dry steam production by 1992, and an additional 550 MW of hot water production by the year 2000.

HISTORY

On February 19, 1980, SMUD filed an Application for Certification (AFC) with the Energy Commission to construct and operate the SMUDGEO #1 power plant. They have also filed a Plan of Utilization with USGS and an application with BLM for a license to construct, operate and maintain an electric generating plant on public land. BLM will act on the application after the environmental report has been prepared and reviewed. Previously, a lease was issued to Aminoil to develop the geothermal resources of the public land. Subsequent involvement by BLM in lease activities is through the procedures and under the direction of USGS.

*CEC, Renewables and Alternative Technologies Synopsis, Staff Draft, CEC-9/1980, Pub. #500-80-012

Currently only two of the anticipated 9 - 26 steam supply wells have been drilled.

A Steam Resource Hearing was held by the CEC on March 13, 1980, to determine the adequacy and availability of steam to run the proposed geothermal power plant. As a result of this hearing, the steam field was deemed adequate.

LOCATION

The Geysers KGRA is a mountainous, rugged, and sparsely populated area located in the northern central portion of the Coastal Ranges (Figure 1). The proposed SMUDGEO #1 project and steam field are located approximately 66 miles north of San Francisco and 61 miles northwest of Sacramento. The site is located in eastern Sonoma County on a ridgetop at an approximate elevation of 3,700 feet. The nearest communities are the unincorporated towns of Anderson Springs and Middletown, located in Lake County approximately 2-1/2 miles east southeast and 9 miles southeast of the site, respectively. The nearest major city is Santa Rosa, located in Sonoma County, approximately 24 miles south of the site.

The entire Federal leasehold, CA 1862, including steam field and power plant site, encompasses approximately 396 acres, including the SW 1/4 section of Section 21, the north half of the NW and the NE 1/4 sections of Section 28, and the north half of the NE 1/4 section of Section 29, T11N, R8W MDB&M.

Access to the site from the nearby community of Middletown in Lake County is via Highway 175 and Socrates Mine Road. Access from the west is via the Healdsburg-Geysers road from Jimtown to The Geysers Resort and then past PGandE Geysers 14 to an emergency fire road.

A transmission tapline will be constructed from the plant site to an existing PGandE 230 kV transmission line located to the west of the site. This line will extend about 3,180 feet, crossing portions of the Aminoil leasehold and the adjacent Union Oil leasehold.

PROJECT FEATURES

The proposed power plant will have the following main features:

- o Two condensing, nonextraction 3,600 rpm turbines operating in tandem.
- o The generator will be a 3,600 rpm hydrogen cooled, three phase, synchronous unit directly coupled to the main turbine shaft.
- o A stainless steel surface condenser will condense spent steam exhausted from the turbine and effect an increase in partitioning H_2S and other noncondensibles from previously used direct contact type condensers which mix the cooling water with the spent steam.
- o A 12-cell wet (evaporative) crossflow cooling tower will be used to dissipate the heat gained by the circulating cool water during its passage through the surface condensor.

- A Stretford hydrogen sulfide abatement system, in which hydrogen sulfide is scrubbed from the vent gas stream and catalytically oxidized to elemental sulfur. SMUD will use a secondary abatement system to abate H_2S contained in the liquid condensate. The secondary abatement system will employ hydrogen peroxide with catalyst.
- Abatement system chemical storage tanks (H_2O_2, $FeSO_4$, and HAA).
- A shop, warehouse, and administration office building.
- Sewage treatment plant.
- A 3,180 foot long transmission tapline connecting to an existing 230 kV transmission line to the west of the site.
- A 2.5 mile long paved access road (from Socrates Mine Road to the plant site.)

STEAM SUPPLY WELLS

SMUD has contracted with Aminoil USA, Inc., to supply the steam necessary to run the proposed geothermal power plant. SMUD anticipates that up to 26 wells will be needed over the lifetime of the power plant. Nine wells are needed to generate power initially. Two extra wells are also required in order to have steam reserve on standby in case of well problems.

Although the Steam Resource Hearing, held March 13, 1980, determined that there is adequate steam available to run the SMUDGEO #1 project, the steam production of a well typically declines over a period of time as the reservoir it draws from is depleted. Thus, as steam production wanes, additional wells will be drilled. In addition, one or two reinjection wells are required to dispose of excess steam condensates and cooling tower blowdown.

To date, only two wells have been drilled on the site, although drilling operations for more are planned. The permitting authority for wells rests specifically with the USGS; although the county issues the Authority to Construct, Building, Grading, Sanitation, and Use permits.

STEAM PIPELINES

Steam will be transported from the wells to the power plant in insulated steel pipelines supported above ground. Steam transmission lines are generally selected for the shortest distance to the generating unit, but the actual layout of the pipeline is largely dictated by the rugged terrain in The Geysers area. Where possible, pipelines will follow road alignments and unstable slopes will be avoided.

WATER SUPPLY

Initial start-up water for the cooling tower will be supplied by Aminoil using steam condensate from nearby geothermal wells. Once the power plant is in operation, make-up water for the cooling towers will come from excess condensate.

III. ENVIRONMENTAL SETTING, IMPACTS, AND MITIGATION MEASURES

GEOLOGY

SETTING

Regional Geology

The proposed project and the entire Geysers KGRA lie in the Central Mayacmas Mountains of the Northern Coast Ranges. The regional geology of the KGRA has been described by McLaughlin (1978, 1977) and McLaughlin and Stanley (1976). Recent mapping of the area by the U.S. Geological Survey indicates that the Central Mayacmas Mountains represent a structurally complex mass of rock which was uplifted by folding and faulting (Figure 4).

The Geysers region experienced a series of folding, faulting, and volcanic events over the last several tens of millions of years. The present range is the product of accelerated folding and faulting which occurred during the last three to six million years. The Collayomi and Maacama faults form the northeast and southwest boundaries, respectively, of the Mayacmas uplift. Volcanism occurred in the area during the last five million years, with Cobb Mountain and other volcanic features in the Clear Lake region being formed within the last two million years. Presently a large body of at least partially molten magma exists at a depth of about 6 miles (10 kilometers) below the Clear Lake area (Donnelly et al., 1977) (Figure 5).

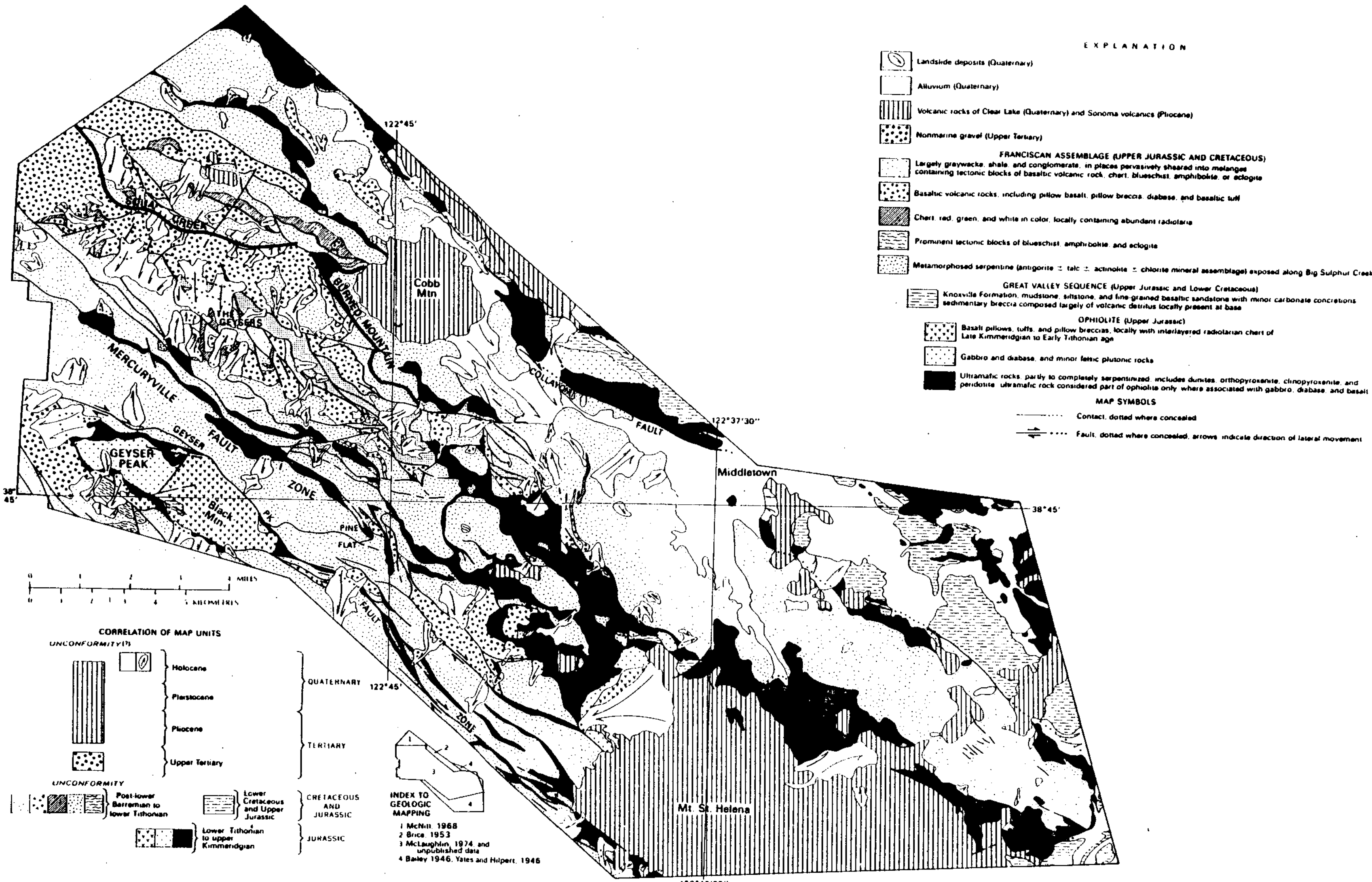
The principal faults within The Geysers region are associated with the complex horst* forming the Mayacmas Mountains. The fumarole activity along Big Sulphur Creek at The Geysers is a surface phenomenon often associated with faulting in an area characterized by recent volcanism (Hamilton and Muffler, 1972).

Regional Seismicity

The KGRA is in a region of moderate seismic activity where the potential seismicity of the San Andreas, Maacama, and Rodgers Creek faults overshadow that of other possible sources (Figure 6 and Table 1). Few earthquakes of magnitude 5.5 or greater have occurred in The Geysers region. The largest historical earthquakes of importance for The Geysers area are the 1969 Santa Rosa earthquake (M 5.6 and 5.7) on the Rogers Creek fault and the 1906 San Francisco earthquake (M 8.25) on the San Andreas fault.

Geologic and seismic evidence indicates that both the San Andreas and Rodgers Creek faults have a significant potential for producing strong earthquakes. Although few strong seismic events can be confidently associated with the Maacama fault, recent tectonic interpretations (Herd, 1978; Dott, 1979) and geologic evidence indicate that this fault has a significant potential for generating strong earthquakes.

*A portion of the earth's crust which has been elevated and separated from the surrounding land by faults.



Source: McLaughlin and Stanley, 1975 AMENDED BY PG&E, OCTOBER 1977

Source: Geysers 18 Final EIR

FIGURE 4: Geologic Map of Geysers

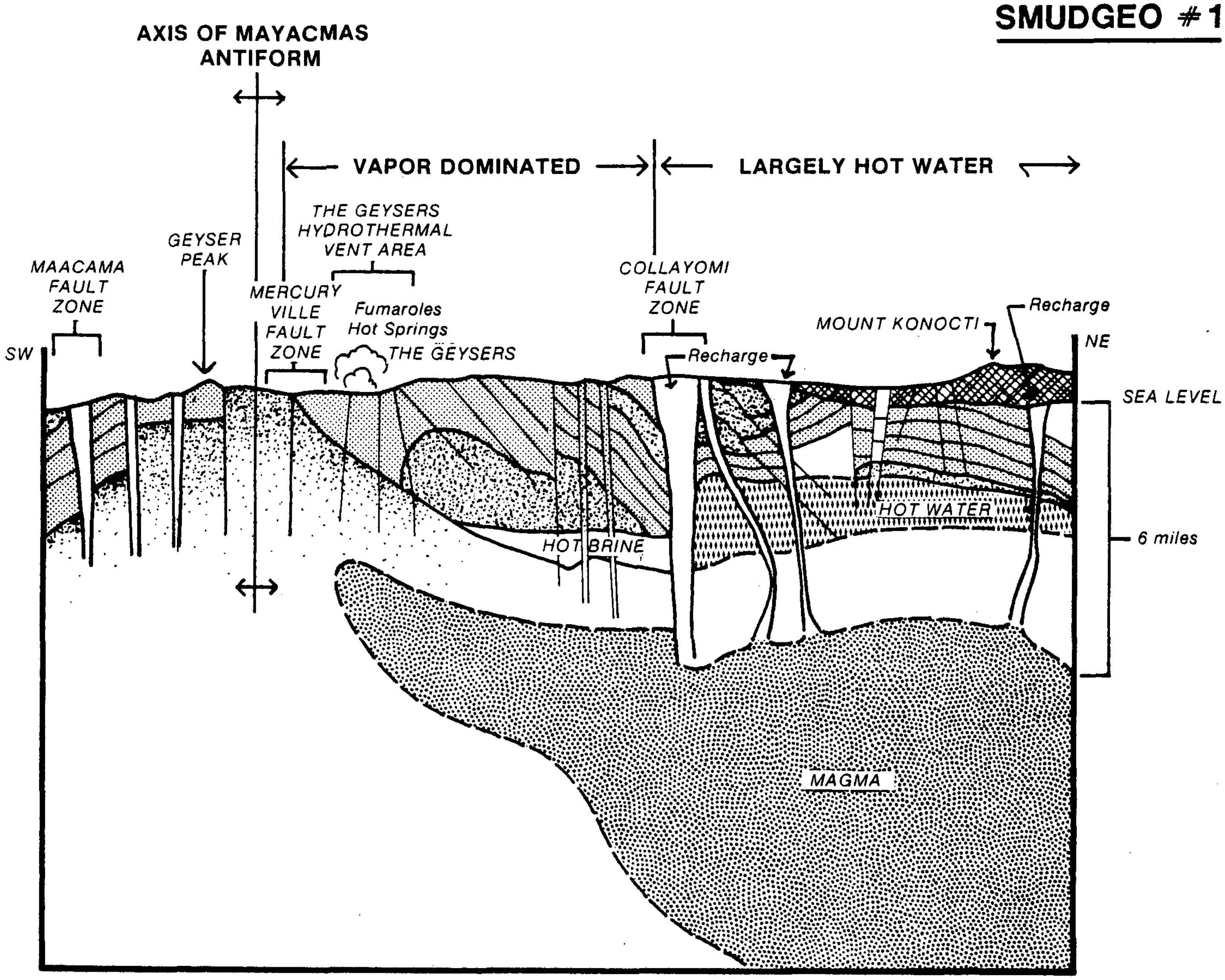


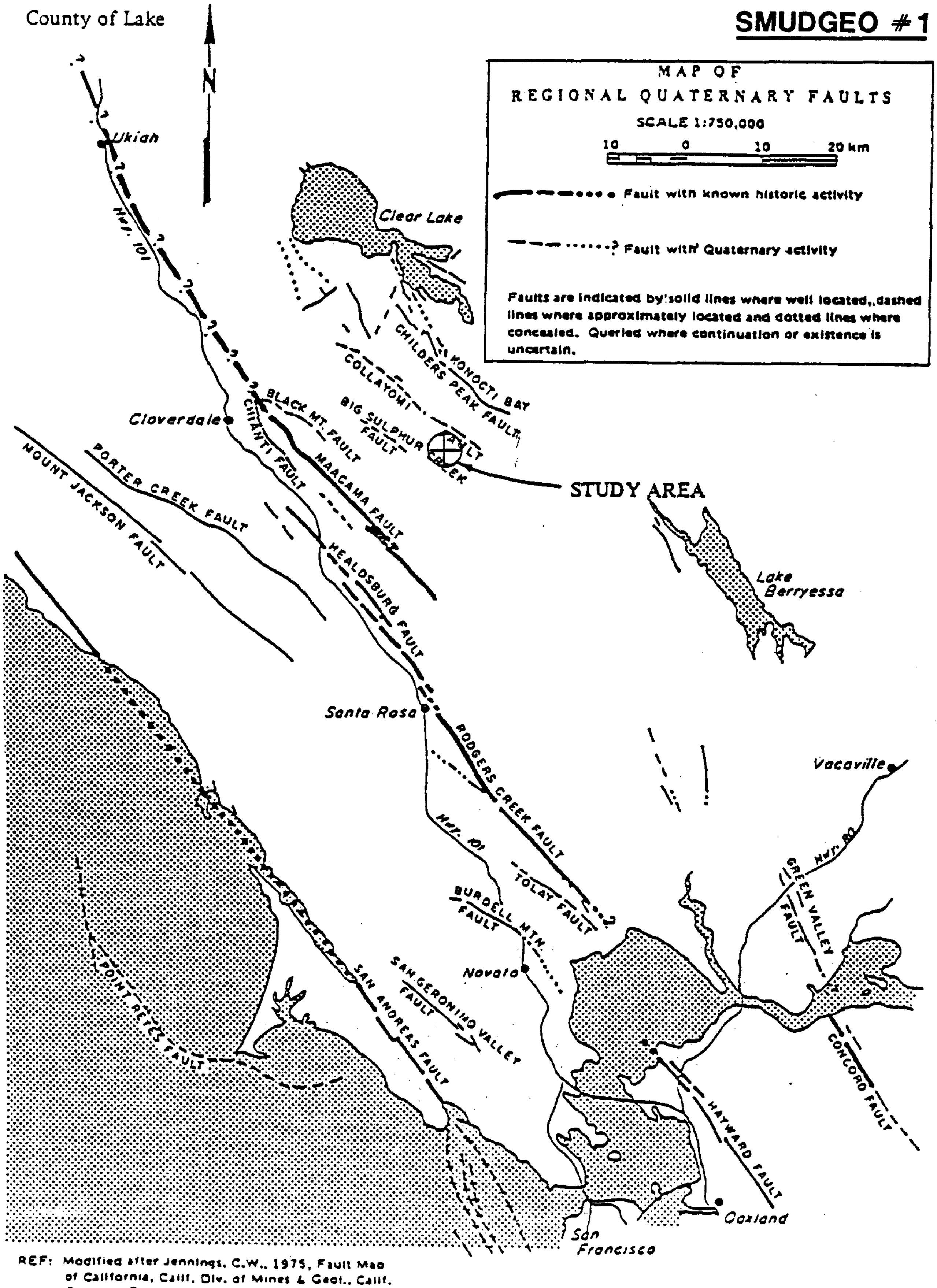
FIGURE 5: CROSS SECTION THROUGH THE GEYSERS—CLEAR LAKE REGION

	Impermeable cap rocks (Serpetinite, greenstone, melange, metagraywacke)		Partially crystallized magma body inferred to be at depth with center below 6 miles
	Fracture networks in graywacke reservoir rocks		Water vapor in steam reservoir above boiling water table
	Clear Lake Volcanics and associated vents providing recharge to geothermal system		Hot water

Structural model for the Geysers geothermal system. Cross-section through The Geysers-Clear Lake region, from the Maacama fault zone on the southwest, to Mount Knocti on the northeast, depicting structural elements of The Geysers-Clear Lake geothermal system.

Source: "Field-trip Guidebook Castle Steam Field, Great Valley Sequence," April 29, 1978, 53rd Annual Meeting, Pacific Sections AAPG, SEPM, SEG. Modified by the California Energy Commission, February, 1979.

Source; Geysers 18 Final EIR 10



REF: Modified after Jennings, C.W., 1975, Fault Map of California, Calif. Div. of Mines & Geol., Calif. Geologic Data Map Series, Map No. 1.

FIGURE 6: Regional Quaternary Faults

TABLE 1

CHARACTERISTICS OF SELECTED QUATERNARY FAULTS IN THE GEYSERS REGION

CHARACTERISTICS	SAN ANDREAS	HEALDSBURG/ RODGERS CREEK	MAACAMA AND ASSOCIATED FAULTS
DISTANCE FROM SITE (km)	53	32	13
MAPPED LENGTH (km)	1,200	42	16.5
TYPE OF FAULT	Right-lateral Strike-slip	Right-lateral Strike-slip probably some small vertical component	Right-lateral Strike-slip
ACTIVITY STATUS			
1) Historic activity	Yes	Yes	Yes
2) Features indicating Holocene activity	Yes	Yes	Yes
3) Features indicating Quaternary activity	Yes	Yes	Yes
Estimated maximum magnitude earthquake	8.3	6.5	6.75-7.0
Remarks	Maximum displacement of 6m in 1906	Magnitude 5.7 earthquake in October 1969	Magnitude 3 to 4.5 earthquakes in 1969, 1971 and 1977

CHARACTERISTICS	COLLAYOMI	BIG SULPHUR CREEK	KONOCTI BAY/ CHILDERS PEAK
DISTANCE FROM SITE (km)	2		
MAPPED LENGTH (km)	About 40	6.4	About 30
TYPE OF FAULT	Right-lateral Strike-slip possibly some vertical component	Normal with possibly some right-lateral strike-slip	Normal, high-angle
ACTIVITY STATUS			
1) Historic activity	None known	None known, possibly small earthquakes	None known, but small earthquakes in area
2) Features indicating Holocene activity	None observed	Yes, also geomorphic features	Geomorphic features suggestive of faulting
3) Features indicating Quaternary activity	Yes	Yes	Yes
Estimated maximum magnitude earthquake	---	---	---
Remarks	Offset terrace gravels with clasts dated as 0.4 million years old.		Offset Quaternary volcanics of the Clear Lake sequence

Modified from Borcherdt, 1975

Other potential sources of earthquakes include The Geysers Peak, Konocti Bay, and Porter Creek faults which, due to their size, distance from the site, associated historical seismicity, and geologic evidence of activity, are not considered to be more likely to produce damaging levels of shaking in the steam field than presently unrecognized sources closer to the site.

Recent microseismic studies by Marks et al. (1978) indicate that microseismic activity increases in areas of existing power plant facilities. A magnitude 5 earthquake is a reasonable upper bound for this anomalous "steam production" area.* On the assumption that the entire steam field will become a steam production area within the next decade, the seismic characteristics of the present steam production area are probably representative of the entire steam field.

Leasehold Geology

The leasehold geology has been mapped in detail by the USGS (McLaughlin, 1977) and is briefly described in the AFC. The leasehold is underlain by ubiquitously sheared and slightly metamorphosed** graywacke sandstone with subordinate amounts of greenstone of the Franciscan formation. The graywacke is apparently repeated in section by two or more thrust faults which transect the leasehold in a general northwest direction at a low angle. This period of deformation probably took place in the Late Cretaceous, and although not considered active today, it is thought to be responsible for the discordant and highly sheared nature of the Franciscan formation.

Mapping by McLaughlin (1978) indicates the presence of short, discontinous, near vertical faults north and south of the Aminoil leasehold, but no major faults are known within the property.

Economic Mineral Deposits

The closest mine is the Socrates Mine, located near the ridge crest on the south side of Big Sulphur Creek about 1.7 mile southwest of the leasehold. This mine was developed for the extraction of mercury and is now inactive.

IMPACTS AND MITIGATION MEASURES

Geologic Hazards

Potential geologic hazards which could credibly affect the leasehold and power plant are shown in the Impact Matrix Section. Geologic hazards, such as liquefaction, expansive and collapsible soils, tsunamis and seiches, are not likely to occur within the leasehold. However, earthquake shaking and

*Conclusion reached at October 25 and 26, 1979, Seismic Hazards Evaluation Methodology Workshop.

**The mineralogical and structural adjustment of solid rocks to physical and chemical conditions, e.g., heat and pressure, which have been imposed at depths below the zone of cementation and weathering.

landslides could potentially damage the power plant and/or related facilities, thereby resulting in potential adverse impacts to public health and the environment or forcing a plant shutdown. For example, rupturing of steam pipelines would result in unabated steam releases into the atmosphere, or collapse of transmission towers and transmission lines could start fires. These are examples of "indirect" impacts which may result from earthquake shaking or landslides. These geologic hazards are discussed in more detail below.

Earthquake Shaking

Earthquake ground shaking is a result of energy release when movement occurs along faults in the earth's crust. Earthquake shaking affects large areas, but generally structures can be designed to adequately withstand this phenomena. Based on present geologic knowledge, California Energy Commission staff believes it unlikely that faults within The Geysers steam field will produce any large damaging earthquakes due to either natural or induced activity during the economic life of the proposed facilities. The strongest shaking at the proposed site would most likely be caused by one of the larger regional faults, such as the Maacama fault.

Due to its proximity to the steam field and the magnitude of earthquake which may occur along it, the Maacama fault is the most significant potential source of earthquakes.* However, the potential ground shaking from earthquakes on the San Andreas and Rodgers Creek faults, from the steam production area, and from "random" seismic events not clearly associated with any source should also be considered in evaluating seismic hazards for The Geysers power plant units.

Earthquake Shaking Mitigation

The proposed facilities can be designed to adequately withstand seismic shaking. Wells and transmission lines are relatively insensitive to seismic shaking and probably require no special treatment except properly sited (i.e., sited on stable ground) and engineered well pads and tower footings. Because of their flexibility, properly constructed transmission lines and pipelines should suffer little damage, even by severe shaking. If damaged, they can usually be quickly repaired.

SMUD proposes to use a dual-level approach to seismic design. The proposed design criteria will ensure that the power plant will be out at operation for only a week should a peak bedrock acceleration of 0.15 g occur of the site and for about one year should a peak acceleration of 0.28 g occur. Based on probablistic seismic hazard analysis performed for other generating units at The Geysers (Shah, 1980), the probability that accelerations of .15 g and .28 g or more will occur at the site in a 30-year facility lifetime is about 22 percent and 5 percent, respectively.

Should damage of the SMUDGEO #1 facility occur due to a seismic event then there may be temporary local outages. However, since this facility represents less than 5 percent of the total generating capacity and because of

*Conclusions reached at October 25, 26, 1979, Seismic Hazards Evaluation Methodology Workshop.

the availability of sufficient reserve margin, it is expected that the power to the consumer can be restored within a reasonable time, not likely to exceed several hours.

Landslides and Slope Instability

Landsliding and slope instability are among the most significant geologic problems facing development of The Geysers geothermal resource. (Bedrossian, 1978) Landslides and unstable slopes may endanger facilities in three ways: 1) a surface facility sited at the base of an unstable slope may be buried by landslide if upslope materials fail and encroach upon the structure; (2) a facility sited on an unstable slope may be pulled downhill and torn apart if the underlying materials are involved in a landslide; and (3) a subsurface facility (such as a well) may be sheared off, torn apart, and/or severely deformed below the surface if it is sited on unstable materials at or near the ground surface. In the case of geothermal steam wells, such an event usually results in well blowouts at the surface.

Landslide and Slope Instability Mitigation

CEC staff believes that the power plant facilities will not be endangered by landsliding. Landslides have been mapped within the leasehold, but none have been revealed within the mapped power plant site. The generating unit, cooling towers, H_2S abatement system and substation will be located on bedrock, undisturbed by landslides.

Impacts on Geologic Environment

Potential impacts on the geologic environment include effects on local fumaroles and hot springs, on the steam reservoir itself, and inducement of landsliding, subsidence, and seismicity. Other impacts on commercial geologic resources (e.g., ores, fossil fuels, gems, which may be commercially exploited by mining, quarrying or drilling) or on noncommercial geologic resources (e.g., caves, mineral collecting, localities), which are of recreational or scientific interest in the vicinity of the proposed project, are not considered significant by CEC staff.

CUMULATIVE IMPACTS

Steam Reservoir/Geothermal Features

Most of the information necessary to define the characteristics of the steam reservoir is the private property of the steam developers and is considered highly proprietary. Therefore, it is not possible to confidently determine what effect this or any other development of The Geysers steam resource will have on the reservoir and surface manifestations, such as hot springs and fumaroles (see Energy and Material Resources). However, the California Division of Oil and Gas (DOG), under the auspices of the U.S. Department of Energy (DOE), is currently compiling and synthesizing the production data obtained by the state over the last 20 years of exploitation. With the aid of the DOG, the California Division of Mines and Geology (CDMG), and the California Energy Commission (CEC), the DOG hopes to be able to characterize the reservoir to aid in answering questions related to future use, energy planning, and overall effects on the geologic resources. A summary report is anticipated in February of 1981. At the present time, however, and given the current technology, The Geysers geothermal field must be considered a finite resource. Each new power plant thus causes further depletion of the once abundant steam resource at an ever increasing rate.

Studies such as that being conducted by the DOG are a first step in understanding the resource and estimating its useful life, however, more advanced modeling studies are necessary to determine efficient management practices, the effect of reinjection policies, evaluation of the behavior of the reservoir during exploitation, subsurface migration of fluids and heat, and the source of the water that is utimately being converted to steam. The CEC is currently determining the feasibility of developing a mathematical model designed to simulate the physical characteristics of the reservoir to answer these and other questions. However, cooperation of developers, utilities, and regulators of the resource must be secured for success of such a project.

Inducement of Landslides, Seismicity, and Subsidence

All current or proposed geothermal developments at The Geysers steam field will contribute to the impacts of induced subsidence (Lofgren, 1978) and induced microseismicity (Marks et al., 1978). These impacts are of no direct significance but, under certain conditions, could contribute to local landslide susceptibility or fault movement. Reinjection of fluids into the steam reservoir may tend to mitigate these impacts. It is not currently feasible to assess in detail either the degree of these cumulative impacts or the degree to which they can be mitigated.

SOILS

SETTING

The only really important characteristics of the environmental setting of soils in the KGRA, in general, and the SMUD project site, in particular, is the heavy precipitation (reference: Hydrology section of EIR) to which they are exposed and the extremely steep slopes on which the soils occur.

The SMUD project site encompasses soils of Los Gatos, Josephine, and Mayman series. The Josephine series consists of light brown, well-drained loams underlain with clay loam subsoil. Permeability of this soil type is moderate, runoff is rapid, and erosion rate is high. The Los Gatos series consists of well-drained loams over clay loams, weathered sandstone, and shale. Permeability of this soil series is moderate, runoff is rapid to very rapid, and erosion potential is high to very high. The Mayman series consist of light to yellowish brown, well-drained, gravelly, sandy loams, underlain by weathered and fractured sandstone. Permeability of this soil series is moderate, runoff is rapid, and the erosion hazard is high.

Whenever any type of construction activity disturbs these soils, the resultant increase in the natural rate of soil erosion and consequent sedimentation will be significant in the absence of an effective erosion control plan.

SMUD estimates the natural erosion rate for the proposed power plant site to be 3.2 tons per acre per year. The accuracy of this figure is open to question since there are no supporting quantitative field data--the estimate was derived from the application of the Universal Soil Loss Equation, which was originally developed to predict soil losses from agricultural land due to rainfall.

IMPACTS

The increase in erosion and consequent sediment resulting from construction will be significant during the time period between the initiation of construction activities and the successful implementation of the erosion control program proposed by SMUD. Previous estimates of this temporary increase have been in the order of 20 times the natural erosion rate.

Ideally, after establishing the erosion control plan, the postconstruction rate of soil loss will be no larger than the preconstruction rate, except for roadways, which are a constant source of sediment. The access road to this project, currently a graded fire road, will to be widened in parts and paved. Also, a new short road from the well pad site to the plant site is proposed. New road construction and widening of the existing road will increase the erosion potential. Unfortunately, at present there are no data available to allow a quantitative field evaluation of any erosion or sediment yield rates in the KGRA, either preconstruction or postconstruction.

The major reasons for controlling erosion are to avoid:

1. The loss of soil resources;

2. The loss of associated biological habitat and watershed resource;

3. The loss of fish habitat due to sedimentation in the streams; and

4. The degradation of water quality caused by sediments.

MITIGATION MEASURES

In order to control erosion on the proposed power plant site and the access road, SMUD proposes mitigation measures which, if implemented correctly, may prove to be effective. These measures include items such as paving the plant site and the access road, upgrading and paving the fire road down to Socrates Mine Road, limit on steepness and height of cut and fill slopes, stockpiling the topsoil for better revegetation after the construction phase, hydro-mulching to enhance rapid revegetation, using diversion ditches, and ditch sedimetation collection systems to prevent any soil from entering Cobb Creek and Calm Creek. All these measures, along with an earth moving moratorium during the winter rainy season, will help to curb the erosion from the affected area.

In order to evaluate the effectiveness of the erosion control plan, SMUD offers to annually quantify the amount of sediments accumulated in the sedimentation control system and to report this information to both the CEC and the U.S. Geological Survey.

If these data show the amounts of soil loss are either larger than expected, not decreasing with time back to the natural erosion rate, or both of the above, SMUD will be required to appropriately modify the erosion control plan in consultation with the CEC and the USGS.

CUMULATIVE IMPACTS

Although the SMUD geothermal project will be by itself a limited contributor to the adverse impacts listed under the "Impacts" section above, the incremental effects of the project are considerable when viewed in connection with the effects of completed projects, projects presently under construction, and probably future projects.

Big Sulphur Creek Watershed

The SMUDGEO#1 project is located within the Big Sulphur Creek watershed. Other projects contributing to this watershed are PGandE projects 1 through 12, 14, and 15 which total 773 MW. Completion of PGandE projects 17 (110 MW), and 18 (110 MW), NCPA 2 (110) and SMUDGEO#1 (72 MW) will bring the Big Sulphur Creek watershed to an installed level of 1,175 MW by fall 1983.

Using the rough approximation of .50 acres of vegetation lost for each megawatt* (this includes all activities, power plant, as well as steam field), the development-related area contributing sediment to the Big Sulphur Creek watershed will be 587 acres by fall of 1983.

THE KGRA

Including Big Sulphur Creek watershed, the entire KGRA currently houses 908 MW. By 1992 CEC staff estimates that dry steam development in this region will total 2,700 MW, with an additional 550 MW from hot water sources expected by the year 2000.** Using the rough approximation of .50 acres of vegetation lost per MW, and assuming no change in current mitigation practices for erosion control and that this approximation applies to hot water development as well, the cumulative result will be 1625 acres of development related disturbance (lost vegetation) contributing sediment to the Big Sulphur Creek watershed by the year 2000. Of this amount, SMUDGEO#1 will contribute approximately 36 acres or 1.1 percent overall. Since there are many assumptions in calculating these cumulative environmental impacts, the figures should be viewed merely as an approximation.

More accurate analysis of cumulative impacts to the KGRA will be found in CEC's forthcoming cumulative study, titled Developmental Effects at The Geysers. This study is targeted for release to the public in 1983, and will address cumulative impacts in the areas of health effects, water related resources, biological resources, socioeconomics, seismic performance and design criteria, erosion and sedimentation, transmission systems, and air quality modeling of the KGRA. Results of the ongoing KGRA erosion/sedimentation study, a joint effort by CEC

*CEC, Cumulative Biological Impacts of Geothermal Development in the Geysers KGRA Summary. Table 3, October 1, 1980.

**California Energy Commission, Renewables and Alternative Technologies Synopsis Staff Draft, September 1980, CEC, Pub. #500-80-012.

technical staff and the Department of Conservation, will be published during the interim. This erosion/sedimentation study will quantify sediment yields for certain projects presently under construction and adjacent watersheds which are undisturbed, and will provide CEC staff with a basis to evaluate the effectiveness of the current erosion/sedimentation mitigation practices employed at The Geysers.

BIOLOGY

VEGETATION

SETTING

The Application for Certification (AFC) by Sacramento Municipal Utility District (SMUD, 1980, pp. 5-48 to 5-76) describes the biological setting of the SMUDGEO #1 project. The following paragraphs are generally based upon the information contained in the AFC document. The Energy Commission staff has verified this information and supplemented it through examination of the site, discussion with appropriate agencies and individuals, and review of other pertinent information.

The vegetation found in the vicinity of the proposed project is typical of the central coast ranges north of San Francisco Bay. It is characterized by a composite of brush (primarily chaparral) and deciduous and mixed evergreen plant communities resulting from a variety of factors including topography, exposure, soil variation, land use, and response to fire.

The plant communities or habitats [based on the classification of Cheatham and Haller (1975)] found on the proposed power plant site and surrounding steam field and shown in Figure 7 include:

- Mixed evergreen forest;
- Knobcone pine forest;
- Californian mixed chaparral;
- Serpentine chaparral;
- Chamise chaparral; and
- Barrens.

The mixed evergreen forest is composed of deciduous and coniferous trees including: madrone (*Arbutus menziesii*), California bay (*Umbellularia californica*), canyon oak (*Quercus chrysolepis*), big-leaf maple (*Acer macrophyllum*) and Douglas fir (*Pseudotsuga menziesii*). The forest community is found on the southwest portion of the lease along Panic Creek, on the northeast portion of the lease along the Cobb Creek drainage, and in an area near the middle of the lease along the Calm Creek drainage. In the more moist portions along the bottom of the drainages are species associated with riparian habitats, particularly where the road to PGandE Units 9 and 10 crosses Cobb Creek.

Knobcone pine forests are characterized by a closed canopy formed by knobcone pine (*Pinus attenuata*) with a dense understory of entangled dead branches. Associated species within the understory are manzanita (*Arctostaphylos* spp.) and California lilac (*Ceanothus* spp.). This community is normally associated with serpentine soils and areas that have been subject to fires. A large stand is identified along the southern boundary of the leasehold along Calm Creek, Figure 7, with other communities located off the leasehold to the south and west.

SMUDGEO #1

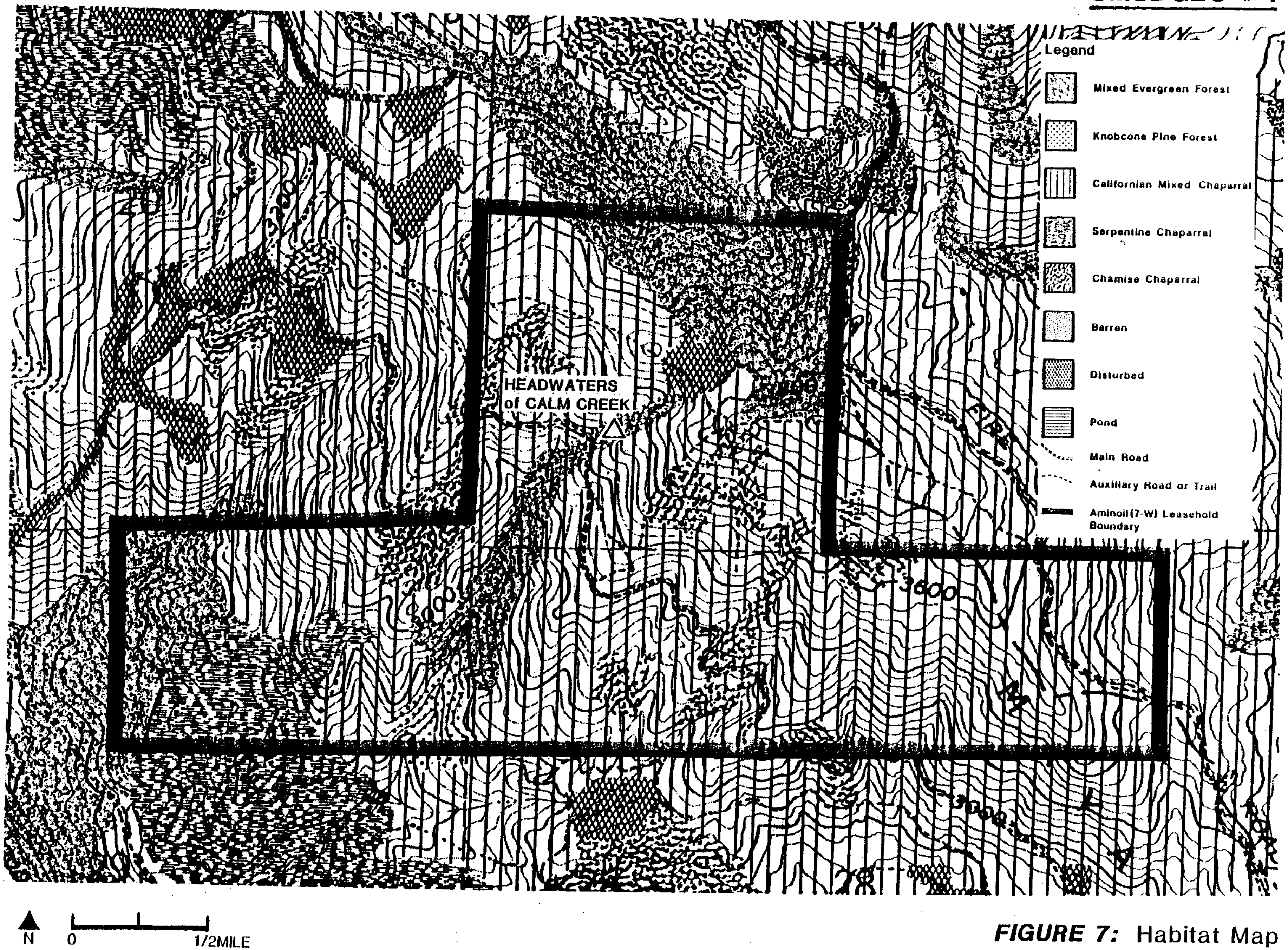
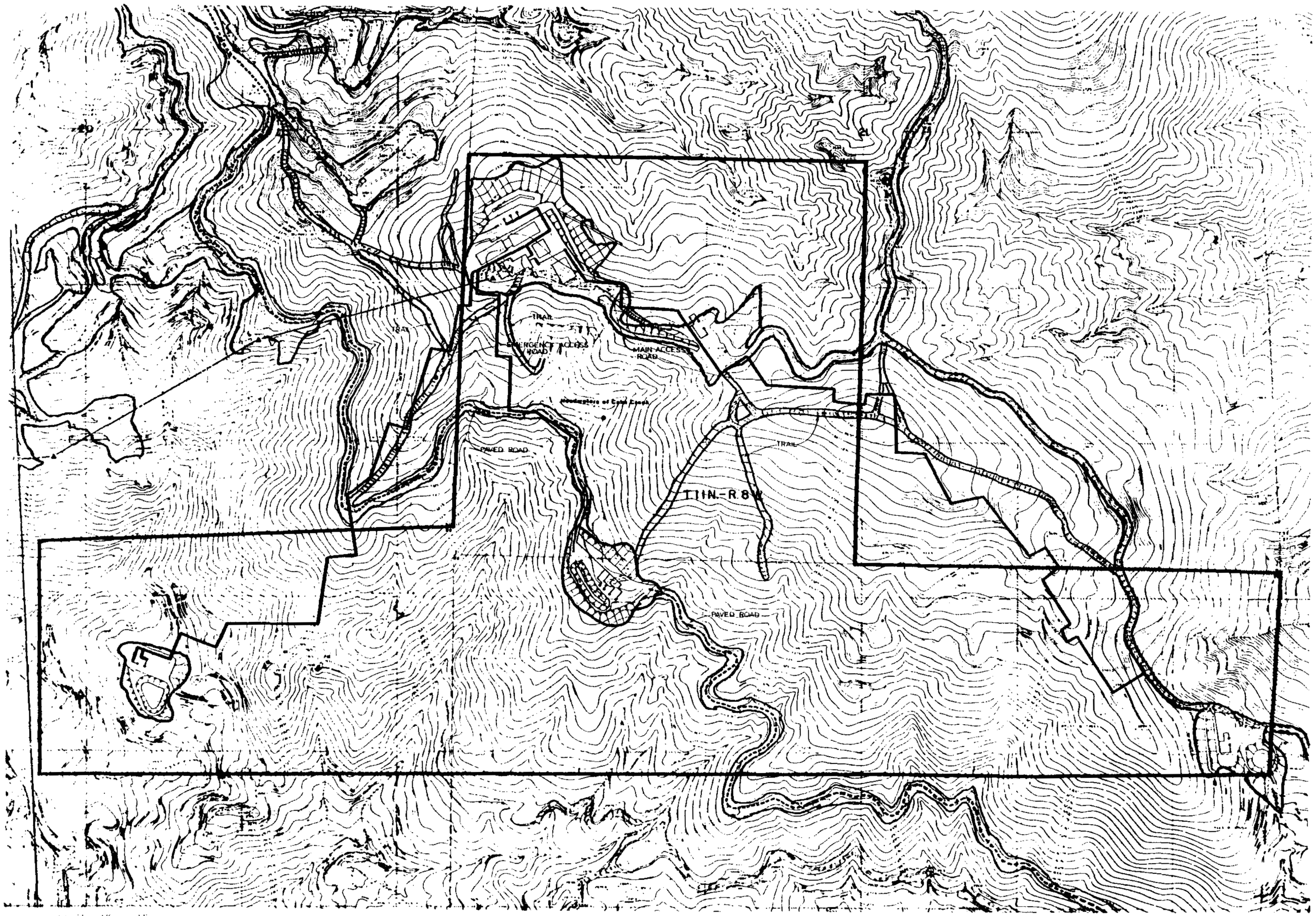


FIGURE 7: Habitat Map



SMUDGEO #1

FIGURE 8: Leasehold Development

The California mixed chaparral is common on the leasehold. The shrubs frequently found in this mixed chaparral form dense, impenetrable thickets. The plant species include chamise (Adenostoma fasciculatum), buckbush (Ceanothus cuneatus) and other species of Ceanothus, mountain mahogany (Cercocarpus betuloides), chaparral pea (Pickeringia montana), manzanita (Arctostaphylos spp.), shrub oak (Quercus spp.), and silk tassel (Garrya spp.). Characteristically, soils are dry, rocky and low in nutrients and the species composition is related to slope, exposure, available moisture, soil type, and fire frequency. Most of the vegetation to be cleared for the power plant site will be in California mixed chaparral.

Characteristic of the serpentine chaparral community are clumps of vegetation where sufficient topsoil and moisture exist. The serpentine soils are highly erodable, nutrient deficient, and contain elements toxic to many plant species, thus effectively restricting the growth and establishment of many species. Plant species which do occur on the serpentine soils are Jepson's ceanothus (Ceanothus jepsonii), chamise, leather oak (Quercus durata), Sargent cypress (Cupressus sargentii), and whiteleaf manzanita (Arctostaphylos viscida). Serpentine chaparral is found on the southwest portion of the leasehold and outside of the leasehold to the northwest.

The chamise chapparal plant community is dominated by chamise (Adenostoma fasciculatum); other brush species do occur but with much lower frequencies. Chamise chaparral occurs on hot, dry south and west facing slopes. The stands are scattered through the central portion of the leasehold. Clearing for the power plant site will remove part of a chamise chaparral stand.

The barren habitats are areas nearly devoid of vegetation due to soil conditions. In the vicinity north of the project, along the ridge of the Mayacmas mountains, areas of serpentine rock outcropping occur. To the south of the project are areas of geothermally altered soils, which also have restricted development of plant communities. Little Geysers is one of these areas. These two types of habitats are particularly important botanically because they support significant numbers and kinds of unique plants. Found on the serpentine barrens are the jewel flower (Streptanthus spp.), of which some species are listed as rare by the California Native Plant Society. The hot springs panic grass (Dichanthelium lonuginosum var. thermale), a state-designated endangered plant, is found in the geothermally altered areas.

The plant communities found at the proposed SMUDGEO#1 power plant site are the California mixed chaparral and the chamise chaparral. The chamise chaparral is located on the southern part of the power plant site with the mixed chaparral occuring over the rest of the area.

No rare or endangered plant occurring on Federal or state lists have been found on the power plant site or on areas that will be disturbed during development of the leasehold. Species on the California Native Plant Society lists are known to occur in The Geysers KGRA but have not been reported in the leasehold.

An on-site field survey for rare and endangered plants was conducted during June 16 - 18, 1980, at the power plant site, and a habitat search was conducted for areas within a one mile radius zone of the site (Osterling, 1980; AFC Response August 11, 1980). Eighteen plant species potentially occur in the area based on available information and agency lists of potential plant species. None of the rare and endangered plant species were found, although potential habitat areas were identified and examined.

IMPACTS

The primary vegetation impacts associated with the proposed project will result from (1) direct disturbance or removal of vegetation during construction and maintenance activities, and (2) aerosol deposition of toxic substances on vegetation or accumulation of these substances in the soil. These impacts will result from activities associated with the power plant, transmission lines, and steam fields. These two impacts are also of concern because of their cumulative nature over time and over the full Geysers KGRA.

Losses Related to Construction

Development of the proposed power plant and its associated steam supply field will result in removal of 57.4 acres of vegetation based on estimates from Figure 8 and the AFC (AFC, p. 5-76); revegetation will occur on some of the cut and fill slopes. The total loss includes 10.5 acres for the power plant, one acre for the transmission line towers, access roads, and line clearing, 22.5 acres for well pads,* 7.3 acres for steam pipelines,* and 16.1 acres for roads. The greatest vegetation loss, approximately 90 percent, will be to mixed California chaparral vegetation. Because of the abundance of chaparral in The Geysers area, this loss is not considered significant for SMUDGEO#1 project by itself. There will be some loss from other plant communities at the well pad on the southwest corner of the leasehold, along the main access road and steam pipelines. Cumulative biological impacts are discussed later in this section.

Losses Related to Operation

While vegetation removal is an easily understood and documented impact associated with geothermal development, impacts from toxic substances are not. Geothermal steam contains boron, hydrogen sulfide (H_2S) and salts, all of which are potentially toxic to vegetation. Cooling tower drift, steam well venting, and other releases of steam or steam condensate have resulted in damage, stress or even loss of some plants. Vegetation stress has occurred at other power plant units, although the extent and severity of stress differs at each unit.

Available information also indicates that the zone of affected vegetation at some of the existing power plant units has increased over a period of years. This may be associated with increased levels of boron occurring in the circulating water of the cooling towers (Malloch, 1979). The significance of these vegetation impacts from cooling tower drift for the life of the power plant can not be determined from available data.

*For information and environmental documentation on leasehold development aside from the power plant, refer to: Environmental Assessment, USGS.

PGandE is conducting a study on the effect of cooling tower drift on vegetation. The study will measure vegetation stress and damage near operational and pre-operational units. The mixed chaparral vegetation around SMUDGEO#1 is similar to that around PGandE Geysers Unit 17, except for the chamise chaparral stands. Studies on drift effects to mixed chaparral will be included in the PGandE drift monitoring program.

Experience at existing plants indicates that the type of H_2S abatement system used affects the impact of drift. After Units 5 and 6 were retrofitted with the iron catalyst abatement system, increased vegetative dieback was observed. PGandE does not yet have enough information on the Stretford abatement system to assess its impact on vegetation, but preliminary results indicate less damage than under the iron catalyst system.*

The drift elimination specification for the SMUDGEO#1 power plant cooling tower is set at a drift loss rate of .001 percent of the 125,000 gallons per minute (gpm) circulating water mass, or 1.25 gpm. This is below specification drift loss rates for existing Geysers units for which there is information on vegetation effects. While the 1.25 gpm drift is a reduction in water loss from the tower, the impacts on vegetation also are affected by the amount of boron in the steam supply, which is the source of boron in the circulating water. Therefore, it is not certain to what extent drift will have an impact on the SMUDGEO#1 project area. CEC staff does not believe that this impact could preclude development of the project; however, it is not possible to say at this time that the impact is insignificant (See Mitigation Measures).

Rare and Endangered Plants

Since no species have been identified within the development areas or a one-mile radius of the power plant site, no impacts to plant species occurring on the state and federal rare and endangered plant lists will occur (Osterling, 1980; AFC Response August 11, 1980).

Plant Species of Special Concern and Areas of Critical Concern

Of the 18 species, which included species on the California Native Plant Society list, species on the Bureau of Land Management and U.S. Fish and Wildlife Service lists for The Geysers area, which were considered in the site studies, none were found. No impacts will affect plant species of special concern.

Areas of critical concern near the project leasehold include Cobb Creek, Calm Creek spring, Birdsong Meadow, riparian areas, and barren areas. Of these areas only the barrens are areas of critical vegetation concern. The importance of the barrens areas which support rare and endangered plants is discussed in previous paragraphs on these species. The other areas of critical concern were considered during the plant surveys and no plant species of special concern were found within the one mile zone of influence.

*Source: Frank Cahn, PGandE Horticulturist, October 6, 1980.

MITIGATION MEASURES

Construction

The disturbed areas associated with the power plant pad development and the main access road will be revegetated. The power plant site revegetation methods are described in the AFC (pp. 5-85 to 5-87A, Revised June 1980). Information on proposed grass, herbaceous, and shrubs species to be used at the site and the density of the plantings are presented in the Wildlife Mitigation Plan (AFC Response, 9/3/80). The cuts and fills resulting from upgrading of the existing fire road from Socrates Mine Road to the power plant will be revegetated.

Vehicle access to nonessential trails in the vicinity of the power plant will be restricted. This will allow natural vegetation to re-establish itself along the trails.

Disturbed areas around the transmission towers will be hydromulched and seeded. Where possible, root crowns and burls will be left intact to facilitate resprouting.

In order to preserve a portion of the mixed evergreen forest, SMUD altered its original plan for a sedimentation basin to be constructed below the power plant to the northeast in a drainage into Cobb Creek. Instead, a check dam drainage system with cross ditches will be constructed on the fill slope. This system will be designed to trap sediments from slope runoff and provide for the removal of the sediment.

When implemented, the revegetation efforts will, to the extent that they include native species, partially compensate for the loss of existing plant communities and will contribute to early re-establishment of vegetation in disturbed areas.

Mitigation efforts associated with well pad development and steam pipelines are discussed in the federal Environmental Assessments, (USGS, 1975, 1979, 1980). Revegetation of cut and fill areas using grass and herbaceous species constitutes the principle mitigation measure.

Operation

The 0.001 percent drift design for the cooling towers is a reduction from earlier designs for towers in use in The Geysers area. SMUD will monitor the effects of drift on vegetation (AFC, p. 5-87B, Revised June 1980). A detailed monitoring program was submitted to the CEC for review in December 1980.

WILDLIFE

SETTING

The wildlife resources of the site are described in the Application for Certification by Sacramento Municipal Utility District. (SMUD, 1980, pp. 5-48 to 5-76 and Appendix H) In addition to a literature survey and general site reconnaissance, small mammal live-trap transects were conducted near the plant site in October and November 1979, songbird transects were made in May 1980 (AFC Response, 6-3-80), aquatic surveys were conducted in Big Sulphur Creek in October 1979, and a study to determine the presence of ringtail was conducted in May 1980. (AFC Response, 6-3-80)

The power plant site is located on a spur ridge of the Mayacmas Mountains. The power plant and adjacent well pad are located on the north side of the ridge; the other well pads are located on the south slopes. Most of the leasehold, a south facing slope, is covered by chaparral. The northern portion of the leasehold, a north facing slope above Cobb Creek, contains mixed evergreen forests. These forests are also found along the creek drainages on the south facing slopes. About 1,155 feet south of the power plant site on Calm Creek is a small spring which provides a year round source of water for wildlife. Intermittent sources of water occur along other portions of Calm Creek and Panic Creek, which drain the south facing slopes of the leasehold, and Cobb Creek, which receives drainage from the north facing slope. All of these creeks drain into Big Sulphur Creek.

Evidence of an extensive burn within the last 15 years covers much of the leasehold. On the north facing slope many of the old conifers killed during the fire remain as snags, important habitat for some wildlife species. Young conifers are now growing and replacing the lost trees.

The chaparral is the most extensive habitat in the project area. It supports a variety of small mammals, migratory and resident birds, and a year round population of black-tailed deer (<u>Odocoileus hemionus columbianus</u>). Mixed chaparrals form an excellent habitat for small mammals. Population densities are usually high, and there is a greater variety of species than in any other habitat. Overall wildlife value for large stands of chaparral habitat by itself is not considered to be high because of the absence of water and the limited diversity in vegetation type and species. Value depends partially on the age of the stand; chaparral stands over 30 years old are considered decadent and of low wildlife value.

Of greater wildlife value are the mixed evergreen forest and associated riparian habitats along the creeks and drainages. These habitats are composed of a variety of plant types and species and, as a result, support a large and diverse assemblage of birds, large and small mammals, reptiles, and amphibians. The presence of water and moist conditions further increases the value of the riparian habitat and mixed evergreen forest. On the leasehold the riparian and forest habitats enhance the value of the adjacent chaparral habitat.

Based on the survey of the literature and on visual surveys, no fish species were identified as occurring in the upper reaches of Cobb Creek and Calm Creek which occur within the leasehold. Rainbow trout (Salmo gairdneri), California roach (Hesperoleucus symmetricus), and suckers (Catostomus occidentalis) occur in Cobb Creek below the major falls; these falls preclude fish passage upstream. The flow of cool waters from Cobb Creek into Big Sulfur Creek is important in maintaining the trout population in the section of Big Sulphur Creek below Cobb Creek. Natural thermal discharges into Panic Creek and its intermittent flow have precluded development of fish populations in this creek.

Three legally protected wildlife species (federally designated "threatened or endangered species" and state designated "rare, endangered, and fully protected species") have ranges which include the project area: the American peregrine falcon (Falco peregrinus anatum), golden eagle (Aquila chrysaetos) and ringtail (Bassariscus astutus).

The American peregrine falcon, a federal and state designated endangered wildlife species, could occur within the project area. This bird is listed by both the state and federal governments as endangered. The project area is about 10 miles northwest of the nearest peregrine falcon eyrie which is in current use. This eyrie is in the vicinity of Mt. St. Helena, an area which has been designated as "Critical Habitat" for the peregrine falcon. (U.S. Fish and Wildlife Service, 1977) Although extensive observations have been made of cliffs on the south and west sides of Cobb Mountain, located approximately one and one-half miles northeast of the project area, there is no evidence of a peregrine falcon eryie in current use. The possibility exists that peregrines do hunt over the project area occasionally, but such usage is believed to be extremely infrequent.

Golden eagles, a state designated fully protected species, are regularly sited in the vicinity of Cobb Mountain. No active nests are known within The Geysers-Calistoga KGRA. Due to the lack of potential nesting areas--cliffs and tall trees--the project area is not considered to be suitable nesting habitat. The project area is within the general foraging areas used by this species.

The ringtail, a small raccoon-like mammal, is a state designated fully protected species. A live trapping survey by Biosystems Analysis, Inc., (AFC Response, June 3, 1980) did not result in any captures of this species, but signs of their presence were evident, and the area judged to be highly suitable. Based on available information, the project area may be used for foraging by this species.

Species of recreational value which are known or expected to occur in the area include the mountain quail (Oreortyx pictus), California quail (Lophortyx californicus), band-tailed pigeon (Columba fasciata), mourning dove (Zenaida macroura), brush rabbit (Sylvilagus bachmani), black-tailed jack rabbit (Lepus californicus), western gray squirrel (Sciurus griseus), black-tailed deer (Odocoileus hemionus columbianus), and black bear (Ursus americanus). Of these, the black-tailed deer is by far of the greatest recreational importance. Densities for the deer may range as high as 0.4 to 0.7 deer per acre in the chaparral habitats (Meneghin, et al., 1977). The leasehold is used extensively by deer throughout the year. Suitable habitat for food, cover, and water is found within the leasehold, and moderate fawning habitat is present in the northern edge of the leasehold.

Trout, a recreational fish species, do not occur within the creeks on the leasehold. No fish or wildlife species of commercial importance are found on the leasehold.

A few animals are identified in the AFC (p. 5-69 to 5-71) as occurring in the KGRA and possibly occassionally occurring in the project area which have been considered by the California Department of Fish and Game as species of special concern. These species included the merlin (Falco columbarius), Cooper's hawk (Accipiter cooperii), the sharp-shinned hawk (Accipiter striatus), prairie falcon (Falco mexicanus), purple martin (Progne subis), and mountain lion (Felis concolor). Of the bird species, only the purple martin was observed breeding on the site during the bird survey by Biosystem Analysis, Inc. (Response, 6-3-80) Purple martins were observed using a large snag in the north portion of the leasehold. The other species may occassionally use the leasehold during foraging activities.

No areas of critical concern have been identified for the power plant site, but areas have been identified on the leasehold and within areas subject to influence by the power plant development. The areas of critical concern are (1) to the northeast, a rather dense riparian habitat along Cobb Creek, including the upstream area below the SMUD power plant, (2) a small spring and the riparian associated hardwood-conifer vegetation surrounding the spring which extends along the Calm Creek drainage located on the south facing slope downhill from the power plant site; and (3) Douglas fir snags in the northern portion of the leasehold and along the upper portion of Cobb Creek. In general, these areas of critical concern are of local wildlife value, providing a diversity of habitat and a water source not abundantly found in the area.

Another area of critical concern identified during the project review is Birdsong Meadow (CDFG letter, April 18, 1980). This area is about two miles southeast of the power plant site. The main access road for the project passes through this meadow. Studies conducted on Birdsong Meadow and Oatgrass Meadow, a nearby meadow, conclude that these meadows support a diverse flora and receive more wildlife use than most habitat types within the Big Sulphur and Kelsey Creek watersheds (Hall, et al., 1979).

There are no known unique wildlife ecological relationships identified as occurring in the planned project area or that are expected to be affected by the project. Existing relationships are typical of those found in similar habitats throughout The Geysers KGRA. The nearby streams, Cobb Creek and Calm Creek, and the spring on Calm Creek, provide water sources which enhance local wildlife use above that which would be found in locations farther from permanent water sources. Because of the variety of habitats within and near the project area, there is locally a high diversity of wildlife.

IMPACTS

The primary impacts to wildlife from development of the power plant and the associated steam facilities will occur as a result of vegetative losses, disturbance from construction activities, and the release of potentially toxic substances during operation. The loss of any vegetation will necessarily result in the loss of some wildlife. The significance of this impact depends on the extent of vegetation loss, the number and kind of wildlife permanently residing in the area or using it transiently, and the amount of habitat loss relative to other habitats of similar value and quality. Because the population levels for most wildlife species are not known for the leasehold, a quantifiable estimate of impacts cannot be made.

Development of the project, including both the power plant site and well pads, will affect wildlife by loss of chaparral habitats (mixed chaparral, serpentine chaparral, and chamise chaparral). The power plant construction in the northwestern portion of the leasehold will eliminate primarily mixed chaparral habitat. The wildlife species most impacted will be the smaller species with restricted home ranges, such as brush rabbit, dusky-footed woodrat, deer mouse, pinyon mouse, and brush mouse. There will be some displacement and a resulting decrease in the number of larger species such as the black-tailed deer, grayfox, and coyote due to a decrease in foraging habitat. The loss of about 55.7 acres of chaparral vegetation has the potential for reducing the number of deer [.4 to .7 per acre (Meneghin, et al., 1977)] by approximately 28 to 39 individuals. In dense chaparral, creating such openings as would occur along roads, pipelines, well pads, and power plant clearings, could enhance wildlife habitat by improving access for larger species such as deer, and create areas of grass or low herbaceous cover which would improve the habitat to some extent for the black-tailed deer and seed-eating rodents and birds. With the diversity of habitat and existing roads and trails on the leasehold, this potential enhancement value is likely to be minimal.

Disturbance to wildlife will also result from increased human activity and noise in the area during construction and operation activities. This will occur at the power plant, steam wells, and along roads associated with the project. The extent of this impact is uncertain. Some reduction in bird nesting and wildlife use is likely to occur adjacent to areas of high human activity and noise, particularly in habitats adjacent to the power plant and well pads. Species sensitive to human activity, such as gray fox, bobcat, and mountain lion, may entirely avoid the area. These species may be replaced by species less sensitive to disturbance.

Both Cobb Creek and Calm Creek can be potentially affected by increased soil erosion and possible accidental releases of toxic materials from the proposed project. Soil erosion and sediment deposition in these creeks will increase because of vegetation removal and soil disturbance during construction. The amount of sediment deposition and resulting impacts to aquatic life in these streams will depend on the effectiveness of the mitigation measures described in the water quality and soils section of this EIR. Increased sedimentation in Cobb Creek or removal of vegetation which would cause an increase in the temperature of the creek could affect the trout population in the lower portion of Cobb Creek and in Big Sulphur Creek, since local trout distribution in Big Sulphur Creek is partially dependent on the inflow of cool water from Cobb Creek.

Potential erosion into Calm Creek, particularly from cut and fill activity in constructing and maintaining the main access road in the vicinity of the power plant, could cause a decrease in the availability of water to wildlife at the spring on the upper portion of the creek. There is also a possibility that the extensive cut and fill operations associated with development of the power pad, roads, and well pads in the area above the spring could alter natural drainage patterns which contribute to the flow of water at the spring.

Development of the main access road could alter water flows which support the wet portion of Birdsong Meadow and erosion from the road could deposit silt in the meadow. The altered natural drainage pattern caused by the existing road has caused deep gully erosion in the meadow. The development of the road between Birdsong Meadow and the power plant site could also increase erosion into Anderson Creek, which could affect the downstream residential trout population.

The increased siltation into these streams from development is likely to result in a significant impact, unless effectively mitigated.

Release of toxic materials such as steam condensate, reinjection fluids, drilling wastes or accidental spills during chemical transport into Cobb Creek, Calm Creek, and Anderson Creek can potentially cause loss of fish and aquatic organisms. Accidental spills of these materials have been recorded on numerous occasions in the geothermal development area. The extent of their impacts will depend on the amount and kind of material released, the stream they are released into, and the volume and flow of water present in the stream. Release of these materials may cause a significant impact.

The proposed project will impact areas of critical biological concern to varying degrees. There will be limited direct disturbance of the riparian habitats; however, there is a potential for impact on the creeks from erosion, sedimentation, and accidental spills as discussed above.

The dense riparian habitat along Cobb Creek and Calm Creek is within 2000 feet of the power plant, a zone which may be affected by cooling tower drift (Malloch, et al., 1979). Vegetation within this distance at existing power plant units have shown evidence of stress and damage. In addition to the potential for some loss of the mixed evergreen forest vegetation from drift, there would be the associated potential for an increase in water temperature in Cobb Creek and Calm Creek due to the loss of shade from the trees. Any upstream increase of water temperature in Cobb Creek could contribute to cumulative effects on local trout distribution in Big Sulfur Creek. Also, the loss of vegetative cover caused by drift could increase the erosion potential into the creeks. Increased sedimentation could affect the trout populations in Cobb Creek and Big Sulphur Creek and decrease the availability of water for wildlife at the spring on Calm Creek. The significance of these potential impacts cannot be determined at this time because they are dependent on the boron levels in the steam supply, on technology used to remove other pollutants from the drift, and on local wind patterns.

The project is not expected to have a significant impact on the rare peregrine falcon or the protected golden eagle and ringtail. The peregrine falcon and the golden eagle are uncommon in the project area, and no project activities are likely to significantly disrupt any foraging that may infrequently occur here. The extent of use of the area by the ringtail is uncertain. While the project will eliminate potential ringtail habitat, no known breeding or critical feeding areas have been identified in the vicinity of the power plant, well pads, or access roads.

Recreational species will be adversely affected by the project. As indicated in the vegetation impacts subsection, the loss of chaparral habitat has the potential for reducing the number of deer by approximately 28 to 39 individuals.

The potential loss of mixed evergreen forest from drift could also adversely affect deer as well as feeding and nesting areas for western grey squirrels, mountain quail, and band-tailed pigeon. California quail, mourning dove, brush rabbit, and black-tailed hare will be impacted by the loss of chaparral vegetation. Black bear may abandon the area because of increased noise and human activity.

As discussed above, potential impacts that could affect water quality and temperature of Cobb Creek could have adverse effects on the distribution of the local trout population and other aquatic organisms in Cobb Creek and Big Sulphur Creek.

The raptor species identified as species of special concern were not frequently observed in the project area, and disruption of this small portion of their foraging area, when considered by itself, would not be significant. The increased human activity and noise associated with construction and operation of the project will likely cause an alteration and decrease in mountain lion usage of the area for foraging.

The purple martin nest sites in the snags are close enough to the power plant to be in the zone affected by cooling tower drift. Studies indicate that in the house martin (Delichon urbica), a bird closely related to the purple martin, nesting is reduced in areas of high pollution levels (Newman, 1980). Depending on the local drift pattern, there is a potential for a decrease in nesting use around the power plant by the purple martin.

The potential effects on the forested areas and the spring on Calm Creek from drift have been discussed above. Additional potential impacts could occur to the spring if development of the pad sites and road disrupt the water source to the spring or if erosion from cut and fill construction cause sediments to fill up the spring.

No direct impacts are expected to affect the Douglas fir snags. These snags are outside of the area that will be cleared for development. Noise and other construction activities may temporarily reduce bird usage and nesting in the snags.

Unless most of the individual impacts upon the areas of critical concern, legally protected species, and recreational species are effectively mitigated, the total impact of the project would be significant to the biological resources.

MITIGATION MEASURES

SMUD discussed general mitigation measures in the AFC (p. 5-85 to 5-89) and submitted a Wildlife Mitigation Plan (AFC Response, 9/3/80). Additional details of the plan will be developed during public workshops with the CEC biology staff, and other concerned agencies: California Department of Fish and Game, United States Fish and Wildlife Service, Bureau of Land Management, and United States Geological Survey.

The measures proposed by SMUD in their Wildlife Mitigation Plan consist of:

1. Sediment control. The sediment pond originally described in the AFC has been replaced by a check dam drainage system along the fill on the northeast facing slope. The check dams will be designed so that collected sediments can be removed. The check dam design will eliminate the adverse effects of locating a large sedimentation basin in the Cobb Creek drainage and associated removal of mixed evergreen forest. If this check dam functions as planned, sediment will be effectively controlled from entering Cobb Creek in the drainage from the power plant portion of the project. However, this is a combined pad on which both the power plant and a well pad will be constructed. No sedimentation retention structure has been proposed as mitigation for collecting sediment in the drainage off of the well pad portion of the combined pad.

2. Protection of Birdsong Meadow. The mitigation for widening the road through Birdsong Meadow for construction traffic will include paving the road and limiting vehicle access onto the meadow. The paving and drainage improvements will reduce impacts of runoff and fugitive dust on the adjacent roadside habitats. The paving should also decrease the amount of sediment entering the local drainages during the rainy season. With the permission of the landowner, the meadow will be fenced along the access road to prevent nonessential vehicular use of roads now traversing the meadow.

   In addition to these measures, the California Department of Fish and Game has recommended measures to reduce the impact to wildlife caused by increased vehicular traffic and noise (CDFG letter, 4-18-80). These measures include the use of shrub plantings along the road to screen the meadow from the traffic, and to provide additional wildlife cover. Some of the mature trees removed from clearing areas along the road should be erected as snags in the meadow to increase wildlife habitat diversity, and to provide nesting, roosting, and feeding areas.

   The CEC biology staff is particularly concerned about adverse impacts to Birdsong Meadow since it was designated as an off-site area to be used in compensation for impacts to Oatgrass Meadow associated with development of PGandE Geysers Unit 18. CEC staff recommends that the measures presented by CDFG be a requirement of the SMUD project, that the new road be designed to avoid gully erosion in the meadow, and erosion caused by the existing road be corrected.

   SMUD will monitor the wildlife use of the meadow and the effectiveness of the erosion control measures. If implemented measures are ineffective, SMUD will take corrective action.

3. Limiting access to nonessential trails. Access to some of the existing vehicle trails in the vicinity of the power plant will be limited.

4. Minimum development of the emergency access road. Development of this road which will connect the power plant with the road to PGandE Units 9 and 10 will be kept to a minimum. Access from the main road will be limited by

installing a locked gate, and branch trails of the access road will be blocked.

5. The main access road from Socrates Mine Road to the power plant will be upgraded to accommodate construction traffic. Following construction, this road will be paved to control sedimentation into local drainages. Cuts and fills will be revegetated to control surface erosion.

6. Revegetation of cuts and fills. To aid in erosion control, the cut and fill slopes at the power plant and along the main access road will be revegetated with grass and herbaceous species. Also, shrub species of value to wildlife will be planted in selected areas at the power plant site and Birdsong Meadow. The list of species to be used and their densities is given in the Wildlife Mitigation Plan (AFC Response, 9/3/80). The methods of planting are described in the Revegetation Monitoring Plan (Response 6-3-80). A mixture of topsoil and chipped vegetation removed during plant site construction will be stored near the site and spread on the slopes prior to hydroseeding.

7. Controlled burns. Controlled burns in chaparral habitats can increase the amount of browse available to deer, and increase habitat diversity which can be beneficial to other wildlife species. This technique is most effective in older chaparral stands which are very dense, have a high amount of woody material, and where uniform stands cover large areas. Three areas on the leasehold have been proposed for controlled burns to compensate for loss of habitat caused by power plant development. The burns will cover approximately 12 acres in each 10-year period during the life of the power plant. All burns are located within the Aminoil (CA-1862) leasehold and will be approximately two to five acres in size. Evaluation for specific burn sites will include factors such as slope, exposure, maturity of vegetation, quality of surrounding habitat, topography, increased erosion potential as a result of burning, and the potential increased quality of edge habitat. The burns will be conducted to manage for existing chaparral habitat and will not be designed to function as firebreaks. SMUD will contribute funds to BLM so that this federal agency can select and conduct the prescribed burning.

8. Cooling tower drift. SMUD will prepare a drift monitoring program. Emphasis will be placed on monitoring potential effects upon the mixed evergreen forest northeast of the power plant site. CEC staff recommends that SMUD monitor the purple martin's use of the snags during the nesting season.

In addition to the above measures, the Wildlife Mitigation Plan discusses measures that will be taken to protect the Calm Creek drainage and the spring. The access road to the power plant which crosses the upper drainage along the spur ridge will be about 1,000 feet above the spring. The road design will direct most of the runoff from the road and cut slopes to a rip-rapped discharge on the northeast slope of the site which drains into Cobb Creek. Some runoff will drain into Calm Creek. Construction activities and the drainage design should not disrupt or disturb the spring on Calm Creek. To assure no significant alteration of Calm Creek occurs, SMUD will monitor water quality and flow in the area of the spring. In the event of adverse impacts, SMUD will develop mitigation in cooperation with CEC, CDFG, BLM, and USGS staff.

CUMULATIVE VEGETATION AND WILDLIFE IMPACTS

Vegetative losses associated with construction and operation of power plants will be significant on a cumulative basis from the full geothermal development of The Geysers KGRA. In view of current and proposed geothermal development, an estimated 2,000 MW by 1987 (CEC, 1979), the potential exists for losing a substantial amount of vegetative cover in The Geysers KGRA. The significance of this impact will depend on its location and distribution in the KGRA and the development, implementation, and effectiveness of mitigation plans. Around existing operating units, PGandE Units 1-11, a maximum total of 100 hectares (247 acres) of vegetation exhibits stress from cooling tower drift (Malloch, et al. 1979). This acreage value also includes losses associated with clearing of vegetation for pads and roads that happen to be within the zone of drift influence. At this time, no quantification of total vegetation loss associated with other aspects of full geothermal development, such as clearings for power plant pads, well pads, steam pipelines, roads, maintenance facilities and other disturbance facilities and other disturbances is available. Ramifications of vegetation losses will cause potential impacts to fisheries from increased erosion and associated sedimentation loss of wildlife habitat and reduced natural aesthetic values as geothermal industrial development displaces the existing natural plant communities.

In addition to individual project-specific impacts, full development of The Geysers KGRA is likely to result in a significant cumulative effect on the fish and wildlife of the region. Combined habitat losses, increased human activity and disturbance, increased soil erosion and sediment deposition in streams which now support fish populations, decreased air quality, accumulated toxic substances from cooling tower or steam wells, improved access and the associated increase in vehicular use and trails, and a greater potential for accidental spills will result in a loss in numbers and quality of wildlife and fisheries. Most of these impacts cannot be quantified or evaluated at this time because of incomplete data on the long-term nature of the impacts and the geothermal areas which will be developed. Studies should be conducted to obtain the needed information and a plan should be prepared to mitigate the impacts of full geothermal development.

However, it is certain that the accumulation of many insignificant impacts over a long period of time and over the entire Geysers KGRA will result in significant biological effects unless proper planning and mitigation are agreed to and effectively implemented by all the groups involved and at all stages of the geothermal development. If unmitigated, the impacts of the SMUD geothermal unit would comprise a substantial contribution to such significant cumulative effects.

WATER QUALITY

SETTING

The 396-acre leasehold (Unit No. 7 West, CA 1862) drains to Cobb and Big Sulphur Creeks and Anderson Creek watersheds (AFC, 1-1). All but about 15 acres of this leasehold is in Sonoma County and the Big Sulphur Creek drainage, which is tributary to the Russian River. The 15-acre portion, located in the north-eastern corner of the eastern arm of the leasehold boundary, lies in Lake County and is tributary to the headwaters of Anderson Creek. Anderson Creek is tributary to Putah Creek, which flows into Lake Berryessa and eventually to the Sacramento River and San Francisco Bay.

Beneficial uses of these streams are defined by the appropriate Regional Water Quality Control Board (RWQCB) in their Water Quality Control Plan (WQCP) for the appropriate watershed. The Cobb Creek-Big Sulphur Creek drainages are under the jurisdiction of the North Coast RWQCB, and beneficial uses are prescribed in their WQCP, North Coast Basin (1B). The Anderson Creek drainage is within the Central Valley RWQCB region, and its beneficial uses are identified in the WQCP Sacramento River Basin (5a).

Principal beneficial uses of Cobb Creek and Big Sulphur Creek, as identified by the NCRWQCB and during past CEC geothermal regulatory cases, are recreation and aquatic and wildlife habitat. Significant information on the quality of the waters of these two creeks is available as a result of studies done by PGandE (1978), Parametrix (1975), NCRWQCB, CDFG, and Ecoview (1974), Atlantis Scientific (1975), Enviros (1973), and RFL (continuous), who have undertaken individual project-specific studies which contain information applicable to this watershed.

The results of water quality monitoring in Anderson and Putah Creeks are available through the CDFG, CVRWQCB, Parametrix (1975), Atlantis Scientific (1975), and Enviros (1973). Beneficial uses of this watershed include recreation, aquatic and wildlife habitat, domestic water supply, and irrigation and stockwatering.

These reports show that water quality in the study areas is adequate to protect the beneficial uses throughout most of the year. However, during the summer season the quality of the streams is marginal, especially in the Big Sulphur Creek Basin. The increased human activity of the summer months coupled with warmer water temperatures and lower flows results in lower quality surface waters. These conditions, whether natural or introduced, help to concentrate pollutants in the waterway systems, thereby posing potential harm to aquatic life and limiting the use of these waters.

Water quality of groundwater in the area is difficult to assess, due to the absence of available water wells in the area (AFC 1.3.1.1.2). The leasehold contains no known groundwater aquifer or springs that will be directly affected by the power plant construction (AFC 5.7.4.2.5).

IMPACTS AND MITIGATION MEASURES

Steam Field Development--Impacts

Steam field development involves constructing of roads and well pads, drilling geothermal wells, and the constructing steam transmission pipelines. Impacts from these operations include erosion and an increase in the opportunity for spills of potentially toxic substances.

Initial development of the steam field includes roadways, well drilling pads, well drilling (both exploratory and production), mud sumps, and equipment landings. Aminoil, the developer of the steam field, must comply with waste discharge requirements from both the NCRWQCB and the CVRWQCB, land-use permits from Sonoma and Lake counties, and, because this is a Federal leasehold, the Geothermal Resources Operational (GRO) Orders 1-4, administered by the U.S.G.S. Aminoil will be responsible for control and mitigation of water quality impacts due to development in leasehold Unit No. 7 west, except for those resulting from construction of the actual power plant. SMUD is responsible for mitigating power plant impacts.

The waste discharge requirements specify criteria for construction and operation of drilling pads and sumps. The pads will be built to minimize erosion and will be adequately contoured to control drainage problems. The drilling mud sumps will be designed to contain all waste water discharged during the lifetime of the well(s), and must be lined to provide a permeability coefficient of 1×10^{-6} cm/sec (allowing a percolation rate of one foot per year or less) (CVRWQCB, Order No. 78-184, and NCRWQCB, Order No. 78-17). (Aminoil is designing the sumps with a clay liner compacted to 0.4×10^{-6} cm/sec--more stringent than state requirements) (AFC 1.2.2.2). In addition, there will be no intentional discharge of wastes from the drilling pad to any surface water drainage course. SMUD is required to measure the quality of the waters in the area during construction periods, and in the event of a spill or discharge the RWQCB's require Aminoil to perform such monitoring.

The county use permit for the steamfield outlines erosion control practices to be utilized, stipulates setbacks or areas not to be disturbed, and restates the requirements of the RWQCB.

GRO Orders 1-4 outline requirements and definitions for the following activities: proper well drilling, spacing, completion, testing, plugging, and abandonment; exploratory operations; requirements and plans; and an environmental monitoring program, to be initiated one year prior to commercial operation.

Well sumps have occasionally failed in the past, releasing the contents into nearby drainages, and sometimes directly into streams. The effects resemble those of erosion and sedimentation (turbidity and siltation), but the possibility of toxic components being present in the discharge fluids also exists. The concentration of any such component contained in the discharge would be highly diluted with the flow reduced by overland travel. Therefore directly attributable impacts from such discharge would be insignificant.

Well blowouts are another source for water quality problems. The release of steam, drilling muds, and hot water could affect the water quality of a stream.

The steam condensate (hot water) does contain high concentrations of dissolved minerals and other toxicants, which could adversely affect the beneficial uses of the stream.

Sump failure and well blowouts are rare and only occur under unusual circumstances.

Steam Field Development--Mitigation Measures

Measures identified to mitigate water quality impacts associated with steam field development include the following:

- Line drilling mud sumps for containment;
- Design, construct, and stabilize the drilling pad to minimize erosion;
- Minimize the number of pads and access roadways;
- Properly dispose the drilling mud from the sumps; and
- Cement and case the wells to 6,500 feet, and utilize new headworks and pressure release valves.(NCPA, AFC, 1979).

Aminoil will utilize the above measures to curtail environmental impacts from steam resource development.

Power Plant Operation, Accidental Spills--Impacts

A geothermal power plant utilizes condensed steam for cooling water. This water is recycled numerous times, which results in a multifold increase in the concentrations of the contained constituents (ammonia, boron, sulfates, arsenic, mercury, etc.). This fluid is considered toxic/hazardous by the California Department of Health Services, Hazardous Materials Management Section (Batham, 1979, NCPA).

The power generation system also includes a Stretford hydrogen sulfide (H_2S) abatement unit. This system utilizes Vanasol, ADA, and an alkali solution to remove H_2S from the condensate stream before it enters the cooling towers. The by-product of this treatment is sulfur. CDOHS, HMMS considers both of the chemicals used in the Stretford system and the sulfur by-product to be toxic or hazardous (Batham, 1979, NCPA).

Spills allowed to leave the power plant pad and reach surface waters could have toxic effects on the aquatic life, change the chemical composition of the water, cause vegetation die-off (which could result in future erosion and sedimentation), and otherwise impair the beneficial uses of these waters in the immediate area and downstream. The impact significance of such a spill is dependent on several factors, i.e., the type of condensate constituents and their concentration, spill location, amount of spill, the existing quality of the receiving water, and the weather.

Both on-site and off-site spills of condensate have occurred at existing Geysers geothermal power plants and are likely to continue on an occasional basis. These spills have resulted from broken or leaking condensate pipelines, cooling tower basin or reinjection sump overflows, and other operational errors. Major spills have been documented the past 15 years by CDFG and NCRWQCB. Impacts appear to be short-term, and there have been few reported fish kills resulting from known spills.

Power Plant Operation, Accidental Spills--Mitigation Measures

Spills have usually originated through human error, and it is unlikely that they can be completely curtailed. However, action taken to prevent spills and their off-site discharge can be improved.

Currently operating geothermal power plants (constructed prior to the authority of the CEC) were designed and built without on-site spill containment systems. SMUD proposes (AFC 5.4.2.3) to pave the entire power plant pad with an impervious material, to provide containment areas within berms and sumps to collect and contain any materials which spill on the plant pad. These sumps, basins, etc., will be constructed to contain greater than twice the maximum potential spill, and the linings will be designed to meet a permeability coefficient of $1x10^{-6}$ cm/sec (SWRCB, 1979).

Spills in the Stretford system will be contained in a separate retention basin, and the chemicals will be routed to the cooling tower basin, then to the reinjection sump. Rainwater collecting in this area will also be redirected to the cooling basin for recirculation and ultimate disposal by reinjection.

Spills from the cooling tower basin will be contained in an area surrounding the basin. The basin itself is below "grade" (ground level) to minimize spills, and the pad is sloped to promote containment and collection of any spill. Spilled condensate will be returned to the basin for recirculation or routed to the reinjection disposal system (AFC 5.4.2.2).

Spills of materials or chemicals at other locations throughout the power plant facility will be contained on site and transported through sumps and drains to the cooling tower basin for recirculation or reinjection (AFC 5.4.2.2). The impermeable surface layer of the power plant pad and the berms and sumps will be constructed of either asphaltic concrete, asphalt, or concrete, and will prevent spilled materials from being absorbed into the soils percolating to groundwater, or being washed into a surface stream, and will provide for more immediate recovery and disposal of those materials.

The cooling tower basin is the primary receiving station for drainage and spill effluent, and is equipped with pumps capable of handling up to 400 gpm (the capacity of the reinjection system). The basin and the reinjection sump are equipped with alarm systems to alert power plant personnel in cases of malfunction. All systems which handle potentially toxic liquids, including the Stretford system, will be equipped with alarms to alert personnel in case of a malfunction or spill, higher than normal pressures, or high liquid levels. (AFC .1.3.3.)

SMUD also agreed to contain and inject all possible on-site rainfall runoff into the steam reservoir (AFC 1.3.13). This will minimize the potential of stray pollutants from general power plant operation and material spills from being washed from the power plant pad into off-site surface water drainages.

Injection of condensate and other chemical substances into the geothermal reservoir is a common practice in the KGRA, and is acceptable to the regulatory agencies (RWQCB, DOHS, USGS, CDFG, and CEC). No adverse effects are anticipated from this practice for the following reasons:

- The reservoir lies far beneath the ground surface and useable groundwater;
- Tight and clayey soils and rock strata are present; and
- Deep well casings will be installed (CEC-SRI study, 1977).

For control of off-site drainages, and in the rare event of an off-site discharge of rainfall, SMUD proposes to construct lined ditches across the toe of the fills to the northeast of the plant pad and along the access roads. These ditches along the power plant fill area will incorporate check dams and energy dissipators for sediment containment and control. These ditches will intercept runoff from the fill and cut areas, allow most of the soil particles to settle out, and channel the runoff water to eventual discharge through energy dissipation devices to the natural drainage tributary to Cobb Creek. Water discharged from this system to the natural drainage courses probably will not contain unnatural (introduced) substances; nor will it be more turbid than other natural drainages in the vicinity.

SMUD will file with the CEC a "Spill Contingency Plan" in conformance with NCRWQCB guidelines, NCRWQCB Order No. 74-151. This plan, similar to the one required of Aminoil for their steam field development, will cover operation of the power plant itself and includes general procedures for (1) notifying company and regulatory agency personnel; (2) spill containment and cleanup; and (3) sampling, monitoring, and reporting spill materials and resultant impacts.

Power Plant Operation, Sanitary Wastes--Impacts

Sanitary wastes will be of limited volume but, due to the slope and type of soils at the power plant site, these wastes cannot be disposed in a common septic tank-leachfield system.

Sanitary Wastes--Mitigation

SMUD will provide two lavatory facilities, with individual sewage lift stations, discharging to a secondary sewage treatment plant, outfitted with chlorination facilities for disinfection of the effluent. The effluent will be discharged into the condensate reinjection system after the cooling tower or reinjection sump basins to minimize the opportunity for contact with, or dispersion of, these wastes (AFC, 1.2.12).

This practice is acceptable to the RWQCB and CDOHS, responsible regulatory agencies (RWQCB, 1979). Any pathogens, or other waste by-products, will be killed or rendered harmless by the intense heat and pressure of the steam reservoir.

Cooling Tower Drift--Impacts

The effects on water quality of the deposition of boron, ammonia, and other constituents emitted in the cooling tower plume is unknown at this time. The cooling tower system employed by SMUD is designed to allow only .001 percent of the circulating water to be emitted as "drift," averaging about 625 lbs/hour (AFC, 5.3.1.2). The chemical composition of the drift depends upon the incoming steam quality and the effectiveness of the abatement systems within the power generation system. Testing and evaluation of PGandE's Units 13 and 15, when these units are on line and operating dependably, will provide this information.

The Lawrence Livermore Laboratory document, An Environmental Overview of Geothermal Development; The Geysers-Calistoga KGRA, Volume 6, Water Quality, 1978, analyzed the drift deposition problem and concluded that cooling tower drift from the newer units is not presently a significant water quality concern.

Cooling Tower Drift--Mitigation Measures

Because the direct effects of cooling tower drift on water quality have been studied and are considered insignificant, SMUD proposes no direct mitigation measures. However, if appropriate, SMUD will evaluate water quality impacts and will monitor soil and vegetation as needed. Water quality degradation may come from flushing accumulated contaminants, but would most likely be due to vegetation losses and ensuing erosion and sedimentation. SMUD will orient its cooling towers parallel to the direction of the prevailing winds at the project site in order to reduce the amount of emission from the cooling tower and to aid in dispersion characteristics.

CUMULATIVE IMPACTS

Geothermal development has many common denominators. Steam field exploration and development practices of the various developers in the KGRA are similar regardless of the county or watershed; terrain and geotechnical characteristics are similar throughout the KGRA; and the design, construction and operation of geothermal power plants are similar regardless of ownership.

Cumulative impacts of steam field development in the KGRA which can directly affect water quality include the loss of vegetation, increased erosion, increased roadway construction and use, more drilling pads, construction and use of sumps for disposal of drilling muds, alteration of drainages by spoil disposal and construction of the above physical features, the increase in heavy equipment traffic (increasing the opportunity for accidental spills) and the increase in overall activity associated with numerous projects in this concentrated area.

Cumulative impacts of power generation which can have a direct effect on water quality in the KGRA are primarily related to erosion, sedimentation, and accidental spills of potentially hazardous/toxic substances. Mechanisms by which the above could occur are as follows:

(a) Construction, use and operation of wider roadways, steam transmission lines, and the power plant itself;

(b) The need to dispose of increased amounts of spoil material;

(c) The transport of heavy equipment, with an attendant increase in heavy truck traffic;

(d) The transport of toxic/hazardous materials and wastes with an associated increased potential for accidental spills that could reach surface waters;

(e) Storage and handling of large volumes of steam and condensate;

(f) An increase in H_2S abatement facilities;

(g) Emission of potentially harmful constituents from cooling towers and venting mechanisms resulting in vegetation loss, soil contamination, erosion, and water quality degradation; and

(h) The overall increase in human and construction-associated activity in this small, confined area will also contribute to overall KGRA impacts.

Most of these impacts are felt immediately, and can be directly measured within the KGRA, and may eventually bring water pollution and the loss of beneficial uses to downstream users. Erosion and sedimentation, and the cumulative effects of pollutant discharges or spills, would present the greatest potential for affecting downstream water quality directly or as a continuing decline in upstream water quality aquatic resources.

The enforcement of requirements in regard to revegetation and erosion control methods and containment of wastes at drilling pads and power plant sites will be the most effective mode of mitigation for cumulative effects. Conscientious construction and operation of facilities within the KGRA is imperative to the success of any mitigation measure.

TABLE 2

Water Quality of Big Sulphur Creek,
At Points Below Cobb Creek & Calm Creek Influences

Characteristic	Units	STATION BS 17.8						STATION BS 18.7					
		1974			1975			1974			1975		
		May	July	Sept.	Jan.	Feb.	Mar./Apr.	May	July	Sept.	Jan.	Feb.	Mar./Apr.
Date	---	5/12	7/12	9/8	1/5	2/9	3/30	5/13	7/12	9/8	1/4	2/8	3/29
Time	---	--	1150	1000	1400	1145	1045	--	1025	1725	1430	1345	1320
Air Temperature	°C	11.7	18.8	16.0	5.6	9.4	14.4	28.3	19.5	20.5	6.1	11.1	18.3
Water Temperature	°C	14.6	20.5	18.5	8.3	10.5	12.0	20.3	18.2	21.5	7.6	9.7	13.4
Stream Flow	cfs	--	6.8	1.9	14.64	21.6	76.2	--	--	--	--	--	--
Total Coliform	MPN/100 ml[2]	93	64	>1100	--	--	--	--	--	--	--	--	--
Turbidity	JTU	<1	<1	<1	<1	70	<1	<1	<1	<1	6	45	<1
Color	APHA	<5	--	--	--	--	--	<5	--	--	--	--	--
pH	---	8.0	8.0	7.8	7.7	7.2	7.2	8.2	8.2	8.4	7.6	7.0	7.2
Alkalinity	mg/liter	124.2	156.4	232.9	118.0	44.9	81.8	128.2	160.6	244.4	113.0	37.9	72.7
Settleable Solids	ml/liter	<0.1	--	--	--	0.10	--	<0.1	--	--	--	0.10	--
Residue, Filtrable	mg/liter	20	--	--	--	22	--	10	--	--	--	155	--
Residue, Non-filtrable	mg/liter	0	--	--	--	29	--	0	--	--	--	9	--
Residue, Total	mg/liter	20	--	--	--	51	--	10	--	--	--	164	--
Boron	mg/liter	6.0	16.0	16.0	6.0	2.8	1.5	12.0	17.0	13.0	1.2	2.8	0.5
Carbon, Total organic	mg/liter	21.0	--	--	--	--	--	51	--	--	--	--	--
Nitrogen, Total	mg/liter	0.1	--	--	--	--	--	0.1	--	--	--	--	--
Nitrite Nitrogen	mg/liter	<0.01	0.13	0.18	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01
Nitrate Nitrogen	mg/liter	0.3	0.45	1.7	0.27	0.79	<0.1	0.3	0.35	0.8	0.24	0.10	<0.1
Ammonia Nitrogen	mg/liter	0.10	0.14	0.12	0.60	1.20	0.38	<0.1	<0.1	<0.1	0.48	0.76	0.30
Ammonia, Un-ionized	mg/liter	0.01	0.01	--	0.005	0.005	0.002	--	--	--	<0.004	<0.004	<0.004
Oxygen, Dissolved	mg/liter	9.3	9.6	7.7	10.7	10.7	8.9	9.5	9.6	7.9	11.0	10.2	9.3
Sulfates	mg/liter	31.0	27.0	23.0	14.0	4.9	7.7	17.0	27.0	18.0	18.0	3.3	10.8
Hydrogen Sulfide	mg/liter	<0.02	--	<0.1	--	--	--	<0.02	--	<0.1	--	--	--
Chlorine, Free	mg/liter	--	<0.1	--	--	--	--	--	<0.1	--	--	--	--
Chlorine, Total	mg/liter	--	0.15	--	--	--	--	--	0.1	--	--	--	--
Chromium	μg/liter	<0.2	--	--	--	--	--	<0.2	--	--	--	--	--
Copper	μg/liter	0.50	--	7.3	<0.2	--	--	0.10	--	6.8	<0.2	--	--
Zinc	μg/liter	<3	--	--	--	--	--	<3	--	--	--	--	--
Arsenic	μg/liter	2.5	0.5	0.4	<0.4	<0.4	0.6	3.5	0.9	<0.4	<0.4	<0.4	<0.4
Selenium	μg/liter	<1	--	--	--	--	--	<1	--	--	--	--	--
Bromine	mg/liter	1.0	--	--	--	--	--	0.5	--	--	--	--	--
Silver	μg/liter	<0.02	--	--	--	--	--	<0.02	--	--	--	--	--
Cadmium	μg/liter	0.35	--	--	--	--	--	0.25	--	--	--	--	--
Mercury	μg/liter	1.02	1.90	0.99	0.02	<0.02	<0.02	1.13	116.0	1.24	<0.02	<0.02	0.4
Lead	μg/liter	4.5	--	--	--	--	--	3.0	--	--	--	--	--
Cyanide	mg/liter	<0.05	--	--	--	--	--	<0.5	--	--	--	--	--
Oil	mg/liter	<10	--	--	--	--	--	<10	--	--	--	--	--

Source: The Effects of Geothermal Energy Utilization on Stream Biota & Water Quality at The Geysers, California Final Report, 1975, Parametrix, Inc.

TABLE 3

Water Quality Monitoring, October 1979
of SMUDGEO # 1 Project Area

PARAMETER	UNITS	BIG SULPHUR 20.8a	BIG SULPHUR 17.9a	CALM CREEK 1.2	COBB CREEK 2.5a
Temperature	°C	17.1	18.7	12.8	13.2
Conductivity	μmhos/cm	279.5	284.5	97.0	92.0
pH		8.2	8.1	7.8	6.9
Dissolved Oxygen	mg/liter	8.50	8.36	8.35	6.18
Alkalinity (Total)	mg/liter	250.0	246.0	86.0	80.0
Alkalinity (Bicarbonate)	mg/liter	298.0	297.0	105.0	97.6
Alkalinity (Carbonate)	mg/liter	6.0	3.0	< 1.0	< 1.0
Total Hardness	mg/liter	250.0	236.5	78.0	81.5
BOD_5	mg/liter	<0.5	< 0.5	<0.5	< 0.5
COD	mg/liter	<1.0	< 1.0	<1.0	< 1.0
TDS	mg/liter	347.0	340.0	102.0	116.0
TSS	mg/liter	2.0	1.5	15.5	4.0
Turbidity	(NTU)	6.9	1.3	2.4	0.8
Ammonia - N	mg/liter	<0.02	< 0.02	<0.02	< 0.02
Nitrate - N	mg/liter	0.031	0.039	0.003	0.006
Orthophosphate - P (Total)	mg/liter	0.12	< 0.01	<0.01	< 0.01
Silica	mg/liter	71.0	35.0	11.0	11.4
Oil and Grease	mg/liter	<3.0	< 3.0	<3.0	< 3.0
Aluminum	mg/liter	0.110	0.075	0.061	0.047
Arsenic	μg/liter	3.0	6.0	0.5	9.0
Barium	μg/liter	20.0	17.0	60.0	15.0
Boron	mg/liter	0.019	0.027	0.005	0.004
Cadmium	μg/liter	0.007	0.011	0.007	0.009
Calcium	mg/liter	34.5	37.3	20.0	16.5
Chloride	mg/liter	1.7	2.6	1.2	1.7
Chromium	μg/liter	20.0	20.0	40.0	11.0
Copper	μg/liter	0.4	0.4	0.5	0.7
Fluoride	mg/liter	0.220	0.120	0.680	< 0.010
Iron	μg/liter	13.0	12.0	10.0	8.0
Lead	μg/liter	<0.05	< 0.05	<0.05	< 0.05
Magnesium	mg/liter	31.0	30.0	7.0	8.1
Manganese	μg/liter	2.3	8.3	3.1	3.3
Mercury	μg/liter	<0.2	< 0.2	<0.2	< 0.2
Nickel	μg/liter	4.9	7.0	6.0	5.0
Potassium	mg/liter	1.80	2.00	0.44	0.47
Selenium	μg/liter	10.0	20.0	9.0	9.0
Sodium	mg/liter	16.30	13.60	4.45	4.15
Strontium	μg/liter	< 1.0	< 1.0	< 1.0	< 1.0
Sulfate	mg/liter	30.0	26.0	9.3	11.0
Sulfide	mg/liter	< 0.2	< 0.2	< 0.2	< 0.2
Titanium	μg/liter	<20.0	<20.0	<20.0	<20.0
Vanadium	μg/liter	< 5.0	< 5.0	< 5.0	< 5.0
Zinc	μg/liter	3.4	1.2	4.0	4.0

S.M.U.D., AFC, Table 5.4-15

HYDROLOGY

SETTING

The proposed 8.8 acre level site for SMUDGEO #1 will be located at an elevation of 3,673 feet in the Big Sulphur Creek drainage basin in Sonoma County. The site will be created by leveling a ridge, and the only runoff from the site will be from precipitation that falls on the site.

Precipitation

The mean annual precipitation at the site is about 80 inches. Normal snowfall is about 20 inches; however, the snow seldom stays on the ground longer than a few days. Approximately 80 percent of the precipitation is received in the months of November through March by frontal type general storms.

Maximum recorded values of precipitation for 24 hours or less from California Department of Water Resources Bulletin No. 195 are presented on the following table for The Geysers Station No. F908865. The recorded values were transposed by a procedure given by Rantz (Technical Report No. 3, Open File Report, USGS, Menlo Park, California, 1971).

Duration (hours)	1/4	1/2	1	2	3	6	12	24
The Geysers Station F908665 (in inches)	0.92	1.25	1.74	2.03	2.48	3.74	5.91	9.58
Transposed Values at the SMUDGEO #1	1.12	1.53	2.12	2.58	3.27	5.09	8.16	13.51

Rainfall frequency duration data for the site is listed on the following table.

RAINFALL FREQUENCY--DURATION AT THE SMUDGEO #1 SITE[1]

Return Period	Duration (Hours)						
(Years)	1/2	1	2	3	6	12	24
2	.52	.82	1.40	1.91	3.22	5.40	8.08
5	.70	1.10	1.88	2.57	4.34	7.27	10.89
10	.83	1.27	2.20	3.01	5.06	8.47	12.69
25	.98	1.49	2.57	3.52	5.93	9.94	14.88
50	1.07	1.65	2.84	3.89	6.56	10.98	16.45
100	1.18	1.81	3.10	4.26	7.15	12.01	17.98

1. Data from California Department of Water Resources Bulletin No. 195 for The Geysers Station (F908665) transposed to the SMUDGEO #1 site using procedure outlined by Rantz.

Surface Water

The stream flow gaging station in the area is Big Sulphur Creek near Cloverdale. This gage was maintained by the USGS (11-4632) from 1957 to 1972, and was rebuilt by PG&E in 1978. Annual runoff from the full 82.3 square mile drainage area is about 139,100 acre-feet for the period 1957 thru 1972 (Geysers #17, NOI).

Maximum overland flow at the site would result from a thunderstorm or short duration-high intensity storm. Runoff will be collected at the site with a drainage system of manholes and catch basins. From the catch basin, storm water will be pumped to the cooling tower basin for reinjection or use as cooling water. Overflow from the site catch basin will be routed to the sedimentation collection system, then into Cobb Creek, tributary of Big Sulphur Creek.

Groundwater

No regional groundwater aquifer of significant yield has been reported in the rock formations of the Mayacmas Mountains in The Geysers KGRA area. The area is principally underlain by variably fractured rock belonging to the Franciscan formation of the Jurassic-Cretaceous age. Franciscan rocks are generally classified as nonwater-bearing except along fracture zones, which may yield sufficient water for minimal domestic needs. Test borings at the project site indicate that no groundwater aquifers are present within 125 feet of the existing ground surface. Investigation of the leasehold revealed no significant groundwater resources.

IMPACTS

Water Supply

Makeup water for power plant cooling will come from condensed geothermal steam. There will be a minimal requirement for sanitation, maintenance, and irrigation purposes (approximately one-acre foot per year at other Geysers developments), which will be brought to the site by trucks.

Groundwater

The paved power plant site is located over no known groundwater basin; therefore, the probability of contaminating groundwater is minimal. The impermeability of the paved power plant pad surface will minimize the chance of drainage or chemicals spilled on the pad surface from percolating to any groundwater aquifiers.

Flood Hazard

Because the plant site, as well as the transmission line, will be located high above the surrounding stream channels, flood hazard from stream-flow flooding is precluded. The flooding concerns involve site flooding from overland flow (precipitation runoff) on the plant site and accidental spills.

MITIGATION MEASURES

SMUD will mitigate any possible environmental impacts due to the 100-year storm by constructing a drainage system as follows. Potential concerns of a 100 year storm center on the great volume of rain in a very short time period, 4 - 6 hours of intense rainfall. Containment, drainage, and diversion of this vast amount of water (up to 1 million gallons) are measures important to preventing adverse impacts from such a storm. The entire site will be surrounded by a 6-inch berm which will form a retention basin to contain rainfall and accidental spills (see Water Quality section for additional information on the retention basin). The site will be graded to slope toward catch basins. From the catch basins, water will be pumped to the cooling tower basin or conveyed by culverts to the sedimentation control ditches. Energy dissipation will be installed at the discharge to the natural drainage course to minimize further channel erosion.

NOISE

ENVIRONMENTAL SETTING

Legal Requirements

Sonoma County

Sonoma County has adopted a Noise Element to the County General Plan. The Noise Element indicates that noise levels between 50 dBA and 60 dBA L_{dn} are acceptable for residential land uses, noise levels between 60 dBA and 70 dBA L_{dn} require noise mitigations for residential land uses, and noise levels greater than 70 dBA L_{dn} are unacceptable for residential land uses (Noise Element Table 42). The noise element also states that the above standard should be used in evaluating all new land uses. The noise levels for geothermal projects have been set in the individual use permits. The most recent use permit (Geothermal Kinetics Resolution No. 58299) has a standard for construction activities of 65 dBA day and 55 dBA night, and for operation of 60 dBA day and 50 dBA night, as measured at a residence.

State

The applicable state regulations are the Cal-OSHA Occupational Noise Exposure Regulations, Title 8 CAC, Article 105, General Industrial Safety Orders. Cal-OSHA regulations are enforced by the Division of Occupational Safety and Health (DOSH) of the Department of Industrial Relations and apply primarily to on-site conditions. These regulations set a 90 dBA employee exposure limit for an 8 hour period and a halving in the exposure time for each 5 dBA increase in the noise level above 90 dBA. There is no direct state regulation of off-site conditions.

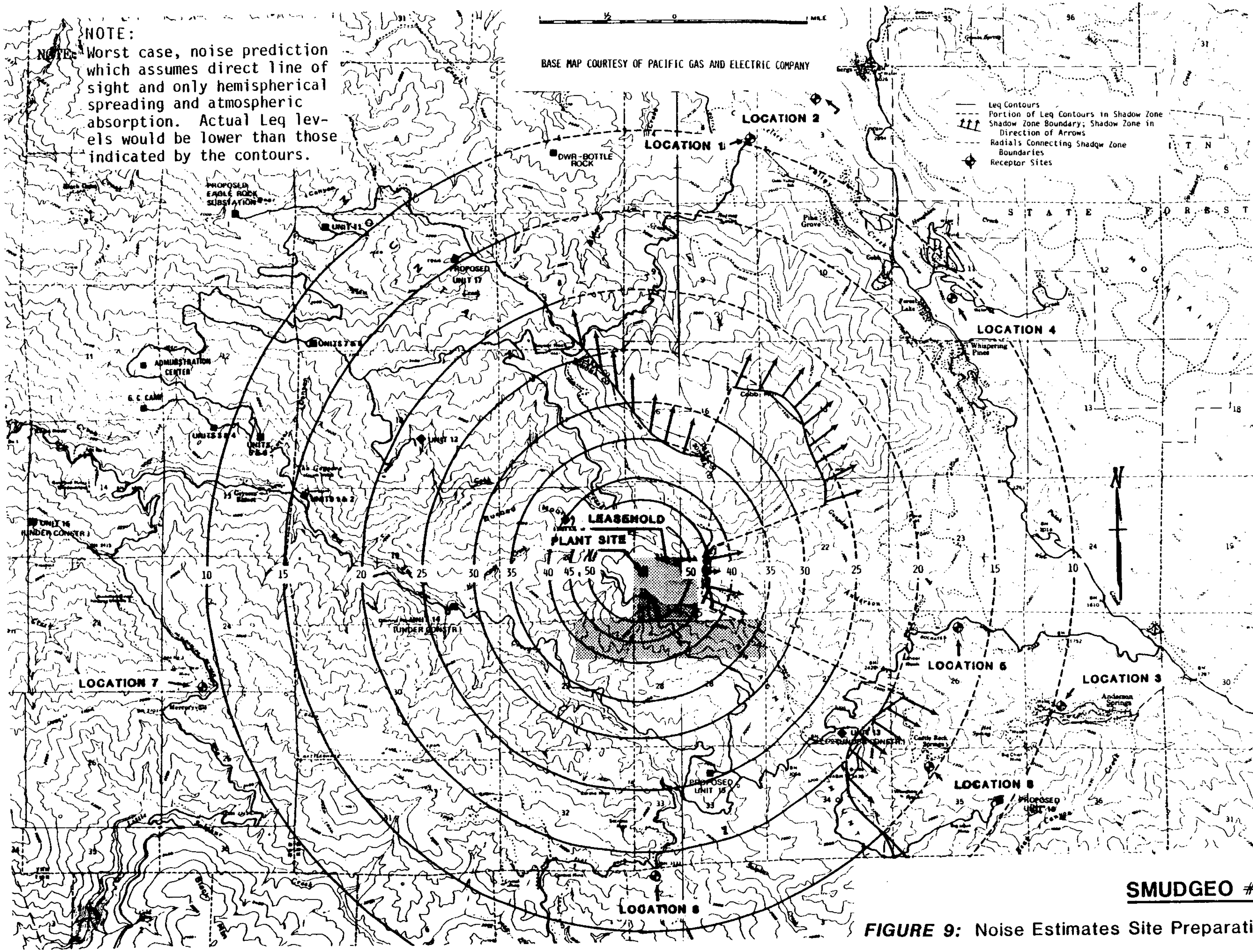
Federal

The EPA has identified an L_{dn} of 55 dBA as providing reasonable protection against community annoyance and activity interference due to noise. (U.S. EPA, 1971) The applicable federal off-site noise regulations are contained in the Geothermal Resources Operation Order No. 4 as published by the Conservation Division of the U.S.G.S. effective August 1, 1975. These regulations set the standard of 65 dBA for all geothermal-related activities as measured at the lease boundary line or 0.8 km (one-half mile) from the source, whichever is greater. However, the 65 dBA may be exceeded under emergency conditions or with the Geothermal Area Supervisor's approval if written permission is first obtained by the leasees from all residents within 0.8 km (one-half mile).

Setting

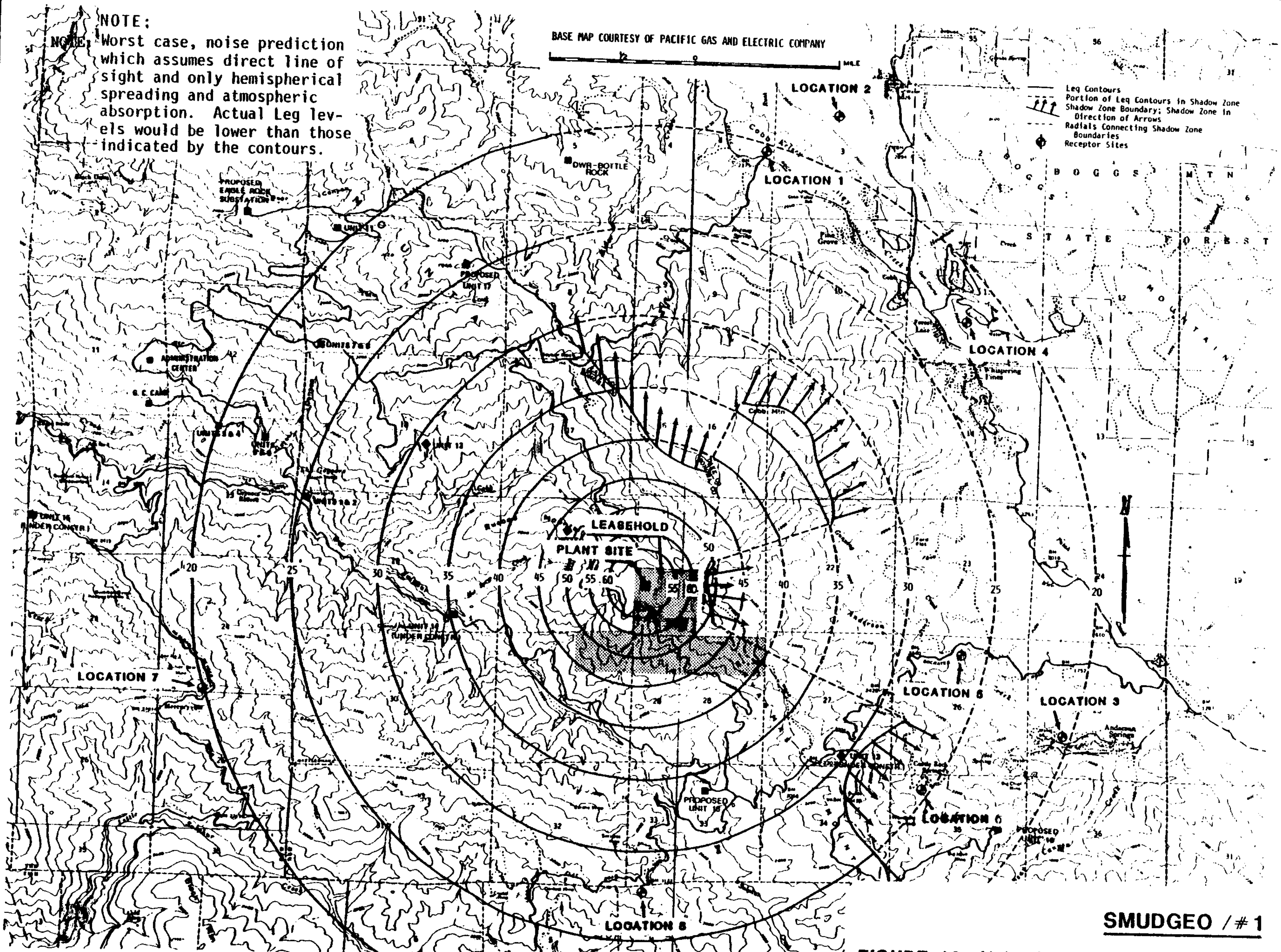
The sensitive receptor nearest to the proposed plant site is a residence off Pine Flat Road (survey point 8), approximately 2.1 miles south of the proposed site. See attached Figure 10 for location of the proposed facility and these and other sensitive receptor locations.

Ambient noise levels at the nearest residential receptor range between 38 dBA (L_1) and 24 dBA (L_{99}). The time energy average level from the 15 minute



SMUDGEO #1

FIGURE 9: Noise Estimates Site Preparation



SMUDGEO / #1

FIGURE 10: Noise Estimates Plant Operation

sample was 29dBA (L_{eq}) (see attached Table 4; also see Table 9 for minimum levels at other receptor points). Noise levels at other locations in the site vicinity were provided in PG&E Geysers Unit 18 AFC Table 5.6-1 (see attached Table 5). Noise levels in the site vicinity typically range between 25 dBA and 46 dBA with occasional peaks as high as 70 dBA. Noise sources in the site vicinity are local and remote steam development activities, local traffic, wind, insect and wildlife activities, and human activities. Noise levels in the vicinity of a site are typical for a quiet rural environment (see attached Table 6 from PG&E Geysers 16 NOI).

The nearest well pad to a sensitive receptor i.e., a single family residence, is approximately 2.1 miles away. Other receptors are farther away.

IMPACTS

The generally accepted criterion for determining the existence of a noise impact is audibility. To determine audibility, one must examine the background or ambient noise levels, the noise source's projected noise levels and the tonal content of the noise. If a source's projected noise level is greater than or equal to the ambient noise level, it would probably be audible. A source whose tonal content is different than the existing ambient would tend to be more audible than one whose content is similar to the existing ambient.

Steam Field

The primary sources of noise from steam field development and operation are given in Table 7. The levels shown are with mitigations applied. Production testing, unmuffled well venting, and well-head master valve changes are potentially significant noise sources in the immediate vicinity of the well pad. This source will not be significant at the nearest receptor because of the remoteness of the site. These activities occur infrequently and can be conducted during daylight hours. The noise conditions in the steam field permit issued by Sonoma County indicate that noise levels at the nearest residence may reach 65 dBA between the hours of 7 a.m. and 10 p.m., and 45 dBA from 10 p.m. to 7 a.m.

Plant Construction

The highest construction noise ranges between 75 dBA and 95 dBA at 50 feet (see Table 8). The higher levels of noise can be attributed to large earth moving equipment and blasting. Measurements made at Geysers Unit 13, with nine pieces of equipment operating, showed an average L_{eq} level of 76 dBA at about 360 feet, from the center of the equipment (PG&E Geysers Unit 18, Page 5-85). The noise levels during site preparation, projected to the nearest sensitive receptor (survey point 8) in Sonoma County, are expected to range from 17-27 dBA L_{eq}. Projected construction noise levels during other phases of construction are expected to be much lower. The projected noise level to the nearest receptors in Lake County are shown on attached Figure 10 or in attached Table 9. During site preparation, construction noise may be barely audible at the nearest receptor in Sonoma County when the construction noise level is in the high range and ambient levels are low. Since construction occurs only during daylight hours, unless unforeseen circumstances require operations during nondaylight hours, the potential impact would be insignificant. Construction noise levels would meet the standards of Lake and Sonoma County.

TABLE 4

EXISTING NOISE ENVIRONMENT DURING QUIET CONDITIONS
LOCATION 8

Date & Time	L_1	L_{10}	L_{50}	L_{90}	L_{99}	L_{eq}	Comments
11/15/79 2:40-2:45pm Thursday	38 dBA	32 dBA	26 dBA	24 dBA	24 dBA	29 dBA	Noise environment controlled by unidentifiable natural sounds and occasional jet and far off general aviation aircraft.

TABLE 5

AMBIENT SOUND LEVELS IN dBA, RE. 20 MICROPASCAL, AT AND AROUND UNIT 18

Date	Time	Point	Inst.	Meas.	Sample Duration	Range	Sound Level, dBA, re 20 Micropascal L_1	L_{10}	L_{50}	L_{90}	L_{99}	L_{eq}	Comments
6/23/77	1400	1	A	Cont.	5 Min.	-	38.8	35.5	33.0	31.0	30.3	33.5	Natural Sounds, Fair Weather
10/25/77 to 10/26/77	1658 to 0758	2 (Site 18)	A	Cont.	15 Hrs.	-	43.3	36.8	31.8	29.8	28.8	34.4	Natural Sounds, Remote Steam Bleed to SE. Very calm - Quiet conditions, fair weather
10/26/77	0345 to 1345	2 (Site 18)	A	Cont.	5 Hrs.	-	46.3	38.0	33.0	27.3	25.8	37.7	Same as above
10/25/77	1705 to 1717	3 to 7	B	D.O.	-	32/40	-	-	-	-	-	--	Natural sounds, calm quiet conditions after working hours at Unit 13.

.NOTES:

1. Abbreviations: Inst. - Instrumentation; Meas. - Measurement, Cont. - Continuous; D.O. - Direct Observation

2. Instrumentation (Inst.) Column

   A (System A): 1" Electret-Condenser Microphone to Gen Rad 1558-BP Analyzer to Bruel & Kjaer 4426 Noise Level Analyzer. Continuous Measurement System with Sample Rate of 1 Sample/Sec.

   B (System B): 1" Electret-Condenser Microphone to Gen Rad 1933 Precision Sound Level Meter. Direct Observation (D.O.) of Meter Scale Approximately 1 Min./Observation

   Calibration of both Systems A & B above in Field with Gen Rad 1562-A Sound Level Calibrator

TABLE 6

A-WEIGHTED SOUND LEVELS, dBA, OF TYPICAL NOISES IN VARIOUS ENVIRONMENTS*. REF. 2 X 10^{-5}N/M²

Subjective Impression	dBA	Community** (Outdoor)	Home or Industry** (Indoor)
	130	Military Jet Aircraft Take-Off from Aircraft Carrier @ 50'. (130)	Oxygen Torch (121)
Uncomfortably Loud	120	Turbo-Fan Aircraft Take-Off @ 200'. (118)	Rock-N-Roll Band (108-114)
	110	Jet Fly Over @ 100'. (103)	Riveting Machine (110)
Very Loud	100	Power Mower (96) Boeing 737, DC-9 @ 6080' before landing (97)	Electric Furnance Area (100) Newspaper Press (97)
	90	Motorcycle @ 25'. (90) Car Wash @ 20'. (89) Diesel Truck, 40 mph @ 50'. (84)	Food Blender (88)
	80	High Urban Ambient Sound (80) Passenger Car, 65 mph @25'. (77)	Garbage Disposal (80) Living Room Music (76)
Moderately Loud	70	Freeway @ 50' from edge (76±6) Urban Shopping Center (60-70)	TV-Audio, Vacuum Cleaner (70) Elec. Typewriter @ 10'. (64) Dishwasher (Rinse) @ 10'. (60)
	60	Daytime Urban Residential (50-60)	Conversation @ 3'-5'. (60) Large Store (60)
Quiet	50	Large Transformers @ 100' (50) Daytime Suburban Residential (40-50)	Average Daytime Residence (40-50)
	40	Lower Limit Urban Ambient Sound (40) Farm in Valley (30-40)	
	30		Studio Speech (30) Quiet Bedroom at Night (20-30)
	20	Daytime Grand Canyon (North Rim) (20)	
Just Audible	10		
Threshold of Hearing	0		Threshold of Hearing for Youths - 1000-4000 Hz

* The noise sources and typical levels were taken from the following sources:

- Peterson, A. P. G. & Gross, E. E. Jr., "Handbook of Noise Measurement", General Radio Company 7th Edition 1972.
- Schultz, T. J., Bolt Beranek & Newman Inc., "Noise Assessment Guideline, Technical Background" Report No. TE/NA 172 prepared for U. S. Department of Housing and Urban Development.
- Wyle Laboratories, "Community Noise", Report No. NTID 300.3 prepared for U. S. Environmental Protection Agency, December 31, 1971.

** Numbers in parenthesis are A-weighted sound levels.

TABLE 7

NOISE LEVELS DUE TO GEOTHERMAL DEVELOPMENT
AND OPERATION ACTIVITIES

Activity	Max. Noise Levels at (50') (15.2m) in dBA	Nearest Receptor[a] Projected Noise Levels at (1100') (3358m) in dBA
Construction of roads and drill pads	90[b]	25-35[c]
Construction of steam pipelines	90[b]	25-35[c]
Mud drilling	85[d]	20-30[c]
Air drilling (cyclonic muffler)	88[d]	25-35[c]
Air drilling in steam (cyclonic muffler)	90[d]	25-35[c]
Well clean-out (cyclonic muffler)	90[d]	25-35[c]
Production testing (cyclonic muffler) (portable test muffler)	90[d] 100[d]	25-35[c] 35-45[c]
Shut-in well venting	75[d]	15
Normal field operations	40-70[d]	10
Steam venting at generating unit (rock-filled muffler)	70[e]	10
Starting steam transmission thru pipelines (unmuffled well venting)	120[b]	35-65[c]
Changing wellhead master valves (unmuffled well venting)	110[b]	45-55[c]

a. Estimated projected levels made by CEC.
b. Estimated from noise measurements.
c. Higher noise levels are based on worst case weather conditions; lower levels are based on normal attenuation of noise.
d. Based upon measurements by P. Leitner.
e. Based upon measurements by PGandE and Union Oil.

Source: Nielson, 1977; Castle Rock Springs Geothermal Steam Area EIR, 1975; Geothermal Pipeline System Unit 16 Castle Rock Springs Area EIR, 1979.

TABLE 8

PROJECTED CONSTRUCTION EQUIPMENT USE

Item	Number Used	Time Use Factor (%)	Range of Measured dBA Maxima (at 50 ft)	Base dBA Used for Estimating
SITE PREPARATION				
Bulldozer	2	75	77-90	89
Dump Truck	2	50	84-87	86
Loader	1	75	77-90	89
Compactor	1	75	75-82	81
Water Truck	1	50	81-94	83
Scraper	2	75	88-91	90
PLANT ERECTION				
Lift Crane	2	70	80-85	84
Backhoe	1	75	86-90	89
Batch Plant	1	40	83	83
Transit Mixer	1	50	84-87	86
Concrete Pump	1	50	74-84	83
Welder	2	80	73	73
Air Compressor	2	75	76-89	88
Lowboy	1	10	84-87	86
Light and Medium Trucks	3	50	81-84	83
Water Truck	1	50	81-84	83
TRANSMISSION LINE CONSTRUCTION				
Crawler Tractor	2	75	85-90	89
Grader	1	75	86-89	88
Hauling trucks	2	75	86-88	87
Mobile Crane	1	70	80-85	84
Air Compressor	1	75	76-89	88
Concrete Mixer Trucks	2	50	84-87	86
Light Trucks	2	50	81-84	83
Medium Trucks	2	50	84-87	86
Chain Saw	1	25	72-88	87
Helicopters*				

*Section 5.8.2.1.3

TABLE 9

ESTIMATED WORST CASE NOISE LEVELS
AND MINIMUM MEASURED BACKGROUND LEVELS

Locations of Nearest Sensitive Receptors: Number	Description	Noise Level During Construction (L_{eq})	Noise Level During Operation (L_{eq})	Minimum Measured L99
1	Pine Grove near Bottle Rock Road	20 dBA	10 dBA	20 dBA
2	Hobergs overlooking Bottle Rock Road	20 dBA	10 dBA	27 dBA
3	Anderson Springs	21 dBA	10 dBA	34 dBA
4	Whispering Pines	22 dBA	11 dBA	32 dBA
5	Socrates Mine Road	26 dBA	17 dBA	38 dBA
6	Verdant Vales School, Castle Rock Springs	25 dBA	16 dBA	48* dBA
7	Mercuryville	20 dBA	10 dBA	26 dBA
8	Pine Flat Road	27 dBA	18 dBA	24 dBA

*Dominated by grading activities at location of Unit 16 site.

Construction traffic noise estimates are provided in attached Table 10. Based on these levels, communities or single residences along the access routes may be exposed to some short-term noise impacts.

Plant Operation

SMUD provided estimated projected noise levels due to operation shown on attached Figure 8 and in attached Table 9. SMUD estimates a project noise level at the nearest receptor to be 18 dBA L_{eq}. Actual noise levels may be less due to ground effects and possible barrier effects. In any case, this noise level will comply with the existing and proposed Sonoma County standards and the USGS standards. Operational noise will not be audible at the nearest receptor.

Noise Tonal Impacts

In the PG&E Geysers Unit 17 AFC, PG&E provided (Appendix G, Figures 9.4-1 through 9.4-3) one-third octave band noise frequency spectrum from operating Geysers units. SMUD agrees that these frequency spectra are representative of the noise expected from the proposed SMUDGEO #1 facility. While certain tonalities would be discernable in the immediate vicinity of the site, it is the CEC staff's opinion that the tonalities would not be discernable at any of the receptors in the site vicinity due to the low projected noise levels to the receptor. This means that the noise resulting from SMUD's geothermal development will not be noticable at the nearest residence to the plant.

Cal-OSHA Requirements

SMUD stated (AFC, Page 1-32) that they will take the following steps to ensure compliance with Cal-OSHA noise regulations:

1. Any unavoidably high noise areas will be posted with signs.

2. As necessary, personal hearing protectors will be supplied and their use enforced during both the construction and operational periods.

3. The hearing of employees routinely subjected to high noise levels will be periodically checked.

If these measures are implemented, the CEC staff will conclude that SMUD will adequately meet the hearing conservation requirements of Cal-OSHA.

MITIGATIONS

SMUD identified (SMUDGEO, AFC pp. 1-32) the following noise mitigations to be applied to the proposed facility:

1. Mechanical equipment will be purchased on the basis of a procurement specification that will encourage manufacturers to supply reduced-noise motors, pumps, valves, and other components.

2. Noisy steam-handling equipment, steam piping, and steam ejector housings will be insulated with materials possessing good acoustic and thermal properties.

TABLE 10

ESTIMATED CONSTRUCTION TRAFFIC NOISE

Assumed Condition	Distance (ft)	Leq (dBA)*
50% of traffic in each direction (65 autos, 5 heavy trucks)	200	49
Same as above	2,000	35
90% of traffic using one access (117 autos, 9 heavy trucks)	200	51
Same as above	2,000	37
10% of traffic using one access (13 autos, 1 heavy truck)	200	42
Same as above	2,000	28

*Assumes a long straight road on a 7 percent grade, the line of sight from vehicle to receiver, and "soft" ground between vehicle and receiver.

3. Waste steam will be routed when necessary through an effective muffling system which will be installed and maintained by the steam supplier;

4. A low-noise office enclosure for the operators will be provided inside the turbine building;

5. The turbine building walls and roof will reduce the propagation of noise to the outside environment; and

6. Any excessively noisy ancillary equipment will be silenced as feasible.

It is the CEC staff's opinion that these are adequate mitigations provided that the following steps are made in applying those mitigations:

1. With regard to mitigation #1 above, the Applicant should take the following steps to "encourage" equipment manufacturers to supply reduced-noise equipment:

   a. Except for the turbine generator set which shall be specified for 90 dBA, a noise specification shall be made a part of specifications for mechanical equipment purchases. This noise specification requires equipment that produces a maximum sound level of 85 dBA at three feet.

   b. If the supplier cannot meet the 85 dBA requirement, SMUD shall undertake appropriate mitigation measures to conform with OSHA/DOSH Standards.

2. With regard to mitigation #3 above, steam-drain lines should be routed back into the condenser so that steam will not be discharged into the atmosphere during unit start ups.

3. With regard to mitigation #3 above, the Applicant shall ensure that the steam supplier utilizes a rock muffler or its equivalent (equivalent noise reduction) to mitigate noise during unit outages.

CUMULATIVE IMPACTS

Other projects in the area of the proposed SMUDGEO #1 project are PG&E Geysers Units 9 and 10, Unit 18, Unit 13, and Unit 16 (see Figure 9). The proposed SMUDGEO #1 project is remote from these units and potential noise sensitive receptors. The other units in the SMUDGEO #1 site area may raise the ambient noise level in receptor locations, such as Camp Verdant Vales and Anderson Springs. Because the SMUDGEO #1 project is remote, it will not add to the impact of the other units.

The effects of the well development and steam field operation noise levels generally exceed the levels for plant construction and operation. These cumulative activities will not increase the impact on the receptors over the well development and well operation noise levels (see Impacts section). Therefore, the CEC staff concludes that no significant impact will result from the combined activities.

CULTURAL RESOURCES

SETTING

Archaeology

Cobb Mountain marks the geographical boundaries of territories traditionally claimed by the Western and Northern Wappo and Central and Eastern Pomo and Lake Miwok Indians.(Kroeber, 1925) Kroeber reports a Western Wappo town, Tekenantsonoma, was located within the developed geothermal field. Its location has not been precisely determined, although a large archaeological site has been recorded by Fredrickson (1974). This large, dispersed archaeological site is characterized by a large house depression, possibly the remains of a dance house, and a number of isolated groups of house pits suggestive of single family hamlets.

A dispersed community organization such as at Tekenantsonoma was common for ethnographic groups in the North Coast Ranges.(Heizer, 1975) In general, each local community appears to have had a single, permanently inhabited town which served as a politically autonomous group, which may have numbered from about 100 to perhaps 300 individuals. Smaller sites, occasionally made up of only a single household, would also be a part of the settlement system, as would be task-specific sites such as camp sites, hunting stations, food processing stations, quarries and manufacturing stations, and sites of religious significance.

Because of different economic focuses, experts believe that settlement systems contrasting with the ethnographic Wappo existed in the North Coast Range during earlier time periods. Details of earlier social and environmental relationships are scant, since little archaeological work has been done within the North Coast Ranges.

No properties listed on, or in process of nomination to, the National Register of Historic Places are present within the leasehold. While no properties within the KGRA appeared in the latest revision of the Natural Landmarks National Registry (Federal Register, 1978), the Mayacmas Mountains have been proposed as a Natural Landmark.

IMPACTS AND MITIGATION

- Impacts

  A survey for archaeological resources in the project area and steam field was conducted by Dr. David A. Fredrickson in November 1979. The survey met the requirements of an intensive archaeological survey as prescribed by the Society for California Archaeology/Archaeological Impact Evaluation, 1976. Due to the rugged terrain and the lack of archaeological sensitivity in the area, the proposed plant, transmission corridor, and related steam field will not impact upon archaeological resources; no sites were recorded in the project area.

o Mitigation

SMUD will make arrangements to have an archaeologist available should artifacts or previously unknown sites be uncovered during initial grading and trenching.

Ethnography

As part of the ethnographic study prepared by David A. Fredrickson, several Native American consultants made an on-site inspection. While no sites of known sociocultural significance were identified within the leasehold, Little Geysers situated about 3/4 mi. south of the project and just outside of the leasehold, was identified by the Native American consultants as holding special social significance. Little Geysers is one of many recently recorded ethnographically significant sites.

IMPACTS AND MITIGATION

o Impacts

The construction and operation of the power plant and steam field will not directly impact Little Geysers. However, adverse indirect impacts could result from the continued development of geothermal resources. Access by Native Americans to Little Geysers may be restricted, and the further development in the area may degrade this significant ceremonial site.

o Mitigation

The eligibility of the Little Geysers site is currently under consideration for inclusion in the National Register of Historic Places. Due to the significance of the ceremonial site, CEC staff recommends that a buffer zone be determined through consultation with Native Americans and ethnographers familiar with the area and site in question.

Paleontology

With respect to paleontological resources, significant radiolarian microfossil (skeletons of single cell marine animals) localities do not exist within the leasehold. No mitigation is required.

History

The historic study revealed no evidence of significant use of the leasehold area. Field surveys disclosed no evidence of either historic or prehistoric archaeological resources within the leasehold.

IMPACTS AND MITIGATION

There will be no impact to historical reosources and no mitigation measures are necessary.

SMUDGEO #1 FINAL JES
TRANSPORTATION

SETTING

Access to the proposed project is either from the east via State Route 175 to Middletown, then to Socrates Mine Road and to a fire road leading to the proposed site, or from the west via Healdsburg-Geysers Road from Jimtown to The Geysers Resort and then past Geysers 14 (via unpaved Union Oil Road) to the fire road leading to the site (AFC, Figure 1.1-2). In most cases, the county roads are paved two-lane roads except Socrates Mine Road, which is mostly an unpaved, graded road. For reference to the roads discussed below, see attached Figure 11.5. A paved, spur road about 2/3 of a mile long will be constructed to connect the fire road and the adjacent well pad site to the proposed power plant site.

Road Condition of Concern

Socrates Mine Road--For the most part, Socrates Mine Road is a narrow, winding, unpaved road. This road, particularly the part which leads through the Aminoil leasehold, has reportedly been a source of increased erosion*[1] which can result in increased turbidity and other water quality problems in Anderson and Gunning Creeks. These creeks supply domestic water to the Anderson Springs Community in addition to other beneficial and riparian uses. In addition, the damage is creating excessive dust and is leading to severely deteriorated road surface.

The road generally has poor alignment; the grades of the road exceed minimum county standards in many places. The road is too narrow in most parts and without adequate shoulders or guardrails where needed. There are two bridge structures located on short radius curves. The bridges are in poor condition because of excessive use.

Lake County estimates an average daily traffic of 684 vehicles per day[2] travel this route and their studies indicate about 20 percent of this figure consists of truck traffic.[3] During the past few years, there has been an average of from two to four major accidents reported to the California Highway Patrol per year.[4] Considering the present condition of the road, one could expect higher accident rates as the amount of traffic increases on this road.

In summary, Socrates Mine Road is below county standards and before any additional traffic is added to this road, it should be upgraded (e.g., improved alignment, construction of adequate surface and base with drainage and erosion control facilities, improved safety measures such as guardrails and proper safety signs, and improved bridge structures over Anderson and Gunning Creeks). Negotiations in regard to these improvements have been going on among the respective road users; as yet, no definite conclusions have been reached.

*For references, see Transportation entries in the "Agencies and People Contacted" section of the Final Joint Environmental Study.

Healdsburg-Geysers Road--This is a two-lane, paved county road and a major access to The Geysers from Sonoma County. This road, in sections, has poor alignment, sharp curves, and short sight distances. The pavement structure, although fair in most parts, is damaged and is in need of repair in some other parts.

Sonoma County[5] estimates that 870 vehicles travel this road in an average 24-hour period and that the traffic mix could range from 2 to 5 percent truck traffic. The road is considered by the county to have high potential for accidents. California Highway Patrol reports indicate an average of 10 to 15 accidents per year[6] on this road.

In summary, sections of the Healdsburg-Geysers Road are below county standards and CEC staff consider them inadequate and unsafe with respect to heavy loads and multi-axle vehicles. To assure safer travelling, Staff recommends upgrading and improvement to Healdsburg-Geysers Road.

Cloverdale-Geysers Road--This road is a poorly maintained, narrow Sonoma County road which connects The Geysers to Cloverdale and Highway 101. The surface is extremely rough, sight distances are inadequate, and heavy trucks will have problems negotiating sharp radii curves.

There is a one-lane bridge over Squaw Creek which may be inadequate for heavy truck crossings. The travelway and shoulders, in some parts, are eroded away leaving the effective width of the road at about eight feet which is barely enough for one lane of traffic.

In conclusion, this road is in poor condition and its use by construction traffic must be prohibited until proper maintenance and safety measures are implemented. The ability to implement this mitigation measure rests with Sonoma County.

Ford Flat Road--This is a three-mile long, narrow, winding, dirt, mountain road. It connects Socrates Mine Road to the Whispering Pines and Cobb area in Lake County. It could also be used as a short-cut to Highway 175 and Bottle Rock Road leading to Kelseyville waste disposal site. This road is inadequate for heavy truck traffic. Lake County[7] emphasizes the fact that commute traffic on this road causes excessive dust and noise problems for the residences along the road and its use must be limited to local residents.

Butts Canyon Road--This Lake County road gives access to the Middletown waste disposal site owned by Geothermal Incorporated. Excessive use by heavy geothermal disposal truck traffic has caused the failure of the road surface. The structure section and drainage of this road is not adequate for heavy traffic. Even though SMUD has not indicated where they will dispose of their geothermal wastes (CEC staff estimates one or two trucks per month), it is likely they will use the Middletown waste site. Adding more heavy truck traffic to this road will only aggravate the existing impaired conditions.

IMPACTS

Light Traffic

During the peak construction phase of the project, SMUD estimates that 65 autos/light trucks will travel to and from the project area per day. The majority of the trucks will use the Healdsburg-Geysers Road, and the light traffic is expected to be divided equally between Socrates Mine Road and Healdsburg-Geysers Road. This small increase in light traffic will not significantly affect the local transportation network. To further decrease the light traffic impact, SMUD will furnish a van-pool for their workers (see "Socioeconomic" section of the JES).

Heavy Equipment Traffic

Construction traffic will reach the power plant site both from Middletown, using State Route 175 and Socrates Mine Road, and from the west, using Healdsburg-Geysers Road and existing roads through developed geothermal areas which are mostly owned and maintained by the Union Oil Company. SMUD estimates that an average of five heavy trucks will travel to and from the site each day during construction (80-AFC-1). This number will reduce to about 10 trucks per week during the operation phase of the plant.

The main impacts of SMUDGEO construction on the roads are summarized below:

Socrates Mine Road--SMUD estimates that about 40,000 tons of cement, aggregate, gravel and asphalt will be transported via Socrates Mine Road. Assuming an average payload per truck at 25 tons, it will take 1,600 trips to take the required material to the construction site. In addition, there may be heavy construction equipment and water trucks transported over this road.

The conditions described in the setting will be aggravated by construction of SMUDGEO #1. Unless these conditions are mitigated, significant adverse impacts to transportation and safety will result.

Healdsburg-Geysers Road--SMUD estimates that about 1,900 tons of steel and concrete blocks will be transported via this road. In addition, heavy construction equipment such as D8 tractors, concrete mix trucks and heavy equipment components for the power plant will be moved via this road. Again assuming the trucks are carrying 25 tons of payload each, an estimated number of 100 trips will be required to haul necessary material and equipment to the site.

Considering the conditions of the road explained in the above Transportation Setting section, the construction of SMUDGEO #1 will further deteriorate this road and unless mitigated, could cause significant transportation and safety problems.

Cloverdale-Geysers Road--SMUD indicates that there will be no construction truck traffic using this road and there is no accurate estimate of passenger car trips which will occur due to the proposed development. Staff estimates that an increase in traffic on this road, due to SMUDGEO #1 construction, may not be significant.

Ford Flat Road--Some traffic on Ford Flat Road, in addition to the present 45 vehicles per day, may be generated by construction of SMUDGEO #1. This could only aggravate the conditions described in the Setting. Staff estimates that an increase in traffic on this road, due to SMUDGEO #1 construction, may have minor significance.

Butts Canyon Road--This is a major access road to the Middletown waste disposal area and if SMUD decides to use this waste disposal area, trucks hauling geothermal waste to the site could exacerbate the conditions described in the Setting. Staff estimates that an increase in truck traffic due to operation of SMUDGEO #1 may not be significant on this road.

In summary, the SMUDGEO #1 project may add to the overall road deterioration within The Geysers KGRA and, due to an increase in traffic volume, may contribute some increase in traffic hazards.

Access Road--Access to the plant will be gained from an existing graded fire road through Birdsong Meadow to a well pad (approximately two miles distance) and then via a new access road (2/3 mile long) to the power plant site. SMUD proposes to widen this road in parts and pave it in order to handle construction traffic. Improvements to the road through Birdsong Meadow will be completed by winter of 1981, but the remainder of the fire road to the well pad will not be paved until construction is completed during the summer of 1983. Paving the road will alleviate dust problems from vehicles and decrease erosion and sediment transport to streams. CEC staff considers these proposed access road improvements to be acceptable. The proposed mitigation measures such as erosion control measures, hydroseeding exposed disturbed surfaces, and placing and maintaining culverts, should decrease or prevent sediment from impacting the Cobb Creek and Calm Creek drainage. (See Biology section of the EIR for impact and mitigation to biological resources.)

MITIGATION MEASURES

Roads within the leasehold are maintained by Aminoil (the steam field developer). County roads are maintained by the respective county. If the county determines that the roads within its jurisdiction are being abused by heavy truck and construction equipment (load limits are set by the County Road Commission), the county will request the involved developers to participate in improvement and maintenance costs.[8]

Socrates Mine Road--As mentioned above, Socrates Mine Road, in its present condition and alignment, is below county standards and could pose a travelling hazard. Staff feels that improving the road is necessary. Major road users (Aminoil, PGandE, Union Oil, SMUD, Occidental, Shell and NCPA) are negotiating with Lake County to improve and upgrade the road. The preliminary plans prepared by Veizades and Associates include widening the road in certain sections, better alignment through tight curves, improving or replacing structures over Anderson and Gunning Creeks, proper base and surface throughout the improved section, and proper drainage and erosion mitigation measures. If these plans are implemented, they will likely result in safer travelling on Socrates Mine Road.

Healdsburg-Geysers Road--As described in the Setting, parts of the Healdsburg-Geysers Road, in its present condition and alignment, are below county standards and could contribute toward traffic hazards. Sonoma County feels that the bridge structure on this road is inadequate for heavy construction traffic. The additional traffic generated by SMUDGEO #1 construction could not only speed deterioration of the pavement, it could also increase traffic accidents on this road, thus making the county liable for damages. To mitigate these adverse impacts, the county may regulate both the nature and flow of traffic over this road. They could limit truck traffic to daylight hours only or even close the road entirely to heavy truck use. Another possible mitigation measure to decrease the county's liability in the event of a traffic accident would be for SMUD to purchase liability insurance to provide coverage during the construction period of this project.

The above-mentioned mitigation measures are considered temporary and really do not solve the inadequacy of the road condition. Staff feels that an appropriate measure would be to upgrade and realign the road where needed, reinforce the bridge to make it adequate for carrying heavy truck loads, and implement adequate drainage and erosion measures. Coordinating efforts among the county's geothermal developers to determine the specific road plans and financial mechanisms to equitably shoulder the costs, will assist in implementing these mitigation measures.

Butts Canyon Road--The section of Butts Canyon Road leading to the Livermore waste disposal area should be improved and maintained with proper base, surface, and drainage systems.

Ford Flat Road--If Socrates Mine Road is improved, geothermal traffic on Ford Flat Road may decrease to an insignificant level. This assumes that travelers would prefer a paved, faster and better aligned road to the winding, graded Ford Flat Road.

The extent of deterioration of other private and county roads due to SMUDGEO #1 alone will likely be insignificant if those roads are properly managed and maintained. However, cumulative impacts to such roads resulting from all geothermal development may still be significant.

CUMULATIVE IMPACTS

The construction of SMUDGEO #1 is expected to start April 1981 and continue through December 1983. During this period there will be five other geothermal projects under different phases of construction and some 15 plants under commercial operation within the KGRA region.

The cumulative work force will peak at about 550 to 590 workers around 1982 and steadily decrease to about 60 at end of 1984 (80-AFC-1). To decrease the number of vehicles traveling within The Geysers area, the construction personnel will be bussed to work, and ride-sharing for smaller work forces will be encouraged.

The CEC staff estimates an average of 20 to 30 heavy trucks per day traveling The Geysers region. As the development and the traffic volume in The Geysers area increases, so do the travel hazards on the road in this area. For 1979 the daily traffic average on Highway 175 is estimated to be 800 (CALTRANS, Office of Traffic Engineering) and a 1980 estimate of traffic on Socrates Mine Road is 684 vehicles per day (Lake County, 1980). Traffic volume data on other Geysers roads is not available at this time.

In summary, the SMUDGEO #1 project may add to the overall road deterioration, and due to increases in traffic volume, may contribute some increase in traffic hazards. To mitigate these impacts, SMUD will negotiate with the affected counties to determine its proportionate share of maintenance costs and methods of financial reimbursement to the counties.

SMUDGEO #1

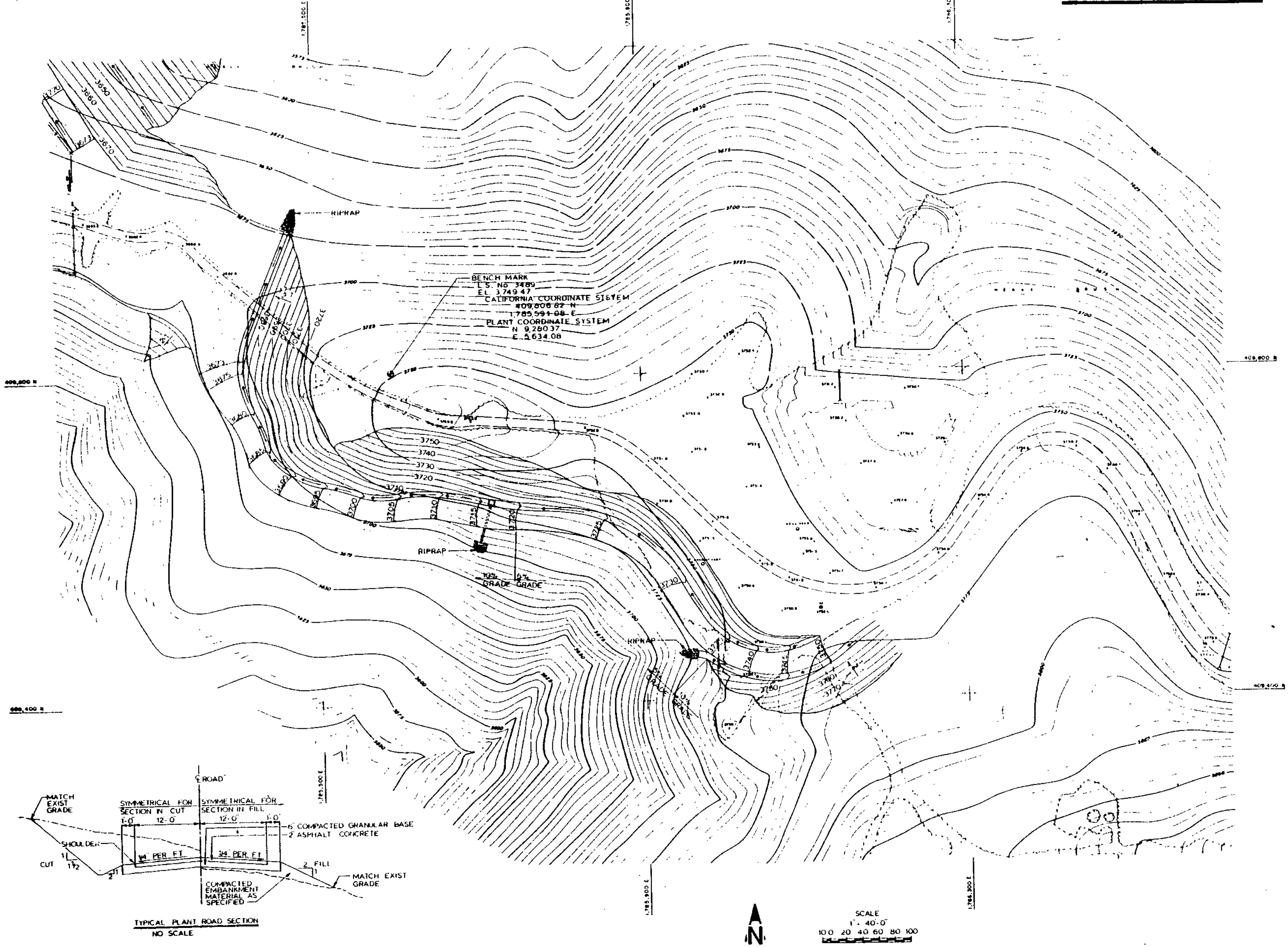


FIGURE 11: Access Road

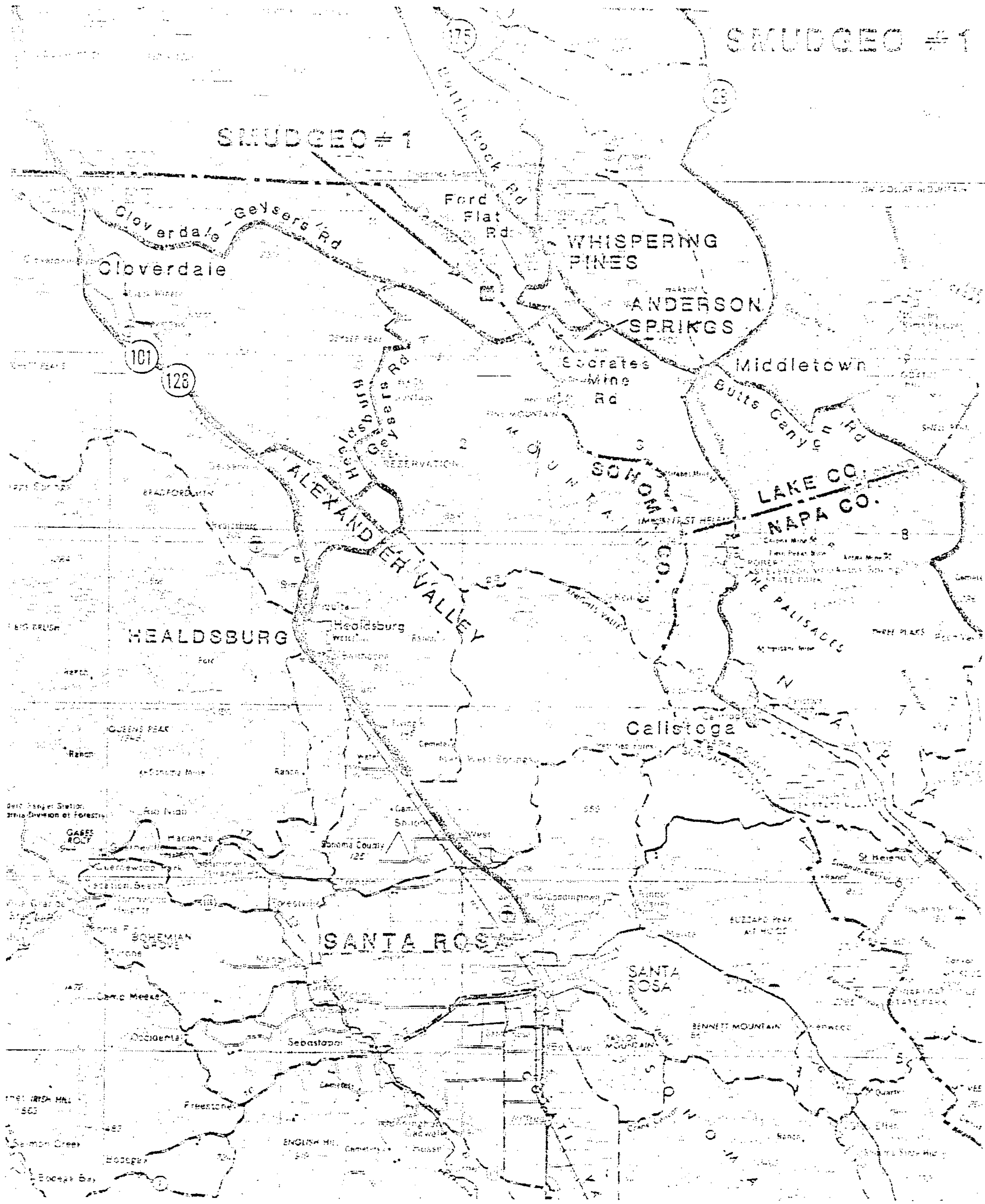


Figure 11.5 ROADS

LAND USE

SETTING

Before the advent of the geothermal development in The Geysers KGRA, the principal land uses in the area were recreation (predominantly hunting) and mining. Mining activities have long been discontinued, and recreation has been limited by difficult access to some portions of the area. Extensive use of nearby areas (e.g., Cobb Mountain) for recreational purposes continues, but geothermal development has ringed the SMUDGEO site area in recent years. With the discontinuance of mining, the only likely land use, aside from geothermal development, is recreational in nature, i.e., hunting, hiking, and off-highway vehicle activity. Most of the ridge is difficult to access, except along existing roads and jeep trails.

PGandE's Geysers Units 9 and 10 lie close to the proposed site to the northwest, and Units 13 and 14 lie to the west and southeast, respectively. Although no facilities currently exist to the northeast of the proposed site, tentative proposals for development in that area have been made by PGandE (80-AFC-1, Figure 1.1 - 2).

The site area is located on federal land; the United States Department of the Interior, Bureau of Land Management, under the provisions of the Federal Land Policy and Management Act of 1976 regulates in land use by developers. BLM issued a lease to Burmah Oil Company (now named Aminoil U.S.A., Inc.) for the development of the geothermal resource in 1971 (lease agreement for Unit 7 West Ca 1862, March 25, 1971), indicating clear intention to develop the geothermal resources on the site. Moreover, surrounding private lands lie within the area designated in the Sonoma County General Plan as a primary geothermal resource area (Sonoma County General Plan, pp. 72 - 73). Geothermal development is therefore an expressly permitted land use. CEC staff find use of the area as a power plant site to be consistent with county and federal land use plans and intentions.

To locate the preferred and alternative power plant sites, SMUD first performed a leasehold evaluation (Figure 12) which eliminated steep and geologically unstable areas from consideration. This left only two potential development sites, the preferred and alternative sites. They used a similar process to establish the preferred and alternative transmission line corridors (Figure 13). The alternatives section of this document discusses the selection processes more thoroughly, but for the purposes of discussing land use, it is important only to realize that SMUD first considered the geologic potential of the entire leasehold to establish the preferred and alternative plant sites, and then used a scoping process to further evaluate the placement of transmission line corridors.

IMPACTS

Development of the SMUDGEO #1 project will continue the current and prospective principal use of the land in this portion of the KGRA. As such, this facility will contribute to a cumulative loss of recreational use and open-space values which has already occurred due to previous geothermal development in the area.

Although long-term effects on the scenic and environmental quality will result from this land use change, these effects will not adversely affect plant neighbors, which themselves are geothermal developers holding leases on private, state, and federal lands. Therefore, the SMUDGEO #1 project by itself will promote no significant adverse environmental effects upon the basis of land use.

MITIGATION MEASURES

No mitigation measures are proposed nor deemed required.

SMUDGEO #1

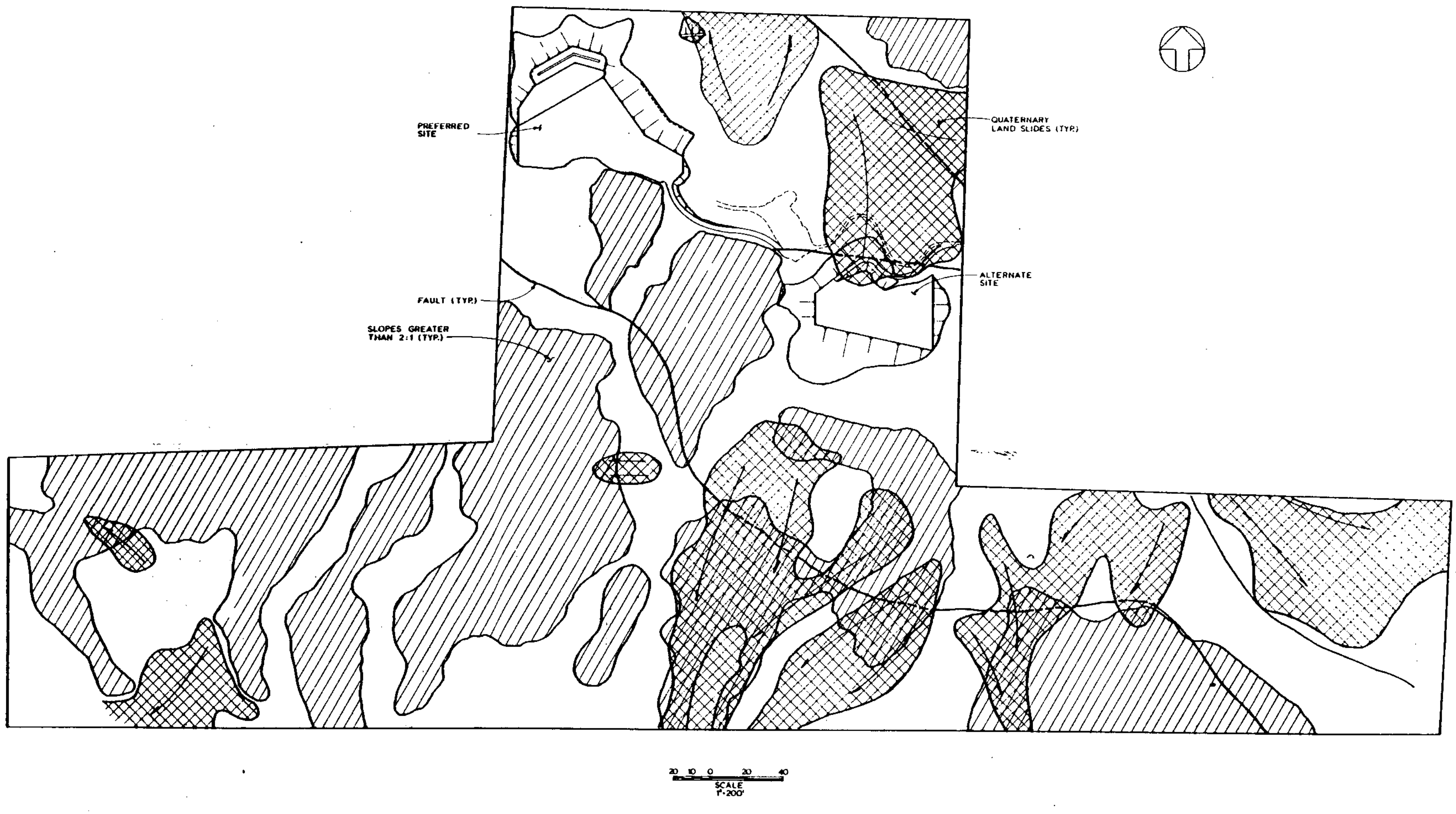


FIGURE 12: Leasehold Evaluation

SMUDGEO #1

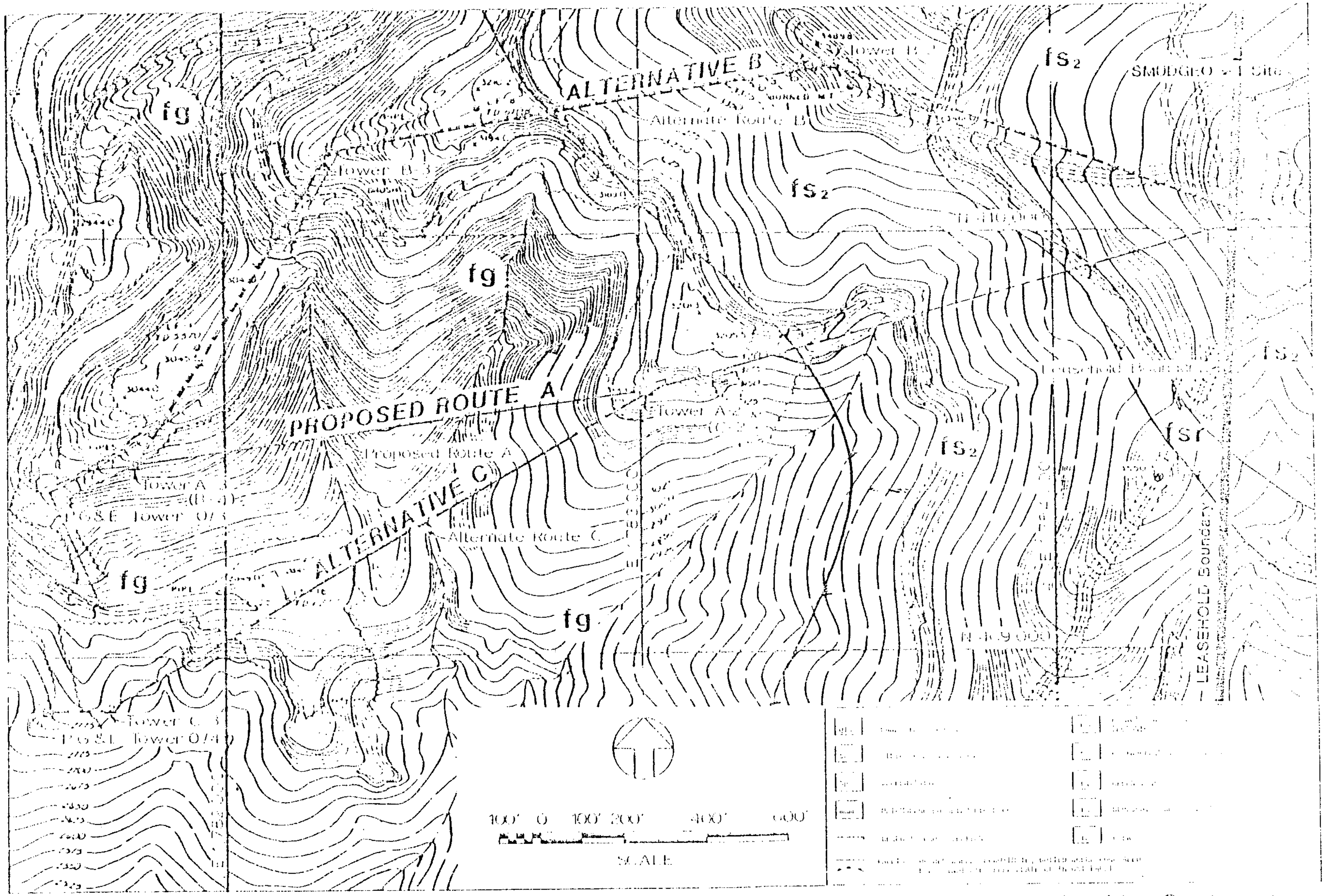


FIGURE 13: Transmission Corridor Geology Map

AESTHETICS

SETTING

The site is located in an area of steep slopes and ridges, immediately to the west of the dominant ridgeline forming the central corridor of the Mayacmas range. The site itself is on a ridge in the area, at an approximate altitude of 3,700 feet. Elevations to the north, west and south are lower than the site, while higher elevations are found to the east and northeast. Vegetation currently on site consists of mixed chaparral, typified by dense, shrublike vegetation less than 10 feet in height. Surrounding sections of the leasehold and adjacent tracts (especially to the near southeast and southwest) contain mixed evergreen forests (AFC, pp. 5 - 117).

Prominent natural features which are in the area include The Geysers Rock (1.5 miles north of the site), the Little Geysers (1 mile south), Cobb Mountain (1.5 miles northeast), and assorted meadow lands. Man-made features in the area consist predominantly of other geothermal power plant facilities and related transmission lines and roads. PGandE Geysers Units 9, 10, 12, 13, 14, and 18 are all located within 2.5 miles of the site. Abandoned mine areas and cabins in the Cobb Mountain area constitute the only other man-made features in the immediate vicinity of the plant. The site does not lie in any areas designated by either Sonoma County or the Bureau of Land Management as being of critical scenic value. The principal highways in the area, California Route 128 and U.S. Route 101, however, are both designated as scenic highways under the Sonoma County General Plan (Sonoma County General Plan, Part II, pp. 127 - 132).

IMPACTS

Foreground views of the facility are possible only within the geographical boundaries of The Geysers KGRA. Due to land forms and vegetation, close-in views would be restricted in areas to the south and east of the plant site. The transmission tap line would be visible from these screened areas to the east of the facility. People exposed to near-field viewscape impacts of the proposed facilities would typically include only (i) individuals in the area in connection with the ongoing geothermal development, and (ii) recreational users in the Cobb Mountain area or dominant ridges of the Lake County side of the KGRA. In light of the extent to which the site vicinity is already in use for geothermal power generation, the viewshed impact of the proposed generating station and associated transmission tap line should be understood to represent a cumulative addition to viewscape impacts rather than a qualitative change in the character of viewscapes from the surrounding area. That is, individuals who would be affected by visual intrusion attributable to the facility are already subject to views of the existent power plants and transmission lines in the area. For this reason, near-field viewscape effects of the proposed facilities are not expected to be significant.

Because the facility site is located on a ridgeline with lower elevations to the south, and northwest, remote views from outside of the KGRA will be possible. Views of the facilities will be possible from various locations to the south of the Alexander Valley, and from Santa Rosa. These same areas are currently subject to views of cooling tower plumes of other generating stations in the KGRA. The SMUD facilities, however, will introduce remote views of a power plant itself upon the area.

The distances from the site to the areas affected are long. Viewers to the south of the site generally will see it from a distance in excess of 10 miles, while those in the northeastern area would be in excess of 15 miles from the site. Some of these will view the facilities from Route 101, which has been designated as a scenic highway by Sonoma County. In light of the long distances involved and the current visibility of cooling tower plumes of existent geothermal facilities at higher elevations, these remote viewscape effects should not be significant.

MITIGATION MEASURES

SMUD will paint the facilities in colors to reduce contrast between the facility and the natural background as viewed by distant viewers.

WASTE MANAGEMENT

SETTING

A number of potentially hazardous liquid and solid wastes are produced during the construction and operation of a geothermal power plant. These wastes include contents of steam well drilling sumps, construction wastes, condensate from the spent geothermal steam, by-products from the H_2S abatement system(s), and sanitary wastes. Potential health hazard mitigation regarding toxic waste disposal is assured through a series of safety-oriented regulations developed by California Department of Health, Environmental Protection Agency, and the Water Quality Control Board.

Currently, all power plants at The Geysers are operated by PGandE. PGandE is hauling all hazardous wastes produced by its operations to Geothermal, Inc.'s Class II-1 hazardous waste disposal site near Middletown in Lake County. Since SMUD is proposing to begin a similar operation, the CEC staff has assumed that the impacts of their operation will be similar to PGandE's.

Drilling Wastes

Drilling wastes consist of drilling mud used in developing the geothermal resource and the borings produced by such drilling.

Construction Wastes

Construction wastes will include excess soil and rock materials, cleared vegetation, miscellaneous debris, oily discharge and residues, unsalvageable wooden shipping crates and skids, cardboard boxes, lumber scraps, concrete wastes, paper, and plastic wrapping.

Operational Wastes

Potentially toxic wastes from the geothermal power generation process include the excess condensate, water from the cooling tower basin, and fluid wastes from air pollution control equipment.

Sanitary Wastes

Sanitary wastes consist of those produced in sanitary facilities used by on-site workers.

Potential Disposal Sites

Wastes produced by geothermal power plant operations must be disposed of at sites approved by the responsible regulatory agencies: the Regional Water Quality Control Board, the Department of Health Services, and the local agencies.

These agencies approve the use of any Class I disposal site or Class II-1 disposal sites that have been approved specifically for these wastes. For environmental protection, all official disposal sites are designed according to constraints established by the regulating agencies: the California Department of Health Services and the Regional Water Quality Control Board. Class I disposal sites are separated from usable groundwater by natural geologic formations and are not subject to flooding. Class II-1 disposal sites are separated from usable groundwater by artificial means, usually must be monitored, and are protected from flooding by a storm or flood having a predicted frequency of once in 100 years.

Geothermal Inc. operates a Class II-1 disposal site near Middletown in Lake County, about six miles from the proposed project area. This operator has a permit to accept all wastes produced by the geothermal power plants in The Geysers KGRA.(Kritikos, 1979; Central Valley RWQCB, 1979)

The IT Corporation operates a Class II-1 disposal site near Kelseyville in Lake County, about 17 miles from the proposed project area. The site operator is fully licensed for disposal of all wastes produced by the existing power plants in the KGRA. Based upon the current rate of waste production from Geysers Units 1 - 12, the current site has a design life of seven years. If the operation proves financially feasible for IT Corporation, additional capacity could be developed.(Simonsen, 1979)

IT Corporation also operates a Class I disposal site near the City of Martinez in Contra Costa County, about 75 miles from the proposed project area. This site is licensed to accept wastes of the type produced in geothermal power plant operations.

IMPACTS

Hazardous wastes are of special concern because of their potential for causing significant adverse impacts on public health and the environment. The California Department of Health Services considers geothermal drilling wastes, cooling tower sludge, and the elemental sulfur produced as a by-product from the Stretford process, as hazardous wastes.(DOHS, 1979) Other hazardous wastes include oils, thinners, and solvents.

Drilling Wastes

See Water Quality Impacts.

Construction Wastes

During the 32-month construction period, the project will produce approximately 3,500 cubic yards of other construction wastes.(Geysers Unit 18 Final EIR, Appendix C) If such wastes were to be stored on site, there would be significant potential aesthetic, biological, and water quality impacts.

Operational Wastes

Based upon data provided for Geysers Unit 17 (PGandE, 1979b), the operation of a 110 MW geothermal power plant using a surface condenser and Stretford system for H_2S abatement can be expected to produce approximately 350 cubic yards of sludge (20 percent solids, 80 percent water) every year. The proposed Stretford system would approximately one cubic yard of sulfur and used process solution per day.

In addition, a secondary H_2S abatement system will be required. This system will add a chelated iron catalyst and hydrogen peroxide to the steam condensate before it passes through the cooling tower. The hydrogen peroxide will oxidize the dissolved hydrogen sulfates or elemental sulfur. Side reactions with the catalyst may result in the production of iron sulfide precipitants. The elemental sulfur and iron sulfide solids are expected to amount to less than 3.5 cubic yards of 20 percent solid sludge per year.

Unless properly disposed of, operational wastes might cause significant adverse environmental impacts on water quality, public health, and vegetation.

Sanitary Wastes

Exposure of people to sanitary wastes through inadequate disposal can result in nuisance odors and the spread of communicable diseases.

MITIGATION MEASURES

Hazardous Wastes

There are number of federal, state, and local laws which regulate the safe handling of toxic waste materials. Compliance with the following requirements will reduce the risk of impacts from hazardous wastes to an acceptable level:

Federal

- Hazardous Materials Transportation Act, Public Law 93-633, 49 U.S. Code 1801 et seq.--The regulations adopted pursuant to this act are codified in Title 49 of the Code of Federal Regulations, Parts 100 through 199. These regulations provide authority to the Secretary of Transporation to guard against risks to life and property which are inherent in the transportation of hazardous materials.

- Federal Resources Conservation and Recovery Act of 1976--Provides the federal requirements for waste management. Although final regulations have been promulgated, their effect upon this project cannot be assessed at this time.

California

- California Water Code, Division 7.5, "Transportation and Disposal of Waste"--Each Regional Water Quality Control Board (RWQCB) may approve sites suitable for the disposal of different kinds of wastes. Section 13360 allows RWQCB to specify the design, location, or type of construction of evaporation ponds and solid waste disposal sites. California Administrative Code, Title 23, Chapter 3, Subchapter 15, "Waste Disposal of Land," contains the regulations implementing these statutes.

- California Health and Safety Code, Division 14, Chapter 6.5, "Hazardous Waste Control"--Allows the Department of Health Services to specify standards and procedures for determining the appropriate classification of wastes and, if hazardous, the proper disposal and transportation methods. California Administrative Code, Title 22, Division 4, Chapter 30, contains the regulations implementing those statutes.

- California Governmental Code, Title 7.3, "Solid Waste Management and Resource Recovery"--Allows the Solid Waste Management Board to license disposal sites or to give the permitting authority to counties which have an approved program. California Administrative Code, Title 4, Division 7, Chapter 3, "Minimum Standards for Solid Waste Handling and Disposal," contains the regulations implementing these statutes.

- "California Assessment Manual for Hazardous Wastes," published by the Department of Health Services--Gives DOHS guidelines for determining the classification of wastes.

- "Waste Discharge Requirements for Non-Sewerable Waste Disposal to Land," published by the State Water Resources Control Board--Provides disposal site design and operational information.

- California Vehicle Code, Sections 2402 and 34501 and the regulations adopted pursuant to it contained in Title 13 of the California Administrative Code, Article 1.3, "Hazardous Materials Definitions," and Article 1.5, "Hazardous Materials Transportation"--These regulations prescribe requirements for shipping hazardous materials by highway. They are enforced by the California Highway Patrol.

Local

- Sonoma County Code, Chapter 22, "Refuse." This code prohibits unlawful waste disposal in Sonoma County.

Limited quantities of potentially toxic or hazardous wastes may be stored on site for a limited period of time. Storage facilities must be maintained in conformance with regulations of the California Department of Health Services and the Regional Water Quality Control Boards.

Transportation of these wastes is also under regulation by the Department of Health Services, Hazardous Materials Management Section. Hazardous wastes being removed from the site for disposal must be carried in trucks by registered haulers who must comply with applicable sections of the California Health and Safety Code and pursuant to DOHS regulations.

The producer of hazardous wastes is responsible for their disposal even after they have been delivered to the hauler. In the event of a spill during handling or transporting of these wastes, protective service agencies, such as the county sheriff, highway patrol, highway department and fire department, generally respond to assist in needed abatement, clean-up or other protective measures. The Department of Health Services and Regional Water Quality Control Boards may provide consulting services if requested.

Hazardous wastes must be disposed of at approved Class I or Class II-1 sites. Available sites are located in Martinez, Middletown, or Kelseyville. SMUD or its contractor(s) should determine whether the proposed disposal site(s) has adequate capacity for estimated wastes produced during the lifetime of the proposed project, and if not, SMUD should determine an alternate disposal site. SMUD has not yet contracted with any waste disposal sites.

Elemental sulfur produced as a by-product of the Stretford process is considered hazardous. As such it is subject to the regulations shown above. However, as a nearly pure sulfur cake this by-product is also saleable, and therefore, SMUD may opt to sell this waste to industry.

Drilling Wastes

By order of the Regional Water Quality Control Board (CVRWQCB Order No. 78-184 and NCRWQCB Order No. 78-17), after the liquid portion of the contents of drilling sumps evaporates, the well field operator should analyze the solid portion. If it is hazardous, it will be disposed of as described in the Hazardous Wastes Mitigation Measures subsection above. If it is not, it will be covered with earth, and the surface will be revegetated. Compliance with these measures and those described in the Water Quality section of the EIR will render drilling waste impacts insignificant.

Construction Wastes

Cleared vegetation and miscellaneous debris may be disposed of on site or at an approved disposal site. Wastes which are not hazardous can be transported by unregistered haulers and disposed of in any site which has been approved by the Regional Water Quality Control Board and responsible local agencies. This procedure will render impacts of such wastes insignificant.

Operational Wastes

Underground Injection

At other units potentially toxic wastes have been disposed of by injection into the steam reservoir through nearby dry or under-productive wells. Tests of the hydrogen sulfide abatement system(s) currently in progress at PGandE's Unit 15 also include an investigation into the toxicity of the wastes produced by the abatement system(s).

Although there have been no studies made to determine the effects of injection of any of these geothermal wastes, no adverse effects are anticipated by either RWQCB or CEC staff because the reservoir lies far beneath any groundwater aquifers and is separated from these aquifers by natural barriers (tight and clay like soils) and deep well casings.(CEC-SRI, 1977)

Sanitary Wastes

Sanitary wastes at the SMUD site will be of limited volume, but they cannot be disposed of on site because the slope and soils of the proposed site do not allow for construction of an adequate leachfield disposal system.

The responsible regulatory agencies (Regional Water Quality Control Boards and Departent of Health Services) have indicated that injection of sanitary liquid wastes back into the steam reservoir is an acceptable practice.(Central Valley RWQCB, 1978; Ed Crawford, CVRWQCB, 1979) If injected into the steam reservoir, any pathogens in this waste would be killed by the intense heat and pressure of the steam reservoir. This mitigation will render this impact insignificant. Solids, however, must be disposed of off site.

CUMULATIVE IMPACTS

Approximately 2,000 cubic yards of sludge (waste from water processing systems at PGandE Geysers Units 3, 4, 5, 6, and 11, and waste from cooling tower basins at Units 1-11) per month is produced by existing power plants and is presently disposed of at a site near Middletown in Lake County. This site is owned by Geothermal, Inc., and is estimated to have a 50-year capacity to accept wastes at the current production rates. In addition, IT Corporation owns several sites which can dispose of these wastes (Kritikos, 1979; Simonsen, 1979; Central Valley RWQCB, 1979). SMUDGEO #1's Stretford system will produce approximately 350 cubic yards of sludge per year, and the H_2O_2 secondary abatement system may produce as much as 3.5 cy of sludge per year. The cumulative impacts of geothermal wastes will affect the capacity of the waste disposal site, but if disposed of properly, the adverse effects upon water quality and public health will be mitigated.

AIR QUALITY

SETTING

The most difficult environmental effects to analyze and evaluate are the impacts of power plant emissions on ambient air quality and the effects that deterioration in air quality have on surrounding plant, animal, and human populations. Several factors account for this difficulty:

a. Reliable up-to-date information on the existing ambient air quality is seldom available for the specific plant site;

b. Emissions from the plant cannot be accurately predicted prior to actual operations because the exact composition and concentration of chemicals in the incoming steam are not known;

c. The effectiveness of pollution control equipment has not been determined over a period of time long enough to assure the assumed figures are reliable; and

d. There is little scientific certainty regarding the nature and extent of harmful effects of geothermal plant emissions, even after abatement to meet governmental standards, upon plants, animals, and humans.

This section examines available information on the ambient air quality at the proposed site, and the climatic conditions that affect air quality. It also examines available information on steam content and ambient air conditions. The purpose of the discussion is to provide baseline information against which the proposed project's emissions and the changes in ambient air quality, which result from those emissions, can be measured and their effects evaluated.

Climate

Preproject Meteorological Conditions--

Weather conditions in the general vicinity of the site have been monitored at various times for several years. Air quality and meteorological monitoring stations established by the Stanford Research Institute (SRI) are located near enough to the proposed SMUD site so that data collected there can be used to determine ambient and meteorological conditions at the plant site.*

The nearest SRI station, SRI-2, is located on Anderson Ridge, (on the same general ridgeline of the Mayacmas Mountains as the plant site), about one and a half miles (2.4 kilometers) southeast of the plant site. Station SRI-6 is

*The data and results from all eight of SRI's meteorological stations are contained in a report prepared in November 1979; see Ronald E. Ruff, Leonard A. Cavanaugh, Janet D. Carr, "1978 Executive Summary Specialized Monitoring Services," (SRI International, 1979), hereafter cited as Ruff, Cavanaugh, and Carr.

located about 4 miles (6.4 km) to the east-southeast, near the eastern end of Anderson Springs. Between 1976 and 1977, these stations monitored ambient concentrations of hydrogen sulfide (H_2S) and meteorological conditions such as temperature, wind speed, and direction.

Another source of data is a network of stations located at the sites listed in Figure 14. The stations were established by SMUD and the California Department of Water Resources to provide a more complete and current data base of ambient H_2S concentrations at the KGRA. These data have not yet been collated and published. When published, they will provide approximately one year of data for review.

Meteorological conditions at the proposed plant site are typical of the general climate in the region, which is characterized by wet winters and dry summers. This general climate is affected by the Pacific High, a semipermanent high pressure system off the Pacific Coast which influences air flow and precipitation over the entire state. The clockwise flow of air around this high pressure area results in northwest winds over California and is also responsible for the persistent subsidence inversion which extends over much of the state during the summer months.

Ambient Air and Dew Point Temperatures--

The complex terrain of the KGRA region is a major factor which affects local climate. The Mayacmas ridge deflects incoming marine air, moderating temperatures within the region. Even so, monthly temperatures at the site can range from 20°F (-6.6°C) in January to over 100°F (37.8°C) in August. Monthly average ambient temperatures measured at SRI-2 and at the NCPA-2 station are shown in Table 11. These values should be representative of the temperatures at the SMUDGEO#1 site.

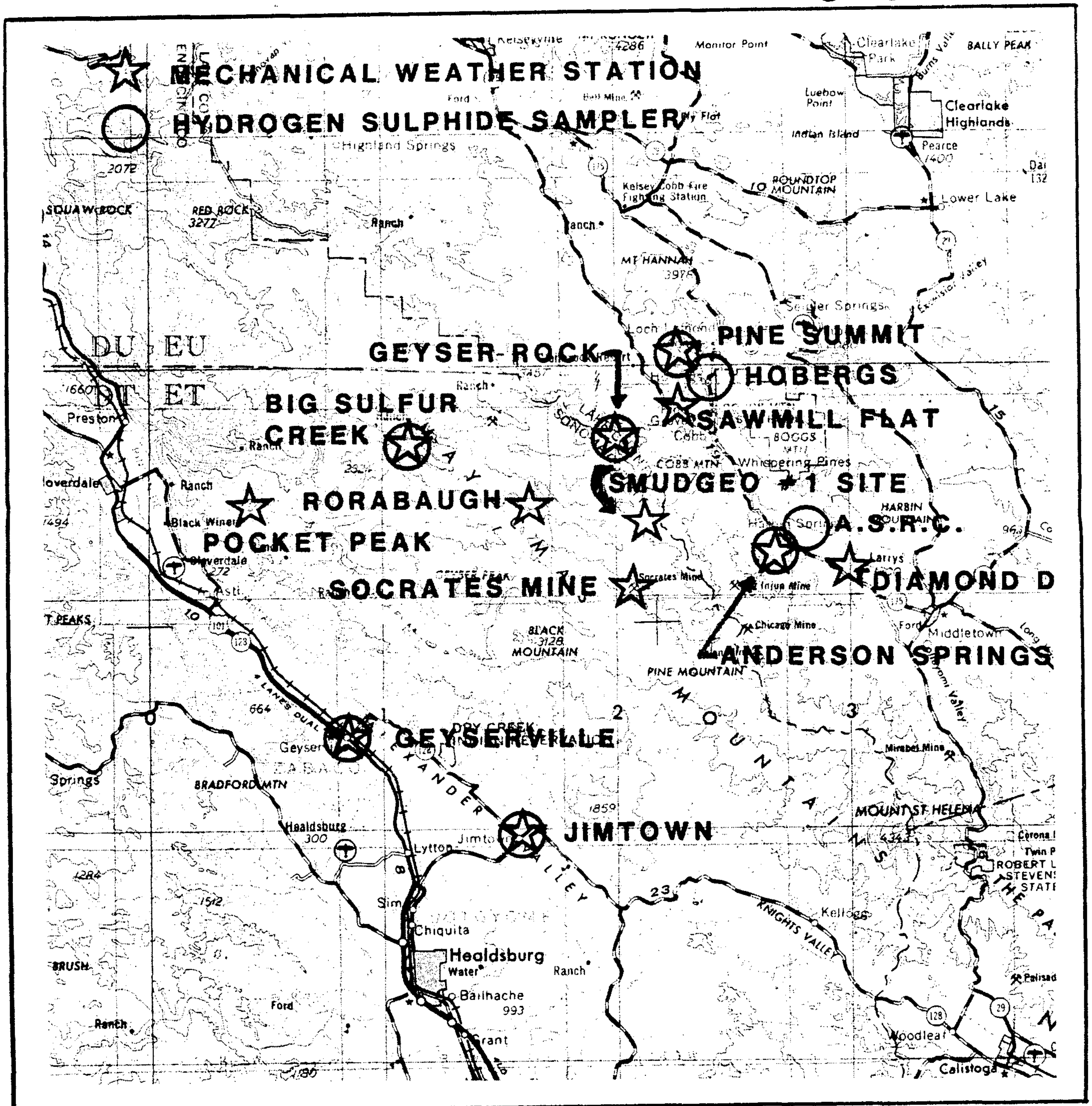


Figure 14: **SMUD/DWR MONITORING STATIONS**

TABLE 11

MONTHLY AVERAGE AMBIENT TEMPERATURES IN PROJECT AREA (°C)

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Anderson Ridge, SRI-2[1]	7°	7°	5.5°	10°	18°	20°	21°	22°	16°	14°	10°	7°
NCPA-2[2]	-1°	-1.6°	2.6°	4.3°	11.7°	13°	19.3°	18.4°	14.9°	13.6°	3.4°	1°

1. Ruff, Cavanaugh and Carr, 1977. Data shown were measured from February 1976 through September 1977.

2. Environmental Systems and Service (contractor for the NCPA-2 met station). Data shown were measured from April 1978 through March 1979.

The cold winter temperatures indicated by the NCPA-2 station data included in Table 11 are important for several reasons. First, the H_2S abatement system proposed by SMUD must be maintained at temperatures at or above 50°F (10°C). Second, low winter temperatures associated with high wind speeds may result in a "downwash" condition in which pollutants from the project site could be driven down the Mayacmas Ridge towards Anderson Springs. Downwash conditions may also occur during spring and summer months. Such temperatures also appear to be associated with "drainage" conditions at Anderson Springs during which cold air containing pollutants can be pulled down the ridge towards the community. An earlier analysis of the SRI data, conducted by Environmental Research and Technology, Inc. (ERT), indicated that the highest concentrations of H_2S measured at Anderson Springs (SRI-6) occur during drainage flow conditions,* (limited mixing conditions were determined to result in the maximum impacts from the SMUDGEO #1 facility; see impact section).

The hot summer temperatures contributed to inversion conditions which trap pollutants below hot air layers, preventing dispersion. A condition called "fumigation" can also occur in hot weather, causing pollutants to be transported downward from vigorous vertical mixing of air flows beneath a low inversion. In this condition, high concentrations of pollutants can accumulate in relatively small areas.

The inversion can lead to "limited mixing" conditions which can "trap" pollutants between the inversion and the ground and intensify concentrations. Limited mixing is distinct from fumigation in that the pollutants are not injected into the stable layer (inversion). This limited mixing condition frequently includes winds which transport the pollutants over the Mayacmas Ridge towards populated areas such as Anderson Springs and Whispering Pines.

Air quality is also affected by the relationships between dew point temperatures and cooling tower plume rise. In general, if the dew point temperature is higher, water vapor or steam emitted from a cooling tower plume condenses more slowly. This allows the hot vapor or steam to rise higher, be carried aloft by wind streams, and be dispersed over wider areas. Conversely, when dew point temperature is lower, the water vapor or steam tends to condense more rapidly. Heat energy is lost, the resulting plume rise is lower, and generally dispersion is less extensive.

The effects of dew point temperature on plume rise are not as strong as the effects of wind speed. In fact, mean dew point temperatures recorded at PGandE Geysers Unit 13 (PGandE, 1979d) during 1977-78 show a fairly narrow range of 34°F (November) to 43°F (August). Although a wider range could be expected at SMUD's ridge-top site (Geysers 13 is at a lower, more sheltered location), CEC staff do not believe this difference would make dew point the predominant factor in determining plume rise or would have a major effect on determining "worst case" meteorological conditions for air quality analysis purposes.

*D. Steffan, L. Wang, G. Hidy, The Geysers Geothermal Area Emissions and Aerometric Data Set (1976-77), (ERT, August 1978) prepared for The Geysers Geothermal Environmental Committee, hereinafter referred to as "ERT Report."

Precipitation--

In general, the amount of precipitation can affect the ambient air concentrations of total suspended particulates (TSP). Heavy rains and snow "scrub" or "wash" these particles from the air. Precipitation also helps dissolve certain water soluble gases or particulates that can be emitted from geothermal plants, such as hydrogen sulfide, ammonia, and boron.

Average annual precipitation at the proposed plant site is approximately 76 inches (see Water Resources for additional discussion). Winter precipitation often occurs as snow above 2,000 feet (610m) and averages about 20 inches annually. Average relative humidity near The Geysers ranges from about 30 percent during the driest months to near 80 percent in the winter.

The high levels of precipitation during winter months are responsible for the fact that the ambient air concentrations of H_2S measured at the SRI stations were generally lower in the winter than in the summer.

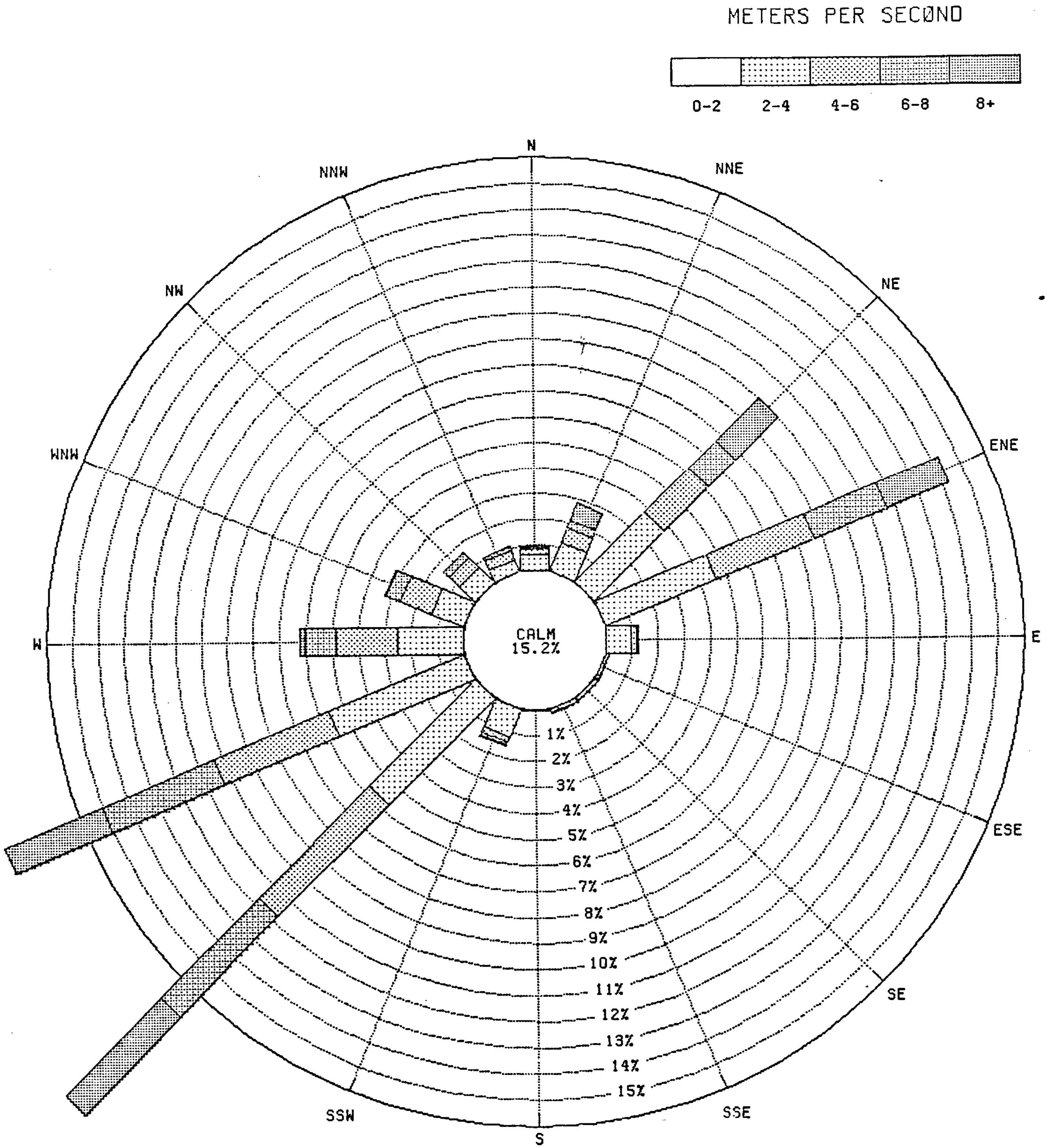
Wind Speed and Direction--

Wind speed in the project area generally increases with elevation. The proposed project site is at about 3,700 feet elevation. Measurements taken at the SMUD meteorological station at the site indicate average wind speeds of approximately 15 mph. SRI data indicate that the frequency of calms (winds less than 1 or 2 mph) is significantly less than 10 percent at exposed elevated peaks.

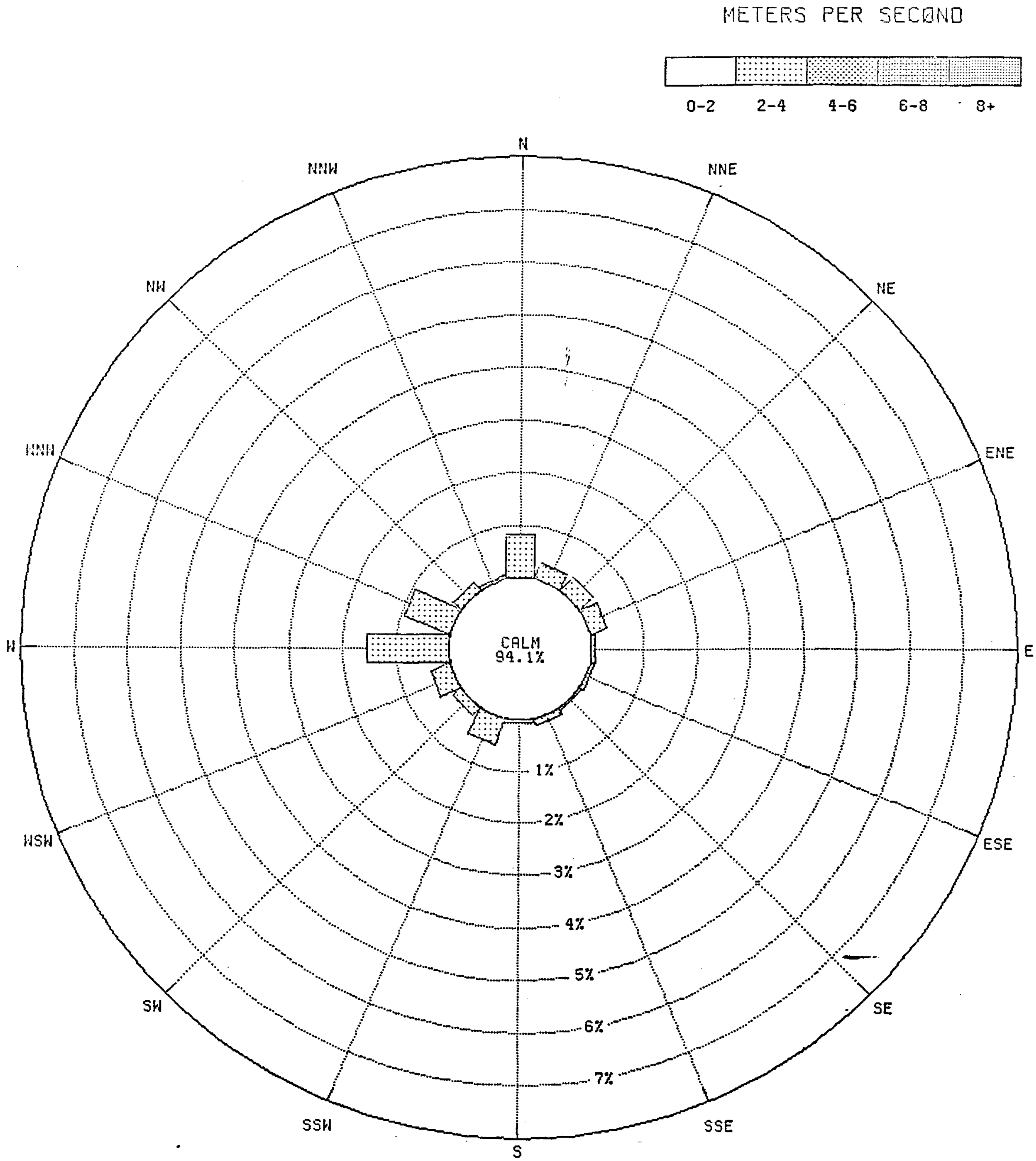
The directional frequency distribution of local wind flow is more complex. At elevations above 3,000 feet (900m), the predominant wind is either from the NE $\pm 45°$ or the SW $\pm 45°$. This distribution pattern is observed during all seasons. The likelihood of westerly and southwesterly winds is particularly important since emissions from the plant can be carried toward Anderson Springs (4 miles to the east), Whispering Pines (3 miles to the northeast), or down into the Collayomi Valley toward Middletown.

Directional frequency of wind flows at the SRI-2 meteorological station located on the ridge southeast of the proposed project site exhibits the typical NE/SW high elevation pattern. Figure 15 presents "wind rose" patterns for the SRI-2 site for the years of 1976 and 1977. Figure 16 presents wind rose patterns for the SRI-6 (Anderson Springs) site for the period from October 1979 to July 1980. Additionally, Figure 17 also presents wind rose patterns for the SMUDGEO#1 site, located northwest of the SRI-2 site on the ridge. Comparison of these sets of wind roses illustrates the effect of local terrain upon wind direction distribution and frequency.

At lower elevations, directional patterns bear little similarity to patterns found at high elevations, as local terrain becomes increasingly important in determining directional distribution. As indicated by the wind rose pattern for SRI-6, there is no dominant wind direction, and this lower area exhibits a high frequency of relative calms although 1976-78 data would indicate a westerly component. Topographic features may cause channeling of moderate or strong flows within valleys and around obstacles. Heating and cooling of slopes tends to create upslope flows over sun heated surfaces and downslope flows at night. Downslope drainage flows are most developed in winter and upslope flows are strongest and most frequent in summer.



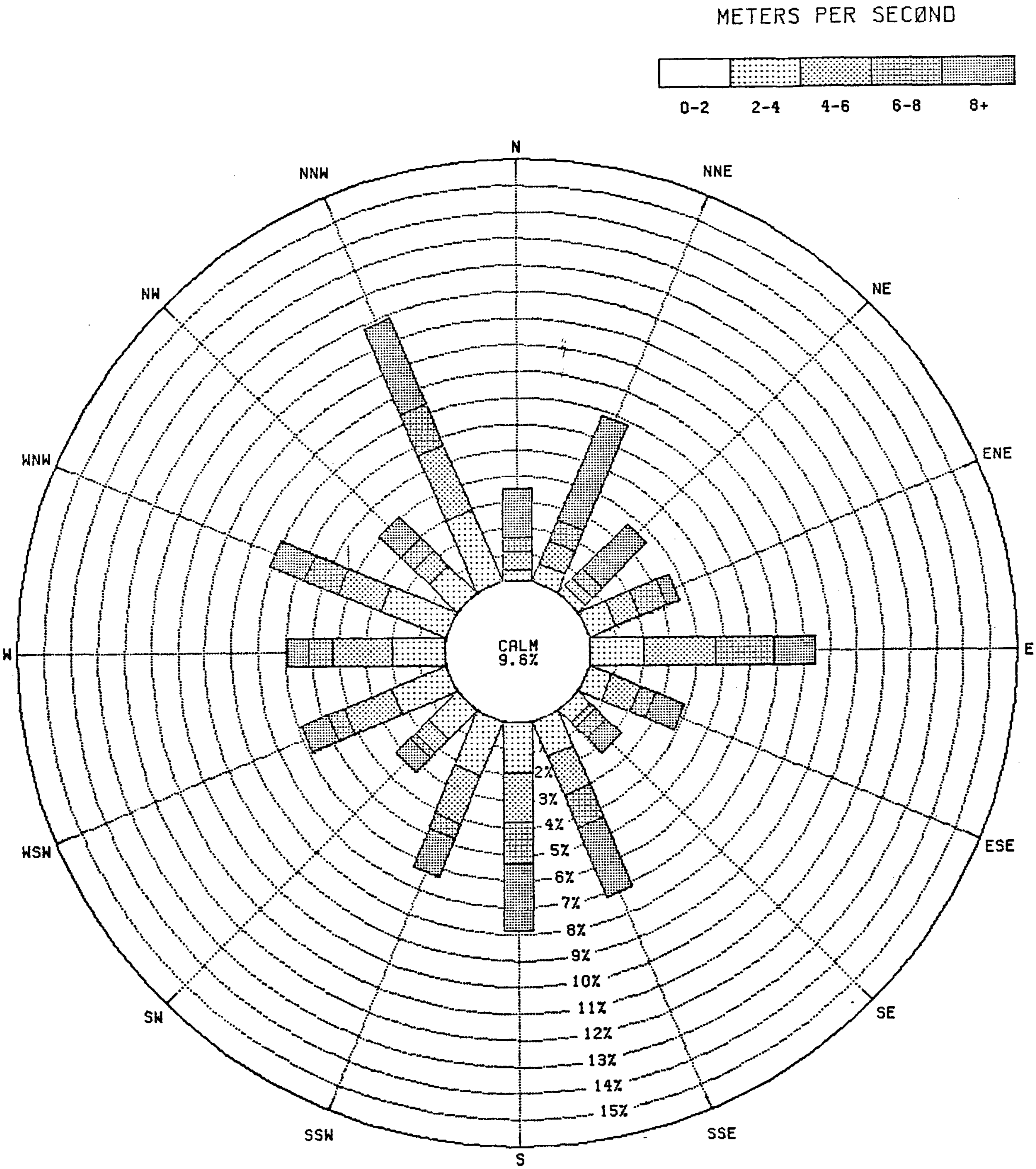
WIND ROSE
FIGURE 15 (SRI-2)
PERIØD ØF RECØRD 2/ 1/76 TØ 12/31/77



WIND ROSE

FIGURE 16 ANDERSON SPRINGS (SRI-6)

PERIOD OF RECORD 10/ 4/79 TO 7/15/80



WIND ROSE
FIGURE 17 SMUD-1
PERIØD ØF RECØRD 9/26/79 TØ 7/31/80

Source: SAI (1980)

Worst Case Meteorological Conditions--

Several studies have been conducted for other CEC regulatory cases to determine worst case meteorological conditions. SRI's study established a data base for determining the predominant meteorological conditions at several points in the KGRA, including ridge-top and valley locations. An objective of this project was to provide data to help clarify correlations between specific conditions, such as temperature and wind speed/direction, and the high H_2S concentrations which have been recorded.

This data base and subsequent analyses and field tracer tests did not result in definitive relationships between particular sources (power plants) and the receptors which they affect. Therefore, SMUD conducted tracer tests for each regime or set of climatic conditions (see Impacts and Mitigation Measures). The purpose of tracer tests is to determine transport and dispersion of a plume under the conditions recorded on that test day. However, those conditions may not result in worst case impacts. Therefore, a model simulation was expected to, in a sense, extrapolate tracer test meteorology to worst case conditions (by worsening some parameters) and thereby result in expected worst case air quality impacts at receptors.

As stated in the AFC (Appendix A), SMUDGEO #1 could be expected to affect receptor areas under the following meteorological conditions:

a. Limited Vertical Mixing: a layer of stable air above the Mayacmas Ridge (which reduces the total volume of air for dispersion--this concentrates the pollutant) coincident with cross ridge winds transporting the plume into Lake County receptor areas.

b. Downwash: high speed ridge winds deflect the plume downward by mechanical fluid motion into an adjacent valley (either into Alexander Valley or into the Lake County side of the ridge).

c. Drainage: high surface cooling and light winds aloft can carry the plume down into Big Sulfur Creek and possibly over the ridge into Lake County around daybreak.

d. Fumigation: the plumes can be transported via a neutral or stable layer to Alexander Valley where the pollutants can be carried down to the ground by drainage winds and subsequent convective mixing as sunrise occurs. Fumigation may also occur in the afternoon because of valley-shadow indirect circulation.

Air Quality

Ambient air quality in the region is influenced predominantly by geothermal steam emissions. Water vapor constitutes about 99.8 percent of these emissions; noncondensible gases and solids comprise the remaining .2 percent. Seventy-one billion pounds of steam were used in 1976 by the 11 operating units of PGandE's Geysers Power Plant.

Characteristics of Steam Content as They Relate to Air Quality--

Composition of the steam varies according to the location of the source within the KGRA. A comparison of the composition of geothermal steam produced from wells supplying earlier PGandE units and one which will supply the SMUDGEO power plant are presented in Table 12. The figures in this table identified as The Geysers are averages based upon the range of values measured for several producing steam wells in the KGRA.

As the table demonstrates, the concentration of regulated pollutants in the steam from the Aminoil well is generally much lower than the average concentrations from other geothermal projects. Only one of the Aminoil wells has been drilled at this time. A total of 10 wells will be required for operation of the plant. Thus, no firm conclusion about ultimate concentrations of these pollutants can be made. However, information from wells drilled for nearby units (PGandE Units 9 and 10, 13, 16, and 18) suggests that the concentrations of pollutants in the southern part of the KGRA will be less than that seen in most other developed areas of the KGRA. These facts imply a greater likelihood of meeting air quality standards as well as a greater likelihood of avoiding adverse environmental impacts.

Characteristics of Existing Ambient Air Quality--

As geothermal development in the KGRA region increases, observation of ambient air quality and meteorological conditions at key locations identify corresponding changes.

In 1975, the California Air Resources Board measured seven major air quality contaminants at two sites in southern Lake County. The two sites are Kelseyville, about 10 miles northwest of the site, and Middletown, about 6 miles to the west. The ARB monitored ozone, carbon dioxide, sulfates, total hydrocarbons, methane, nonmethane hydrocarbons, and coefficient of haze (reduced visibility). According to the ARB, the California ambient air quality standards for each of these parameters was not exceeded during the monitoring period of April 14 through May 12, 1975. No similar or more recent monitoring for the parameters has been undertaken, despite the fact geothermal development has increased since 1975.

Pollutants associated with development of geothermal resources which are of concern in maintaining ambient air quality include suspended particulate matter, hydrogen sulfide, sulfur dioxide and radon. The ambient air conditions for each of these pollutants is described below.

Suspended Particulate Matter (TSP)--

Lake and Northern Sonoma County Air Pollution Control Districts conducted a six-month program to monitor suspended particulate matter in the region. During the period of February through August 1977, 24 hour average suspended particulate matter concentrations ranged from 1.74 ug/m^3 on Socrates Mine Road (March 14, 1977) to 76.05 ug/m^3 in Middletown (August 11, 1977). The higher values observed in Middletown probably reflect the contributions from nongeothermal sources in Middletown such as vehicular traffic, construction activities, and agricultural activities. All reported concentrations are below the California ambient air quality standard (TSP) of 100 ug/m^3 averaged over 24 hours.

TABLE 12

NONCONDENSIBLE GASES AND SOLIDS IN STEAM (AVERAGED)

FROM WELLS SUPPLYING GEOTHERMAL POWER PLANTS

	Percent by Weight	
Noncondensible Gases	The Geysers*	SMUDGEO**
Carbon Dioxide	0.3260	0.1500
Hydrogen Sulfide	0.0222	0.0060
Methane	0.0194	0.0100
Ammonia	0.0194	0.0025
Nitrogen	0.0052	0.0050
Hydrogen	0.0056	0.0020
Ethane	Negl	No Data
Total Noncondensibles	0.398	0.176
Solids		
Arsenic***	0.019	0.01
Boron***	16.0	10.0
Mercury***	0.005	0.001

* Overall average from 61 producing wells supplying The Geysers Power Plant, measured in 1972-1974 (NSCAPCD, 1974). Characteristic of wells change with time, validity of 1972-1974 data may be questionable.

** Based on one well proposed to supply SMUDGEO; measured by Aminoil USA (May 1980).

*** Parts per million, by weight.

Hydrogen Sulfide (H_2S)--

As part of its study, SRI measured ambient concentrations of H_2S at eight locations in the region from 1976 to 1978. SRI then derived hourly averaged concentrations of H_2S. Figures 18 and 19 and Table 13 present the distribution and frequency of times when the concentration equalled or exceeded the state ambient air quality standard of 0.03 parts per million (ppm) of H_2S at each monitoring point during 1976-77 and during 1978. Exceeds may be understated by today's standard, e.g., the ARB has determined that concentrations which equal or exceed 25 ppb constitute violations.

The SRI data indicate that H_2S levels in the Geysers Rock area (SRI-1), and on the ridgecrest above Anderson Springs (SRI-2) are somewhat higher than those of other monitored areas. Both sites are near producing geothermal fields. SRI-2 is the monitoring station nearest the proposed project site (1.5 miles to the southeast). The data indicate that 1976 H_2S levels at this site exceeded the state standard approximately 10 percent of the time (640 hours from a total of 7,325 hours monitored). During 1977, the 30 ppb standard was exceeded approximately 5 percent of the time (360 hours from a total of 8,372 hours monitored). Data for 1979 are not available.

SRI-2 generally records high H_2S levels when the winds are from the southwest. The distribution of H_2S concentrations versus time of day also peak during the night or early morning hours. It is probable that natural fumarole activity coupled with emissions from geothermal development activities (operating PGandE units and wells) to the southwest of Cobb Mountain are the primary contributors to H_2S concentrations recorded at SRI-2 during west or southwest winds.

Data from SRI-6 for 1977, located below the ridge in Anderson Springs, indicates that the state standard of 30 ppb H_2S was exceeded about .3 percent of the time (25 out of 8,201 hours monitored). Most of the violations in 1977 occurred during evening hours with low southwesterly winds. For SRI-2 and SRI-6, Figures 20, 21, and 22 provide H_2S data for each major wind direction, indicating the percentage of time various wind speeds occurred and the percent of time various levels of H_2S occur. The most recent data for Anderson Springs, provided by SMUD's monitor established in late 1979, indicate relatively low H_2S concentrations. This may be due to an unseasonable climate during 1980. Also, this monitor was removed in June 1980--before excessive H_2S concentrations historically occur.

It is extremely difficult to determine the exact sources of H_2S during periods when state standards are violated. The existing Geysers development contributes to these violations. Winds west of the Mayacmas ridge carry H_2S emitted from the plants and steam fields over the ridgecrest. Drainage flow downslope could subsequently dominate this wind flow and cause pollutants to flow toward Anderson Springs.

Sulfur Dioxide (SO_2)--

As part of its study, SRI measured SO_2 concentrations at Anderson Springs (SRI-6) and Pine Summit (SRI-4). Over 7,000 measurements (hourly average) were taken at each station between February and December 1976. At no time did SO_2

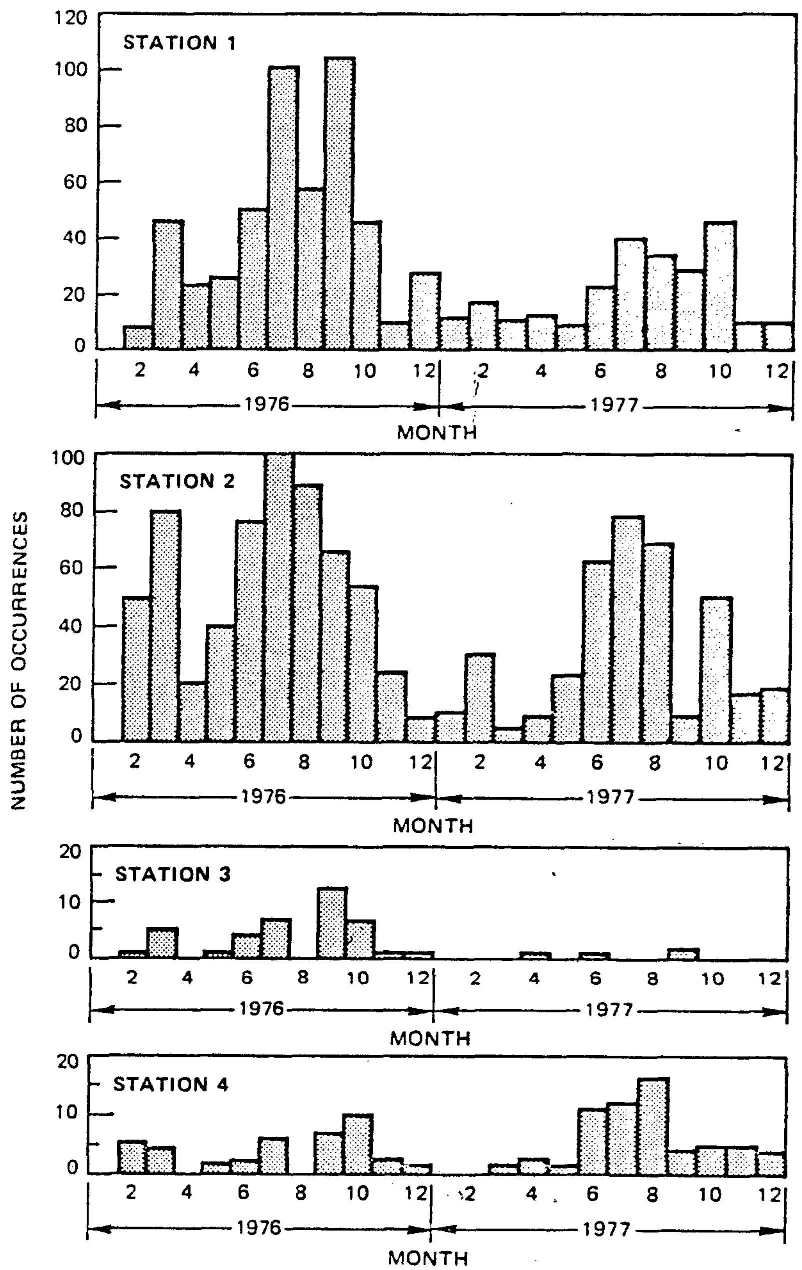


Figure 18 - DISTRIBUTION OF H_2S HOURLY AVERAGE AT OR ABOVE 30 ppb

Source: Ruff and Cananaugh (1978)

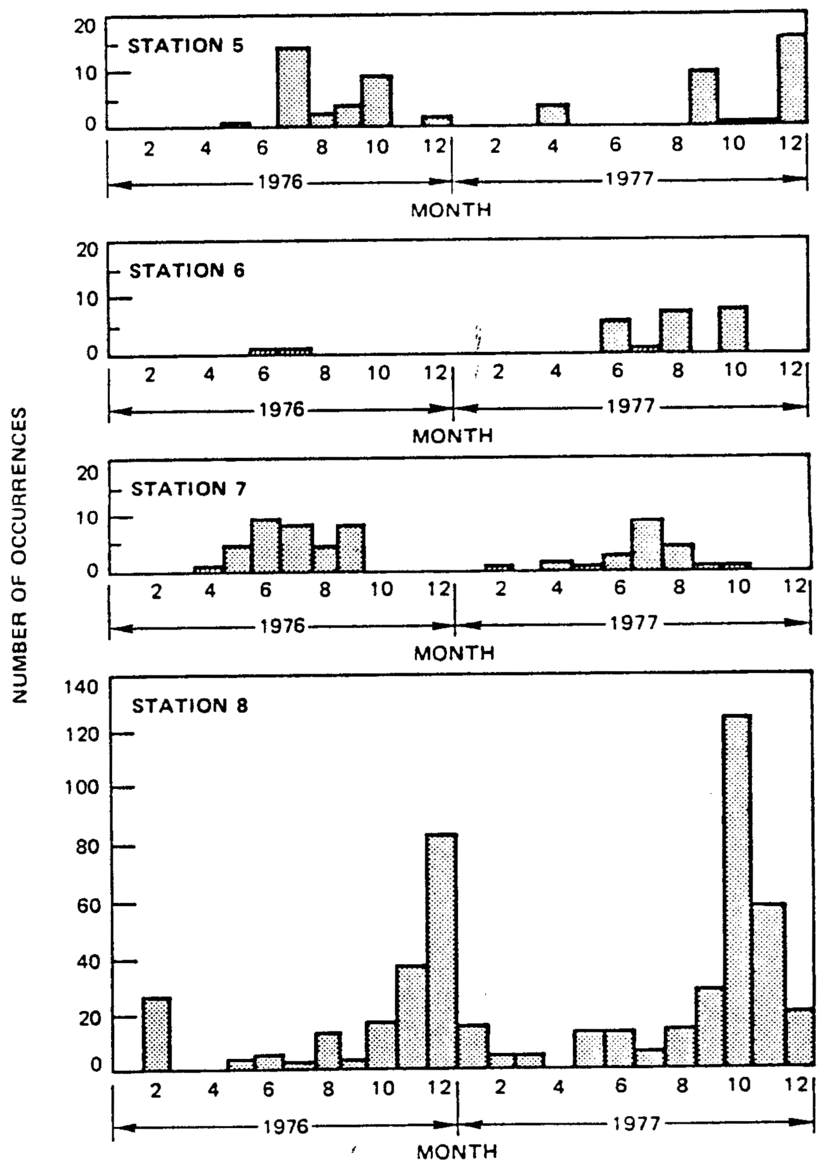
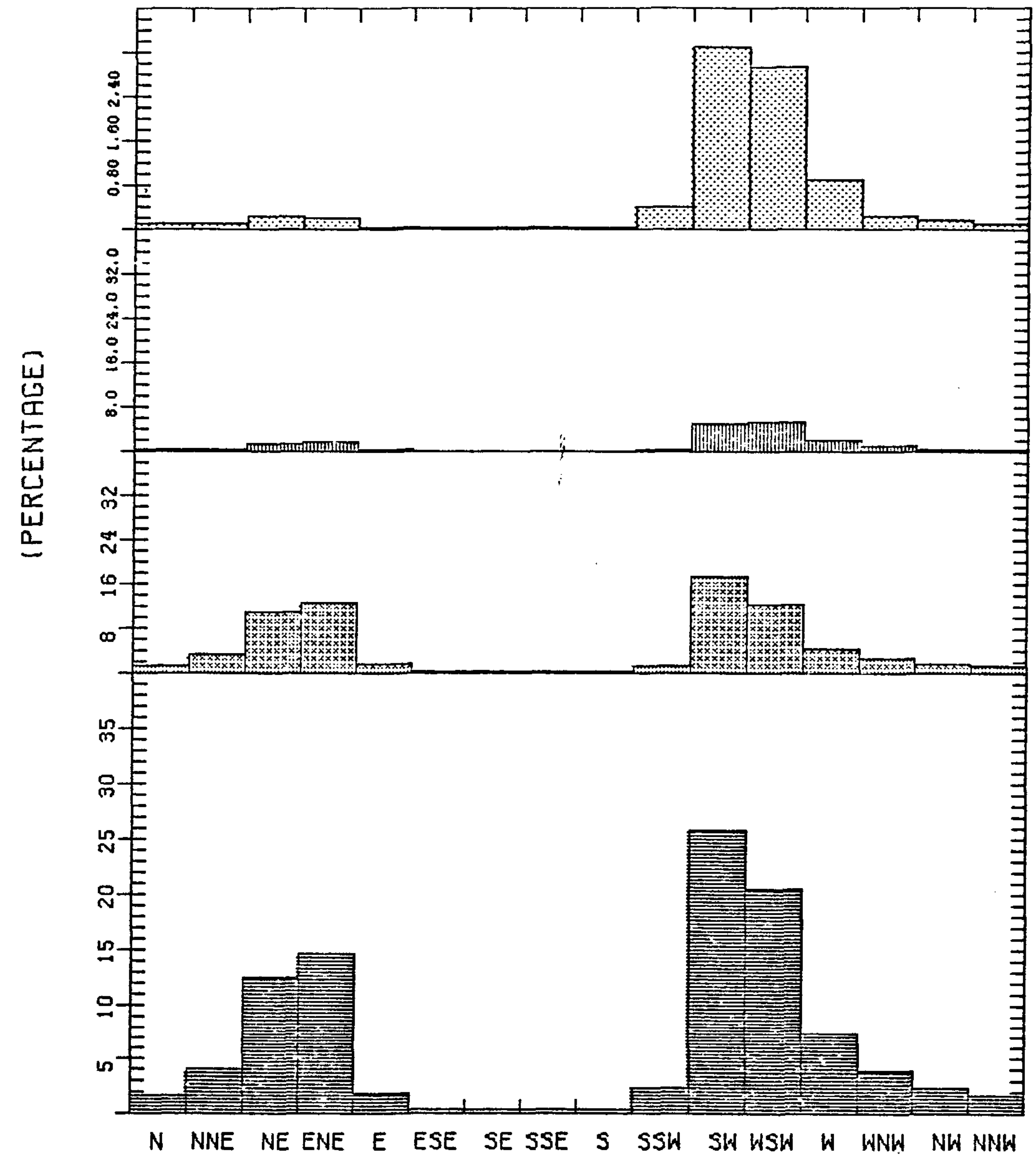


FIGURE 19 DISTRIBUTION OF H_2S HOURLY AVERAGES AT OR ABOVE 30 ppb (concluded)

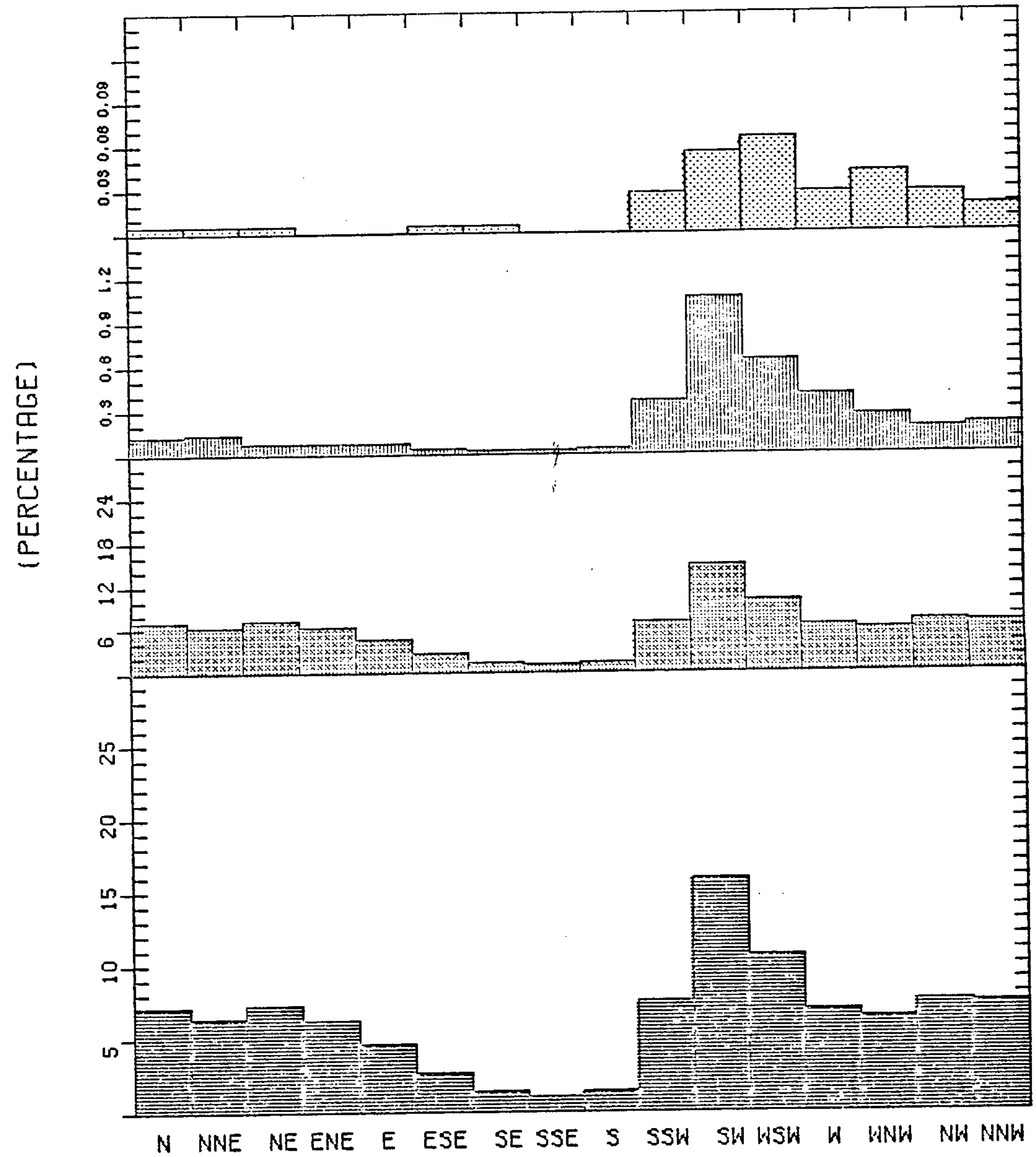
POLLUTANT : H2S
STATION CODE : SRI 2
SAMPLING PERIOD : 76-32 TO 77-366



SHADE	CONCENTRATION (PPB)	NO. OF SAMPLES
	ABOVE 25.0	1284
	BETWEEN 10.0 AND 25.0	2737
	BELOW 10.0	10482
	ALL	14503

FIGURE 20

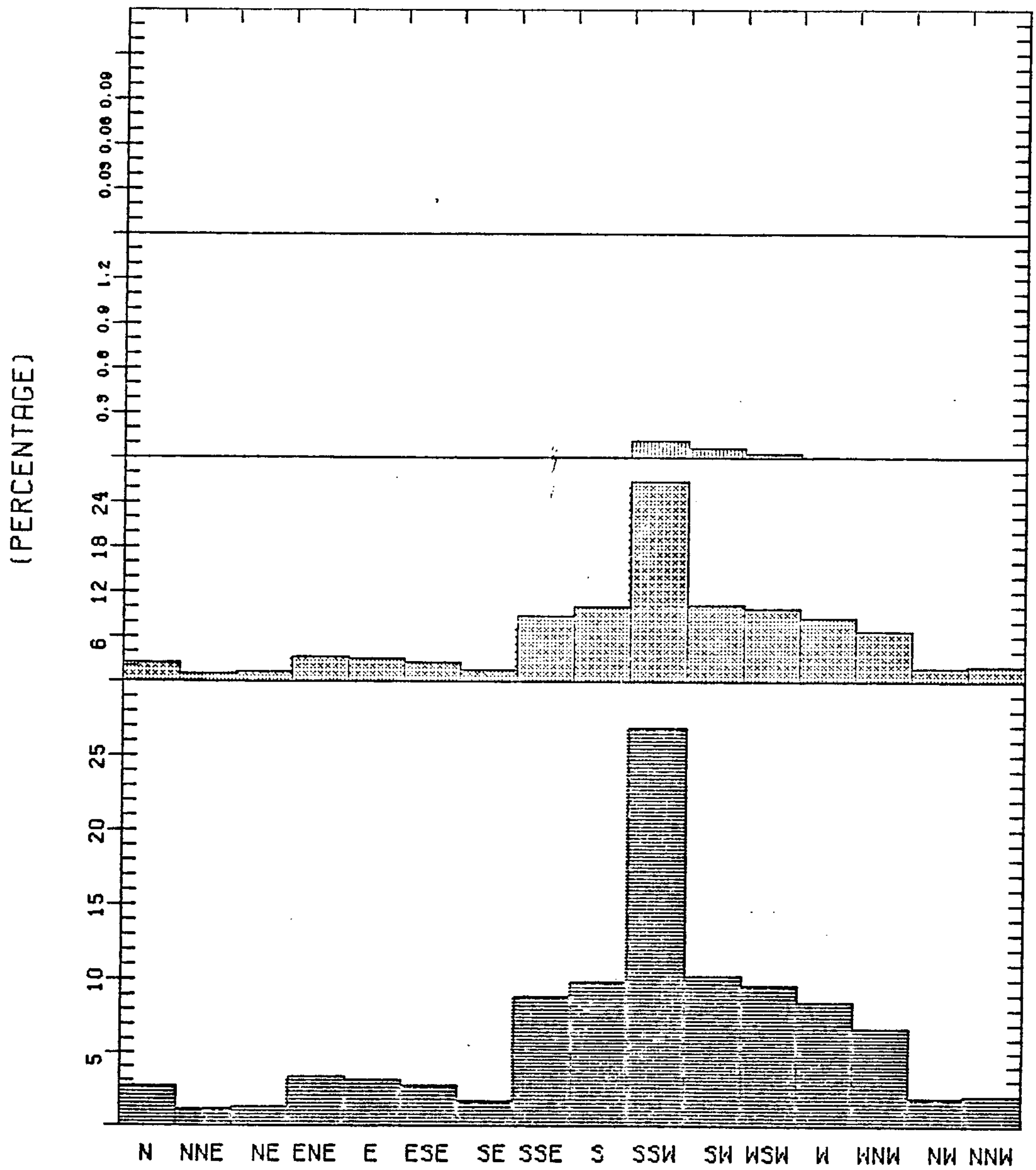
POLLUTANT : H2S
STATION CODE : ANDERSON SPRINGS
SAMPLING PERIOD : 78-32 TO 78-366



SHADE	CONCENTRATION (PPB)	NO. OF SAMPLES
	ABOVE 25.0	62
	BETWEEN 10.0 AND 25.0	806
	BELOW 10.0	20874
	ALL	21742

FIGURE 21

PØLLUTANT : H2S
STATIØN CODE : ANDERSON SPRING
SAMPLING PERIØD : 79-278 TO 80-167



SHADE	CØNCENTRATIØN (PPB)	NØ. ØF SAMPLES
	ABØVE 25.0	0
	BETWEEN 10.0 AND 25.0	9
	BELØW 10.0	4486
	ALL	4495

FIGURE 22

TABLE 13

DISTRIBUTION OF H_2S HOURLY AVERAGES (30 ppb): 1978

Station		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
1 Geyser Rock	≥30[a]	5	2	1	14	1	23	56	28	7	23	12	16	188	2
	Days[b]	1	2	1	7	1	9	18	11	5	9	7	8	79	22
	Counts[c]	597	602	719	675	691	590	723	687	612	724	558	657	7835	89
2 Anderson Ridge	≥30[a]	3	1	2	1	13	84	62	22	33	23	10	46	300	4
	Days[b]	2	1	2	1	6	18	14	7	14	13	6	16	100	27
	Counts[c]	600	539	712	679	676	575	591	481	497	596	659	711	7316	84
3 Kahm Ranch	≥30[a]	0	0	0	0	0	0	0	1	0	1	0	0	2	0.03
	Days[b]	0	0	0	0	0	0	0	1	0	1	0	0	2	0.5
	Counts[c]	470	605	727	673	694	645	719	710	700	682	372	578	7575	86
4 Pine Summit	≥30[a]	0	0	0	0	0	3	18	18	10	14	0	0	63	0.9
	Days[b]	0	0	0	0	0	1	7	8	6	5	0	0	27	8
	Counts[c]	607	595	611	692	335	646	714	728	712	547	242	553	6982	80
5 Whispering Pine	≥30[a]	0	1	7	2	0	0	3	0	3	6	3	0	25	0.3
	Days[b]	0	1	5	1	0	0	2	0	2	4	3	0	18	5
	Counts[c]	562	571	687	683	698	634	723	716	666	648	537	420	7545	86
6 Anderson Springs	≥30[a]	0	0	0	0	0	2	0	2	0	0	0	0	4	0.05
	Days[b]	0	0	0	0	0	1	0	2	0	0	0	0	3	0.8
	Counts[c]	587	601	609	689	705	645	726	719	690	687	697	742	8097	92
7 Sawmill Flats	≥30[a]	0	0	0	0	0	1	3	0	0	4	0	0	8	0.1
	Days[b]	0	0	0	0	0	1	2	0	0	2	0	0	5	1.4
	Counts[c]	605	613	734	655	696	646	725	719	710	331	380	725	7539	86
8 Aidlin Ranch	≥30[a]	12	9	0	0	0	0	66	41	7	94	62	9	300	6
	Days[b]	9	6	0	0	0	0	16	10	3	17	10	6	77	21
	Counts[c]	552	358	0	0	0	0	673	689	677	592	501	716	4758	54
Monthly totals:	≥30	20	13	10	17	14	113	208	112	60	165	87	71	890	
	≥30	12	10	8	9	7	30	59	39	30	51	26	30	311	

a ≥30 ppb = number of H_2S hourly averages at or above 30 ppb. (The actual measurement per hour must have averaged 29.5 or more.)

b Days = number of days with at least one hour reading at or above 30 ppb.

c *Counts = number of valid hourly averages* (percent counts correspond to valid data capture for 1 January through 31 December).

Source: Ruff and Cavanaugh (1979)

concentrations ever exceed the state standards for SO_2 (0.5 ppm hourly average or 0.05 ppm daily average). In fact, only rarely (1.1 percent of the time) did the hourly average concentrations of SO_2 at Anderson Springs exceed .005 ppm.* Thus, SO_2 concentrations are not expected to approach or exceed ambient air quality standards.

Radon (Rn)--

General findings regarding emission and presence of radon-222, radium-226, and lead-210 from The Geysers and surrounding areas have been issued in a report by LFE, Environmental Analysis Laboratories (LFE, 1977). The findings are summarized below:

- Emission sources at The Geysers contain concentrations of radon-222 above average ambient air concentrations. Most of the radon-222 passes through steam pipelines into power plants and out off gas ejectors through the Stretford unit to the cooling tower. Free venting wells and particle separators constitute other sources of emissions.
- Some habitable areas at The Geysers show concentrations of radon-222 above average environmental levels, but not outside the range of permissible environmental levels. All measured values, except in infrequently encountered off gas ejector plumes, were below 3 pCi/liter, the California Department of Health Services ambient air standard for radon-222 in uncontrolled areas.
- Populated areas around The Geysers were found to have no more than average ambient environmental concentrations of radon-222.
- Near site environment and population areas near The Geysers did not show any sign of accumulating radium-226 and/or lead-210 in soil, vegetation, or water.

Findings on accumulation of radium-226 and lead-210 are nonconclusive, as soil sampling will not necessarily show significant accumulation. See Public Health section for discussion of possible testing methods.

*See Ruff, Cavanaugh, and Carr, page 6, Table 3, Distribution of SO_2 Hourly Averages, 1976.

AIR QUALITY

IMPACTS AND MITIGATION MEASURES

Climate

Impacts Associated with the Proposed Project--

Persistent emission of heated water vapor can affect several microclimate variables. Addition of this vapor to the atmosphere slightly increases ambient temperature and humidity and reduces insolation (incoming solar radiation). Due to the relatively low volume of emissions in relation to the absorption capacity of the overlying air mass, CEC staff does not expect emissions from the proposed project to significantly affect local humidity and temperature.

During calm winter nights when drainage or downslope wind flows are predominate, emission of water vapor may slightly increase the frequency and duration of fog within one-half to one mile of the proposed project site.

Air Quality

Geothermal emissions influence ambient air quality in The Geysers KGRA. Water vapor constitutes about 99.8 percent of these emissions, and noncondensible gases and dissolved mineral salts comprise the remaining 0.2 percent. As indicated previously, noncondensible gases in geothermal steam include carbon dioxide, hydrogen sulfide, methane, ammonia, nitrogen, hydrogen, and ethane. Salts may include mercury, boron, arsenic, and other suspended particulate matter.

Of the gases present in the steam, CEC staff expects all except hydrogen sulfide to have no significant environmental impact. Ambient hydrogen sulfide (H_2S) is due both to natural sources, such as fumeroles, and to man-made sources, such as well drilling or power plant operation. The portion of H_2S present from natural sources is only a fraction of that present from man-made causes.

The Northern Sonoma County Air Pollution Control District (NSCAPCD) reports that complaints about H_2S odor from The Geysers began in 1972 and concludes that an emission threshold was reached at that time. Emission data show an average annual H_2S emission rate of 482 lbs/hr in 1971, 919 lbs/hr in 1972, 850 lbs/hr in 1980, and a projected 1984 rate of 699 lbs/hr (NSCAPCD).

Complaints about H_2S odor had already occurred in Lake County prior to 1972. Winds transport H_2S emitted in Sonoma County across the Mayacmas ridgecrest into southern Lake County. Geothermal emissions affect local air quality to such a degree that the Lake County Air Pollution Control District (LCAPCD) declares significant levels of contaminants to be present in Cobb Valley and adjoining areas.

Potential Sources of Pollutant Emissions--

Air pollutants from a typical geothermal power project can be emitted from two principal sources: (1) the power plant itself, including cooling towers, and

(2) steam wells and steam transmission lines. The first source produces emissions during routine operation of the steam turbine-generator, while the latter sources produce significant emissions only when the steam turbine-generator shuts down and steam from the transmission lines vents into the atmosphere. This condition is called "stacking."

SMUDGEO #1 will be designed with a turbine bypass mechanism which, unlike existing plants, will significantly reduce stacking occurrences and corresponding emissions. SMUDGEO #1 and DWR/Bottle Rock are the only new plants committed to use this bypass mechanism.

In addition, small quantities of pollutants can be emitted from the steam transmission line from the well bleedlines, leaky gaskets, or the clean-out of particulate collectors. These emissions are continually released at numerous points throughout the leasehold, but their impacts are generally considered insignificant.

The two most important air pollutants that will be emitted from the SMUD project are hydrogen sulfide (H_2S) and particulates (total suspended particulates or TSP). Both pollutants are present in the incoming steam and must be controlled by various abatement systems.

Particulate Sources and Quantities--

The amount of particulates entering the plant is expected to be less than 3 lbs/hr. Particulates can be emitted from several points in the steam cycle. Particulates that are not removed by the strainers in the steam transmission line will proceed through the turbine and, during the condensation process, become part of the condensate. The condensate will eventually pass into the cooling towers, where part of the particulates will be released into the atmosphere in the form of drift. Additional particulates can be transported by noncondensed gases into the Stretford H_2S abatement system where the majority of particulates are scrubbed out, although Stretford chemicals may be an additional source of particulates. The particulates will then be emitted with the gases from the Stretford system's cooling tower or transported to the plant cooling tower, then emitted to the atmosphere.

A third potential source of particulates is the secondary H_2S treatment process. SMUD will use peroxide treatment if the other methods now under investigation do not prove viable. Condensate treatment systems often use peroxide/iron sulfate catalyst to transform dissolved hydrogen sulfide (H_2S) into ammonium sulfate [$(NH_4)_2SO_4$], which can be emitted as a solid or particulate. Other solids may also be formed in the chemical reaction. Until the required extent and method of secondary H_2S treatment is determined, the amount of particulates that could result from this process cannot be determined.

Including an assumed contribution from secondary H_2S treatment, the plant's total particulate emissions will be approximately 3.4 lbs/hr,* which includes 0.8 lbs/hr from the main cooling towers and 2.6 lbs/hr from the Stretford cooling tower.

Hydrogen Sulfide Sources and Quantities--

The greatest potential source of H_2S emissions from the proposed power plant is the amount of H_2S dissolved in the spent steam. Left untreated, the spent steam would contribute significantly to violation of applicable standards for H_2S emissions.

For the proposed project (as in others recently proposed) the primary H_2S abatement equipment will consist of a surface condenser and the Stretford process.

---

*To arrive at particulate emission figures, CEC staff used the following assumptions:

(1) Total concentration of all solids in the steam condensate is 38 ppm--the maximum of an estimated range (AFC);

(2) Hydrogen sulfide content in the incoming steam is the maximum of the expected range--80 ppm (AFC);

(3) Steam condensate flow is 983,000 lbs/hr (AFC);

(4) The percentage of H_2S remaining in steam condensate after partitioning is 35 percent of the incoming H_2S;

(5) All of the H_2S dissolved in the condensate is converted to ammonium sulfate $(NH_4)_2SO_4$ (see Table 12, there maybe insufficient ammonia in SMUDGEO steam to complete this reaction, assumption is worst case based upon ammonia concentrations in other geothermal wells);

(6) Up to 10 ppm of catalysts are added to the condensate; and

(7) The ratio of total circulating water solids to total condensate solids is at the maximum of its range--approximately 6:1;

(8) AFC stated plant operating flow rates, including:

- a cooling tower air flow of 9,240,000 ft^3/min.;
- a maximum cooling tower drift rate of 0.001 percent of the hot water flow rate; and
- a maximum hot water flow rate of 139,260 gallons per minute.

With these assumptions, the cooling tower particulate emissions due to the additional solids content of the condensate after secondary treatment will be approximately 0.8 lbs/hr.

The success of the H_2S abatement system depends in part on the efficiency of the partitioning which occurs in the surface condenser. That portion of the spent steam which is partitioned into noncondensible gases will be diverted to the Stretford process for treatment, which will remove virtually all of the H_2S in the noncondensibles. Any remaining gases can then be exhausted to the atmosphere from the Stretford cooling towers or the plant cooling tower.

That portion of the spent steam which condenses at the surface condenser eventually circulates through the main power plant cooling towers, becoming the most significant potential source of H_2S emissions. If the surface condenser is unable to partition most of the H_2S in the spent steam into the noncondensible gases, SMUD will have to resort to some form of secondary H_2S removal from the condensate in the flow between the surface condenser and the cooling towers. Thus, the critical task of the surface condenser is to provide cooling in such a way that it maximizes the partitioning of H_2S and other noncondensible gases from the steam so that the H_2S gas can be treated in the Stretford unit.

Based on the limited data from the initial Aminoil steam well, SMUD estimates the range of H_2S concentration in the steam entering the power plant will be 40 to 80 parts per million, by weight (ppmw) (SMUD AFC, Table 1.2-3). The total amount of H_2S entering the plant, based on an expected incoming steam flow of 983,000 lbs/hr, could range from 39 to 79 lbs/hr.

A combination of primary and secondary abatement systems must meet the degree of power plant emissions abatement required by air quality standards and emission limitations.

Compliance With Emissions Limitations--

The New Source Review Rules and emission limitations of the Northern Sonoma County Air Pollution Control District (NSCAPCD) regulate emissions from the proposed project. Under the federal Clean Air Act, the district must determine whether a proposed project's emissions will prevent the attainment, interfere with the maintenance, or cause a violation of a national ambient air quality standard.

Under state law, the same determination must be made with respect to state ambient air quality standards which may be in addition to or more stringent than federal ambient standards. The California Air Quality Standard for H_2S is 0.03 ppm (parts per million) for a 1-hour average. This standard reduces annoyance caused by H_2S odors. In addition, NSCAPCD rules impose certain emissions limitations for various pollutants which must be met before a permit can be granted.

Emissions Limitations--

The NSCAPCD adopted H_2S emission regulations which reduce the total emissions from existing as well as future sources.

These regulations attempt to bring the KGRA into attainment with the California H_2S ambient air quality standard. Under NSCAPCD Rule 455(b), H_2S emissions from a geothermal plant cannot exceed 100 grams per gross megawatt-hour (100 g/GMWh). For the 72.3 MW (gross) SMUDGEO #1 power plant, the 100 g/GMWh limitation converts to 15.9 lbs/hr.

Rule 455 (b) also states that, beginning January 1, 1985, all power plants must meet the doubly stringent limit of 50 g/GMWh. SMUDGEO could not exceed approximately 8 lbs H_2S/hr under this revised emission limit.

SMUD conditionally committed to the 50 g/GMWh limit in the AFC. After a series of workshops between interested parties, SMUD set 8 lbs H_2S/hr as their emission rate unless the results of their air quality assessment show they can increase it to no higher than the mandated 100 g/GMWh.

Emissions Analysis of Primary H_2S Abatement System--

If one assumes that the H_2S content in incoming steam remains within the range expected by SMUD (60 + 20 ppmw, or 40 to 80 ppmw), then the total amount of H_2S entering the plant will range from about 39 to 79 lbs/hr.* To meet the 8 lbs/hr limitation will require an overall abatement efficiency of 79.5 percent to 89.8 percent, depending on the H_2S concentration in incoming steam.

The Ralph M. Parsons Corporation, manufacturer of the Stretford units for PGandE's Geysers Units 15, 17, and 18, now offers guarantees that the treated gas stream leaving its Stretford unit contains no more than 10 ppm by volume H_2S. The Stretford process exhibits removal efficiencies exceeding 99 percent and emission rates of less than 1 lb/hr. The SMUDGEO #1 Stretford unit supplier will be Peabody; removal efficiency would be similar.

Thus, the feasibility of meeting the 80 percent to 90 percent total abatement efficiency without secondary treatment of the steam condensate depends upon the ability of the surface condenser to partition approximately the same percentage--80 to 90 percent of H_2S from the steam as noncondensed gas.

When SMUD filed its AFC with the Energy Commission, it expected to achieve a partitioning efficiency from the surface condenser of 90 percent or higher; that is, 90 percent of the H_2S present in the turbine exhaust steam would be separated from the steam condensate as noncondensed gas. As stated, an efficiency of 90 percent will meet the present emissions limitation for H_2S.

However, test results from PGandE's Unit 15, the first Geysers Unit to employ a surface condenser, suggest that partitioning efficiencies of 90 percent may not be feasible. The following test results from the Unit 15 project are relevant to the proposed project:

*Based on the following calculations:

$$\frac{40 \text{ lbs of } H_2S}{1 \times 10^6 \text{ lbs of steam}} \times \frac{0.983 \times 10^6 \text{ lbs of steam}}{1 \text{ hour}} = 39.3 \text{ lbs } H_2S/\text{hr}$$

(The same calculation for 80 ppmw gives a figure of 78.6 lbs H_2S/hr.)

a. The partitioning efficiency so far achieved by Unit 15's surface condenser is about 67 percent. A comparable efficiency at SMUD's plant, given an H_2S input rate of 39 to 79 lbs/hr, results in H_2S emissions of 13 to 26 lbs/hr in the absence of secondary treatment.

b. The test results suggest that partitioning efficiency decreases as the concentration of H_2S in incoming steam decreases. For Unit 15 the concentration of H_2S is 180 $\pm$ 10 ppm. SMUD expects it to be 60 + 20 ppm. SMUD's partitioning efficiency may therefore be less than 67 percent.

c. Unit 15 test results indicate that the relative acidity, or pH, of the steam condensate is an important factor in maintaining partitioning efficiency. H_2S tends to remain in the condensate if the condensate is basic (pH greater than 7.0). The presence of ammonia in incoming steam tends to make the condensate basic in the absence of compensating acidic chemicals. The pH level of steam entering SMUD's plant cannot be determined until additional steam wells are drilled. Data from SMUDGEO's only well, provided by Aminoil, indicate a pH range of 5.0 to 7.0. PGandE attempted to determine the probable pH of steam condensate from a surface condenser by sampling steam from Unit 3. The results from Unit 3 indicate a pH of 7.1.

These facts indicate that the probable level of H_2S emissions following primary condensate treatment could range from 13 to 26 lbs/hr. This exceeds the 8 lbs/hr emission rate to which SMUD conditionally committed.

MITIGATION MEASURES

SMUD will install a secondary H_2S abatement system which will begin operation simultaneously with the generating unit. SMUD will continue to operate and maintain the H_2S abatement systems as long as needed to meet existing and future applicable air quality standards and regulations.

Emissions Analysis of Secondary H_2S Abatement System--

Whether it is feasible to provide sufficient secondary treatment to meet Rule 455(b) was addressed by the CEC in its certification proceedings for PGandE's Unit 17. The incoming H_2S concentration for PGandE Unit 17 is 350 $\pm$ 100 ppm. This corresponds to a H_2S flow rate of 516 to 957 lbs/hr.

Applying the 67 percent partitioning efficiency data to the highest expected H_2S content of the steam supplies to the Unit 17 and SMUDGEO #1, the H_2S removal requirement by secondary treatment would be approximately 315 lbs/hr of H_2S for Unit 17 and 26 lbs/hr for SMUDGEO. This indicates that the required capacity of storage tanks and size of other system components, as well as the reduction of side effects such as sludge creation, make the problems of a secondary H_2S treatment system substantially smaller for the proposed project than those expected for Unit 17. The Commission found the PGandE proposals for secondary treatment feasible, and therefore staff expects they are also feasible for the SMUD project.

SMUD agreed to install a secondary condensate treatment system (SMUDGEO AFC, page 1-30). Three preliminary abatement methods were investigated by SMUD:

1. Hydrogen Peroxide (with or without catalyst),
2. Stripping with inert gas, and
3. Condensate pH control with carbon dioxide (Ammonia fixation).

Peroxide oxidation, the first method listed above, is successfully employed at existing units at The Geysers. This method chemically alters the H_2S in the condensate to a more innocuous form. Tests of this type of system at PGandE's Units 3, 4, 5, 6, and 11 showed average abatement of 92 to 95 percent. Assuming 85 percent of H_2S in the condensate is removed along with 50 percent partitioning (worst-case) and 99+ percent H_2S removal by the Stretford unit, overall H_2S emissions will amount to 5.9 lbs/hr (at 79 ppm incoming H_2S). This is, of course, significantly lower than the 15.9 lbs H_2S/hr limit required by NSCAPCD Rule 455(b). Only 60 percent abatement meets Rule 455(b), and 80 percent secondary abatement control meets the 50 g H_2S/ GMWh limit which applies to SMUD. (See Table 14.)

Stripping and ammonia fixation affect the condensate chemistry so that the H_2S can be removed as a gas and treated by the Stretford Unit.

The stripping process uses an inert gas to drive H_2S from the condensate. The stripping gases move up a vertical column (the stripping tower) while the condensate flows down through the column. The stripper gas contains carbon dioxide which reacts with the ammonium hydrogen sulfide in the condensate and results in hydrogen sulfide gas formation. The hydrogen sulfide gas is sent to the Stretford unit for oxidation. Ammonia fixation increases partitioning in the condenser by affecting the way ammonia chemically participates during condensation. Carbonic acid can be manufactured from the noncondensible gas leaving the Stretford unit and subsequently injected into the condenser. The carbonic acid reacts with the ammonia in the steam and reduces the amount of hydrogen sulfide in the condensate which leaves the condenser by reducing the condensate pH.

Preliminary technical and economic analyses of the inert gas stripping and ammonia fixation techniques encouraged SMUD to further investigate these methods under bench scale testing. SMUD has committed to use hydrogen peroxide with ferrous sulfate and hydrokyacetic acid for condensate treatment if test of alternatives are positive SMUD may modify the design, with NSCAPCD and Commission approval.

Recommended Postcertification Procedures--

Areas of uncertainty concern (1) H_2S concentrations and pH levels in incoming steam, (2) achievable partitioning efficiencies for the surface condenser, (3) extent of necessary secondary treatment systems, and (4) reliability of and amounts of solid wastes produced by the secondary treatment system (recent data indicate that no significant amounts of solids would be formed; however, staff still has uncertainties). Because of these uncertainties, CEC staff recommends the postcertification procedures described below to ensure compliance with Rule 455(b). Due dates for responses expected from postcertification procedures will be developed during the Energy Commission's postcertification proceedings on compliance and monitoring requirements.

TABLE 14

CONDENSATE TREATMENT REMOVAL EFFICIENICIES
TO MEET 50 g/GMWh* (@ 72.3 GMW)

H_2S in Steam (lbs/hr)	Partitioning (%)	H_2S in Condensate %	lbs/hr	Condensate Removal Efficiencies Required (%)
200	95	5	10	20.0
	90	10	20	60.0
	75	25	50	84.0
	50	50	100	92.0
	25	75	150	94.7
100	95	5	5	-
	90	0	10	20.0
	75	25	25	68.0
	50	50	50	84.0
	25	75	75	89.3
80*	95	5	4	-
	90	10	8	-
	75	25	20	60.0
	50	50	40	80.0
	25	75	60	86.7
50	95	5	2.5	-
	90	10	5	-
	75	25	12.5	36.0
	50	50	25	68.0
	25	75	37.5	78.7

*Anticipated case, based on 80 ppb H_2S in steam and 1,000,000 lbs/hr steam flow rate.

**Grams per groww megawatt hour.

Source: SMUDGEO #1 AFC

1. The Applicant shall provide the United States Geological Survey (USGS), Commission Staff (through the Compliance Audit Manager--CAM), and NSCAPCD, for their review, design information on the following:

   a. Stretford system,

   b. Turbine by-pass,

   c. Condensate Treatment,

   d. Condenser/sparger system, and

   e. Solids removal system (if required).

   The information will be provided when it becomes available, but no later than 60 days before manufacture of equipment is ordered.

2. If the Applicant proposes a secondary treatment system other than the hydrogen peroxide system, the Applicant shall submit information to USGS, NSCAPCD, and CEC demonstrating that the system can achieve H_2S emissions of no more than 5 lbs/hr.

MONITORING AND COMPLIANCE

1. The Applicant shall as a minimum undertake the following monitoring and compliance programs. As described in 2-6, the Applicant shall submit a monitoring program at least 60 days prior to start up of the SMUDGEO #1 facility to USGS, NSCAPCD, and the CAM. Continous H_2S and total volume flow rates measuring methods will be considered. NSCAPCD will advise the ARB, USGS, and CAM on the acceptability of the programs.

2. The Applicant shall develop and implement a program to measure at least quarterly inlet steam constituents.

3. The Applicant shall develop and implement a program to measure H_2S in the noncondensible gas flow and in the off-gas vents of the Stretford unit to the cooling tower.

4. The Applicant shall develop and implement a program to measure H_2S concentrations and liquid flowrate of the condensate H_2S concentrations downstream of the secondary condensate treatment system prior to its release to cooling tower circulating water. The Applicant shall also provide a measuring point upstream of the treatment point if design allows although only one monitoring device shall be required.

5. The Applicant and NSCAPCD shall develop and implement a program to monitor ambient H_2S and TSP concentrations and/or other pollutants prior to and during operation of the SMUDGEO #1 facility at locations and for a duration to be mutually agreed upon. The Applicant shall submit the monitoring plan to CAM for approval at least 120 days prior to start up of the program.

6. The Applicant shall develop and implement a program to monitor the H_2S abatement system's performance. Results of this monitoring program shall be submitted to NSCAPCD, USGS, and CAM as follows:

a. The Applicant shall provide a compliance report on the results of the monitoring program within 100 days after the facility has been declared operational. The monitoring activity is to cover a minimum period of 75 days after the time the facility has been declared operational. The report shall contain data obtained during the 75 day monitoring period. A minimum of 30 days of data (not necessarily consecutive days) at 90 - 100 percent rated power generation shall be required (a compliance report shall be issued by the Applicant--in any case--within 100 days the facility has been declared operational). The report shall contain as a minimum H_2S concentrations in the off-gas and condensate, power generation rates, abatement systems' settings at time of tests, a description of the abatement system's failures, if any, and data obtained in Items 2, 3, 4, and 5 above.

b. If, during the first 75 days of monitoring described in Item a, 90 - 110 percent rated power has not been achieved for a minimum total equal to 30 days, monitoring shall continue and a second report is to be submitted within 25 days of obtaining 30 total days at 90 - 110 percent rate power. The second report shall include a summary statement of why 90 percent rated power was not being achieved, and a description of any corrective action taken.

c. Upon review of the information in Items a and b the Air Pollution Control Officer of the NSCAPCD shall within 30 days present to the Applicant, USGS, and CAM findings on conformity of air quality standard(s).

d. If the APCO finds that the facility has not met applicable emissions limitations, the Applicant shall prepare and submit its response to the USGS, the CAM, and NSCAPCD. The response shall be submitted within 30 days after the submittal of the report(s) to be applied to the facility or other actions taken to meet the emission limitations. The report will also describe a schedule for implementation of these measures.

e. Upon review of the information in Item d, the USGS, CAM, and NSCAPCD shall jointly determine whether actions proposed by the Applicant will comply with emission limitations.

f. After the implementation of the approved mitigation measures the Applicant shall conduct monitoring programs described in Items a and b. The NSCAPCD shall perform the actions described in Item c.

7. After obtaining a finding of conformance described in Item 6.c, the Applicant shall continue to monitor the H_2S emissions from the power plant and report on the status of compliance as required by NSCAPCD, but not less than on a quarterly basis. In case of noncompliance, actions identified in Items 6.d, 6.e, and 6.f, will be required to return to a condition of compliance.

The SAI Study--

Air quality impacts at nearby receptor areas due to the projected emissions from SMUDGEO #1 were investigated by Systems Applications, Incorporated (SAI). SAI's impact assessment integrated field tracer tests with computer modeling. The objective of this approach was to incorporate real-world information from the tracer studies into a mathematical computer simulation. Also, the results of the tracer studies provided a base line against which the modeling results could be compared. After making these comparisons to improve model performance, the model was expected to be capable of predicting ambient air quality at The Geysers when SMUDGEO #1 begins operation in 1984.

Basically there were four components involved in predicting impacts from SMUDGEO #1:

1. Plume Rise Model--The height which the plume rises from the cooling tower significantly affects where ground level pollutant concentrations will be detected and how high these concentrations will be. From several equations describing the plume rise, SAI decided on the Winniarski and Frick (1978) equations.

2. Transport and Dispersion Model--Once the pollutants enter the atmosphere, numerous meteorological characteristics (wind speed and direction at various altitudes, air and ground temperatures, etc.) affect the plume in which the pollutants travel. Another consideration is how the factors which affect plume rise (plume temperature, humidity, exit speed, etc.) interact with the atmosphere. SAI developed and used a numerical, gridded model called "Airshed." The Airshed Model incorporates three components: the Plume Rise Model (discussed above); a three-dimensional wind model which describes wind speed and direction in complex (or extremely mountainous) terrain; and a "Puff Model" which characterizes, as the name implies, small puffs of gas released to the atmosphere. The Puff Model was required so that the travel and dispersion of gases could be more accurately characterized as they leave the cooling towers. Once these puffs grow sufficiently large, they enter the "gridded" portion of the Airshed Model where their travel and dilution are more correctly characterized at the larger scale. The incorporated Airshed-Plume Rise-Puff Model is called The Geysers Hybrid Model.

3. Worst-Case Meteorology--As described earlier, meteorology plays a key role in determining under what conditions one particular emission source will affect a receptor area and how significant the impacts will be. To determine what meteorological conditions would lead to, the worst-case concentrations contributed by SMUDGEO required several public workshops between SMUD's consultants and regulatory representatives. Determining worst-case meteorology required collective experience and a review of available data so that several complex atmospheric phenomena could be described in ranges of relatively simple parameters.

4. Tracer Tests--Gases were released under several candidate worst-case weather conditions under which SMUDGEO #1 would most likely affect receptor areas. Detectors in these receptor areas indicated cumulative hourly concentrations of tracer gases. SMUD conducted six tracer tests (one being unsuccessful) for five meteorological conditions.

Both the modeling and the tracer test program rely on historical data (discussed in the "Setting") to characterize the meteorological conditions which prevail when SMUDGEO could be expected to affect receptor areas. Regulatory agencies and SMUD established the tracer test criteria by reviewing the historical record and setting a range of atmospheric conditions during which a plume from the proposed plant would travel toward receptors. The computer simulation modeling effort required use of the atmospheric field information from the tracer tests to ensure that the model treated the plume in approximately the same way that the atmosphere at The Geysers would. The model also required results of tracer tests conducted at the site to provide for evaluation of model performance.

Meteorological regimes are associated with particular seasons. For example, limited mixing occurs usually during spring through summer. Table 15 shows the result of combining the SRI data base and, using the parameters established to describe each regime, determining months when the stated conditions typically exist. In the case of limited mixing, it is apparent that SMUD conducted the tracer test during a period when one would not normally expect the occurrence of limited mixing conditions. Though the tracer test methodology is always subject to concerns that the results may not really represent worst-case impacts, testing during a season when a particular meteorological regime would not be expected to develop further confounded SMUD's attempts to establish worst-case impacts. This is where the SAI Geysers Hybrid Model played an important role in addressing the aforementioned concerns.

Projected Impacts--

Based on the SMUDGEO #1 emission rate of eight lbs H_2S per hour, SAI* determined peak H_2S concentrations. (Summarized in Table 16.) Fumigation and nocturnal drainage were not simulated by modeling because CEC staff expects impacts due to SMUDGEO under these two regimes to be significantly less than those during limited mixing and downwash conditions (the peak observed concentrations under drainage and fumigation were significantly less than 0.1 ppb).

Figures 23 through 26 illustrate predicted impacts during limited conditions. The lines on these figures, called "isopleths," indicate places where the ambient H_2S concentration is equivalent. Figures 23 and 25 present the concentrations which resulted when gas was released at 1,150 feet and at 350 feet above the ground, respectively. These heights represent the altitude to which plumes could be expected to rise: the 1,150 foot release should represent plume height under normal operating conditions while the 350 feet release should simulate plume height during stacking. Figures 24 and 26 present the results of simulating, with the Hybrid Model, plume motion and diffusion under tracer test conditions.

The equivalent worst-case H_2S impact observed during the tracer test was approximately one ppb** (Figure 25). This value was observed approximately

*T.W. Tesche et al., Assessment of the Sacramento Municipal Utility Districts Proposed Geothermal Power Plant--Volume III. Final Worst-Case Air Quality Analysis (SAI), October 3, 1980.

**The peak value in Figure 25 is .118, SMUDGEO #1 is limited to 8 lbs H_2S/hour, so the predicted ambient H_2S value is 8 lbs H_2S/hour X 0.118 equals 0.94 ppb H_2S.

TABLE 15 NUMBER OF DAYS PER MONTH THAT ADVERSE METEOROLOGICAL REGIMES OCCUR AT THE GEYSERS*

Meteorological Regime	Month J	F	M	A	M	J	J	A	S	O	N	D
Sonoma County fumigation	0	0	0	0	4	5	12†	8	13	10	0	0
Limited Mixing	0	0	0	0	5	1	9	13	14	10	0†	0
Lake County downwash	1	1	2	13	14	17†	15	19	13	7	4†	9
Sonoma County downwash	2†	3	3	3	5	4	3	1	1	2	3	7
Nocturnal drainage	5	1	1	1†	0	0	2	1	2	3	8	3

*Overlapping weather regimes cause some days to fall into the category of more than one weather pattern (e.g., fumigation and drainage).

†Months during which SMUD tracer tests were conducted.

Tesche, T.W. and, G.E. Moore, "Assessment of The Sacramento Municipal Utility District's Proposed Geothermal Power Plant -- Volume III", Systems Application, Incorporated, June 15, 1980.

TABLE 16 PEAK CONCENTRATIONS DUE TO SMUDGEO #1

Meteorological Condition	Receptor Areas	Tracer Test	Tracer Simulation	1984 Simulation
Limited Mixing	Anderson Springs, Whispering Pines, Collayomi Valley	0.9 ppb	0.6 ppb	0.8 ppb*
Downwash	"	0.8 ppb	0.3 ppb	--
Downwash	Sonoma County (Alexander Valley)	0.9 ppb	0.1 ppb	--

*Impacts only under limited mixing conditions were simulated for 1984 emissions at The Geysers.

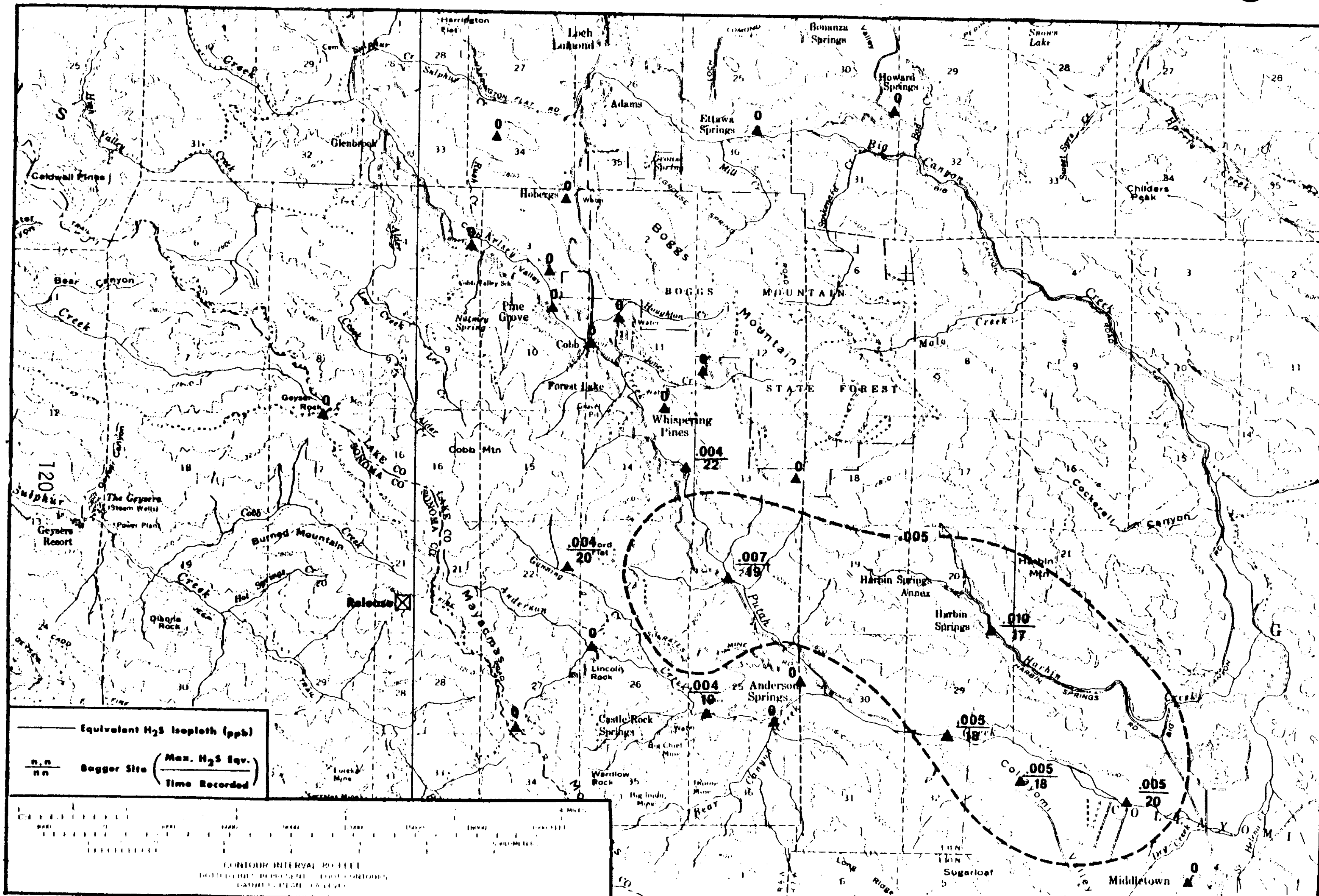


FIGURE 23 EQUIVALENT H_2S ISOPLETHS FOR LIMITED MIXING -- 1150' TRACER RELEASE

(ppb H_2S/lb)

Source: SAI (1980)

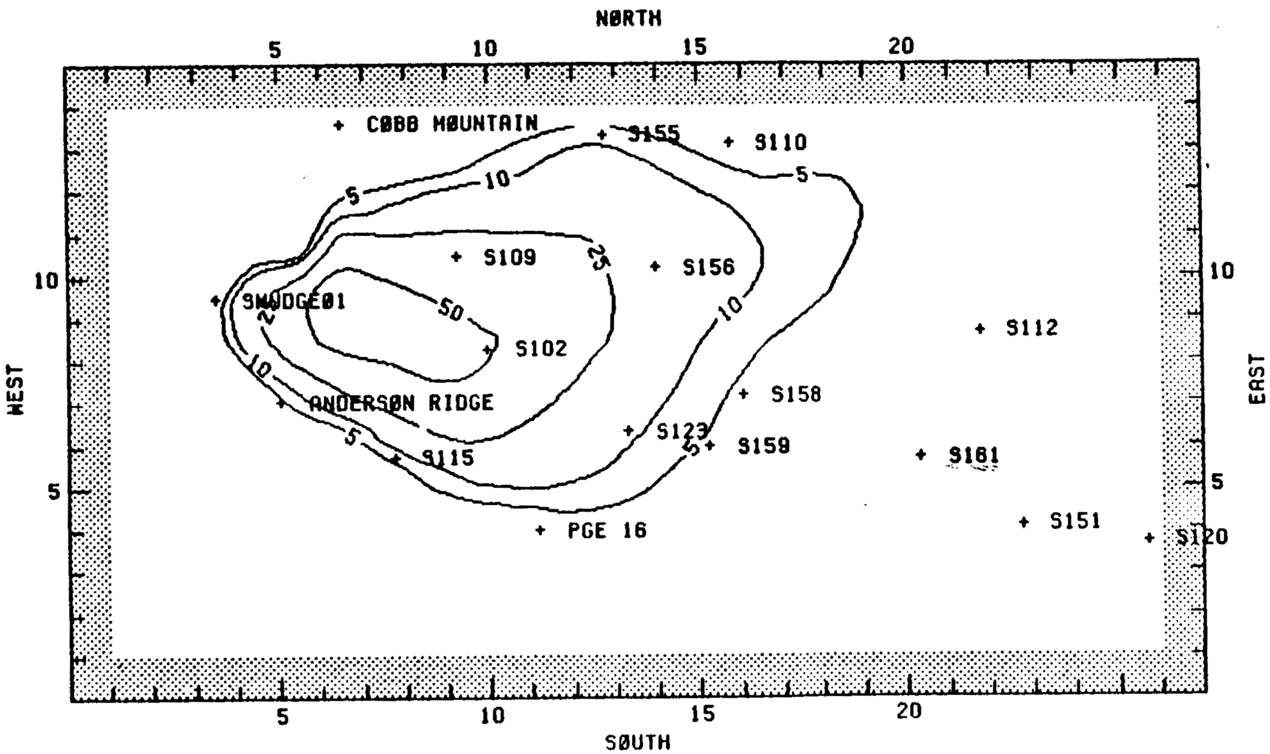


FIGURE 24

EQUIVALENT H_2S ISOPLETHS FOR LIMITED MIXING --- 1150' MODEL SIMULATION (ppt)

Source: SAI (1980)

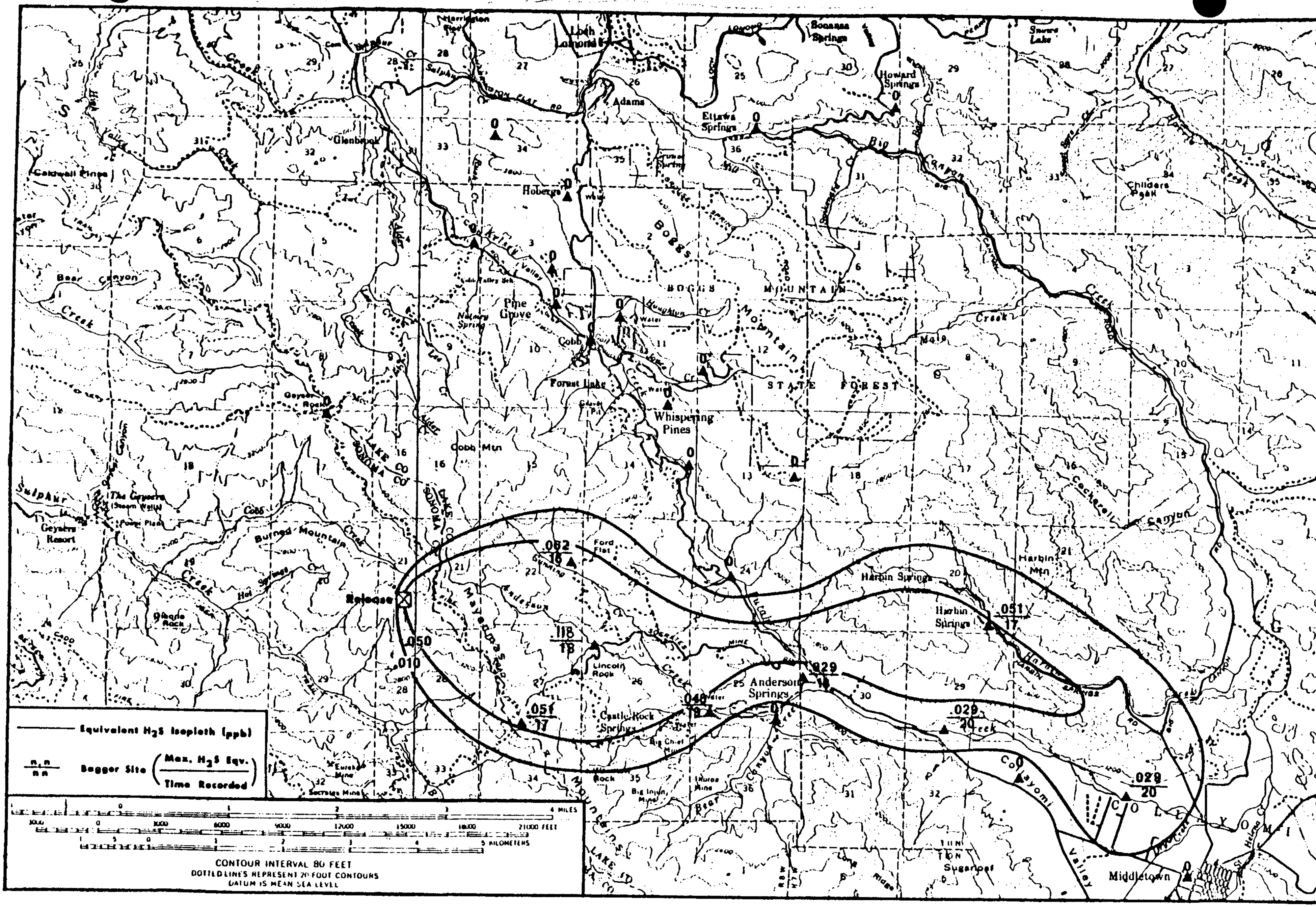


FIGURE 25 EQUIVALENT H_2S ISOPLETHS FOR LIMITED MIXING -- 350' TRACER RELEASE

(ppb H_2S/lb)

Source: SAI (1980)

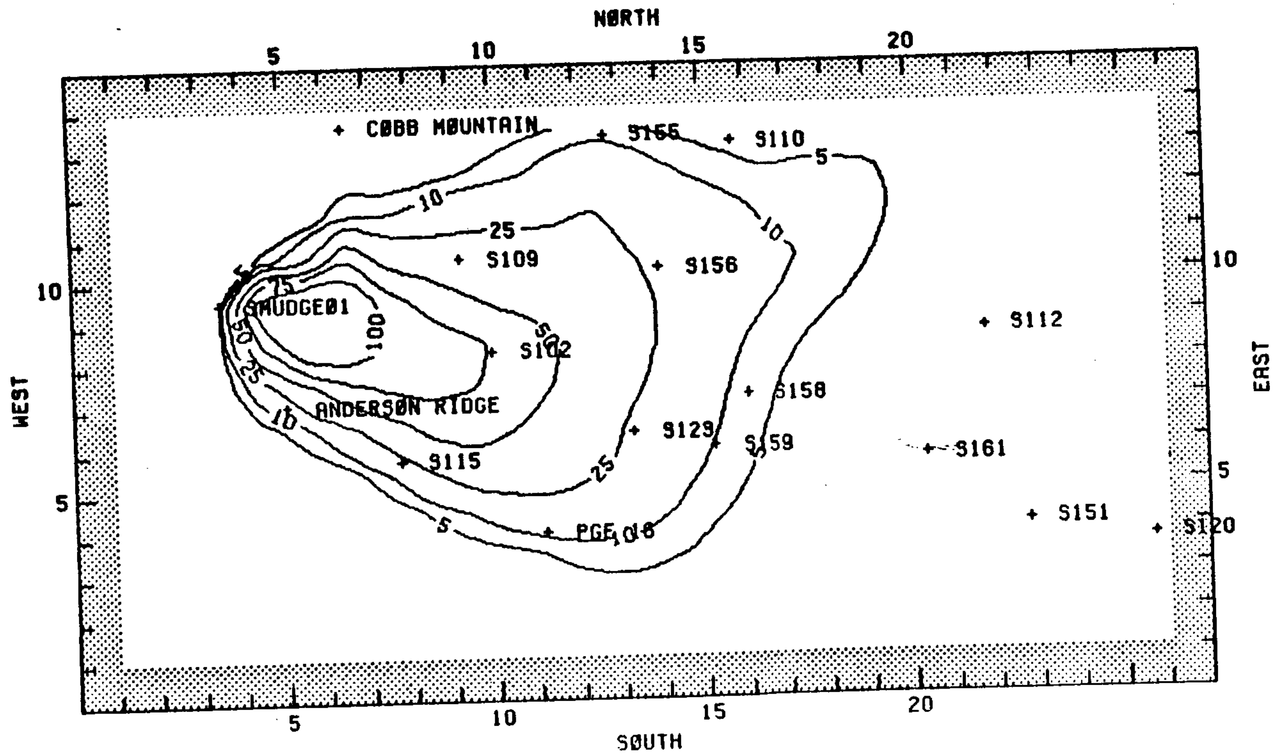


FIGURE 26

EQUIVALENT H_2S ISOPLETHS FOR LIMITED MIXING --- 350' MODEL SIMULATION (ppt)

Source: SAI (1980)

two miles west of Anderson Springs. For simulating impacts at receptors in this area, involved parties assume that worst-case concentrations occurring up to two miles from Anderson Springs represent worst-case impacts at sensitive receptors. Using pertinent data describing the meteorology which occurred during the tracer test day, the Hybrid Model simulated plume transport and diffusion. The model predicted a peak concentration of approximately 0.6 ppb at the same geographic location as 1 ppb was observed during the tracer test.

The mountainous or "complex" terrain at The Geysers makes it extremely difficult to simulate plume motion in the atmosphere. Complexity notwithstanding, comparing the tracer test results with those of the modeling shows a promising degree of correlation. In fact, as discussed before, the tracer test approach includes the major uncertainty as to whether the gas was released during "worst-case" weather conditions. Therefore, the reader should view results from both methodologies in terms of their relative uncertainties.

Hybrid Model simulations of other tracer tests resulted in predicted peak concentrations that differ from observed values by a factor of 1.5 to 3. Applying this to the peak value of 0.6 ppb, from Figure 26, results in a range of 0.9 ppb to 1.8 ppb. There is no way of telling how far off the tracer value of 0.94 ppb H_2S is from a worst-case impact. The fact that the tracer test was not conducted during a month when limited mixing conditions typically occur further confounds the issue.

The range established, when accounting for uncertainties in the modeling, also appears reasonable for impacts expected for a power plant located close to the ridgecrest and emitting H_2S at a comparatively low rate.

Conclusions based on the tracer test and simulation indicate that SMUDGEO #1 will contribute ambient H_2S concentrations of no greater than two ppb at sensitive receptor areas.

Predicted Impact--

To overcome the concern that the weather was not suited for worst-case impacts during tracer tests, a day was selected, from the SRI data base, during which elevated H_2S readings occurred in receptor areas. July 28, 1976, was selected, and pertinent data conditions were input to the model. Figure 27 illustrates the impacts predicted for emissions of eight lbs/hour of H_2S from SMUDGEO #1. The peak value predicted is 0.75 ppb H_2S. Applying the 1.5 to 3 factors yields a range of 1.1 ppb to 2.2 ppb H_2S--slightly higher than tracer test and simulation results.

Considering the uncertainties involved with the approaches (established tracer test methodology and state-of-the-art modeling) used in these analyses, a reasonable estimate of the worst-case impact from SMUDGEO #1 emissions in 1984, under limited mixing conditions, will be no greater than approximately two ppb H_2S at sensitive receptor areas.

This contribution, in and of itself, will not constitute a violation of the state ambient air quality standard for H_2S. However, the background or "cumulative" concentration to which existing plants contribute must be added to SMUDGEO's incremental impact to determine if there will be violations of the standard in populated areas when SMUDGEO #1 begins operation.

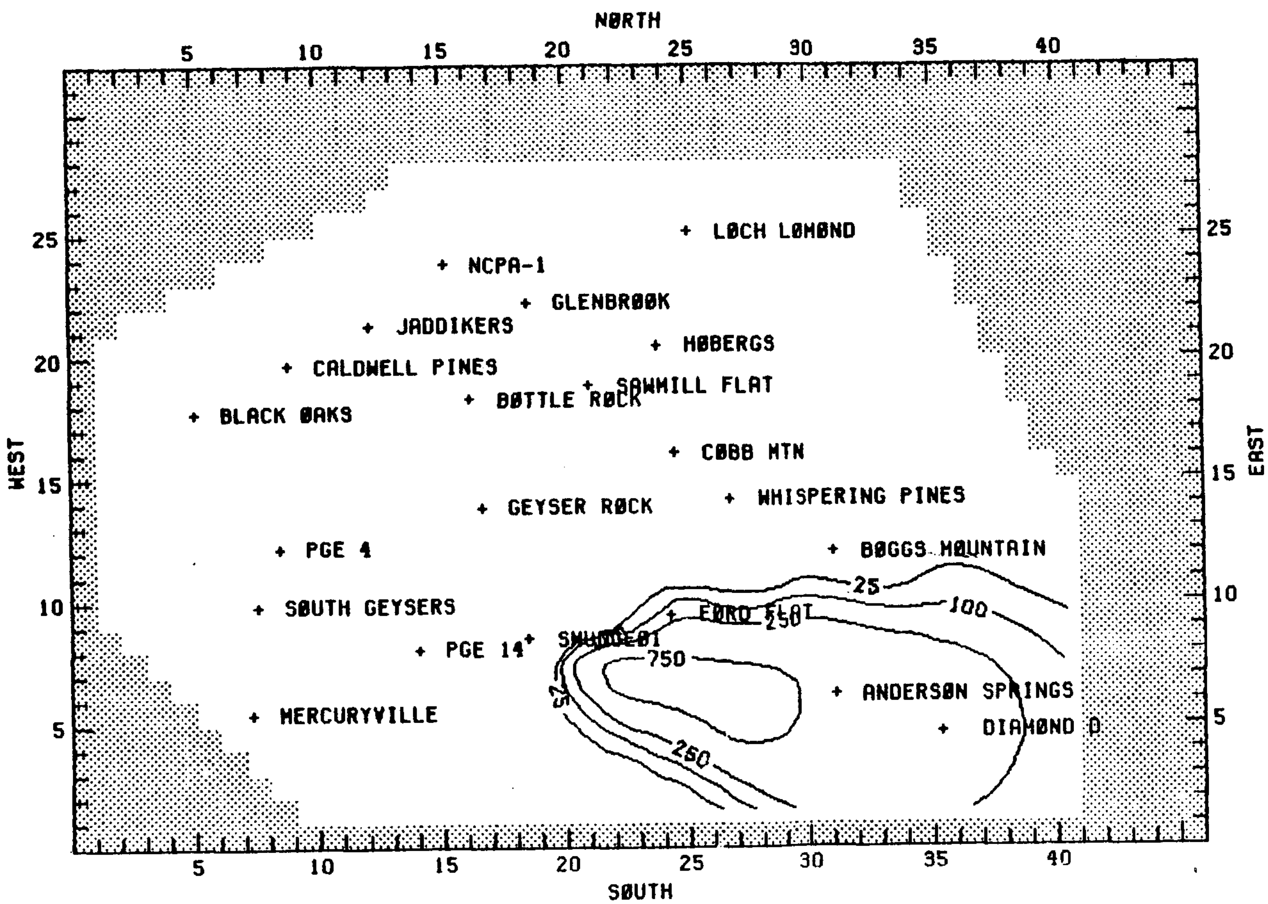


FIGURE 27 PREDICTED 1984 WORST-CASE H_2S CONCENTRATIONS DUE TO SMUDGEO #1 EMISSIONS (ppt)

Source: SAI (1980)

AIR QUALITY

CUMULATIVE EFFECTS

Climate

Moist air plumes from a cooling tower generally disperse rapidly in the atmosphere due to their buoyancy, air entrainment, and atmospheric turbulence. Beyond a radius of about one-third mile (about one-half kilometer) from a particular cooling tower structure, the combined contribution from all operating cooling towers affects the environment.

In the absence of an intense inversion, the cumulative contribution of water vapor to the atmosphere from all power plants presently operating in The Geysers KGRA would result in only minor changes to the area's climate.

For the annual average wind speed of 15 miles per hour (SMUD meteorological station), the contribution at downwind distances of 5 to 10 miles (8 to 15 kilometers) from the operating units at The Geysers is less than 0.1 gram of water vapor per cubic meter of air. At the coldest temperatures expected in the area, saturated air would contain at least three grams of water vapor per cubic meter. This addition of water vapor corresponds to a change of less than 1°F in wet-bulb temperature readings.

During the dry season of April through October, the capacity of the air for water vapor ranges from 6 to 40 grams per cubic meter, so the addition of cooling tower water vapor from all units during this period will not change the wet-bulb temperature more than 0.5°F. During this dry season, the area is generally in or above the inversion so that the relative humidity is low and the addition of cooling tower water vapor causes an insignificant change (CEC Staff Analysis, 1979).

However, one concern expressed by members of the scientific community is that even minor changes in temperature and humidity may impact sensitive plant species and their ability to survive (Neilson, 1975a; Ecoview 1975j; Leitner, 1978).

Air Quality

Comparisons between the tracer tests and the model simulations focused on model capability in predicting future incremental air quality effects from SMUDGEO #1. These results indicate model precision and accuracy in predicting H_2S concentrations, especially peak values at sensitive receptor areas, due to emissions from a single-point source.

SMUDGEO #1 will begin operation in late 1983, and it will be one of several units operating at The Geysers KGRA at that time. Therefore, it is necessary to determine the background air quality (to which SMUDGEO will be contributing) to conclude what the overall or cumulative result will be. As with the incremental impacts simulation, the cumulative effects prediction requires some form of evaluation to establish credibility and for use as a "yardstick", i.e., how closely the model simulates observed real-world concentrations.

Model Evaluation--

To accomplish this, a day (July 28, 1976) was selected during which H_2S standard violations occurred at sensitive receptors. The meteorological parameters for that day were input and the model predicted impacts which should have been seen under those weather conditions. Figures 28 and 29 and Table 17 summarize the H_2S concentrations observed at several locations during July 28, 1976, and the corresponding concentrations predicted by the model.

For Geyser Rock (SRI-1) and Anderson Ridge (SRI-2) stations, the model generally underpredicts while at sensitive receptor sites such as Whispering Pines (SRI-5), Anderson Springs (SRI-6), and Sawmill Flat (SRI-7), there is relative agreement between predicted and observed concentrations.

Total Projected Impacts--

Projecting ambient air quality in 1984 required the input information for worst-case meteorology and the expected emission rates for units operated by the Pacific Gas and Electric Company (PGandE), the Department of Water Resources (DWR), Northern California Power Agnecy (NCPA), and SMUD.

From the results described in the previous discussion of project impacts, maximum ground level concentrations predicted at one location actually occur as far away as approximately 1.5 to 2 kilometers (0.9 to 1.2 miles). This degree of latitude should also apply to interpreting the results of the cumulative impacts prediction.

Figures 30 and 31 show the predicted worst-case background concentrations expected in the vicinity of sensitive reactors at Anderson Springs during the simulated worst-case day. The SAI simulation shows approximately 24 ppb contributed by the NCPA-1 and PGandE units, while approximately 0.1 ppb results from DWR emissions. When the 0.75 ppb value from Figure 27 is added to this background, the total concentration is approximately 25 ppb of H_2S. It should be noted that emissions from proposed NCPA-2 (3.2 km southwest of Anderson Springs) were not included in this prediction. NCPA-2 emissions could reasonably be expected to contribute approximately as much as SMUDGEO #1 to concentrations in Anderson Springs.

The Air Resources Board, which sets and enforces ambient air quality standards, determined that ambient concentrations of H_2S which equal or exceed 25 ppb (0.025 ppm) constitute violations, (ARB, Thomas Austin letter to Michael Tolmasoff dated April 2, 1980).

The uncertainties in the predicted background concentrations to which SMUDGEO emissions will add also bear consideration, since the peak simulated value is so close to the 25 ppb level. Values for several of the parameters for the model simulation were intentionally input at the most extreme or conservative end so that the model would tend to overpredict rather than underpredict. The predicted cumulative concentration is so close to the violation level that,

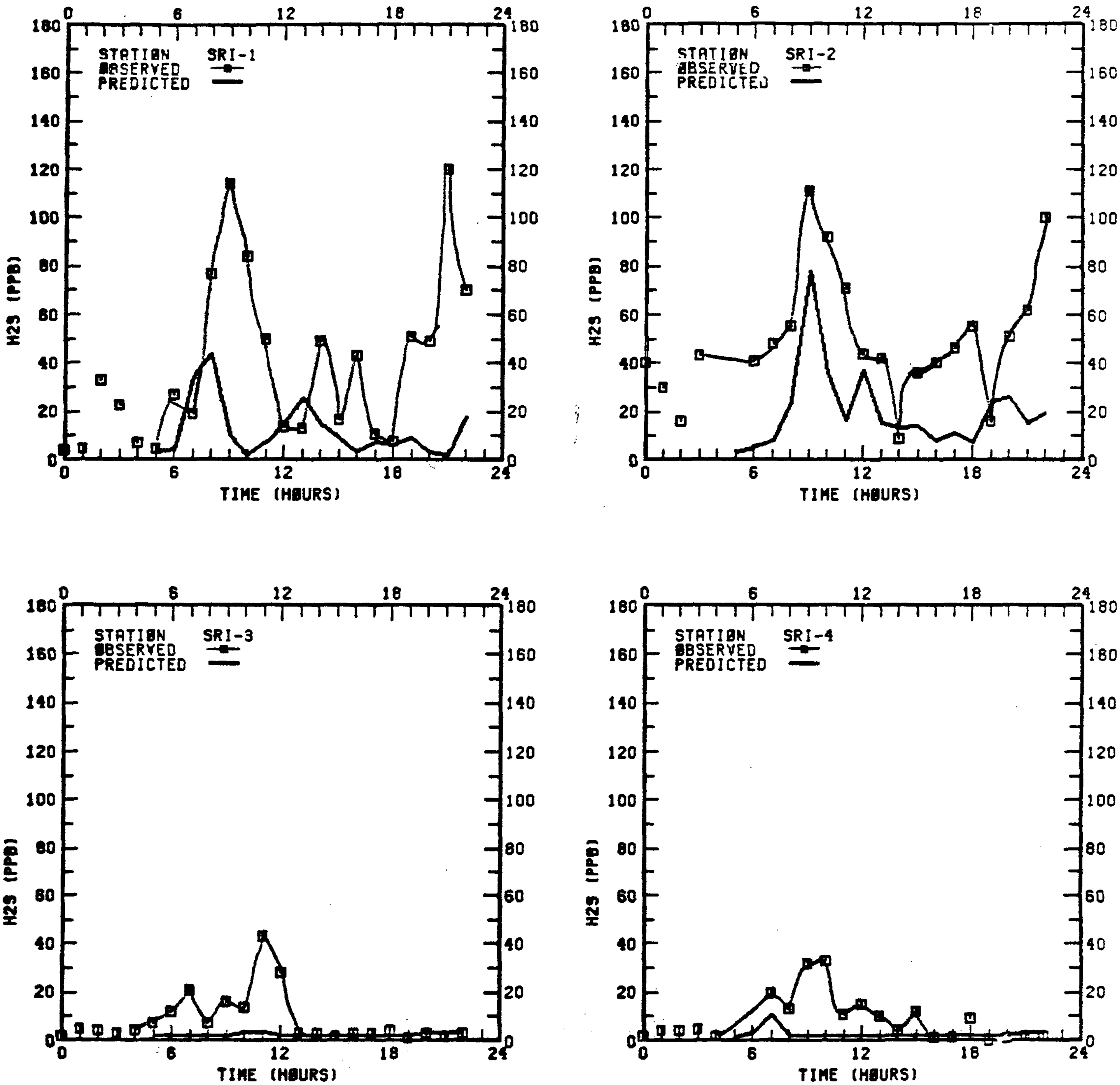


FIGURE 28 PREDICTED AND OBSERVED H_2S CONCENTRATIONS (ppb) FOR 28 JULY 1976

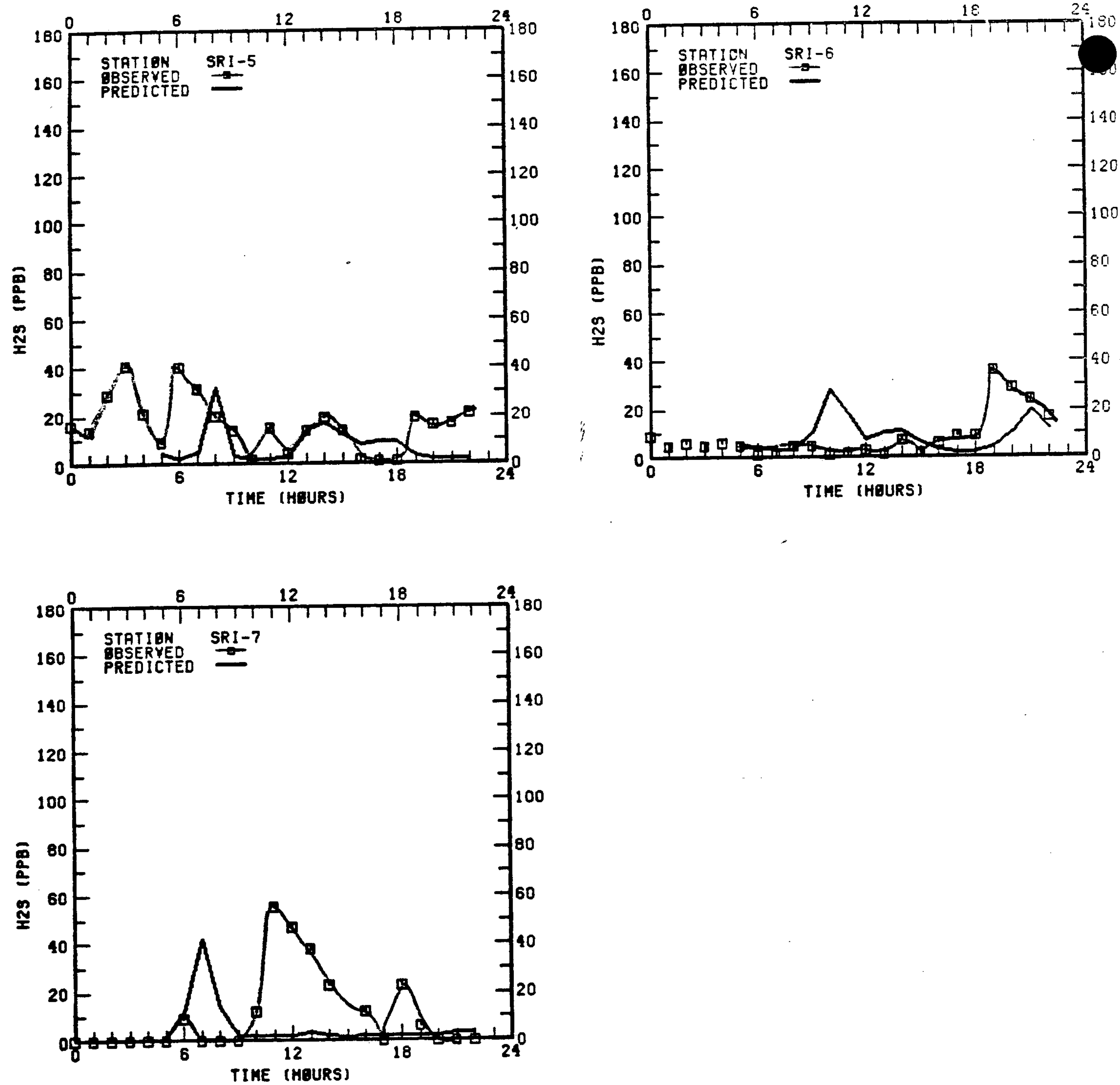


FIGURE 29 PREDICTED AND OBSERVED H_2S CONCENTRATIONS (ppb) FOR JULY 1976 (CONCLUDED)

TABLE 17 PEAK PREDICTED AND OBSERVED H_2S CONCENTRATIONS FOR SEVEN STATIONS

Station	Maximum Hourly Equivalent H_2S Concentration (ppt)				Ratio of Predicted to Observed Maximum Concentrations
	Predicted	Hour	Observed	Hour	
Geyser Rock	68	0800	114	1000	0.60
Anderson Ridge	79	0900	111	1000	0.71
Kahn Ranch	3	1000	43	1200	0.07
Pine Summit	20	0700	33	1100	0.61
Whispering Pines	33	0800	31	0800	1.06
Anderson Springs	45	1000	36	1900	1.25
Sawmill Flat	48	0700	55	1300	0.87

Source: SAI (1980)

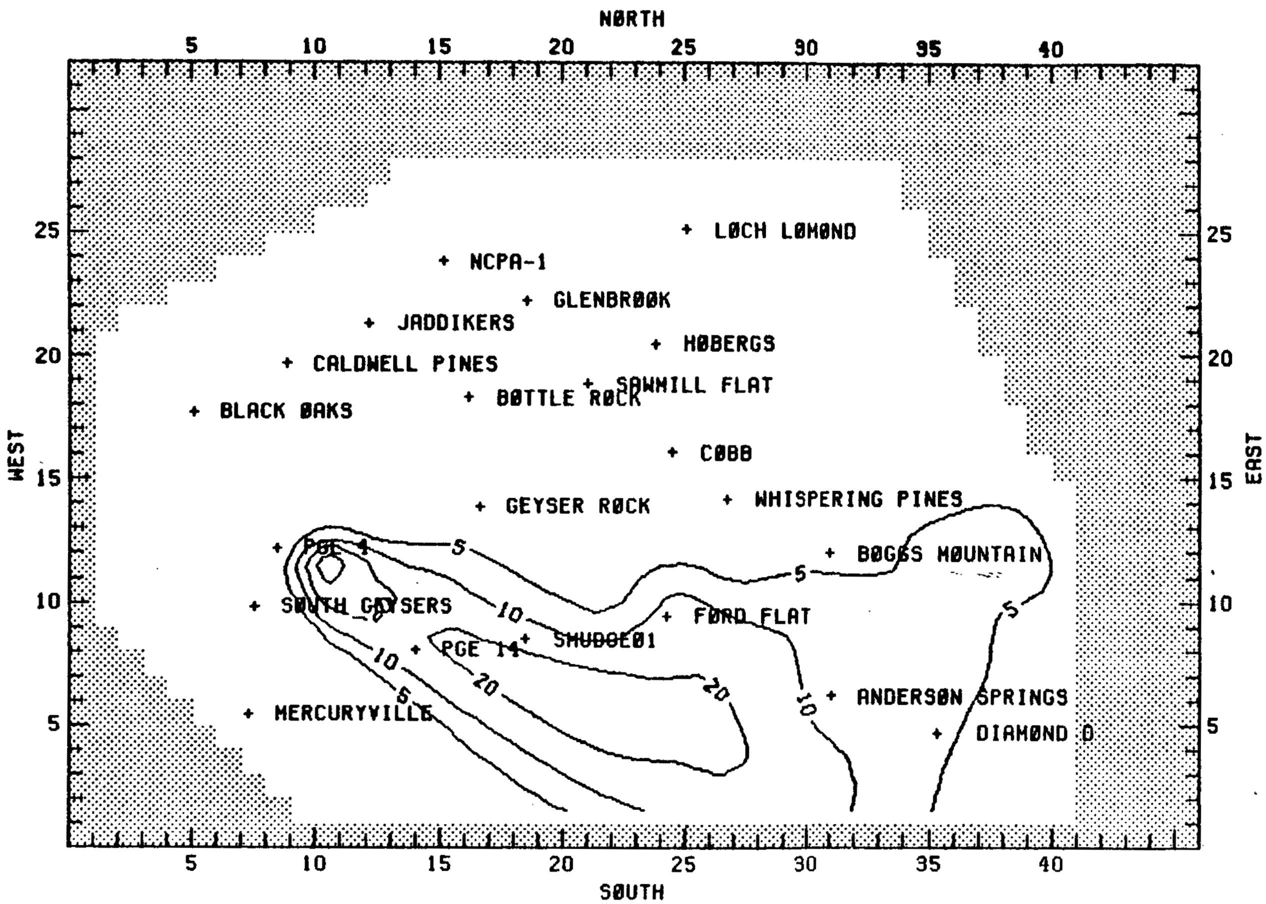


FIGURE 30 PREDICTED 1984 GROUND-LEVEL H_2S CONCENTRATIONS DUE TO PG&E AND NCPA-1 EMISSIONS (ppb)

Source: SAI (1980)

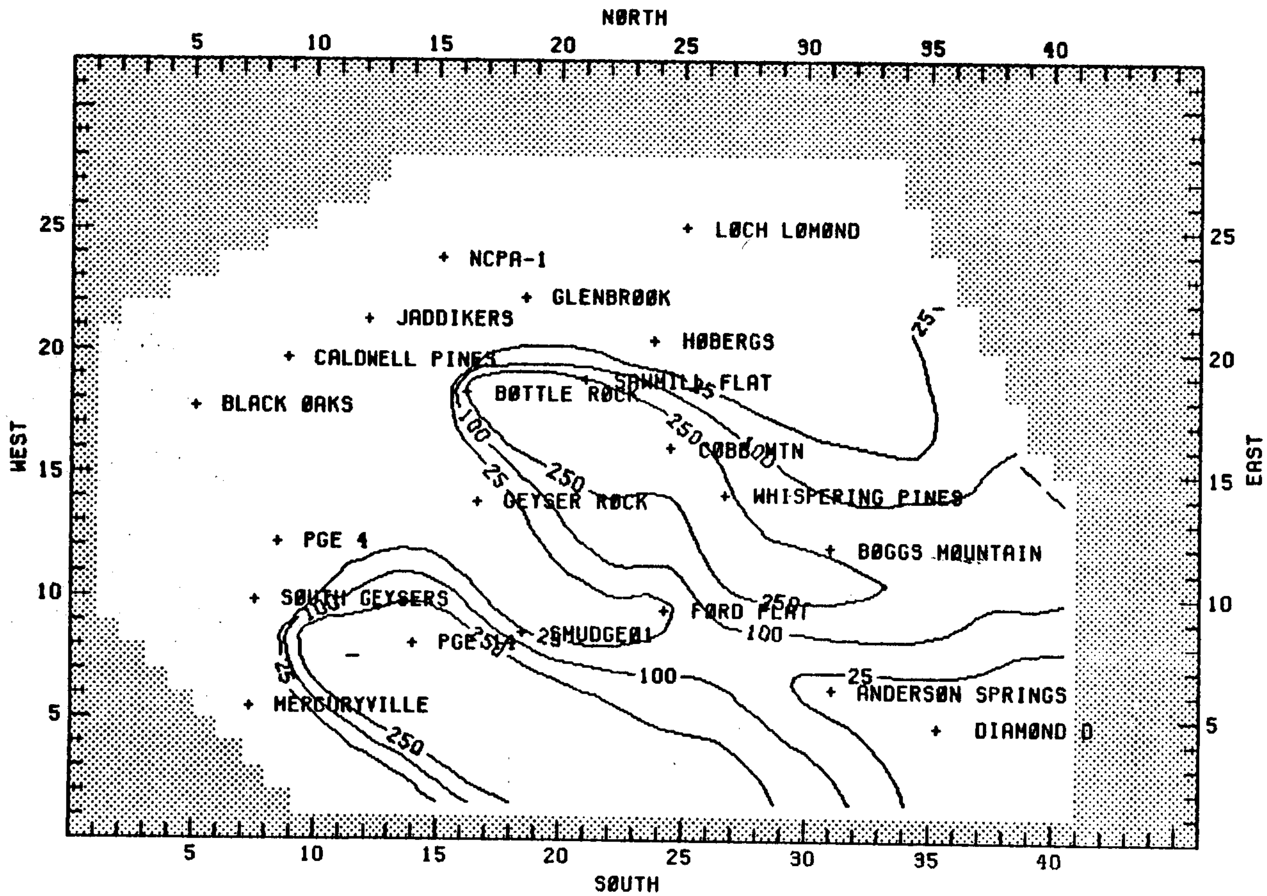


FIGURE 31 PREDICTED 1984 GROUND-LEVEL H_2S CONCENTRATION DUE TO DWR BOTTLEROCK AND SOUTH GEYSERS EMISSIONS (ppt)

Source: SAI (1980)

given the uncertainties of the accuracy and precision of the model results, it appears possible that violations will occur after SMUDGEO's start-up. The bulk of this predicted cumulative concentration is, of course, the 24 ppb background value. Therefore, SMUDGEO will not individually cause a violation of the H_2S ambient air quality standard, but it is likely that the cumulative effect will be considerable, i.e., the effects of siting SMUDGEO #1 are significant when examined in connection with existing power plant emissions and those of proposed plants.

Mitigation Measures

The obvious method of lessening the elevated H_2S concentrations is to reduce existing power plant emissions. The Air Resources Board determined that Best Available Control Technology (BACT) can limit geothermal plant emissions to five lbs H_2S/hour. (This represents a three lbs H_2S/hr reduction from SMUDGEO's currently proposed eight lbs H_2S/hr emission rate.) For a typical 55 MW plant, the 5 lbs/hour rate converts to approximately 38 grams/gross megawatt/hour (g/GMW-hr) compared to the NSCAPCD Rule 455(b) limit expected, by 1985, to be 50 g/GMW-hr for new plants. It is currently 200 g/GMW-hr for existing plants.

In comparison, emissions from existing plants range from approximately 2,180 g/GMWh from the oldest plant down to about 36 g/GMWh for the newest operating plant--this does not include, of course, the 35 lbs H_2S/hr emitted from the "Wild Well." A fundamental approach to reducing existing emissions could include one or all of the following:

(i) Accelerate the retrofit schedule for the existing plants (they are not expected to be in compliance with the 200 g/GMWh requirement until 1984-86); and/or

(ii) Control the H_2S emissions from the "Wild Well" (staff is not aware of any proposed plans to control its emissions); and/or

(iii) Divert steam from the least clean plants and/or those plants which degrade the air quality most significantly and use this rerouted steam to generate electricity at newer or retrofitted cleaner power plants. The units whose steam had been diverted could then be shut down.

These options are presented not as the only alternatives for reducing the likelihood of H_2S violations at The Geysers but rather to illustrate the possibilities. Also, investigating any of these or other avenues would necessarily require technical and economic feasibility studies. However, until such studies are required and conducted, reductions of H_2S emissions cannot be expected by the time SMUDGEO #1 begins operation, while newer proposed plants will be required to control H_2S emissions to extremely low levels--without any apparent likelihood of affecting existing air quality problems at The Geysers.

Determination of Compliance--

Given the maximum 1984 background H_2S concentration at receptor areas and the incremental impact expected from SMUDGEO #1, the last step in determining compliance with air quality standards is to add the worst-case impacts predicted from these analyses.

As described in the previous section, the predicted worst-case background is approximately 24 ppb and is projected to occur in the Anderson Springs area. The incremental concentration expected from SMUDGEO is less than two ppb in the same vicinity. Therefore, the analyses indicate that, given the uncertainties, a violation to the H_2S ambient air quality standard of 0.03 ppm may occur in sensitive receptor areas. The Northern Sonoma County APCO issued a Conditional Determination of Compliance which requires that SMUDGEO #1 meet the 5 lbs/hr BACT emission rate unless ambient monitoring, during 1981-83, indicates that concentrations are below 21 ppb H_2S. Lower concentrations will allow SMUD to increase up to eight lbs/hr.

Data collected regarding ambient total suspended particulates (TSP) indicate no historical occurrences of particulate standard violations at sensitive receptors. SMUDGEO #1, as proposed, is not a major source of TSP and is likely to neither contribute to nor cause a violation of the standard.

Assuming the TSP is transported to the same receptor areas as were projected for H_2S emissions and assuming TSP impacts are proportional to their emission rate, an approximation of the expected ambient concentration is calculated below.

8 lbs H_2S/hr = 1 ppb ambient concentration
= 1.4 ug/m^3 ambient concentration
3.4 lbs TSP/hr = 42% H_2S ambient concentration
= 0.6 ug/m^3 ambient concentration

In contrast to the 100 ug/m^3 (24-hour average) ambient air quality standard for TSP, the impact from SMUDGEO #1 appears insignificant.

Compliance During Abnormal Conditions--

Analysis of project impacts must consider both anticipated emissions during regular operation (eight lbs H_2S/hr emission rate) and during abnormal conditions. A geothermal power plant periodically ceases operations due to either scheduled routine maintenance or because of an unscheduled forced shutdown. When this occurs at most power plants at The Geysers, the steam supply is vented directly to the atmosphere (without any abatement) in a mode referred to as "stacking." SMUDGEO #1 would emit, during stacking, approximately 79 lbs H_2S/hr without abatement (80 ppm H_2S x 983,000 lbs steam/hr = 79 lbs H_2S/hr).

The results of modeling and tracer analyses indicate that SMUDGEO #1 emissions will cause no greater than 2 ppb H_2S concentration contribution at Anderson Springs during normal operation. During stacking, this contribution would increase approximately 10 times (79 lbs/8 lbs = 9.9). While this does not constitute a violation, if stacking occurred during the worst-case conditions when 1984 background H_2S concentrations are approximately 24 ppb, the combination of these concentrations would exceed the state ambient air qualtiy standard of 0.03 ppm (30 ppb).

Northern Sonoma County APCD Rule 230 (New Source Review) states that a new source cannot be permitted if its contribution results in a violation of an ambient air quality standard.

Mitigation Measures--

For abnormal operating conditions, SMUD and Aminoil should exercise the following measures:

- o SMUD will use a mechanism for bypassing steam around the turbine to the condenser which will be designed to route steam to the regular abatement systems (Stretford unit and condensate treatment) during start-up and shutdown.

- o The turbine bypass mechanism will route full steam flow to the condenser during turbine-generator shutdown. If the corrective actions can be completed within 96 hours of the trip, Aminoil will reduce steam flow to 35 percent of normal. If a longer outage is expected, then each well flow will be reduced to a small bleed flow. H_2S abatement will continue to operate in this bypass mode.

- o The proposed plant will use 100 percent backup systems for most critical components (including condensate pumps, air compressors, and coolers) and, where economically feasible, SMUD will provide components with spare parts installed (SMUDGEO #1 AFC, page 7-1).

Prevention of Significant Deterioration (PSD)--

The federal Clean Air Act Amendments of 1977 prevent significant deterioration of the existing air quality in those places where the air quality is presently better than the National Ambient Air Quality Standards. Areas are categorized into one of three classes: Class I areas permit practically no deterioration and limit the siting of new sources greatly; Class II areas allow a moderate amount of deterioration; and Class III areas can accept greater, but defined, amounts of deterioration. In any event, Class I, II, or III areas do not allow new source impacts to such a degree as to exceed the National Ambient Air Quality Standards.

The proposed project is located in an area presently designated as Class II. All assessed impact areas are also classified as Class II. The nearest Class I area is approximately 50 miles north of the proposed project site. A recent EPA letter to SMUD dated November 26, 1980, would indicate that the SMUDGEO #1 facility would acquire a PSD permit for H_2S.

Under PSD regulations, the maximum permissible deterioration in ambient particulate levels in a Class II area is 37 ug/m^3 (24-hour averaging time). Assuming the estimated particulate emission rate of approximately 3.4 lbs/hr, the maximum impacts from the project on ambient TSP will be on the order of 0.6 ug/m^3 (averaged over one hour) at sensitive receptor areas. This impact would be even less if averaged over 24 hours, as specified by the PSD Class II allowable deterioration increment. Consequently, the impact of the proposed SMUDGEO #1 facility would be far below the allowable Class II increment, and the facility would be too far from the nearest Class I area to cause any significant air quality deterioration.

PSD regulations also require the application of best available control technology (BACT) to sources of any regulated pollutants. Although H_2S is not directly regulated by PSD regulations, H_2S is a federally regulated pollutant in some circumstances. Consequently, EPA requires BACT for H_2S at this facility. Since the federal definition of BACT is similar to "reasonably available (state of the art) control technology," and less stringent than state BACT requirements, the CEC staff expects the use of Stretford abatement supplemented by secondary condensate treatment to satisfy the federal BACT requirement.

HEALTH AND SAFETY

PUBLIC HEALTH SETTING

Two aspects of the existing environmental setting of the proposed facility relate to potential impacts on public health: existing levels of pollutants in the environment and the human population which could experience adverse health effects.

Existing Pollutant Levels

The existing ambient air concentrations of hydrogen sulfide, total suspended particulates, sulfur dioxide, and sulfates in the vicinity of the project site are discussed in the Air Resources Setting. Refer to Appendix B for a discussion of the effects of these pollutants on human health.

Ambient air concentrations or steam concentrations of asbestos have not been measured in The Geysers KGRA (Robertson, 1980; Weslowski, 1980; CEC, 1980a). The contact of asbestos-containing serpentine rock formations with the geothermal steam reservoir or steam well appears to be minimal due to the well casing in the upper levels where serpentine is found. Existing asbestos levels in the ambient air of The Geysers KGRA are probably too low to present a significant health hazard, due to typically low levels (roughly 1 percent) of asbestos in serpentine rock of California; however, a mapping study is currently under way to characterize the geologic formations of The Geysers KGRA (Ross, 1980). CEC staff and LCAPCD are currently developing programs to quantify any asbestos emissions and resultant ambient concentrations produced by geothermal power plants.

Ambient air concentrations of radon-222, mercury, arsenic, ammonia, boron, silica, benzene, and anthraquinone disulfonic acid have not been recently measured in the immediate vicinity of the project or in areas which could be impacted by the plant. However, these measurements and measurements in rural areas elsewhere in the country may suggest concentrations to be expected in The Geysers KGRA (see Impacts). The following paragraphs summarize available monitoring results from The Geysers KGRA.

Radon-222 (^{222}Rn) in the atmosphere at The Geysers KGRA was measured by Lawrence Livermore Laboratory for PGandE during 1975-77 when 11 geothermal power plant units were operational (Anspaugh, 1978). The highest recorded ^{222}Rn concentrations in air were 0.5 picoCuries* per liter (pCi/l) at Units 1 and 2 and 1.4 pCi/l at the SRI Station 7 (Sawmill Flat). These peak values are below the California emission limitation for ^{222}Rn of 3 pCi/l (annual average) above background in uncontrolled areas.

Ambient air concentrations of mercury have not been monitored in populated areas near The Geysers KGRA. Two studies on mercury concentrations in ambient air in nonpopulated areas within The Geysers KGRA report concentrations ranging from less than 0.001 ug/m^3 to 0.018 ug/m^3 (Robertson, 1977), and from 0.005 ug/m^3 to 0.400 ug/m^3 (Jepsen, 1973). Mercury mining was very common in the area at one time; thus, abandoned mercury mines and tailings may contribute significant amounts of mercury to ambient air levels.

*picoCurie = 10^{-12} curie. A curie is a unit of radioactivity.

Other environmental sources of mercury include drinking water and food. Data on existing water concentrations of mercury are minimal. Single samples of surface waters in the vicinity of Anderson Springs in October 1976 yielded levels below 1 mg/l (PGandE, 1977). The criteria established by the United States Environmental Protection Agency for drinking water is 0.05 ug/l (EPA, 1976).

High concentrations of mercury have been measured in fish at Clear Lake, not far from The Geysers KGRA (Week, 1978). Although the mercury content in most fish tested was below the recommended safe level of 1.0 ppm in edible fish, a small number of the fish sampled exceeded this value. CEC staff believes such high levels are caused by sources other than mercury emissions from geothermal power plants at The Geysers KGRA, yet by inference residents of this area may carry a significant burden of body mercury already and any addition to the environment would increase this burden.

PGandE reports that ambient air arsenic concentrations at Unit 11 in 1977 range from less than 0.010 ug/m^3 to 0.044 ug/m^3 (PGandE, 1979). Ambient concentrations of boron in the atmosphere have not been measured at this time.

There has been relatively little monitoring of ambient air concentrations of ammonia at The Geysers KGRA. Periodic monitoring during 1976 and 1977 at a number of locations in The Geysers KGRA reported one hour average ammonia concentrations ranging from 0 to 0.263 parts per million (ppm) (DWR, 1978).

Existing Human Population in the Vicinity of the Proposed Site

PGandE reports that in January 1977, 3,737 residents lived within 10 miles of Cobb Mountain, as shown in Table 18 (PGandE, 1978b). This figure includes residents of communities near the project site, but it does not include seasonal residents in the area that may cause the population to triple during summer months (Ecoview, 1978). The approximate age distribution for these people is given in Table 18. Human receptor sites nearest the proposed site are discussed in the Noise and Land Use Setting sections.

From data provided in Table 18, CEC staff infers that approximately 22 percent of the population in that area could be classified as sensitive to pollutants due to age (e.g., the very young and the elderly). In addition, the percentage of pollutant-sensitive persons tends to increase from late spring to early fall (LCAPCD, 1980).

No reported studies describe existing status of public health in the vicinity of The Geysers, and no reported cases of adverse public health effects clearly attribute the cause to pollutants from The Geysers power plants, although some residents of Lake County have reported health effects which they attribute to the emissions from geothermal operations (Grew, 1978; Madill, 1978; and Schaaf, 1978). A survey of 142 Cobb Valley residents reported that 72 percent of the respondents disagreed that geothermal development would have no odor impacts (Vollintine and Weres, 1976).

TABLE 18

POPULATION DISTRIBUTION IN THE GEYSERS KGRA

Age Group*	Area: Within 7 Miles of Units 5 & 6	Within 10 Miles of Cobb Mountain	Within 30 Miles of Units 5 & 6
0-5	182 (10.5%)	322 (8.6%)	14,487 (8.8%)
6-17	439 (25.3%)	888 (23.8%)	36,342 (22.1%)
18-34	335 (19.3%)	685 (18.3%)	34,715 (21.1%)
35-64	586 (33.8%)	1,321 (35.3%)	53,999 (32.8%)
65+	194 (11.2%)	521 (13.9%)	25,188 (15.3%)
Total Population	1,735	3,737	164,731
Total Area	154 mi^2	314 mi^2	2,827 mi^2
Population density (persons/mi^2)	11.3	11.9	58.3

* January 1977 ages

Source: PGandE, 1978b

HEALTH AND SAFETY

PUBLIC HEALTH IMPACTS

INTRODUCTION

The potential for public health impacts from the project depends on the ambient air concentrations of pollutants to which the population would be exposed, duration of exposure, and toxicity of the pollutants (see Appendix B). These ambient air concentrations consist of existing or background levels plus the increment added by the proposed project. The project will emit and increase existing concentrations of hydrogen sulfide, radon-222, ammonia, total suspended particulates, mercury, arsenic, boron, anthraquinone disulfonic acid, and vanadium. In addition, project emissions may increase levels of sulfur dioxide, sulfates, silica, and benzene.

The public health analyses and conclusions contained in this document are based on the air quality analyses conducted by SMUD and CEC staff, SMUD's responses to data requests from CEC staff, and independent CEC staff analysis. Table 19 lists ambient air quality standards for regulated pollutants, and Table 20 lists values for assessing potential public health impacts from nonregulated pollutants in ambient air.

Standards for both occupational exposure and ambient air quality exist for certain geothermal contaminants. Occupational standards are intended to protect generally healthy workers exposed to certain pollutants for limited time periods (e.g., work hours), often under controlled conditions. Ambient air quality standards are generally intended to protect a more diverse population containing potentially sensitive individuals (e.g., the very young, the elderly, the acutely or chronically ill, etc.) from longer term exposure. Both types of standards are based on concern for human health, but they often provide different levels of protection. An appropriate ambient air quality standard for a given pollutant may be several orders of magnitude lower (more restrictive) than an occupational exposure standard for the same pollutant.

Since California Ambient Air Quality Standards (CAAQS) are based at least in part on public health protection, CEC staff believes that compliance with the standards should result in adequate protection of public health. The absence of an ambient air standard to protect public health from a given pollutant, however, does not necessarily mean that the pollutant poses no threat to human health. Rather, such absence may reflect a lack of sufficiently reliable data upon which to base a legal standard, or the considerable time required for the rule-making procedures to establish standards rather than a lack of need or concern. For example, there is no adopted ambient air quality standard for arsenic--yet arsenic and certain arsenic compounds are known toxicants and suspected carcinogens.

The 1977 Amendments to the Clean Air Act direct the U.S. Environmental Protection Agency (EPA) to determine the health risk posed by certain nonregulated pollutants including arsenic; and if a potential danger to public health exists, establish criteria and regulations for their control. To date, the EPA has not adopted regulations or standards for any potentially harmful power plant

Table 19

AMBIENT AIR QUALITY STANDARDS

Pollutant	Averaging Time	California Standard	Primary Federal Standard
Carbon Monoxide	12 hours	10 ppm(11 mg/m^3)	-
	8 hours	-	10 mg/m^3 (9 ppm)
	1 hour	40 ppm(46 mg/m^3)	40 mg/m^3 (35 ppm)
Hydrogen Sulfide	1 hour	0.03 ppm(4 mg/m^3)	-
Non-Methane Hydrocarbons	3 hours	-	160 ug/m^3 (0.240 ppm)
Lead	30 day	1.5 ug/m^3	-
Nitrogen Dioxide	Annual Average	-	100 ug/m^3 (0.0500 ppm)
	1 hour	0.25 ppm(2.47 mg/m^3)	-
Oxidant (Ozone)	1 hour	0.10 ppm(0.20 mg/m^3)	240 ug/m^3 (0.120 ppm)
Sulfur Dioxide	Annual Average	-	80 ug/m^3 (0.03 ppm)
	24 hours	0.05 ppm(131 ug/m^3)*	365 ug/m^3
	1 hour	0.5 ppm(1310 ug/m^3)	-
Sulfates	24 hours	25 ug/m^3	-
Suspended Particulate Matter	Annual Geometric Mean	60 ug/m^3	75 ug/m^3
	24 hours	100 ug/m^3	160 ug/m^3
Radon-222	Annual Average	3 pCi/1** ***	3 pCi/1** *** 1 pCi/1 ****

* When standards for total suspended particulates of oxidant are being exceeded.

** Above natural background, at point of release to the environment, in uncontrolled areas.

*** Secondary standards for radon-222 itself.

**** The same conditions as the other radon standards, but radon-222 in combination with its short lived daughters is considered.

emissions. In the interim, the CEC should be concerned about emissions from geothermal power plants such as arsenic and other nonregulated pollutants, which are generally known to be or suspected of being harmful to human health.

For those pollutants which are not subject to adopted ambient air quality standards, several agencies and research groups have suggested what they consider to be safe levels of maximum permissible ambient air concentrations of certain pollutants. Methodologies and criteria for determining these levels vary, often resulting in quite different values. Neither CEC nor other state or federal agencies have adopted any of these suggested levels as standards. CEC Staff analysis, therefore, applies the range of those values suggested by agencies and research groups as a guide for assessing the potential for public health impacts.

Threshold Limit Values (TLV^R) adopted by the American Conference of Governmental Industrial Hygienists, ". . . refer to airborne concentrations of substances to which nearly all workers may be exposed day after day without adverse effect. Because of wide variation in individual susceptibility, however, a small percentage of workers may experience discomfort from such substances at concentrations at or below the threshold limit; a smaller percentage may be affected more seriously by aggravation of a pre-existing condition or by development of an occupational illness...Threshold limits are based on the available information from industrial experience, experimental human and animal studies, and, when possible, from a combination of the these. The basis for established values may differ from substance to substance; protection against impairment of health may be a guiding factor for some, whereas reasonable freedom from irritation, narcosis, nuisance, or other forms of stress may form the basis for others" (ACGIH, 1979). As previously noted, safe levels for generally healthy workers exposed for limited duration under controlled conditions may not represent safe levels for continual exposure of the general public, which can include pollutant sensitive individuals.

The publication, Multimedia Environmental Goals for Environmental Assessment (EPA, 1977) lists "levels of significant contaminants...in ambient air...that are judged to be appropriate for preventing certain negative effects in surrounding populations." The Multimedia Environmental Goals (MEGs) developed as a first effort at establishing "a procedural approach to evaluate and rank a large number of pollutants for the purpose of environmental assessment." Such assessments can be used to determine further research needs and to set pollution control strategy development priorities.

Estimated permissible concentrations for the MEGs were derived using TLV^Rs or recommendations of the National Institute for Occupational Safety and Health (NIOSH), adjusting the values for continual exposure and incorporating a margin of safety. For some pollutants two values are listed: one based on toxicity, the other based on carcinogenic potential. Estimated permissible concentrations based on carcinogenic potential indicate estimated acceptable risk levels rather than established safe concentrations, since threshold levels for carcinogenic effects may not exist (EPA, 1977).

The MEGs receive criticism for their rather simple derivation and other inherent limitations or inconsistencies (such as the differing end points used in setting the TLV^Rs upon which the MEGs are based). CEC staff is currently following efforts by EPA to refine the MEGs.

The Wilcox (1973) study was part of a progam with the EPA "to provide the analysis necessary to form a basis for planning and developing hazardous pollution control technology." The presumed safe ambient air quality levels reported by this study constitute estimates made by a panel of six experts. These experts in the fields of epidemiology, air pollution, and toxicology took experimental results, statistical data, and subjective philosophies of life into consideration to arrive at levels below which they would not expect any adverse health effects. Ideally, these proposed concentrations should be safe for the entire population to breathe daily. However, not all of the estimates for each pollutant are similar; not all of the experts have identical bases for their opinions. Table 20 lists the average of the six levels suggested by the experts.

CEC staff includes these values, along with other values in Table 20, for use as a guide for determining which pollutants do not pose a health hazard, and where a more in-depth analysis might be required.

Most available air quality data for The Geysers KGRA are expressed in terms of maximum hourly average pollutant concentrations. In order to make comparisons with suggested safe annual average concentrations, CEC staff assumes, as a worst case, that annual average pollutant concentrations are one-tenth the maximum hourly averages. Staff bases this assumption on historical H_2S data for The Geysers KGRA (Ruff et al., 1978). This value compares favorably to the value of roughly 0.1 predicted by a model used to compare pollutant concentrations in urban settings at various averaging times (Larsen, 1971), and to the worst case value of 0.09 ± 0.02 calculated by Tesche et al. (1980) from historical data for The Geysers KGRA. CEC staff assumes that the relationship between maximum hourly average and annual average concentrations is similar for geothermal pollutants other than H_2S.

A list of assumptions used in this analysis is found in Appendix C.

Regulated Pollutants

Hydrogen Sulfide (H_2S)--The California Ambient Air Quality Standard (CAAQS) for H_2S is 0.03 ppm (1 hour average). Although public health protection was considered, this value was based on the average H_2S odor threshold obtained in a study conducted by the California Department of Public Health (CARB, 1970). In that study H_2S odor thresholds for 16 individuals ranged from 0.012 to 0.069 ppm; the geometric mean value was 0.029 ppm H_2S. A more recent report, prepared by Lawrence Berkeley Laboratories, states that if the standard is to be based on known odor threshold, "then the standard should be lowered by a factor of 3 to 5 to the more recently accepted value for the odor threshold." (Case, 1977) The current standard is under review by DOHS and may be lowered, raised, or left unchanged by CARB (Beard, 1980).

Adverse health effects reported to result from exposure to low H_2S concentrations, e.g., nausea, headaches, and dizziness, are not associated with concentrations below 0.03 ppm. Assuming these symptoms are caused by H_2S exposure, compliance with the CAAQS for H_2S appears to protect public health. However, even at these levels, the odor of H_2S would be noticeable to at least some of the general public (Miner, 1969).

Table 20

SUGGESTED LEVELS FOR NONREGULATED POLLUTANTS IN AMBIENT AIR*

Pollutant	Type of Value	Source	Concentration	Averaging Time
Ammonia	California Occupational Standard	Cal/OSHA	25 ppm	8 hours
	Suggested Ambient Level Goal	EPA, 1977	0.06 ppm	annual average**
	Foreign Ambient Air Quality Standards	Russia and East European Countries	0.14-0.71 ppm	24 hours
Arsenic	Suggested Occupational Standard	NIOSH	2.0 ug/m^3	15 minutes
	Threshold Limit Value	ACGIH	50 ug/m^3	8 hours
	Presumed Safe Level	Wilcox, 1973	5.9 ug/m^3	24 hours
	Suggested Ambient Level Goal	EPA, 1977	0.005 ug/m^3	annual average**
Boron	Presumed Safe Level	Wilcox, 1973	50 ug/m^3	24 hours
	Suggested Ambient Level Coal	EPA, 1977	7.4 ug/m^3	annual average**
	California Occupational Standard	Cal/OSHA	10 mg/m^3 boron oxide	8 hours
Mercury	Presumed Safe Level	Wilcox, 1973	0.8 ug/m^3	24 hours
	Suggested Ambient Level Goal(based on toxicity)	EPA, 1977	0.1 ug/m^3	annual average**
	Suggested Ambient Level Goal(based on carcin-ogenic potential)	EPA, 1977	0.01 ug/m^3	annual average**
	California Occupational Standard	Cal/OSHA	50 ug/m^3	8 hours

Table 20, continued

Pollutant	Type of Value	Source	Concentration	Averaging Time
Vanadium	Presumed Safe Level	Wilcox, 1973	6.8 $\mu g/m^3$	24 hours
	Suggested Ambient Level Goal	EPA, 1977	1.2 $\mu g/m^3$	annual average*
	Threshold Limit Value	ACGIH	0.5 mg/m^3 (dust) 0.05 mg/m^3 (fume)	8 hours
	California Occupational Standard	Cal/OSHA	0.5 mg/m^3 (dust) 0.1 mg/m^3 (mist)	8 hours
ADA (anthraquinone disulfonic acid)	Suggested Ambient Level Goal	EPA, 1977 Supplement 2	260 $\mu g/m^3$	annual average*
Hydrogen Peroxide	Threshold Limit Value	ACGIH	1 ppm	8 hours
	California Occupational Standard	Cal/OSHA	1 ppm	8 hours
Iron	Threshold Limit Value	ACGIH	10.0 mg/m^3 (iron oxide fumes) 1.0 mg/m^3 (iron salts) 0.08 mg/m^3 (iron pentacarbonyl)	8 hours
	California Occupational Standard	Cal/OSHA	10.0 mg/m^3	8 hours
Copper	Suggested Ambient Goal	EPA, 1977	0.5 $\mu g/m^3$	annual average*
	Threshold Limit Value	ACGIH	0.2 mg/m^3 (metallic copper fume) 1 mg/m^3 (dusts and mists)	8 hours

Table 20, (continued)

Pollutant	Type of Value	Source	Concentration	Averaging Time
Benzene	Threshold Limit Value	ACGIH	30 mg/m^3 (10 ppm)	8 hours
	Emergency Temporary Occupational Standard	U.S. Labor Department (EPA, 1977)	3 mg/m^3 (1 ppm)	8 hours
	California Occupational Standard	Cal/OSHA	10 ppm	8 hours
Silica	California Occupational Standard	Cal/OSHA	$\frac{10\ mg/m^3}{1\%\ SiO_2+2}$ (respirable)	8 hours
	Suggested Occupational Standard	NIOSH	50 ug/m^3	8 hours

---

* See Introduction for a discussion of the validity of these values.

** Although an averaging time for Suggested Ambient Level Goals is not stated within the document, EPA-600/7-77-136, the authors have indicated that these goals are most applicable to annual average concentrations. Contact person at EPA - G. L. Kingsbury, Research Triangle Institute, (919) 541-6000

Abbreviations: Cal/OSHA - California Occupational Safety and Health Administration;
NIOSH - National Institute for Occupational Safety and Health;
ACGIH - American Conference of Governmental and Industrial Hygienists;

CEC staff estimates the H_2S content in the untreated steam to be a maximum of 80 ppm, based upon test results from one well (see Air Quality Impacts). The accuracy of this value in representing average steam levels for the entire steam field is doubtful. Estimates based on a steam flow rate of approximately 1 million lb/hr indicate total unabated H_2S emissions at a maximum of 80 lb/hr.

SMUD proposes to limit H_2S emissions during operations to 8 lb/hr with a surface condenser, a noncondensible gas removal system, hydrogen peroxide treatment of condensate (if necessary), and Stretford process equipment (AFC, p. 5-4). This abatement level will require a system having an efficiency in excess of 90 percent. The feasibility of attaining this level of abatement efficiency and associated recommendations are discussed in the Air Resources Impacts section.

CEC staff determined that an emission limitation of 5 lb/hr or 8 lb/hr of H_2S during normal operation and stacking would allow the project to comply with emission regulations and limitations (see Air Quality Impacts). However, exceedances of the CAAQS for H_2S already occur, and this project will increase the likelihood of future exceedances. See Air Resources and Public Health Cumulative Impacts and Mitigations for further discussion of this issue.

Total Suspended Particulates, Sulfur Dioxide, Carbon Monoxide, Nitrogen Dioxide, Oxidant, Lead, Nonmethane Hydrocarbons, and Sulfates--CEC staff believes that if the ambient air quality standards are not violated, the public should be sufficiently protected from adverse health impacts associated with inhalation of these pollutants. From previous experience with geothermal power plant projects, CEC staff expects potential public health impacts due to emission of these pollutants from the project to be insignificant (CEC, 1980 a and b).

Radon-222 (^{222}Rn)--Reports indicate ^{222}Rn concentration in the project steam supply to be 15 + 10 nCi/kg (AFC, Table 1.2-3). ^{222}Rn steam concentrations monitored at Units 1 through 11 ranged from 5 to 30.5 nCi/l and averaged 16.2 nCi/l (Anspaugh, 1978). Results of these monitoring programs for Units 1 - 11 indicate that ^{222}Rn emissions from a geothermal power plant meet applicable standards.

DOHS submitted the minimum program requirements for monitoring ^{222}Rn to the CEC. DOHS bases these requirements on the contention that there is sufficient uncertainty about the emission levels of operating geothermal power plants and their cumulative impact downwind. To reduce this uncertainty, DOHS requires that periodic samplings be continued to allow for adequate impact assessment. SMUD agreed to include a ^{222}Rn monitoring program as a condition of certification for the proposed project (AFC, p. 6-4).

Nonregulated Pollutants (Ammonia, Arsenic, Benzene, Boron, Mercury, Silica, ADA, and Vanadium)

The following analysis of impacts from nonregulated pollutants is based on steam composition data listed in Table 12. The maximum expected emission rates and the maximum incremental impact on ambient air concentrations of nonregulated pollutants from the project's emissions are estimated in Table 21. The assumptions used in this analysis are found in Appendix C. CEC staff determined

TABLE 21

NONREGULATED POLLUTANT IMPACTS FROM SMUDGEO #1 POWER PLANT

	Concentration in Steam Supply (ppm)[a]	Maximum Expected Emission Rate (lb/hr)[b]	Impact on Ambient Concentration[c] ($\mu g/m^3$)	Background Ambient Concentration[c] ($\mu g/m^3$)	Resultant Ambient Concentration[c,d] ($\mu g/m^3$)	Ambient Level Goal-Air[c,e] ($\mu g/m^3$)
Ammonia (NH_3)	25±15	40	4.8	1.4-7[f]	5.2-11.8	43
Arsenic (As)	<0.15±0.05	0.20	0.024	0.001-0.0044[h]	0.025-0.030	0.005
Boron	3.1±3.1[q]	6.2	0.74	-[j]	0.74	7.4
Benzene (C_6H_6)	<0.050-0.150 ±0.050[k]	0.200	0.024	0.054	0.078	7.1[r]
Mercury (Hg)	<0.001	0.001	0.00012	0.001-0.018[e] 0.005-0.4[m]	0.001-0.4	0.1 0.01[p]
Silica (SiO_2)	<5.0[k]	5	0.6	-	0.6	-
Anthraquinone Disulfonic Acid (ADA)	-	0.005[n]	0.0006	-[j]	0.0006	260
Vanadium (V)	-	0.01[n]	0.0012	0.005-0.024[o]	0.006-0.025	1.2

See next page for footnotes.

TABLE 21 continued

a. Based on analysis of a single well (Revised AFC, p. 1-7 and Table 1.2-3).

b. Based on incoming steam flow rate of 1,000,000 lb/hr (Revised AFC, Table 1.3-2).

c. Expressed as annual average; obtained by multiplying hourly average by 0.1 (See Introduction). Based on air quality analysis showing that each pound of H_2S emitted from the proposed facility will add a maximum of $1.2 ug/m^3$ to ambient H_2S concentration at Anderson Springs (See Introduction and Appendix D)

d. Summation of estimated background concentration and impact on ambient concentration.

e. Estimated permissible concentration; toxicity based on health effects (EPA, 1977).

f. Measurements of urban air concentrations (Wagoner, 1976).

g. Monitoring in Geysers KGRA (DWR, 1978).

h. Measured near Unit 11 (PG and E, 1979).

i. Deleted

j. No background data available.

k. SMUD Response to Interrogatories, Public Health, June 3, 1980.

l. Particulate mercury measurements in Geysers KGRA (Robertson, 1977).

m. Vaporous mercury measurements in Geysers KGRA (Jepsen, 1973).

n. Assuming a 55 MW facility emits half the amount of these pollutants emitted by a 110 MW facility (PG and E Geysers Unit 16 AFC, Vol. I, Appendix H, p. 14).

o. Measurements of rural air concentrations (Wagoner, 1976).

p. Estimated permissible concentration; toxicity of zero-threshold pollutants based on genotoxic effects (EPA, 1977).

q. Based on 10 ± 10 ppm B_2O_3, 31% boron (SMUD Response to Interrogatories, June 3, 1980 - Public Health).

r. Estimated permissible concentration; toxicity based on genotoxic effects would be no more than $0.7 ug/m^3$, in accordance with the NIOSH recommended occupational level of 1 ppm.

that an emission rate of 5 lb/hr would increase ambient H_2S concentrations in Anderson Springs by 2 ppb or 6 ug/m^3 (or 1.2 ug/m^3 per lb H_2S emitted). The value of 1.2 ug/m^3 per lb nonregulated pollutant emitted is used in this analysis.

Data on actual emission rates, environmental transport, and background ambient air concentrations of these nonregulated pollutants in The Geysers KGRA is either absent, of questionable validity, or not applicable in this analysis. Thus, the estimates presented in Table 21 are tentative at best. Where numerous sources of uncertainty reduce the level of confidence in such analyses of significant effects, CEC staff removed uncertainties by requiring source and environmental monitoring as a condition of compliance (see Mitigation Measures). In concurrence with this approach, Lake County Air Pollution Control District included steam and ambient air monitoring of nonregulated pollutants as a condition of compliance for similar projects (LCAPCD, 1980a and b).

There is a high probability that, due to current limited use of H_2S abatement systems, negligible amounts of ADA exist in the background air of The Geysers KGRA. CEC staff conclude that resultant ambient concentrations of ADA, including contributions from the project, would be similar to the ADA concentrations presented in Table 21 and that they should not cause adverse health impacts.

The project's maximum contribution to the ambient boron concentration (annual average) is much less than the most stringent suggested ambient level, 7.4 ug/m^3 (annual average). Based on available data, it appears to be highly improbable that the project's boron emissions would adversely impact public health.

A significant probability exists that the project's contributions, especially in combination with contributions from other power plants, to ambient air concentrations of arsenic, ammonia, benzene, mercury, silica, and vanadium will result in ambient air concentrations exceeding the MEG's suggested ambient goals (see Cumulative Impacts). The failure to meet these goals do not necessarily mean that adverse health impacts would occur;* rather, these failures demonstrate the need for:

- o Better monitoring and characterization of nonregulated pollutant emissions;**
- o Additional research regarding transport and health impacts of nonregulated pollutants;*** and
- o Development of ambient air quality standards for these nonregulated pollutants based upon the protection of public health.***

*For example, a recent study (Larson et al., 1978) reported mean concentrations of ammonia in human breath of 157 ug/m^3 (0.23 ppm) which exceeds the MEG value by nearly a factor of 4.

**Within the statutory authority of the CEC.

***Within the statutory authority and responsibility of CARB, DOHS, and EPA.

Based on the large degree of uncertainty, CEC staff recommends implementation of a monitoring program for ammonia, arsenic, asbestos, benzene, mercury, silica, and vanadium. Included in this program should be monitoring of ambient air concentrations in Anderson Springs and other affected population centers, and steam concentrations, as described in the Compliance Monitoring Report. This report will be jointly developed by CEC and SMUD.

CUMULATIVE IMPACTS

Future development at The Geysers will increase the total quantity of pollutants emitted into the atmosphere and may increase ambient pollutant concentrations locally and possibly regionally. This project will contribute to the cumulative impacts of total geothermal development.

Regulated Pollutants

Hydrogen Sulfide--The NSCAPCD has adopted regulations for retrofit H_2S abatement at existing units, which will reduce the potential cumulative impacts from H_2S emissions at The Geysers KGRA.

If the CAAQS for H_2S is enforced, the public should not be exposed to H_2S concentrations of 0.03 ppm or greater. However, existing hydrogen sulfide concentrations in populated areas near The Geysers KGRA occasionally violate the standard with only 15 units on line. Units on line now total 15, and 20 units are expected to be on line once the project begins operation. Unless compliance with the standard is enforced, even greater and more frequent violations could result from future development (see Air Resources Impacts). Although experts do not know at this time if adverse health effects result from exposure to low levels of H_2S, by inference, increasing H_2S concentrations will increase the possibility of adverse health impacts (see Appendix B, Table B-1).

Radon-222 (^{222}Rn)--If this project and future facilities comply with the California and federal ^{222}Rn effluent standards, the public should not be exposed to greater than 3 pCi/l of ^{222}Rn, or 1 pCi/l of ^{222}Rn and its daughter products, above natural background radiation at the point of release. SMUD will be required to monitor ^{222}Rn concentrations in incoming steam, as specified by DOHS, to ensure compliance with these ^{222}Rn standards.

Nonregulated Pollutants (Ammonia, Arsenic, Asbestos, Benzene, Silica, Boron, Mercury, ADA, and Vanadium)

Operation of this project, existing power plants, and future power plant units at The Geysers KGRA will increase the concentrations of these pollutants in nearby populated areas. At this time it is not possible to accurately determine the resultant ambient air or water concentrations.

Potential cumulative impacts on ambient air concentrations of nonregulated pollutants at Anderson Springs, Whispering Pines, and other population centers from existing power plants can be crudely estimated using results from H_2S studies (Knuth and Giroux, 1979; Tesche et al., 1980). PGandE currently conducts water quality studies of upper Putah Creek (CEC, 1980), and a regional water quality monitoring program developed by the CEC, geothermal utilities, and other state agencies will be implemented soon.

For the reasons stated in the Introduction and earlier in this section, projected exceedances of the MEGs or other suggested levels do not necessarily indicate that adverse health impacts will occur. This can only be determined after establishing safe levels of exposure to the pollutants.

MITIGATION MEASURES

Mitigation of potentially adverse health effects from exposure to geothermal pollutants could be achieved by reducing emissions of those pollutants where possible (methods of H_2S abatement are discussed in the Air Resources Impact section). There are no demonstrated technologies for abating emissions of ^{222}Rn or nonregulated pollutants from geothermal power plants, although H_2S abatement systems, particularly upstream treatment, may scrub pollutants other than H_2S to some degree (Accurex, 1980).

Health Related Monitoring Programs

Monitoring alone would not mitigate any potential public health impacts; rather it would assist in determining the impact of the project, and geothermal development in general, on ambient pollutant concentrations and ultimately on public health. DOHS is involved with EPA in a plan to study field and source sampling for ^{222}Rn and its daughter products. Plans exist for indoor radiological monitoring as well. These efforts represent an attempt to minimize uncertainty in anticipating the dose impact associated with the operation of The Geysers units (Vold, 1980). CEC staff proposes a program for 1981 - 1982 to assess the health status of residents in The Geysers KGRA.

The need for establishing a baseline ambient air monitoring and incoming steam monitoring program is based upon the following:

- o Available data on background air concentrations of nonregulated pollutants are outdated and inadequate for use in determining resultant concentrations in populated areas.
- o Ongoing and future development will increase pollutant emissions at The Geysers during the operating lifetime of this project.

CEC staff recommends the following monitoring programs:

- o Baseline ambient monitoring (preoperational) for ammonia, arsenic, benzene, mercury, silica, and vanadium for one year prior to commencement of the project operation.
- o Incoming steam monitoring (preoperational) for ammonia, arsenic, benzene, mercury, silica, boron, and ^{222}Rn.
- o Mass balance measurements (operational) for arsenic and mercury.
- o Ambient monitoring (operational) for ammonia, arsenic, benzene, mercury, silica, boron, and ^{222}Rn if incoming steam monitoring data indicates the need for such monitoring.

These programs will be described in the Compliance Monitoring Report to be developed by CEC staff and SMUD during the AFC proceedings.

Worker Health and Safety Programs

Geothermal power plants can pose risks to workers' health and safety. These risks primarily relate to toxic and potentially carcinogenic chemical compounds associated with geothermal steam and H_2S abatement systems to which workers may be exposed. Such exposures may occur during routine operation, accident or upset conditions, repair and maintenance activities, and process or system modification activities.

Workers may accidentally come into contact with many of the potentially toxic and potentially carcinogenic substances (e.g., H_2S, ammonia, ^{222}Rn, mercury, arsenic, boron, and chemicals associated with H_2S abatement systems) in geothermal steam, waste streams and during handling of chemicals used in abatement systems. Adverse effects of such exposures could include dermatitis, acute chemical poisoning, chronic illnesses and, potentially, cancers after some induction latency period (see Appendix B).

General Industry Safety Order 3203 (Subchapter 7 of Chapter 4, California Administrative Code, Title 8) requires employers to have an accident prevention program to reduce or prevent occupational injuries and illnesses, and to conduct periodic inspections to correct unsafe conditions. Employers must comply with California Administrative Code, Title 8, Chapter 4, Group 16 (Articles 107 - 112) which refers to control of hazardous substances. The California Division of Occupational Safety and Health (DOSH) enforces compliance with state occupational safety and health standards. DOSH must inspect the plant if there is a complaint from an employee. If worker conditions are found to violate an occupational standard, DOSH will determine what corrective actions are required. There is generally no means for ensuring that an employer has an adequate accident prevention program until DOSH receives a worker complaint regarding worker health or safety.

In 1976, NIOSH received reports that Geysers Unit 11 workers, while performing maintenance of the H_2S abatement system, developed skin rashes (dermatitis) and sore throats (pharyngitis) (NIOSH, 1978). As a result, the process was automated, and only a few cases of skin rashes and sore throats were reported in the last few years. Such incidents lead to the conclusion that the medical problems may be associated with exposure to H_2S abatement system residues, but the precise causal agent has yet to be identified.

SMUD will request recommendations from the Cal/OSHA Consultation Service regarding the adequacy of SMUD's worker health and safety program during project construction (AFC, p. 6-6). CEC staff recommends that, in addition, SMUD should request the assistance of the Cal/OSHA Consultation Service in evaluating the program proposed for operation of the project. Verification of the program's adequacy will be described in the Compliance Monitoring Report.

Should an emergency occur which requires emergency medical or evacuation response, SMUD can call Sonoma County for assistance. SMUD agrees to reimburse the county for the costs of such an emergency response.

IV. PROJECT ALTERNATIVES

There are a wide variety of potential alternatives to the proposed project power plant. These alternatives assume that the basic need and purpose of the project is to supply 65.2 MW net of base load generation capacity to SMUD by late 1983. The alternatives are no project, alternative location, alternative facilities, alternative size, alternative designs, alternative means of accomplishing project objectives, alternative transmission facilities, alternative steam gathering facilities, and alternative uses of geothermal steam.

NO PROJECT

The construction and operation of the SMUDGEO #1 power plant would generate 491 million kilowatt hours (kWh) of energy each year (based upon an 80 percent capacity factor). Without this project SMUD would continue to generate its power from existing sources, and would rely more heavily on mandatory conservation measures until they could bring other proposed power plants on line. Denial of this project will impede SMUD's efforts to diversify power sources and will impede SMUD's efforts to gain increased reliability.

ALTERNATIVE LOCATIONS

The location of a geothermal power plant is limited to areas containing proven geothermal resources within a designated leasehold and to specific areas within that leasehold in regard to topographic and geologic features and environmental concerns. In addition, the power plant must be located at a distance no greater than one mile from each geothermal steam supply well. Transport beyond this distance causes the steam to lose the temperature and pressure required to efficiently operate the steam turbine.

SMUD selected their proposed and alternative sites based on the site selection criteria* listed below:

SITE SELECTION CRITERIA

Category I (Mandatory)
- o On the leasehold.
- o Slope less than 2:1.
- o Adequate space available.
- o No geologic hazard (fault, landslide).

Category II (Avoid or Mitigate)
- o Rare and endangered species.
- o Critical habitats.
- o Sensitive paleontological, archaeological, or ethnic areas.
- o Adverse atmospheric dispersion characterics.

Category III (Evaluate)
- o Mineral resources.
- o Earthwork required for site preparation.
- o Site development costs.
- o Central location to minimize steam lines.

*SMUDGEO#1 AFC, Table 1.1-1.

Figure 12 illustrates the application of the site selection criteria on the leasehold. The major factors determining potentially suitable sites are the topography (slope) and geologic hazards such as landslides and faults. These, combined with the other criteria, resulted in only two potential site areas, labeled "preferred" and "alternate" on Figure 12.

Both potential sites are on a ridge, which normally corresponds with favorable atmospheric dispersion characteristics. As discussed in the appropriate sections of AFC Chapter 5.0, the other criteria of Category II are satisfied. As discussed in AFC Section 5.5.6 (Geology), there are no known commercial mineral resources (other than geothermal steam) anywhere on the leasehold, and both sites are approximately equally central for the transmission of steam. Thus, the choice between the two potential sites is reduced to an economic evaluation.

Site development plans were prepared for the two sites and compared. Preparation of the preferred site will require cutting approximately 180,000 cy of material off the top of the hill and placing approximately 71,000 cy as fill along the northern side of the site. (The remainder of the excavated material will be used by the steam supplier.) The area within the fence is approximately 5.3 acres, and the area of the access road on the south and west of the fence and the parking area outside the fence is about 1.6 acres. All major structures will be constructed on in-place bedrock within the cut area. An exploratory boring program was performed to qualify this site.

The alternate site development would require cutting approximately 264,000 cy of material, considerably more than for the preferred site. All of the cut material would be used for fill. The level area would be approximately 5.6 acres. Areas that would have to be avoided are a possible fault along the north side and an existing Aminoil well pad (Well No. 37-21). Aminoil plans further development on the well pad. One boring (No. 10) was placed at the extreme northern side of the site; this boring encountered a fault or shear zone at a depth of approximately 70 feet. For these reasons, this potential site was relegated to an "alternate" or backup status.

ALTERNATIVE FACILITIES

The primary determinate for consideration of alternative facilities is the time required for planning, design, licensing, and construction of an alternative facility in relation to the date when the electricity is required to be on line. Due to the long lead times required to construct coal-fired, nuclear, and hydroelectric generating plants, these types of plants are not considered as feasible alternatives to the project.

New energy sources such as fuel cells, solar, tidal energy, magnetohydrodynamics, and wind power have limited applications, will not be commercially available within the necessary time frame, and would not provide sufficient base load reliability comparable to this project. Oil-fired generating plants such as combined-cycle units, the repowering of existing generating plants, and cogeneration are all possible alternatives because the lead time required from planning to operation varies from slightly less to a little more than the time required for a geothermal project. However, using fuel oil for combustion purposes is contrary to the Federal Powerplant and Industrial Fuel Use Act, which precludes the use of fuel oil for new generation facilities with only a few exceptions.

ALTERNATIVE SIZE

SMUD believes that a 72 MW plant is the optimal size based on the quality and quantity of the steam within the steam field. Geothermal power plants of a smaller magnitude are feasible, but they do not significantly reduce the initial environmental loss due to power plant construction. Therefore, an optimal design is desirable. Geothermal power plants can be larger or smaller in size. In The Geysers KGRA, the PGandE Geysers Unit 13 power plant currently produces 135 MW, the largest in The Geysers. PGandE's Geysers Units 17 and 18 (recently certified by the Commission) and its proposed Geysers Unit 16 are all rated at 110 MW. Some geothermal plants, such as PGandE Unit 15 and the CDWR Bottle Rock project, are each 55 MW. The smallest power plant in The Geysers is PGandE Unit 1, which produced only 11 MW.

The components of a geothermal generating facility which allow some flexibility of design are the cooling systems and the hydrogen sulfide abatement systems.

Proposed Cooling System

The proposed cooling system is comprised of a surface condenser, which condenses the steam exhausted from the turbines, and a twelve-cell, fan-assisted, wet-type cooling tower, which cools the water heated during its passage through the surface condenser.

Prior to start-up of the power plant, the cooling system will be charged with approximately 1,000,000 gallons of water. The steam supplier, Aminoil, will supply this water from within the leasehold. Once the power plant is in operation, the initial start-up water lost during the evaporative cooling process at the cooling tower will be supplemented by steam condensate from the surface condenser. Excess condensate not needed to replace cooling water lost through evaporation and drift emissions will be reinjected into the steam reservoir.

Alternative Cooling Methods

- Direct Contact Condenser--This system has been used by PGandE in their Geysers Power Plant Units 1 through 12. In this cooling method, steam exhausted from the turbines is mixed directly with the cooling water and then pumped to the cooling tower. The initial cost of this system is less than a surface condenser, but it does not give the degree of H_2S partitioning that can be achieved with the surface condenser in conjunction with the Stretford process for H_2S abatement.

- Air-Cooled Condenser--With this system, the exhaust steam from the turbines is condensed in a tubular type of heat exchanger by air passing over the tubes. This system has three major disadvantages: large size, greatly increased cost, and decreased operating efficiency. An air-cooled condenser requires an extremely large surface area in order to be effective, and the chemical and physical properties of the steam in The Geysers require use of higher-cost materials, thereby increasing costs. The efficiency of the power plant and Stretford H_2S abatement unit would probably be reduced because of size factors associated with an air-cooled condenser, which would increase turbine back-pressure much of the time.

- Closed-Cycle Cooling--The cooling water, in a closed-cycle system, circulates within a closed system using surface condensers and indirect contact, water-to-air, "dry" cooling towers. All the condensate would be reinjected if such a system were used for the proposed plant site. The noncondensible gases in the steam would still have to be removed from the condenser and treated to comply with air quality standards. However, complete reinjection would eliminate H_2S emissions that occur in direct water-to-air contact type towers.

  The use of a closed-cycle cooling system would approximately double the total cost of the proposed power plant. The capital cost of a closed-cycle system could be reduced by reducing the capacity of the plant during the summer peaking period, but this would reduce the value of the generating capacity.

- No Cooling System--In this system, the turbine exhaust steam is discharged directly to the atmosphere from the turbine and requires no cooling. This system was considered in early geothermal power cycle studies but was found to be very inefficient due to the level of back pressure in the turbine units. In order to generate the same amount of power much more steam is required per unit of power generated. Direct discharge of the exhaust steam to the atmosphere also requires consideration of noise mitigation and would not comply with air quality standards.

- Once-Through Cooling System--Use of this system would eliminate the need for a cooling tower but is not considered practical for the SMUDGEO #1 project since the large water supply required is not available in The Geysers areas nor within economically reasonable transport distance.

- Natural-Draft Cooling Tower--A natural-draft cooling tower is not practical for a power plant of this size, since it would have to be very large to create the required air flow. In addition to creating greater visual impact, the larger natural-draft towers would also compound the difficulty of locating satisfactory plant sites in the mountainous terrain of The Geysers KGRA. The cost of this type of tower is several times greater than the cost of the proposed mechanical-draft cooling tower.

Proposed H_2S Abatement Systems

SMUD will use the combination of an improved surface condenser turbine by-pass to deal with occasional steam venting conditions* and Stretford chemical scrubbing process to initially reduce the H_2S emissions. Further reduction of H_2S emissions, as required by the APCO in the Determination of Compliance, will be accomplished with a secondary abatement system using hydrogen peroxide with catalyst.

*Steam venting occurs during plant start-up or shut-down. This condition, known as "stacking," would send untreated steam into the air unless corrective measures are taken.

- The Stretford Process

  The Stretford and H_2O_2 abatement systems scrub the steam once it is exhausted by the turbine. After leaving the turbine the steam condenses and splits into two flow paths. One path contains gaseous chemical constituents including H_2S, while the other flow path contains liquids. The gas flow path contains the majority of the H_2S. This gas stream passes through the primary abatement system which employs the Stretford chemical scrubbing process to treat the H_2S.

- H_2O_2 with Catalyst

  The second flow path contains liquids resulting form the condensed steam and includes chemical constituents such as H_2S which are absorbed by the liquid. This second path containing the smaller amount of H_2S, also requires treatment in order for the plant to meet H_2S emission standards. SMUD's secondary abatement system will employ hydrogen peroxide with a catalyst to promote a high H_2S removal efficiency.

- Turbine By-Pass

  As part of the overall H_2S abatement system, a piping system will be installed to divert steam around the turbine to the surface condenser during plant start-up or shut-down conditions. This will give the steam access to the abatement systems; without this system steam would vent into the air untreated.

Alternative H_2S Abatement Systems

- The Metal Catalyst System--Hydrogen sulfide dissolved in water, in the presence of air and at normal temperatures, is unstable and undergoes oxidation to form free sulfur. This reaction is ordinarily slow but can be accelerated by use of appropriate catalysts such as dissolved ferric ion. In the process the ferric ion is regenerated so that more hydrogen sulfide is oxidized. The iron concentration in the cooling water is maintained at 30 ppm by weight or higher. The condenser off-gas is released in the cooling water so that its hydrogen sulfide content is also oxidized. The major problems associated with the iron catalyst system are corrosion of metal parts in contact with the cooling water and rapid accumulation of sludge.

  A metal catalyst, supplemented either with hydrogen peroxide or with caustic soda, is being used continuously at PGandE Units 3 and 6 and Unit 11. This system will also be used at other PGandE Units only during H_2S episodic alert days.

  PGandE reports that they have achieved 90 percent abatement in their existing direct condenser units by use of high concentrations of iron catalyst. However, systems using this form of abatement experienced serious operational problems which caused reduced reliability due to sludge formation and induced corrosion. By using an iron catalyst with their H_2O_2 system, SMUD can probably avoid such reliability problems. This is due to the smaller quantities of H_2S as well as the nature of the catalyst itself.

- Sulfur Dioxide pH Control--Injection of sulfur dioxide (SO_2) into the condensate to control the pH of the condensate and to displace the H_2S dissolved in the condensate is an attractive method for reducing the amount of H_2S in the condensate. Sulfur obtained from the Stretford process could be burned to provide a readily available source of SO_2.

  Significant development and prototype testing remain to be done on this system before it can be adapted for commercial use. However, if the Stretford process does not provide the necessary H_2S abatement, the use of sulfur dioxide pH control should be considered and evaluated as a secondary H_2S abatement method.

Other H_2S abatement systems which have been or could be used are discussed below. Most have proven ineffective or have been displaced by the Stretford and surface condenser/partitioning process.

- EIC Process

  This process is one that can treat steam upstream of the power plant. It removes the H_2S in the steam by a scrubbing process similar to the Stretford process. It uses a chemical solution whose main constituent is copper sulfate. The system has not been used commercially; however, it has undergone pilot plant testing on one well at a PGandE plant in The Geysers under a development contract funded by the DOE. The attractive features of the process appear to be:

  (a) Potential for high H_2S abatement efficiency and partial removal of other undesirable steam constituents.

  (b) Potentially superior combined capital/operational cost aspects than the Stretford and hydrogen peroxide system combination costs.

  (c) Regeneration capability of the chemical solution and in the scrubbing process.

  (d) Potentially cleaner steam supply to the power plant, which in turn reduces potential problems or maintenance at the plant.

  (e) H_2S abatement capability in a steam stacking process.

  (f) Waste that is generated in the EIC process is joined with the cooling tower purge stream to be reinjected.

  (g) Potential for retrofitting existing power plants.

  The unknown aspects are:

  (a) Actual abatement efficiency as a commercial process.

  (b) Reliability of the system.

  (c) Carry-over of chemical products to the power plant that may be detrimental to the plant.

  (d) Costs, including steam penalties.

Although the EIC process has not been used commercially, the Department of Water Resources proposes to use it on their Bottle Rock project in Lake County. The H_2S concentration for the Bottle Rock project is so high that the EIC process will be installed in addition to two other abatement techniques. SMUDGEO #1 does not have such high H_2S concentrations; so, SMUD can reduce its emissions adequately using only Stretford and H_2O_2 with catalyst.

- Steam Converters--An old geothermal industry process, the steam converter, was the only effective way of reducing the high gas content of the steam. However, the process seriously degrades the quality of the steam, and nearly double the mass of steam is required to produce the same amount of power as unconverted steam.

- Preplant Oxidation--PGandE has briefly experimented with the injection of oxygen (O_2) into the incoming geothermal steam, upstream of the turbine units. The results were not encouraging, since injection of twice the amount of O_2 theoretically required for full oxidation only caused an H_2S reduction of 5 percent. Upstream injection of H_2O_2 has also been tried but with poor results.

- The Burner-Scrubber System--This system mixes the condenser off-gases with air and burns them. The system was used on PGandE's Unit 4 but was discontinued because it was unable to reduce H_2S emissions by more than one-half of that required and because the off-gases are only marginally flammable.

- The Deuterium Process--The Deuterium Corporation has installed and tested a liquid absorption type of scrubber to remove H_2S from a portion of the incoming steam at PGandE's Unit 7. Details of the process are considered proprietary information, but early test results indicated 90 percent or better H_2S abatement. There were problems associated with regeneration of scrubber solutions which have yet to be resolved.

  The Deuterium process has been developed to produce "heavy" water (deuterium) and requires copious amounts of process steam, electrical power, and hydrogen sulfide. Therefore, the process would be a secondary geothermal industry rather than an abatement system.

ALTERNATIVE MEANS OF ACCOMPLISHING PROJECT OBJECTIVES

Energy Conservation

The discussion of need in the chapter on "Project Description" refers to the Energy Commission's adopted forecast for energy and peak demand. The forecast incorporates some conservation measures. New and expanded measures will be implemented by SMUD, thereby reducing electrical demand in the SMUD service area.

Geothermal base load electrical generation is specified by the Energy Commission as a "preferred" technology (CEC, 1978) and is relatively cost-effective compared to other alternative electrical generation technology. Conservation is an alternative technology that would be more applicable as an alternative to other less preferred and less cost-effective forms of electrical generation.

ALTERNATIVE TRANSMISSION FACILITIES

Transmission Structures

Any number of designs for towers, insulators, and conductors are presently available. SMUD proposes to use double circuit, steel lattice towers and ACSR conductors. An alternative design consisting of large-diameter, steel pole-type towers was initially considered but later discarded due to the difficulty in establishing a firm footing for the pole-type towers.

An underground, low pressure, oil-filled, self-contained cable could be used as an alternative for the overhead transmission line. Underground transmission would require excessive clearing, grading, and trenching and would significantly increase the estimated cost of the project. Undergrounding the proposed transmission line would reduce the visual impact and physical obstruction, but the greatly increased installation costs and the possible effects of erosion or slope failures on cable reliability make this an undesirable alternative.

Transmission Routes

A transmission tapline will be constructed from the plant site to an existing PGandE 230 kV transmission line located to the west of the site. SMUD proposed three alternative routes for the transmission tapline. Refer to attached Figure 13.

Alternative A

Alternative A is approximately 3,000 feet long and requires 3 double circuit steel lattice towers. All of the structures could be reached by existing roads (or land that is already cleared and graded) with the exception of Tower A-3, which would require approximately 600 feet of new access road. This line would terminate at PGandE Tower 0/3.

Alternative B

Alternative B is approximately 3,400 feet long and requires 4 double circuit steel lattice towers. As with Alternative A, all of the towers could be reached by existing roads (or land that is already cleared and graded) with the exception of Tower B-3 (same as Tower A-3), which would require approximately 600 feet of new access road. This line would also terminate at PGandE Tower 0/3.

Alternative C

Alternative C is approximately 3,180 feet long and requires 3 double circuit steel lattice towers. This alternative is the same as Alternative A except the last Tower C-3 is located approximately 600 feet south of the last tower for Alternatives A and B, and the line terminates at PGandE Tower 0/4. All of the towers could be reached by existing roads with the exception of Tower C-3, which would require approximately 300 feet of new access roads.

Both SMUD and CEC staff consider Alternative C to be the preferable alternative. It requires only 300 feet of access road as compared to 600 feet for Alternatives A and B, thus minimizing cost and environmental impact. Also, it has less transmission losses than either of the other alternatives, as it terminates on the PGandE line at a point closer to the destination of the power and therefore has a shorter electrical path. Alternative C is slightly longer than Alternative A but is not significantly more expensive, as it requires the same number of towers, with only minimal additional cost for the additional conductors. Accordingly, Alternative C is overall the least expensive and, in addition, conserves energy by preventing unnecessary transmission losses.

ALTERNATIVE STEAM GATHERING FACILITIES

Alternative Structures

In order to maintain the high temperature of the geothermal steam, it must be transported in insulated pipes. Physical and chemical properties of the steam resources constrain the types of materials feasible for use in construction of the gathering system. Since the steam often carries solid debris and other foreign materials which settle out as the steam is transported, the steam gathering system must have vents and centrifugal filters at intervals along the pipeline. These vents and traps must be accessible for periodic cleaning and maintenance. For these reasons an above-ground construction of the steam gathering system is preferred.

Alternative Routes

In order to maintain the maximum usefulness of the natural steam resource, the distance between the steam supply and the power generating facilities must be minimized. The exact location of the steam supply pipelines and support towers associated with the SMUDGEO #1 project are not yet available. The policy of the federal agencies which manage the lands within the proposed project area is to encourage the lessee of the lands to route the steam gathering system along the existing system of access roads constructed during the development of the geothermal resource. The steam developer also would prefer to route the gathering system along already existing roads, since it provides easier access for maintenance of the system and reduces costs.

ALTERNATIVE USES OF GEOTHERMAL STEAM

In addition to its use for electrical generation, geothermal steam can be used for a variety of domestic and industrial processes. Typically, these processes depend on a resource with a 100° to 150° temperature range, which is considered "moderate." Direct heating uses of geothermal energy include water heating, space heating and cooling, food processing, refrigeration, and process-heating applications. The most common of these uses are direct heating for buildings or for industrial dehydration processes. The most efficient uses of this heat require that the user be not more than a mile away from the resource due to heat loss in transportation, and there are no residences within this distance. Geothermal resources above 150°C are considered to be potential for commercial power production; these additional temperature resources could also provide process heat to favorably located industries. The steam resources at The Geysers are about 250°C.

V. GROWTH INDUCING IMPACTS SOCIOECONOMICS

SETTING

The site is located in Sonoma County near the border separating Lake and Sonoma counties in the KGRA. These counties historically share in the growth effects attributable to geothermal development in the KGRA and CEC staff expects them to share in the development directly attributable to the SMUDGEO #1 facility.

Sonoma County has a population of approximately 284,400 (California Department of Finance, January 1, 1980) and grew moderately in recent years due principally to spillover growth from the San Francisco Bay area. Overall population growth of the county has been 3.2 percent per year since 1970. Growth in the geothermal development area was more modest. Population in Healdsburg and Cloverdale, the two towns closest to the KGRA, increased by 2.6 percent and 2 percent, respectively, over the same period (Ibid., and California Department of Finance, September 1975).

The county economy is a diverse one, as would be expected with an area developing a more urban character. The northern portion of the county near the KGRA, however, is of more distinctly rural character. Principal economic activities center on natural resource development and agriculture, with forest products, dairy and poultry farming, and vineyards providing the basis for the local economy. Historical geothermal development also plays a role in the economic growth of the area.

Lake County has a population of 35,200 (California Department of Finance, for January 1, 1980) and has grown rapidly. High in-migration created growth of 6 percent per year since 1970, (Ibid., and California Department of Finance, September 1975) which is sufficient to double the population every 12 years. A significant part of this in-migration has been retired persons seeking the low-cost housing and a scenic rural atmosphere, which Lake County has historically offered. Permanent population in the towns closest to the Socrates Mine Road, leading to the SMUDGEO #1 site, is approximately 2,400. These communities all lie within 15 miles of the site by road and include Anderson Springs, Cobb, Hobergs, Loch Lomond, Middletown, and Whispering Pines. Further growth takes place in unincorporated areas along the Cobb Mountain/Bottle Rock Road area. Principal industries of the county consist of recreation and tourism (especially in the area of Clear Lake) and general service sector activities, although agriculture and timber production are in evidence as well (AFC, pp. 5-109, and Table 5.10-3).

Current public service capacities diverge markedly between the two counties. Northern Sonoma County has experienced moderate growth, yet no major strains of public services despite a general tightening of housing supplies in recent years. Vacancy rates in Healdsburg and Cloverdale were 8 percent and 6 percent, respectively, in 1975 (California Department of Finance, September 1975). By July of 1979, however, these rates had fallen to 1.8 percent and .9 percent, respectively (Federal Home Loan Bank of San Francisco, November 1979). Nonetheless, school age populations are down in Sonoma County, with only three of the seven school districts located in the northeastern part of the county being at or near present capacity (AFC, pp. 5-113). Roads into the area do not meet county standards needed for the transport of heavy equipment (see Transportation Section of the JES for more details). CEC staff believes public safety services are adequate.

Lake County, however, has been unable to accommodate its more rapid growth rate. Although no vacancy data has been collected in the last 10 years, housing stocks are known to be in short supply. Partly because of resource constraints at the local government level, county land use planning efforts have not yet met standards of the Office of Planning and Research; and in the interim period county land use controls have been ineffective. The county reports haphazard distribution of mobile homes along county roads. Growth has strained local school capacities, with both school districts in closest proximity to the site, Middletown and Kelseyville, predicting overcrowded facilities by the fall of 1980 (AFC, pp. 5-113). Geothermal worker families have historically played an increasing role in the growth of the Middletown District (Reany, June 1980).

Moreover, the inability of the county to raise sufficient tax revenue to expand its public infrastructure complicates these problems. Characteristically, housing prices are low in the area, indicative of the largely recreation/agricultural character of the county, and hence provide low assessed values on a per-family basis. Reductions in assessments required by passage of Proposition 13 in 1978 have further restricted tax revenues. Total tax revenues received by the County fell to $3.6 million in fiscal 1978-79 from $5.4 million only one year earlier (California State Controller, January 1980). Total revenues (including all state subventions) fell over the same period by 5.5 percent, during a period when inflation (as measured by price indices for state and local government purchases) was approximately 9.4 percent (Bureau of Economic Analysis, 1980). Real purchasing power of the county therefore declined by almost 15 percent while county population (and hence public service requirements) increased rapidly. Since only Geysers Unit 13 is currently located in Lake County, geothermal tax revenues have not contributed substantially to lessen service capacity problems accompanying the county's rapid growth. The resulting picture is therefore one of a county with overloaded infrastructure which is fiscally constrained from the capital expenditures required to ease the shortages.

Locational Characteristics of Geothermal Development

Of all geothermal power plants currently on line in the KGRA, only Geysers Unit 13 is located in Lake County. Because of this, and the good roads from the Big Sulfur Creek Basin to Sonoma County communities, the distribution of construction worker residences has been highly skewed in favor of Sonoma County. An informal survey taken before early 1979 by PGandE revealed that about 75 percent of plant construction workers then in the area resided in Sonoma County (1979-AFC-3, pp. 5-106). Recent testimony in the Geysers 16 proceedings, however, indicates that 25 to 50 percent of the PGandE geothermal construction force currently resides in the Middletown/Cobb Mountain area alone, with others living in communities around Clear Lake (Carter, August 1980). Future development plans currently known for all utilities seeking projects in the area, reveal a general shifting of development proposals from the Big Sulphur Creek eastward toward the border areas joining the counties and the Lake

County side of the KGRA (AFC, Figure 1.1-2). As this occurs, locational incentives favoring Lake County residences for new construction workers will be enhanced, as the layout of public roads in the area lead most easily into the Lake County communities. The recent closure of Pine Flat Road has completed the gradual restriction of free access to individuals across the KGRA from Lake to Sonoma counties. All roads into the area are now being paved and maintained by resource developers, and are closed to public traffic. As alternative routes from the site area to Sonoma County communities using major thoroughfares would require commuting distances in excess of 50 miles, closure of these roads will potentially restrain ability of geothermal construction workers to commute to residences in Sonoma County.

IMPACTS

Introduction

The SMUDGEO #1 station is only one of eight proposals which would currently be expected to be under construction during the time frame envisioned for the SMUD project. Other proposals include PGandE Units 16 - 18, Northern California Power Agency Units 1 and 2, and California Department of Water Resources Bottle Rock and South Geysers projects. Socioeconomic impacts are regional rather than site-specific in character; hence, it is appropriate to view the impacts attributable to construction of any single unit within the context of the cumulative development occurring from the construction of all facilities. Facility-related growth effects should therefore be assessed both as a cumulative addition to ongoing development during the construction period and as a proposal in its own right. An assessment of cumulative effects is included below.

Population

Under current plans, the construction force required for the construction of the SMUDGEO #1 facilities will be in the area between April 1981 and February 1984. SMUD estimates the peak work force to be approximately 125 by October 1982 (AFC, p. 5-110), with 60 - 70 representing an average level of activity at the site. SMUD has estimated the total population increase in each county attributable to construction of the facilities to be 110--45 construction workers and families and 65 induced newcomers attributable to enhanced general business and employment opportunities in the region due to the direct facility-related growth. These estimates are based upon the following assumptions (AFC, pp. 5-111 - 112):

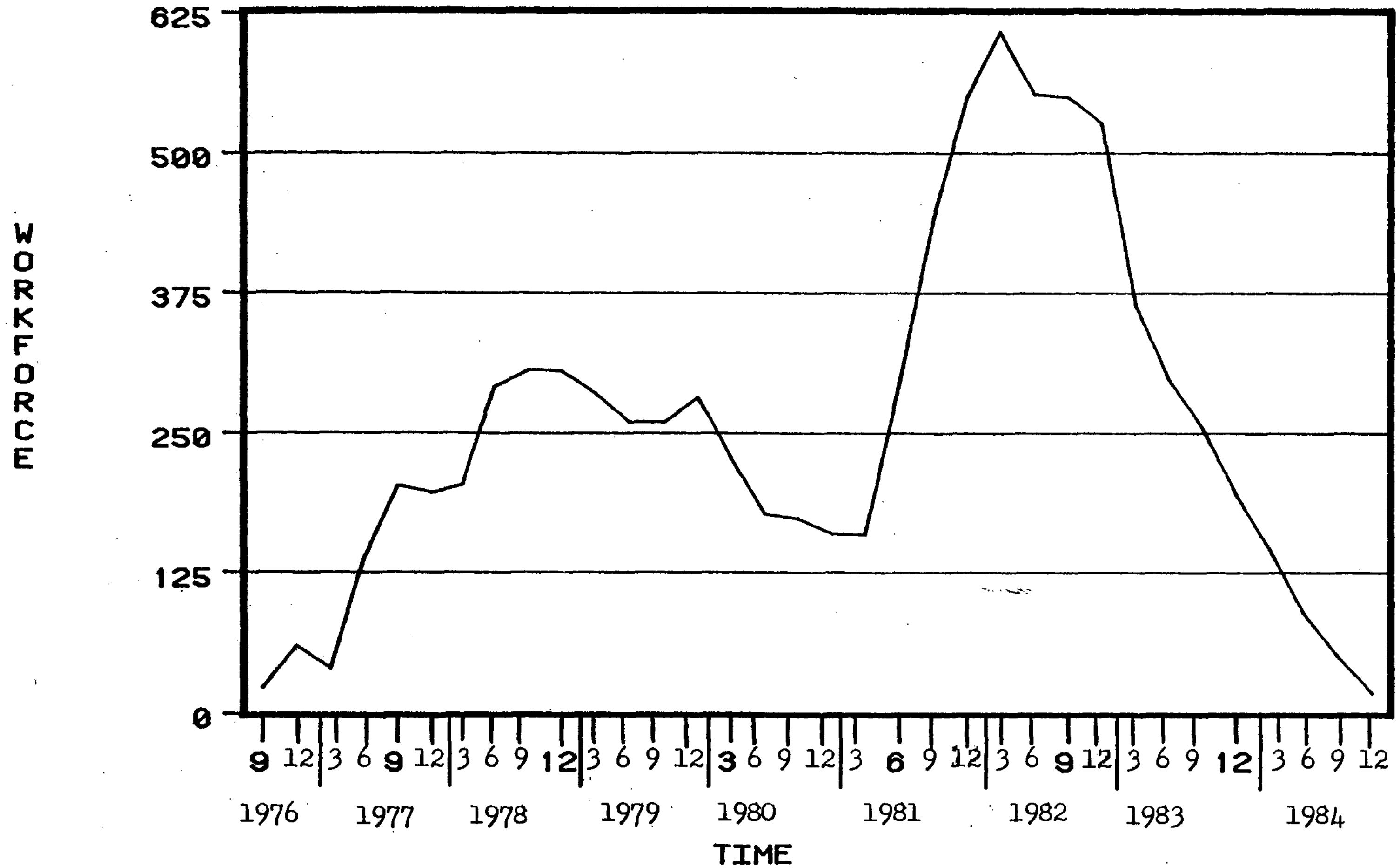
- o Forty workers will migrate into the area, 20 locating in each county;
- o Half of immigrating workers will bring families, consisting of a spouse and 1.5 children on the average;
- o One indirect job is assumed created per each immigrant construction worker.

CEC staff concurs with these assumptions as being reasonable in light of available data.

Cumulative Population Growth

Incorporating the individual construction force projections made by PGandE, N.C.P.A., DWR, and SMUD in their NOI/AFC submittals leads to a total construction work force in the area as shown in Figure 32 below. Peak construction

FIGURE 32
ESTIMATED CONSTRUCTION PERSONNEL
GEYSERS KGRA: 1976-1984



Source: Interrogatory response from the Pacific Gas and Electric Company, June 1979 and individual construction work schedules as included in utility NOI/AFC submittals in the following proceedings: PGandE Units 16-18, NCPA Units 1 and 2, DWR Bottle Rock and South Geysers, and SMUD Geothermal #1. Schedules have been adjusted to reflect delays in regulatory proceedings as they have occurred through May, 1980. Personnel represent power plant construction forces only, and do not include steamfield workers.

work force (exclusive of steam field crews) is expected to be approximately 610 by early 1982, and would decrease rapidly after the Summer of 1983. Assuming further that:

- o All of the approximately 300 workers that were employed during the 1978 peak construction period still reside in the Lake, Sonoma, Napa, and Mendocino County area and are available for further work on geothermal projects;
- o One-half of immigrating construction workers settle in each county;
- o Forty percent of the additional construction force already live in the four-county area;[1] and
- o One-half of immigrating construction workers bring families with them, each on the average consisting of a spouse and 1.6 children.[2]

The total population growth in Lake and Sonoma counties would be approximately 214. This is almost 9 percent of the current population in the southern portion of Lake County closest to the KGRA, while constituting less than 2 percent of the current population of Cloverdale and Healdsburg combined. Given the current conditions in southern Lake County, CEC staff believes the effects of this cumulative growth in Lake County to be significant. Impacts will be insignificant upon Sonoma County.

Labor Market and Housing

On the basis of current information, project-related population impacts will probably exacerbate current housing supply problems in Lake County. This effect is a contribution to the cumulative impacts of all construction rather than a project-specific problem. In light of historically greater housing supplies in northern Sonoma County, both in the Healdsburg-Cloverdale area and also in nearby Santa Rosa, pressure upon housing stocks attributable to the SMUDGEO #1 project in Sonoma County will not be substantial.

An adequate labor pool exists in both Sonoma and Lake counties to assure that problems in staffing local concerns do not arise as current employees leave to work in the geothermal fields. The construction force required in general is highly skilled, and should not therefore draw large numbers of less-skilled employees of the agricultural/natural resource sectors which form the heart of the local economy. Moreover, unemployment rates (indicating availability of labor) are higher in both Lake and Sonoma counties than in the state as a whole (California Employment Development Department). Therefore no adverse labor market shortages in local industries will occur in either county due to project or cumulative effects over the near term.

1. This is the average found by Mountain West Research, Inc., in their research of demographic patterns and construction worker origin. See Construction Worker Profile: Summary Report (Tempe, Arizona, December 1975), pp. 1 - 7.

2. Ibid., with rounding.

Public Services

Population influx attributable to SMUDGEO #1 and other facilities during the early 1980s will further strain the already over burdened public services in Lake County. Schools in the county, especially, will experience problems as children of in-migrant families augment current capacity shortages. It must, however, be reiterated here that public service capacity difficulties of the county are caused by the rapid rate of general population increase, of which the geothermal work force is a small part. Continuation of the 7 percent population growth rate over the 1980 - 1984 span would mean an additional 10,000 inhabitants, of which only 214 would be tied to power plant construction forces (exclusive of steam field crews). Adverse impacts attributable to geothermal work force in-migration will be confined to the southern portion of the county, where geothermal development has already been a significant factor straining public resources (AFC, p. 5-115).

No evidence currently available suggests strong adverse public service effects in Sonoma County attributable to continued geothermal development. The county's modest growth, relatively large populations, and lack of current capacity problems are believed sufficient conditions to assure that geothermal development-induced population will not promote significant effects.

Fiscal Impacts

As the SMUDGEO #1 facilities are owned by a municipal utility, these facilities are not subject to local property taxation. The site and steam field equipment all lie on federal land, but are subject to taxation on the value of improvements. A portion of federal geothermal steam royalties and rent will be refundable to both counties under the provisions of Assembly Bill 1905. Payments currently projected for Lake and Sonoma counties attributable to completion of the SMUDGEO #1 facilities under the provisions of AB 1905 are $42,930 per year for Lake County and $116,070 per year for Sonoma County (Van Horn, July 1980). Payments will not begin, however, until operation commences. Otherwise, no direct property taxation is expected. Both Lake and Sonoma counties are expected to incur economic costs attributable to the project itself (as opposed to the attached population, as discussed above). These costs consist principally of truck-related road damage and miscellaneous expenses such as occasional police patrols, permit inspections, etc.

MITIGATION MEASURES

SMUD proposes to coordinate a plan to provide a bus transportation program for construction workers to Sonoma County via the Union Oil Company's private road. Designed to provide locational incentives for worker location in Sonoma County, the proposed transportation program will serve to shift craft union workers to the Sonoma County side of the KGRA. This will substantially reduce the contribution of geothermal facilities to adverse socioeconomic impacts promoted by cumulative geothermal development upon southern Lake County.

SMUD will come to agreement for compensation of its proportionate share of incurred costs with both Lake and Sonoma counties.

VI. SUMMARY OF ENVIRONMENTAL CONSEQUENCES

Unavoidable Adverse Environmental Effects

For project impacts judged to be significant unless mitigated, this section summarizes adverse effects remaining after implementation of all proposed mitigation measures. This summary includes those impacts which would be significant as well as those rendered insignificant through effective mitigation. For more thorough discussion of each topic, refer to the specific section of the Environmental Analysis Chapter of this EIR.

AIR QUALITY

The Northern Sonoma County Air Pollution Control Officer (NSCAPCO) issued a conditional Determination of Compliance (DOC) for SMUDGEO #1 which indicates that the project will contribute incrementally to an existing violation of the California Ambient Air Quality Standards (CAAQS). To achieve compliance, the APCO requires SMUD to limit their H_2S emissions to from 5 to 8 lbs/hr, depending on the results of ambient air quality monitoring during 1982 and 1983. SMUD will employ Best Available Control Technology (BACT) to reduce their emissions accordingly; however, even if they could reduce their emissions to zero, it would not eliminate the probability of violations occurring in the KGRA. Factors contributing to the air quality violation are cumulative in nature, with existing power plants contributing heavily. The main point, in terms of environmental consequence, is that air quality in The Geysers is reaching the point of impending violation. SMUDGEO #1 will contribute incrementally to this violation, but on a very small scale.

Small quantities of potentially deleterious substances contained in geothermal steam may be carried in the cooling tower plume, lifted into the air, and deposited on soils, vegetation, wildlife, and populated areas. The effects of small concentrations and cumulative deposition of substances such as radon, mercury, arsenic, and boron are not sufficiently understood, and the significance of the impacts is unknown. The use of BACT, mentioned above, will reduce these emissions considerably; nevertheless, small amounts will be deposited on the local environment as a result of SMUDGEO #1.

PUBLIC HEALTH

The project will contribute incrementally to violations of the CAAQS for H_2S, and will increase the possibility of public odor complaints as well as the potential for adverse health impacts in The Geysers area. The project's emissions of nonregulated pollutants, in combination with other power plant emissions will increase the possibility of adverse health effects from these pollutants. Comparison to suggested safe levels or proposed standards for exposure to nonregulated pollutants is difficult due to the scarcity of data on steam quality, actual emission rates, and transport of nonregulated pollutants.

In view of the data uncertainties and public concern with health issues, CEC staff recommends that SMUD monitor steam quality, ambient air pollutant concentrations, and the health status of local residents in order to determine A) the need for further abatement of H_2S and other nonregulated pollutants, and B) the acceptability of additional power plants in the area.

GROWTH INDUCING IMPACTS

SMUDGEO #1 by itself will not induce significant growth in either Sonoma or Lake County; however, cumulatively all geothermal developments contribute to growth of the counties. Roads in both counties are impacted, as are many public facilities. Public schools in Lake County have been particularly impacted by the influx of geothermal workers' families. SMUD will attempt to reduce the disproportionate impact to the Lake County school system by providing incentives for workers to locate in Sonoma County. Additionally, SMUD will negotiate with both counties regarding compensation for road maintenance.

GEOLOGY

Topographic Modification

The original ridgetop will be reduced 40 feet in elevation, in order to prepare a level site for the power plant.

Earthquake Shaking

There may be an increase in microseismic activity due to the presence of a geothermal power plant; however, accurate predictions regarding such activity are not possible. Not enough is known about the phenomenon as relates to geothermal power plants. However, it is anticipated that such microseismic activity will not have far-reaching effects. Some degree of subsidence is expected due to reduction of the geothermal steam reservoir.

Compliance with design criteria will reduce the risk of earthquake-induced structural damage to an acceptable level.

Landslide and Slope Stability

Proposed design and construction methods combined with the site specific geology would probably reduce the hazard to insignificance.

Differential Settlement

Proposed design and construction methods would reduce the hazard to insignificance.

Erosion and Drainage

A presently indeterminable amount of soil will be displaced because of the project due to construction and subsequent erosion. CEC staff estimates that total development (including well field and power plant) will eliminate about 56 acres of vegetation in the leasehold. Of this disturbed acreage, approximately 36 acres will contribute eroded sediments to the watershed.

The actual rate of erosion is difficult to determine, but conservative estimates* of the natural erosion rate at the site indicate 3.2 tons per acre per year of sedimentation. The rate of erosion will increase considerably

*Derived from Universal Soil Loss Equation, used in predicting agricultural losses due to rainfall.

during construction, but should return closely to the natural rate once SMUD's erosion control plan is instituted. The proposed design, construction, and mitigation measures will reduce erosion and drainage hazards to insignificance.

Loss of Mineral Resources (Geothermal Steam)

Reduction of the geothermal steam reservoir may occur; if so, the impact could be significant. Because the size and extent of the steam reservoir are unknown, the potential rate of depletion is also unknown. To some extent reinjection of geothermal fluids and steam condensate may mitigate this hazard, but the extent of possible mitigation is unknown.

HYDROLOGY

Flood Hazard

Mitigation measures such as proper drainage controls and construction of berms should preclude environmental damages to the power plant or to the adjacent area. Through proposed design and construction methods, the hazard will be reduced to insignificant.

WATER QUALITY

Drilling Operation

Sump Wall Failure

Release of drilling mud into a nearby waterway as a consequence of sump wall failure could cause a significant increase in stream turbidity. Although the effect on water quality would be of short duration, sedimentation of this sort settling in a stream could have significant long-term impacts on fisheries. Mandatory compliance with Regional Water Quality Control Board rules and the federal Geothermal Resource Operational Orders, as well as the proposed engineering practices will minimize the risk of sump wall failure, but will not reduce the impact of such an incident should it occur.

Well Blowouts and Well Pad Design

A well blowout could cause ejected drilling mud, hot water, and condensed steam to enter a waterway, resulting in an adverse effect on the stream. Furthermore, steam from such a well blowout would typically damage vegetation in a radius of as much as 100 yards from the well. If Aminoil, the steam supplier, avoids unstable areas for well pads and complies with the state Division of Oil and Gas Regulations, blowouts should be uncommon. The risk of a blowout, rather than its impacts, would be reduced by such mitigation.

WATER RESOURCES

A total of 4.5 million gallons of water will be irrevocably committed to the project. Of this, 3.5 million gallons will be used during construction, and will be trucked into the site from a source in Middletown. The remaining 1 million gallons needed for initial charge to the cooling towers will come from condensed steam from within the leasehold. Beyond the 4.5 million gallons needed for construction and initial startup, less than one acre-foot of water per year will be needed for power plant operation. This water will be supplied from outside sources, but in view of the relatively small amount required yearly, there should be no significant adverse effect on the water resources of the area.

Accidential Spills

If chemicals used in the H_2S abatement process were to spill and reach surface waters, they could cause adverse effects on the fish population in Cobb Creek. The entire power plant will be bermed adequately to hold the maximum possible spill. The proposed design and construction and operation measures should serve to adequately mitigate against the possibility of adverse effects from accidental spills.

VEGETATION

Development of the power plant site will result in the permanent loss of approximately 6.9 acres of vegetation. The majority of this vegetation is chaparral, but because of the abundance of chaparral in the KGRA, this loss is not considered to be significant.

Total development, including power plant site, well pads, steam pipelines, and access roads will result in the loss of appoximately 56 acres of vegetation. Again this is mostly chaparral.

Additional yet unpredictable losses and damage to vegetation may occur near the plant site due to the presence of toxic substances such as boron, H_2S, and salts in cooling tower drift. It is possible that drift may cause some loss to the adjacent mixed evergreen forest.

Because it is a ridge-top site, atmospheric dispersion may occur at a high rate, and could conceivably lessen the negative impacts from cooling tower drift. The magnitude of the impact to vegetation from cooling tower drift, however, is unknown at this time.

Rare and Endangered Plants

No known rare and endangered plants have been identified in the areas proposed for development at the power plant site.

Areas of Critical Concern

Two types of barrens (serpentine and geothermally altered areas) are found northeast of the leasehold. These are considered to be of critical concern because of their unique plants (see Biological Section for details); however, because of their distance from the power plant, no impact is expected.

WILDLIFE

Three legally protected wildlife species have ranges which include the project areas: the American peregrine falcon; the golden eagle; and the ringtail. Use of the area by peregrine falcons is infrequent, whereas the golden eagle and ringtail both forage within the project area.

During the construction phase these species will likely avoid the site and adjacent areas. Whether they will return to their original forage once the plant is operating remains unknown; however, SMUD has taken particular care in designing an environmentally sensitive sediment catchment system to minimize potential impact to Cobb Creek and the riparian zone frequented by the ringtail.

Species of recreational value include various species of quail, the band-tailed pigeon, mourning dove, brush rabbit, black-tailed jack rabbit, western gray squirrel, black-tailed deer, and black bear. Of these, the deer are of the greatest recreational value. The deer will suffer some loss of chaparral habitat, but this should be mitigated by the proposed controlled burn program which will increase browse and should offset the initial loss of chaparral.

NOISE

The nearest sensitive receptor, a single-family residence, is located over two miles away from the site. Noise levels from the site, neither during construction nor during operation should exceed acceptable levels at this distance. The proposed mitigation measures should render noise impacts on sensitive receptors insignificant.

Provided that SMUD complies with Cal/OSHA requirements during construction and operation of the plant, and that they incorporate the design mitigation measures, the noise impact on workers should be insignificant.

WASTE MANAGEMENT

During the construction phase, the project will produce approximately 3,500 cubic yards of construction waste. During operation, the Stretford system (H_2S abatement) will produce approximately 350 cubic yards of sludge and sulphur per year. Other waste estimates include 100 gallons per year of waste oil and 2,500 gallons per year of sewage.

Based on estimates by PGandE (Geysers 16 AFC), wastes from the secondary H_2O_2 abatement system could amount to as much as 3.5 cubic yards per year of sludge (40 percent solids/60 percent water).

SMUD has agreed to comply with safety standards and regulations concerning the storage, handling, transport, and disposal of wastes. Through implementation of design, construction, and operational safeguards, the potential hazard of waste disposal is reduced to insignificant.

CULTURAL RESOURCES

No significant impact.

LAND USE

No significant impact.

AESTHETICS

This ridgetop site will be visible from portions of Routes 101 and 128, which have been designated as scenic highways by Sonoma County. Viewers from the south will see it at a distance of from 9 - 12 miles, while those in the northeast will be in excess of 15 miles away. In light of the long distances involved and the current visibility of cooling tower plumes from existing facilities at higher elevations, CEC staff does not consider these distant views of the power plant to be significant. Nevertheless, SMUD has agreed to mitigate these impacts by painting the facilities to minimize contrast with the natural background.

TRANSPORTATION

During the construction period (April 1981 - December 1983), an average of five heavy trucks will travel to and from the site each day. This number will reduce to about 10 trucks per week during the plant operation phase, after December 1983. Construction traffic will reach the site either from Middletown via State Route 175 and Socrates Mine Road or from the west via Healdsburg-Geysers Road and existing roads through the geothermal development area.

Heavy truck usage causes rapid deterioration to roads; thus, the project will contribute to road maintenance problems.

Because SMUD has proposed a van pool system to transport its workers to and from the site, the modest increase in lighter traffic on the roads due to the project will not be significant.

IRREVERSIBLE ENVIRONMENTAL CHANGES AND IRRETRIEVABLE COMMITMENTS OF ENERGY AND MATERIALS

Environmental categories not listed have no irreversible changes.

Air Quality

During the 30-year lifetime of the plant, there will be a limited contribution to pollutant concentrations in the ambient air. Once the plant is decommissioned and the steam wells are no longer producing, the contributions to air pollution will cease. Thus air quality will not be affected permanently and irrevocably, but it will be affected during the lifetime of the project.

Health

CEC staff cannot determine from available data whether plant emissions will cause irreversible adverse health effects, but adherence to existing health standards on regulated pollutants should render impacts from regulated pollutants insignificant. Monitoring nonregulated pollutants and their effects will determine the need for additional abatement.

Soils

A presently undeterminable amount of soil will be lost because of the project due to construction and subsequent erosion.

Hydrology

The 3,500,000 gallons of water needed during power plant construction and the 1,000,000 gallons of water needed to initially charge the cooling tower basin will be irretrievably committed to the project, but constitute insignificant amounts.

Vegetation and Wildlife

11.3 acres of vegetation and wildlife which presently occupy the project site will be lost. 6.9 acres will not be revegetated. Total development, including steamfield and power plant site, will result in the loss of about 56 acres of vegetation, some of which will be revegetated. If SMUDGEO #1 operates indefinitely, the vegetation lost to the project will constitute an irreversible change. However, if the project is eventually decommissioned, the facilities should be removed and the site revegetated. This latter procedure, if successful, would also restore the wildlife habitat lost to the project.

Noise

If Cal/OSHA requirements are met, there should be no significant irreversible noise effects (e.g., hearing loss) as a result of the project.

Safety

Some serious or fatal accidents may occur as a result of the project (especially from vehicle accidents), but these would not be abnormal for energy resource development projects.

Land Use and Aesthetics

The commitment of the leasehold area to geothermal development will likely be an irreversible change. Other land uses will be permanently precluded in the area. The aesthetic impacts of the facility will also be permanent. However, if the project is eventually decommissioned, the area could be used for recreation and wildlife habitat, and if the facility is removed and the site revegetated, the aesthetic impact will be substantially reduced. However, modification of the landform, i.e., reduction of the ridgetop elevation by 40 feet, will be permanent. Cumulative land use impacts in the KGRA may be irreversible, since areas once developed typically remain that way. Even if plant facilities are removed and sites are revegetated, roads would remain providing access to formerly undisturbed wildlife habitat.

Energy and Material Resources

Implementation of this project would entail the commitment of the workers' time to construct it and a portion of the useful life of the equipment that could otherwise have been used to implement a different project.

Material

Much of the material used in the project such as concrete would be irreversibly committed, but some portions, such as various systems, components, and equipment, or structural steel, expensive metal alloys, and catalysts may be reused. Fossil fuels used would be irretrievably committed.

Steam Resource

The geothermal steam which will be used to power the proposed facility will be irretrievably committed to use and irreversibly discharged. Approximately 983,200 pounds per hour of steam will be used to power the turbines. A small percentage of that steam will be condensed and reinjected into the steam reservoir. The present and projected use of the geothermal steam to produce electrical power precludes it from being used for other purposes.

Depletion of the geothermal resource would be a significant environmental change if the steam reservoir does not recharge. It is unclear whether geothermal steam is a renewable resource, and if so, what period of time is required for the resource to be renewed.

THE RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF THE ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

SHORT-TERM USES

The proposed SMUDGEO#1 project will offer short-term (30 or more years) benefits by providing electricity to the SMUD service area while allowing SMUD to diversify its electrical generation resource base. The project provides short-term employment and other fiscal benefits to individuals and Sonoma and Lake counties. It will also cause stress on some of the public services and facilities such as schools and roads, especially during the construction phase of the project.

LONG-TERM PRODUCTIVITY AND CUMULATIVE IMPACTS

Long-Term Productivity

The proposed project will have potential long-term (greater than the life of the project) adverse effects on vegetation, wildlife, land use, aesthetics, and the geothermal resource (see Irreversible Environmental Changes Section). Because use of geothermal resources for electrical generation is relatively new, the significance of some of its effects is unknown, including the potential health effects of long-term exposure to varying concentrations of hydrogen sulfide and other potentially deleterious components of geothermal steam and emissions, and the long-term production capacity of the KGRA.

If the steam for the project proves to be a reliable long-term source for electrical power, the benefits of development will be long-term, but the adverse impacts could also increase proportionally.

CUMULATIVE IMPACTS

The project will contribute to the cumulative impacts of geothermal development in The Geysers KGRA, which are significant and increasing.

These cumulative impacts are made no less significant by the fact that substantial portions of the KGRA have, in effect, become "industrialized" due to geothermal development. The proliferation of well pads, access roads, steam conveyance lines, transmission lines, and power plants is gradually altering the undisturbed natural environment of The Geysers KGRA, and no amount of mitigation at individual project sites can alter this basic fact.

Current and Anticipated Development

The following list summarizes the status of geothermal development within the KGRA.

PGandE Unit	Net MW	Commercial Operation	Target For Operation
1	11	9/25/69	
2	13	9/13/63	
3	27	4/28/67	
4	27	3/02/68	
5	53	12/15/71	
6	53	8/18/72	
7	53	11/23/72	
8	53	11/23/72	
9	53	10/25/73	
10	53	11/30/73	
11	106	5/31/75	
12	106	3/01/79	
13	135	4/15/80	
14	110	9/12/80	1980
15	55	6/17/79	
17	110	Under Const.	1982
18	110	Under Const.	1983
NCPA 2	110	Under Const.	1983

Proposed Units

Unit	MW	Target For Operation
SMUDGEO #1	72	1983
DWR Bottle Rock	55	1984
DWR South Geysers	55	1986
PGandE 16	110	1983
Total	1,530	

CEC staff predicts maximum development of the KGRA at 2,700 MW dry steam production by 1992, with an additional 550 MW from hot water production by the year 2000.

Accurate assessment of the cumulative impacts of geothermal development at the KGRA is in a fledgling stage. Although an attempt has been made in each section of this environmental document to address cumulative impacts, each of these effects should be viewed as extremely speculative. There simply is not enough data to make an accurate statement at this time; nor is it logical to propose mitigation of these impacts until the needed data is available. For this reason CEC will make a special cumulative impacts study to be published in 1983. This study, Development Effects at the Geysers, will address the following topics: health effects of H_2S; water-related resources; biological resources; socio-economics; seismic performance and design criteria; erosion/sedimentation potential; transmission system; and air quality modeling. Once this study is complete, we will have an accurate picture of the cumulative impacts of geothermal development at the KGRA. At that time it will be appropriate to discuss proposed mitigation of these impacts.

CATEGORICAL CONCERNS

It is difficult to determine to what degree impacts associated with the SMUDGEO#1 project will contribute to the cumulative impacts of the overall development in the KGRA. Cumulative impacts are of concern in the areas of land use and aesthetics, air quality, public health, water quality, erosion and sedimentation, biological resources, and safety.

Land Use and Aesthetics

Increasing development of geothermal resources with related soil and vegetation disturbance and removal, and the construction of large, visible structures will inevitably alter the character of the landscape and the potential uses and characteristics of the land. Proposed and recommended erosion control measures, revegetation procedures, and landscape and design features should reduce the potential for significant adverse impacts.

There is a growing concern that geothermal development (in the KGRA) may have already or soon will reach an impact saturation point which would preclude further development of geothermal resources for electrical generation or other uses.

Air Quality

Emissions of potentially deleterious substances including boron and mercury present in the geothermal steam and in the cooling tower plume may be carried in the air and deposited on soils, vegetation, wildlife, and populated areas. Although studies of potential effects have been initiated, there is insufficient information available to determine what, if any, are the effects of cooling tower emissions and drift deposition. Proposed and recommended design features for cooling towers should reduce the potential for significant adverse impacts related to deposition of cooling tower drift. Recommended monitoring programs should provide a data base for study of potential impacts of cumulative deposition.

Public Health

Emission of hydrogen sulfide into localized and regional air sheds could produce an increasing number of complaints about odor and disagreeable physical reactions in sensitive populations of the general public. The potential for harmful physical effects related to long-term exposure to low levels of H_2S remains an unanswered question. Proposed and recommended hydrogen sulfide abatement system(s) are expected to reduce H_2S emissions to levels required to meet standards for ambient concentrations of H_2S. Recommended monitoring programs should provide a data base for study of long-term effects of exposure to low levels of H_2S.

Water Quality

Use of geothermal steam produces a number of toxic substances including boron, mercury, and arsenic which are present in the spent steam condensate. Proposed and recommended design features to prevent discharge of toxic substances into natural watercourses and/or groundwater should reduce the potential for significant impacts. Although SMUD appears to have designed adequately to prevent the significant hazard of a toxic spill, as the number of operating power plants in the KGRA increases, the probability of major, serious toxic spills would also increase.

Erosion and Sedimentation

By the year 2000, CEC staff estimates that 1,625 acres of land in the Geysers KGRA will be disturbed due to geothermal development. Each acre of disturbance will contribute an unknown amount of sedimentation. Of the 1,625 contributing acres, SMUDGEO#1 will have added 36 acres, or 2.2 percent overall.

Biology

For this project the natural vegetation losses and associated wildlife habitat are estimated at 10.5 acres for the power plant and a combined steam field and power plant development loss of 57.4 acres. This represents about 14.5 percent of the 396-acre leasehold or 1.04 acres/MW for the 55 MW power plant size and 0.80 acres/MW for the 72 MW power plant. These projected losses are based on a 30 year operating life of the project. If the power plant continues in operation for a longer period, the need for development of additional wells can be expected in order to compensate for the decline of steam from the initial wells. This would result in additional vegetation and associated wildlife losses.

While the loss of 57 acres may seem insignificant when considered as a single project, the cumulative unmitigated loss of natural vegetation and associated wildlife are significant when considered on the bases of full geothermal development.

An estimate for existing geothermal development is 11.5 percent vegetation loss per leasehold which amounts to 0.93 acres/MW.[1] For geothermal development of

1. From a CEC staff report on cumulative biological impacts in preparation (Draft release expected about February 1981).

2,000 MW this would be 1,860 acres of vegetation loss or 2,790 acres for development of 3,000 MW. Loss of this acreage is significant and the remaining habitat may become so disrupted and/or fragmented as to be undesirable and unusable for wildlife use. This could cause a corresponding decline in biological species numbers and diversity. Attempts to enhance remaining habitat associated with power plant disturbance through erosion control, revegetation programs, and prescribed burning of chaparral may be successful, but could potentially be overcome by the cumulative effects of combined disturbances. Implementation of proposed and recommended erosion control measures, revegetation procedures, and the prescribed burning programs for full field development should reduce the potential for significant adverse impacts on habitat.

Safety and Transportation

Transport by truck over the narrow Geysers area access roads increases the possibility of spillage, probably by an accident such as a wreck with another vehicle or the truck going off the road. As the number of power plants in The Geysers KGRA increases, so will the number of transport vehicles. This will increase the possibility of accidents on the roads and the chances for any type of off site accidential spill. Proposed and recommended safety precautions and procedures will reduce the potential for significant adverse impacts from the storage or transporting of toxic or hazardous materials.

REASONS FOR DEVELOPMENT AT THIS TIME

The project is proposed by SMUD at this time because it heightens their service capacity and permits them to diversify their power sources, thereby improving on overall system reliability. Geothermal is a relatively inexpensive source of base load power available to SMUD, and reduces the need for constructing other types of power plants. The policy of the Energy Commission is to encourage and expedite the processing of geothermal power plants consistent with need and environmental protection.

BIBLIOGRAPHY

BIBLIOGRAPHY

Accurex, 1980. Assessment of H_2S Control Technologies for Geothermal Power Plants. Prepared by Accurex Corporation for the California Energy Commission. CEC Pub. #P300-80-004, February 1980.

Ahlberg, G., 1951. "Hydrogen Sulfide Poisoning in Shale Oil Industry," Archives of Industrial Hygiene and Occupational Medicine.

Altshuler, S.L., 1978. Status Report Studies of Cooling Tower Emissions at The Geysers Power Plant, PGandE Report 420-78.

ACGIH-American Conference of Governmental Industrial Hygienists, 1977. Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with intended changes for 1977.

AIHA-American Industrial Hygiene Association, 1963. Hygienic Guide Series--Hydrogen Sulfide.

Ames, B.N., 1979. "Identifying Environmental Chemicals Causing Mutations and Cancer." Science, Vol. 204 (4393), p. 587.

Amimoto, P.Y., 1978. Erosion and Sediment Control Handbook. EPA 440/3-78-003. Environmental Protection Agency, Water Planning Division, Washington, D.C. 197 pp.

Anderson, W.L., 1978. Waterfowl Collisions with Power Lines at a Coal-Fired Power Plant. Wildlife Soc. Bull. 6(2), Summer, 1978.

Anspaugh, L.R., 1978. Final Report on the Investigation of the Impact of the Release of ^{222}Rn, Its Daughters, and Precursors at the Geysers Geothermal Field and Surrounding Area. Lawrence Livermore Laboratory, Environmental Sciences Division. March 20.

AFC - Application for Certification--SMUDGEO #1, Sacramento Municipal Utility District, 1980, 1 Volume.

Arbib, R., 1979. The Blue List for 1980. American Birds, 33(6):830-835.

Atlantis Scientific. EIR for Ford Flat Geothermal Steam Area, Lake County, 1976.

Bachman, J.M. and Weigold, J., 1975. Position Paper on Regulation of Atmospheric Sulfates, EPA 450/2-75-007, Office of Air Quality and Water Management, EPA.

Banks, R.S.; C.M. Kannianen; and R.D. Clark, 1977. Public Health and Safety Effects of High-Voltage Overhead Transmission Lines: An Analysis for the Minnesota Environmental Quality Board. Minnesota Department of Health, October, 1977.

Barnes, J., 1975. Toxic Hazards in the Use of Herbicides. Herbicides; Physiography, biochemistry, ecology. Academic Press, New York, Vol. 2, pp. 373-391.

Barrett, S.A., 1908. The Ethno-geography of the Pomo and Neighboring Indians. University of California Publications in American Archaeology and Ethnology. Volume 6, pp. 1-332.

Bean, W., 1973. California: An Interpretive History. McGraw Hill Co., New York and Toronto.

Beard, J., 1979. California Department of Health Services Air Quality Advisory Committee. (415) 497-5546. Personal Communication with N. Post, December 14.

Beardsley, R.K., 1948. Cultural Sequences in Central California Archaeology. *American Antiquity. Volume 14, No. 1: 1-28.*

Beardsley, R.K., 1954. Temporal and Areal Relationships in Central California Archaeology. University of California Archaeological Survey Reports. Nos. 24-25. Berkeley.

Bennyhoff, James A., 1977. Ethnography of the Plains Miwok. Center for Archaeological Research at Davis. Publication No. 5. Davis.

Berg, Gary and Thomas F. King, 1974. Archaeological Impact Evaluation: Porter Creek Road Between Tarwater Road and Mark West Springs. Manuscript on File at the Cultural Resources Facility, Sonoma State University. AIR# S-138.

Bickel, Polly McW., 1976. Toward a Prehistory of the San Francisco Bay Area. Ph.D. Dissertation. Harvard University.

Bjourn, T.C., M. Bruseun, M. Molnav, J. Milligan, R. Klount, E. Chaco, and C. Schaye, 1977. Transport of Granitic Sediment in Streams and its Effect on Insects and Fish. Bulletin 17. College of Forestry, Wildlife and Range Sciences, University of Idaho, Moscow.

Blake, M.C., Jr., Barlow, J.A., Frizzel, V.A., Jr., Schlocker, J., Sorg D., Wentworth, C.M. and Wright, R.H., 1974. Preliminary Geologic Map of Marin and San Francisco Counties and Parts of Alameda, Contra Costa and Sonoma Counties, California. U.S. Geological Survey, MF-574.

Boyce, D.A., 1979. California Peregrine Falcon Reproductive Success and Protective Effort in 1979. U.S. Fish and Wildlife Service, Sacramento, California.

Bridges, J.E. and Frazier, M.J., 1979. The Effect of 60-Hertz Electric and Magnetic Fields on Implanted Cardiac Pacemakers. Prepared for EPRI by IIT Research Institute: EIA-1174, Final Report, September, 1979. p. 5-8.

Britt, D.L., and Hushon, J.M., 1976. Biological Effects, Criteria and Standards for Hazardous Pollutants Associated with Energy Technologies. Mitre Publications MTR-7283.

Bureau of Economic Analyses, U.S. Department of Commerce. Survey of Current Business, V. 60, #6 (June, 1980) Table 20, p. 16.

California Administrative Code, Title 27, § 66535, Storage of Hazardous Waste; § 66510, Operation Requirements for Hauler

CARB--California Air Resources Board, 1970. "Ambient Air Quality Standards," Section IX.

California Department of Finance, Population Research Unit, Census Report (Sacramento, July 1976), pp. 16, 36.

California Department of Finance, Population Research Unit, "Population Estimate of California Cities and Counties: January 1, 1979 and January 1, 1980." Report #80 E-1 (Sacramento, May 1, 1980).

California Department of Fish and Game. 1978. At the Crossroads, 1978 - A Report on California's Endangered and Rare Fish and Wildlife. Sacramento, California.

California Department of Fish and Game (CDFG). 1979. Endangered and Rare Plants of California. List of protected species compiled by CDFG Rare Plant Office, Sacramento, California.

California Division of Mines and Geology, 1977. Environmental Geologic Analysis of the Porter Creek Study Area, Sonoma County. Author, Charles F. Armstrong.

California Employment Development Department, Employment Data and Research Division: "Monthly Labor Force Data for Counties: Annual Average, 1979" Report #400-C (April 18, 1980).

CEC, 1980b. PGandE Geysers Unit 16 Hearing, April 2, 1980, Lakeport, CA. Tr. 7855: Kris Wirth, PGandE.

CEC-SRI (Stanford Research Institute), 1977. Environmental Analysis for Geothermal Developments in the Geysers Region.

CEC Biennial Report, 1979.

CEC, 1980a. NCPA No. 2 Geothermal Power Plant, Final Joint Environmental Statement. CEC Publication No. P700-80-002, March.

California Energy Commission, Geothermal Policy Report, 3/22/78.

California Inventory of Historic Resources, 1976. Published by the Resources Agency Department of Parks and Recreation. State of California. Sacramento.

California State Controller: Annual Report--Financial Transactions Concerning Counties of California. Fiscal Year: 1978-1979. January, 1980.

Case, G.D., Bertolli, T.A., Bodington, J.C., Choy, T.A., and Nero, A.V., 1977. Health Effects and Related Standards for Fossil Fuel and Geothermal Power Plants. Vol. 6 of Health and Safety Impacts of Nuclear, Geothermal, and Fossil-Fuel Electric Generation in California. Lawrence Berkeley Laboratories, LBL 5287. January 1977.

Cederholm, C.J., and L.C. Lestvelle. 1974. Observations on the Effects of Landslide Siltation on Salmon and Trout Resources of the Clearwater River, Jefferson County, Washington. 1972-73. Fish. Res. Institute, University of Washington, Seattle.

Chaney, Ralph W., 1951. Prehistoric Forests of the San Francisco Bay Area. In Geologic Guidebook of the San Francisco Bay Counties (California): California Division of Mines Bulletin 154, pp. 193-202.

Cheatham, N.H., and J.R. Haller. 1975. An Annotated List of California Habitat Types. Mimeograph published by Univ. of Calif. Natural Land and Water Resources Systems.

The Condensed Chemical Dictionary. 1971. Revised by G.G. Hawley. Eighth Edition.

Contra Costa County Planning Department. Undated. File Data. Maps showing significant wildlife sightings and natural areas. Martinez, California.

Cornwell, G. and H.A. Hochbaum. 1971. Collisions With Wires -- A Source of Anatid Mortality. Wilson Bull. 83(3):305-306.

Cordone, A.J. and D.W. Kelley. 1961. The Influences of Inorganic Sediment on the Aquatic Life of Streams. California Fish and Game, Vol. 47(2): 189-229.

CRWQB. 1975a. Water Quality Control Plan, North Coastal Basin 1B, Abstract. California State Regional Water Quality Control Board, North Coast Region 1. July, 1975.

CRWQB. 1975b. Water Quality Control Plan, Sacramento River Basin, (5A) California State Regional Water Quality Control Board, Central Valley Bay Region 5. July, 1975.

Damon, Lowell F., 1980. An Archaeological Survey of a Portion of a Proposed PG&E Transmission Line Located on the North and South Shores of Carquinez Strait Near the Carquinez Bridge, Solano and Contra Costa Counties, California. Report Prepared for Pacific Gas and Electric Company, San Francisco. Manuscript on File at Cultural Resources Facility, Sonoma State University.

Damon, Lowell F., 1980a. Lakeville-Sobrante 230 kV Transmission Line Archaeological Sensitivity Map. Letter Report to J.A. McCullough, Pacific Gas and Electric Company, San Francisco. Report on File at Cultural Resources Facility, Sonoma State University.

Devege, G.A., 1956. "H_2S, A Pathological Factor in Coal Mining" Rev. Med. Miniere 9(32):14-18.

Donnelly, J.M., Hearn, B.C. Jr., and Goff, F.E., 1977. The Clear Lake Volcanics; California Geology and Field Trip Guide to The Geysers-Clear Lake Area. Geological Society of America, Cordilleran Section.

Dott, R.H., Jr., 1979. Comment on "Intracontinental Plate Boundary East of Cape Mendocino, California: Geology, v. 7, p. 322-323.

Durocher, N.L., 1969. Air Pollution Aspects of Boron and Its Compounds. Prepared for the Department of Health, Education, and Welfare. PB-188 085.

East Bay Municipal Utility District (EBMUD), 1970. Land Use Master Plan.

East Bay Municipal Utility District (EBMUD), 1973. Educational Land Use Survey.

East Bay Municipal Utility District (EBMUD), 1975. EBMUD Trails.

Ecoview Environmental Consultants. EIR for Shell Lease #CA-949, Well Pads C&D (formerly "Shell U.S. Geothermal Leasehold, Wells 3&4"), 1975.

Edison Electric Institute. Glossary of Electric Utility Terms. 86 pp.

EPA - refer to U.S. Environmental Protection Agency.

Federal Home Loan Bank of San Francisco, Santa Rosa SMSA Housing Vacancy Survey, San Francisco: November 1979.

Fox, C. 1964. The Effects of Five Herbicides on the Numbers of Certain Invertebrate Animals in Grassland Soil. Canadian Journal of Plant Science, 44:405-409.

Fox, K.F., Jr., Sims, J.D., Bartow, J.A. and Helley, E.J. 1973. Preliminary Geologic Map of Eastern Sonoma County and Western Napa County, California. U.S. Geological Survey, MF-483.

Fredrickson, David A., 1973. Early Cultures of the North Coast Ranges. Ph.D. Dissertation. University of California, Davis. Report on File at the Cultural Resources Facility, Sonoma State University.

Fredrickson, David A., Thomas M. Origer and Pamela Roberts, 1975. An Archaeological Survey of the Proposed PG&E Transmission Line from Pine Flat to Lakeville Substation, Sonoma County, California. Manuscript on File at the Cultural Resources Facility, Sonoma State University. AIR# S-230.

Fredrickson, David A., W.H. Wright III, Mark S. Ziegenbein, Marc M. Druckman and Helga Ritter, 1978. Paleontological Resource Investigations in Units 16, 18, 19, 20 and 21 Areas of the Geysers Region, Lake and Sonoma Counties, California. Prepared for Pacific Gas and Electric Company, San Francisco. Report on File at Cultural Resources Facility, Sonoma State University.

Fredrickson, David A., James P. Quinn and Deborah Rippey, 1979. An Archaeological Survey of Portions at the Proposed PG&E 230 kV Transmission Line from Pine Flat to Lakeville Substation, Sonoma County, California. Report on File with the Cultural Resources Facility, Sonoma State University.

Fredrickson, David A., Lynn Eiseman, Christian Gerike and Jennie L. Goodrich, 1979a. A Preliminary Cultural Resources Study of the Lakeville-Sobrante 230 kV T/L Project Area. Prepared for Pacific Gas and Electric Company, San Francisco, California. Report on File at Cultural Resources Facility, Sonoma State University.

Gerike, Christian, 1980. Tulucay S/S and Vaca-Dixon S/S to American Canyon Junction Study Corridor Archaeological Sensitivity Map. Letter Report to J.A. McCullough, Pacific Gas and Electric Company, San Francisco. Report on File at the Cultural Resources Facility, Sonoma State University.

Gerow, B. and R. Force, 1968. An Analysis of the University Village Complex with a Reappraisal of Central California Prehistory. Stanford University Press. Stanford.

Gibbons, D.R. and E.O. Salo. 1973. An Annotated Bibliography of the Effects of Logging on Fish of the Western United States and Canada. USDA Forest Service General Technical Report PNW-10, Portland, Oregon, 145 pp.

Gifford, Edward W. and A.L. Kroeber, 1939. Culture Element Distribution IV: Pomo. Berkeley: University of California Publications in American Archaeology and Ethnology 37(4):117-254.

Grant, W. and D. Tompkins, 1977. Effects of Herbicides on Species Diversity of Two Plant Communities. Ecol. 58(2):398-406.

Grew, P.C., 1978. Report of the State Geothermal Task Force. Prepared for the State of California, Office of Planning and Research.

Gurinov, B.P., 1952. "Limits of Allowable Concentrations of Hydrogen Sulfide in Atmospheric Air of Inhabited Localities" Limits of Allowable Concentrations of Atmospheric Pollutants, V.A. Ryazanov, editor. (Translated by B.S. Levine, U.S. Public Health Service.)

Haggard, H.W., 1925. "The Toxicology of Hydrogen Sulphide," Journal of Industrial Hygiene, 7(3):113-121.

Hall, D.J., T.J. Harris-Haller, N.L. Crane. 1979. Physical description and wildlife use of Birdsong and Oatgrass Meadows located within The Geysers Unit 18 leasehold area. Pacific Gas and Electric Company Department of Engineering Research, Report 411-79.220.

Hall, J.D. and R.L. Lantz. 1969. Effects of Logging on the Habitat of Coho Salmon and Cutthroat Trout in Coastal Streams. In: T.G. Northcoed (Ed.), Proceedings of a Symposium - Salmon and Trout in Streams. University of British Columbia, Vancouver, Canada, pp. 355-375.

Hansen, R.M. and D.R. Johnson. 1969. Effects of Range Treatment with 2, 4-D on Rodent Populations. Journal of Wildlife Management, 33(1):125-132.

Harvey, R.C. 1975. Benefits and Hazards of Herbicides. Industrial Vegetation Management, 7(2):8-12.

Hauge, C.J., M.J. Furniss, and F.D. Euphrat. 1979. Forest Practice Rules and Soil Erosion in the Coast Forest District: In: Guide Book for a Field Trip to Observe Natural and Management-Related Erosion in Franciscan Terrain of Northern California. The Cordilleran Section of the Geological Society of America, U.S. Geol. Survey, Menlo Park, California.

Heizer, Robert F. (Editor), 1978. Handbook of North American Indians, Volume 8 (California). Smithsonian Institution. Washington, D.C.

Helley, E.J., and Herd, D.G., 1977. Map Showing Faults with Quaternary Displacement, Northeastern San Francisco Bay Region, California. U.S. Geological Survey, MF-881.

Helley, E.J., Lajoie, K.R., Spangle, W.E. and Blair, M.L., 1979. Flatland deposits of the San Francisco Bay Region, California - their geology and engineering properties, and their importance to comprehensive planning. U.S. Geological Survey, Professional Paper 943.

Herd, D.G. and Helley, E.J., 1977. Faults with Quarternary Displacement, Northwestern San Francisco Bay Region, California. U.S. Geologic Survey, MF-818.

Herd, D.G., 1978. Intercontinental Plate Boundary East of Cape Mendocino, California, "California Geology," California Division of Mines and Geology.

Hertlein, L.D., 1951. Invertebrate Fossils and Fossil Localities in the San Francisco Bay Area. In Geologic Guidebook of the San Francisco Bay Counties (California): California Division of Mines Bulletin 154, pp. 187-192.

IIEQ--Illionis Institute for Environmental Quality, 1974. "Hydrogen Sulfide Health Effects and Recommended Air Quality Standard." IIEQ Document #74-24.

Indiana Air Pollution Control Board and U.S. Public Health Service, 1964. "The Air Pollution Situation in Terre Haute, Indiana, with Special Reference to the Hydrogen Sulfide Incident of May-June 1964.?

Jennings, C.W., 1975. Fault Map of California. CDMG, Map No. 1.

Jennings, C.W., 1977. Geologic Map of California. CDMG.

Jepsen, A.F., 1973. "Measurements of Mercury Vapor in the Atmosphere," Trace Elements in the Environment, Advances in Chemistry Series, Number 123.

Johnson, P.A., 1973. Ecological Effects of Herbicide Sprayings in Shaping Plant Communities on Transmission Line Rights-of-Way. Edison Electric Institute.

Jones and Stokes Associates, Inc. 1978. Terrestrial Ecology of the Castle Rock - Lakeville Transmission Line. Report submitted to Pacific Gas and Electric Company, October, 1978.

Katz, M., 1980. "Advances in the Analysis of Air Contaminants," Journal of the Air Pollution Control Association 30(5): 528-557.

King, T., M. Moratto and N. Leonard III, 1979. Recommended Procedures for Archaeological Impact Evaluation. Society for California Archaeology. Los Angeles.

Kirven, M. 1980. Peregrine Falcon Foraging Study in the Geysers-Calistoga Known Geothermal Resource Area, Sonoma County, California, 1979. USDI, Bureau of Land Management, Washington, D.C.

Kirven, M. 1979. Phase I Field Study, Peregrine Falcons of Mount Saint Helena in the Geysers-Calistoga Known Geothermal Resource Area. U.S. Department of Energy Grant No. ET-78-6-03-2068.

Knuth, W.R. and Geroux, H.D., 1979. Geysers Cobb Valley Air Quality Impact Study. Prepared for Meteorology Research, Inc.

Kounberg, H.A., 1976. EPRI's Research Program on Biological Effects of Electrical Fields; in Proceedings on the First National Symposium on Environmental Concerns in Rights-of-Way Management, R. Tillman (Ed.), pp. 135-141.

Koski, K.V., 1972. Effects of Sediment on Fish Sources. Washington Department of Natural Resources Management Seminar, Lake Limerick, Washington.

Kroeber, A.L., 1925. Handbook of the Indians of California. Bureau of American Ethnology Bulletin, Volume 68. Smithsonian Institution. Washington, D.C.

Kuchler, W., 1977. Natural Vegetation of California. Map of potential natural vegetation prepared for: Barbour, M.G. and J. Mayor (Eds.), 1977. Terrestrial Vegetation of California. Wiley-Interscience.

Larsen, R.I., 1971. A Mathematical Model for Relating Air Quality Measurements to Air Quality Standards. EPA Office of Air Programs Publication No. AP-89. November 1971.

Larson, T.V., P.S. Covert, R. Frank and R.J. Charlson, 1977. "Ammonia in the Human Airways: Neutralization of Inspired Acid Sulfate Aerosols," Science 197:161-3.

Lawrence Livermore Laboratory. 1978. An Environmental Overview of Geothermal Development: The Geysers-Calistoga KGRA, Volume 6, Water Quality.

Lawrence Livermore Laboratories. An Environmental Overview of Geothermal Development; The Geysers-Calistoga KGRA, Volume 6, Water Quality, 1978.

LCAPCD-Lake County Air Pollution Control District, 1980a. Determination of Compliance, PGandE Geysers Unit 16 Geothermal Power Plant. September

LCAPCD, 1980L. Determination of Compliance, DWR/Bottle Rock Geothermal Power Plant. September.

Leonardos, G., Kendall, D., Barnard, N. 1969. "Odor Threshold Determinations of 53 Odorant Chemicals," Jour. Air Pollut. Contr. Assoc., 19(2):91-95.

Lofgren, B.E., 1978. Monitoring Crustal Deformation in The Geysers-Clear Lake Geothermal Area, California. U.S. Geological Survey Open-File Report No. 78-597.

Louderback, G.D., 1951. Geologic History of San Francisco Bay. In Geologic Guidebook of the San Francisco Bay Counties (California): California Division of Mines Bulletin 154, pp. 75-94.

Madill, P.V., 1978. Letter re: Ann Schaaf. Submitted November 18, 1978, in the case before the California Energy Commission, DWR Bottle Rock Power Plant NOI, Docket No. 78-NOI-7.

Malloch, B.S. et. al. 1979, Assessment of Vegetation Stress and Damage Near The Geysers Power Plant Units. PGandE Report 420-79.3.

Marks, S.M., Ludwin, R.S., Louis, K.B., and Bufe, C.G., 1978. Seismic Monitoring at The Geysers Geothermal Field, California. U.S. Geological Survey Open-File Report No. 78-798.

McLaughlin, R.J., 1977. "The Franciscan Assemblage and Great Valley Sequence," in The Geysers-Clear Lake Region of Northern California, and Field Trip Guide to The Geysers-Clear Lake Area. Geological Society of America, Cordilleran Section.

McLaughlin, R.J., 1978. Preliminary Geologic Map and Structural Sections of the Central Mayacamas Mountains and The Geysers Steam Field, Sonoma, Lake and Mendocino Counties, California. U.S. Geological Survey Open-File Report No. 78-389, Scale 1:24,000.

McNeil, W.J. and W.H. Ahnell. 1964. Success of Pink Salmon Spawning Relative to Size of Spawning Bed Materials. U.S. Fish and Wildlife Service Spec. Sci. Rep.-Fish. 469.

Meneghin, G.R., M.R. Miller, G.R. Zitney, R.W. Schlorff, P. Leitner, J.F. Hurley. 1977. The Geysers Wildlife Study, Interim Report. PGandE.

The Merck Index, 1968. P.S. Stecher, Editor. Merck and Co., Inc. Eighth Edition.

Miller, M.W. and Kaufman, G.E., 1978. "High Voltage Overhead," Environment 20(1):6-36.

Miner, S., 1969. Air Pollution Aspects of Hydrogen Sulfide. Litton Systems, Inc., Bethesda, Maryland. Prepared for National Air Pollution Control Administration. NTIS #PB-188 068, September 1969.

Mitchell, C.W., and Yant, W.P., 1925. "Correlation of the Data Obtained from Refinery Accidents with a Laboratory Study of H_2S and Its Treatment." Investigation of Toxic Gases from Mexican and Other High-Sulphur Petroleums and Products, Dept. of the Interior Bureau of Mines, Bulletin 231:59-81

MAQB--Montana Air Quality Bureau, 1980. Montana Ambient Air Quality Study, as reported in "Control District News," Journal of the Air Pollution Control Association 30(5): 582-583, May 1980.

Morse, R.R. and T.L. Bailey, 1935. Geological Observations in the Petaluma District, California. Geological Society of American Bulletin. Volume 46, No. 10, pp. 1437-1456.

Mountain West Research, Inc. Construction Worker Profile: Summary Report (Tempe, Arizona, December 1975), pp. 1-7.

NAS--National Academy of Sciences, 1977. Ammonia, Subcommittee on Ammonia, Committee on Medical and Biological Effects of Environmental Pollutants, Assembly of Life Sciences.

National Institute of Health, 1941. "Hydrogen Sulfide: Its Toxicity and Potential Dangers," Public Health Institute 56:684 (NIH)

NIOSH--National Institute for Occupational Safety and Health, 1974. Criteria for a Recommended Standard--Occupational Exposure to Ammonia, U.S. Department of Health, Education and Welfare, Publication No. 74-136 (NIOSH)

_______, 1977. Criteria for Recommended Standard--Occupational Exposure to Hydrogen Sulfide, U.S. Department of Health, Education, and Welfare.

_______, 1978. Health Hazard Evaluation Determination Report 77-121-490, Pacific Gas and Electric Company Geysers Power Plant, Healdsburg, California. Okawa, M.T., Milby, T.H., and Whorton, D., May 1978.

_______, 1978b. Response to Staff Interrogatories--taken from The Geysers Demographic Data--C. Bangent 1/4/77.

_______, 1979b. Application for Certification, Geysers Unit 18.

National Register of Historic Places, 1978. Federal Register 143:26. Department of Interior, National Park Service (February 7, 1978).

Nava, Julian and Bob Barger, 1976. California: Five Centuries of Cultural Contrasts. Glencoe Press. Encino.

Newman, James R. 1980. Effects of air emissions on wildlife resources. U.S. Fish and Wildlife Service, Biological Services Program, National Power Plant Team, FWS/OBS-80/40.1 32 pp.

Newton, M. and L.A. Norris, 1975. A Discussion on Herbicides and a Statement on 2, 4, 5-T and TCDD. Journal of Forestry, 73(7):410-412.

Nichols, D.R. and N.A. Wright, 1971. Preliminary Map of Historic Margins of Marshland, San Francisco Bay, California. S.F. Bay Region Environment and Resources Planning Study, Contrib. No. 9. USGS, U.S. Department of Housing and Urban Development.

Nilsen, T.H., Wright, R.H., Vlasic, T.C. and Spangle, W.E., 1979. Relative Slope Stability and Land-Use Planning in the San Francisco Bay Region, California. U.S. Geological Survey, Professional Paper 944.

Northern California Power Agency, 1979. NCPA No. 2, AFC, Sonoma County, prepared by Sal Engineers, Inc., Santa Clara, California.

(NYPSC) New York Public Service Commission, 1978. Opinion No. 78-13, Case 26529 and 26559: Common Record Hearings on Health and Safety of Extra-High Voltage Transmission Lines. June 19, 1978. p. 8-74.

NYPSC, 1977. Staff's Initial Brief, Cases 26529 and 26559--Common Record Hearings and Health and Safety of 765 kV transmission lines. August 30, 1977, pp. 62-66.

Origer, Thomas M., 1978. Archaeological Survey of the Luftkin Property. Memo Report to David A. Fredrickson. Report on File at the Cultural Resources Facility, Sonoma State University.

Origer, Thomas M., 1978a. Archaeological Survey of the Bechtel Property. Report on File at the Cultural Resources Facility, Sonoma State University.

Origer, Thomas M., 1978b. Archaeological Survey from St. Helena Road through Gean Mills et al. Property. Report on File at the Cultural Resources Facility, Sonoma State University.

Osterling, Ralph S. 1980. Rare plant survey on Sacramento Municipal Utilities District Geothermal Unit 1 plant site and one mile zone of influence. For Stone and Webster Engineers, Denver, Colorado.

Pacific Gas and Electric Company, Application for Certification: Geyser Unit 18. CEC catalog 79-AFC-3 (1979) p. 5-106.

Pacific Gas and Electric Co. 1978. Geysers Unit 18 Site Specific Studies, Description of Water Quality Characteristics, PG&E Report 411-77.73, prepared by Lucy Enriquez.

Pacific Gas and Electric Co. 1976. Geysers Unit 16 Site Specific Studies Preliminary Investigation of Water Quality Characteristics; Department of Engineering Research; Report 411-77.9, April 14, 1977.

Parametrix, Inc., The Effects of Geothermal Energy Utilization on Stream Biota and Water Quality at the Geysers, California, 1975. prepared for Union Oil.

Peri, David W., Scott M. Patterson and Jennie L. Goodrich, 1979. An Ethnographic Survey of Native American Cultural Resources for the Proposed PG&E Castle Rock Jct.-Lakeville 230 kV Transmission Line, Sonoma County, California. Prepared for Pacific Gas and Electric Company, San Francisco. Report on File at the Cultural Resources Facility, Sonoma State University.

Peri, David W., Scott M. Patterson and Susan L. McMurray, 1978. An Ethnographic and Historical Cultural Resources Study of the Aminoil, Little Geysers, Ford Flat, Cobb Mountain (Units 16, 18, 19, 20 and 21). Geothermal Leaseholds, Sonoma and Lake Counties, California. Report on File with the Cultural Resources Facility, Sonoma State University.

Phillips, R.W., R. Lantz, E. Claire, and J. Moring. 1975. Some Effects of Gravel Mixtures on Emergence of Coho Salmon and Steelhead Fry. Tran. Amer. Fish. Soc. 104(3):461-473.

Powell, R.W. 1974. Inventory of Rare and Endangered Vascular Plants of California. California Native Plant Society, Spec. Publ. No. 1

Raven, P.H. and D.I. Axelrod. 1978. "Origin and Relationships of the California Flora." University of California Publ. in Botany, Vol. 72, U.C. Press.

Real, C.R., Toppozada, T.R. and Parke, D.L., 1978. Earthquake Epicenter Map of California. California Division of Mines and Geology, Map Sheet 39.

Remsen, J.D. Undated. The Species of Special Concern List: An Annotated List of Declining or Vulnerable Species in California. Museum of Vertebrate Zoology, University of California, Berkeley, California. Unpublished.

Robertson, D.E., 1980. Pacific Northwest Laboratory, Batelle Memorial Institute, Richland, WA (509) 376-5664. Personal communication with T. Phillips, September 25.

Robertson, D.E., Crecelius, E.A., Fruchter, J.S., and Ludwick, J.D., 1977. "Mercury Emission from Geothermal Power Plants," Science 196:1094-1097. June 3, 1977.

Robertson, D.E. and Wilkerson, C.L., 1980. "Accumulation of Trace Elements in Soils in the Vicinity of Geothermal Power Plants at The Geysers," Pacific Northwest Laboratory Annual Report for 1979 to the DOE Assistant Secretary for Environment, Part 4, Physical Sciences, February 1980. Publication #PNL-330/UC-48.

Rosen, L.C. and Molenkamp, C.R., 1978. An Environmental Overview of Geothermal Development: The Geysers-Calistoga KGRA Vol. 2 Air Quality. Lawrence Livermore Laboratory.

Ross, M., 1980. Research Geophysicist, U.S. Geological Survey, 1703-860-6667). Personal communication with T. Phillips, October 15.

Rubin, H.H., Arieff, A.J., 1945. "Carbon Disulfide and Hydrogen Sulfide Clinical Study of Chronic Low-Grade Exposures," Jour. of Ind.Hyg. and Tox., 27(5): 123-129.

Ruff, R.E., Cavanaugh L.A., and Carr, J.D., 1978. 1977 Executive Summary of Specialized Monitoring Services. Prepared by SRI International.

Sacramento Municipal Utility District, SMUDGEO#1 AFC, 1980. Sonoma County prepared by SMUD and Stone & Webster Engrg. Co., Denver, Colorado.

Sample, L.L., 1950. Trade and Trails in Aboriginal California. Berkeley: University of California Archaeological Survey Report 8.

Sax, N.I., ed., 1975. Dangerous Properties of Industrial Materials, Fourth Edition. Van Nostrand Reinhold Co., New York, N.Y.

Scott, R.E., L.J. Roberst, and C.J. Cadbury, 1972. Bird Deaths From Power Lines at Dungeness. British Birds, 65(7):273-286.

Scott-Walton, B.; K.M. Clark; B.R. Holt; D.C. Jones; S.D. Kaplan; J.S. Crebs; P. Polson; R.A. Shepherd; J.R. Young, Potential Environmental Effects of 765 kV Transmission Lines: Views before the New York State Public Service Commission, Cases 26529 and 26559, 1976-1978. Prepared by SRI for U.S. Department of Energy, Report No. DOE/EV-0056, November 1979, pp. II-1 to II-28.

Shah, H.C., 1980, A Report on Seismic Hazard Analysis Bottle Rock and South Geysers Power Plants: prepared for California Department of Water Resources, May 1980, 70 p.

Sharp, C.W. and T.E. Adams, Jr. (Eds.), 1974. Erosion Control Symposium Proceedings. University of California Cooperative Extension, Davis, California. 134 pp.

Simmons, W.S., 1979. "The Effects of Long-Term Exposure to Low Concentrations of Hydrogen Sulfide on Human Health and Well-Being in the Ambient Atmosphere." Testimony before the California Energy Commission in the case of Department of Water Resources Notice of Intention for Bottle Rock Power Plant, 78-NOI-7.

Sims, R.D., Fox, K.F., Jr., Bartow, J.A. and Helley, E.J., 1973. Preliminary Geologic Map of Solano County and Parts of Napa, Contra Costa, Marin and Yolo Counties, California. U.S. Geological Survey, MF-484.

Simson, R.E., Simpson, G.R., 1971. "Fatal Hydrogen Sulphide Poisoning Associated with Industrial Waste Exposure," Medical Journal of Australia, 1: 331-334.

Solano County Planning Department. The Area Plan for South Solano County.

Solano County Planning Department, 1978. Bennett Valley Study.

Sonoma County Community and Environmental Services Division. Franz Valley Specific Plan; revised November 1979.

Sonoma County, Planning Division, Sonoma County General Plan (January 10, 1978). Part 5, pp. 72-73, and Part II, pp. 127-132.

Stanford Research Insitute. 1977. Environmental Analysis for Geothermal Development in the Geysers Region, Volume II: Master Environmental Assessment, by SRI, for the CEC.

Stebbins, G.L. and J. Major, 1965. Endemisum and Speciation in the California Flora. Ecol. Mong. 35(1):1-35.

Stern, A.C., 1977. Air Pollution, Academic Press.

Steward, Omer C., 1943. Notes on Pomo Ethnogeography. Berkeley: University of California Publications in American Archaeology and Ethnology 40(2): pp. 29-62.

Stirton, R.A., 1936. Cenozoic Mammal Remains from the San Francisco Bay Region (California): University of California Publications, Department of Geological Sciences Bulletin. Volume 24, No. 13, pp. 339-409.

Stirton, R.A., 1951. Prehistoric Land Animals of the San Francisco Bay Region. In Geologic Guidebook of the San Francisco Bay Counties (California): California Division of Mines Bulletin 154, pp. 177-186.

Stradford, Richard A., 1976. Archaeological Survey of Proposed Geysers-Lakeville Transmission Line Route. Letter Report to Robert Nunez, Pacific Gas and Electric Company. Report on File at the Cultural Resources Facility, Sonoma State University.

Stradford, Richard A., 1977. Archaeological Survey, Geysers-Lakeville Transmission Line. Letter Report to William Chilson, Pacific Gas and Electric Company. Report on File at the Cultural Resources Facility, Sonoma State University.

Svirbely, J.L., Dobrogorski O.J., and Stokinger, H.E., Enhanced Toxicity of Ozone-Hydrogen Peroxide Mixtures, American Industrial Hygiene Assoc. Journal. Vol. 22, p. 21-26.

Tesche, T.W., J.L. Haney, W.D. Jensen, G.E. Moore, B.R. Weir, and W.R. Knuth, 1980. Assessment of the Sacramento Municipal Utility District's Proposed Geothermal Power Plant--Final Worst-Case Air Quality Analysis, Chapter 7, SAI No. 205-EF80-166; Prepared for Stone and Webster Engineering Corporation; prepared by Systems Applications, Inc. and Meteorology Research, Inc. September 15.

USDA, Soil Conservation Service. 1972. Soil Survey of Sonoma County. U.S. Government Printing Office, Washington, D.C. 188 pp.

USDA, 1977. Soil Survey of Contra Costa County. U.S. Government Printing Office, Washington, D.C. 122 pp.

USDA, Soil Conservation Service. 1977. Soil Survey of Solano County. U.S. Government Printing Office, Washington, D.C.

USDA, Soil Conservation Service. 1978. Soil Survey of Napa County. U.S. Government Printing Office, Washington, D.C.

USDA, Soil Conservation Service. 1980. Soil Survey of Marin County. Unpublished.

USDA, Soil Survey Staff. 1952. Soil Survey Manual. U.S. Department of Agric. Handbook No. 18. U.S. Government Printing Office, Washington, D.C. 503 pp.

U.S. Department of Commerce, Bureau of the Census. 1970 Census of Population: California. PC(1)-C6 (Washington, D.C., April, 1972), Tables 41, 42 and 44.

U.S. Department of the Interior, Bureau of Land Management, and Burmah Oil Company. Lease Agreement - Parcel Unit 7 West Ca. 1862, March 25, 1971.

U.S. Environmental Protection Agency, 1977. Multimedia Environmental Goals for Environmental Assessment. EPA-600/7-77-136 (EPA)

U.S. Environmental Protection Agency, 1976. Quality Criteria for Water. EPA 440/9-76-023.

U.S. Fish and Wildlife Service (USFWS). 1979. List of Endangered and Threatened Wildlife and Plants. Federal Register, 44(12):3654.

U.S. Fish and Wildlife Service. 1979. List of Endangered and Threatened Wildlife and Plants. Federal Register, January 17, 1979.

U.S. Fish and Wildlife Service. 1978. Avian Mortality at Man-Made Structures: An Annotated Bibliography. Biol. Serv. Proj. FWS/OBS-78/58, Washington, D.C.

United States Geological Survey, Sept. 1975, Environmental Assessment #14, USGS, Menlo Park, CA.

USGS, Sept. 1979. Environmental Assessment #130-9, USGS, Menlo Park, CA.

USGS, June 1980. Environmental Assessment #136-80, USGS, Menlo Park, CA.

Vallejo, City of. City Planning Department. Specific Area Plans 1, 2, 3, 4, and 5.

Vallejo, City of. 1980. City Planning Department. Map of Subdivision Activity.

Vold, E., 1980. Radiologic Health Section, California Department of Health Services, (415) 323-2750. Personal communication with T. Phillips, January 16 and October 8, 1980.

Vollentine, L. and Weres, O., 1976. Public Opinion in Cobb Valley Concerning Geothermal Development in Lake County, California. Lawrence Berkeley Laboratories.

Wagoner, 1976. Compilation of Ambient Trace Substances. Draft of Report prepared by Research Triangle Institute under Contract No. 68 02-1325 for U.S. Environmental Protection Agency. Available from Tucker, W.G., Project Officer, IERL-EPA, Research Triangle Park, NC.

Waldbott, G.L., 1973. Health Effects of Environmental Pollutants, The Mosby Company, St. Louis, MO.

Walton, A.H. and Simmons, W.S., 1978: Public Health Considerations Relative to The Geysers Power Plant, Flow Resources Corporation.

Water Quality Control Plan. Sacramento River Basin, 5A, 1975. Central Valley Regional Water Control Board, Sacramento. Prepared by Consortium: Bay-Valley Consultants; Bechtel, Inc., CH_2M-Hill; Consoer, Townsend & Assoc,; and Hydroscience, Inc.

Water Quality Control Plan, North Coast Basin, 1B, 1975. North Coast Regional Water Quality Control Board, Santa Rosa. Prepared by Consortium: Brown & Caldwell, Water Resources Eng., and Y.T.O. and Assoc.

Week, L.E., 1978. "Clear Lake Laboratory Results." Memorandum to W.S. Johnaon, California Regional Water Quality Control Board from L.E. Week, Department of Fish and Game--Region III, March 22, 1978.

Weigel, Lawrence E., 1980. Lakeville (to) Sobrante 230 kV TL Survey. Letter Report to J.A. McCullough, Pacific Gas and Electric Company, San Francisco. Report on File at the Cultural Resources Facility, Sonoma State University.

Weres, O., Tsao, K., and Wood, B., 1977. Resource, Technology, and Environment at The Geysers. Energy and Environment Division, Lawrence Berkeley Laboratory. LBL 5231, July 1977.

Weslowski, J.J., 1975. Asbestos in The California Environment. Air and Industrial Hygiene Laboratory, Lab Services Branch, California State Department of Health. AIHL Report No. 164-A. June.

Weslowski, J.J., 1980. California Department of Health Services, Air and Industrial Hygiene Laboratory. (415) 540-2469. Personal communication with T. Phillips, September 25.

WHO--World Health Organization, 1973. Trace Elements in Human Nutrition. WHO Technical Report 532.

Wilby, F.V., 1967. "Variation in Recognition Odor Threshold of a Panel," Journal Air Pollution Control Association, 19(2): 96-100.

Wilcox, S.L., 1973. Presumed Safe Ambient Air Quality Levels for Selected Potentially Hazardous Pollutants, The Mitre Corporation. MTR-6401.

Yant, W.P., 1930. "Hydrogen Sulfide in Industry: Occurrence, Effects and Treatment," Am J. Pub. Health, 20:598-607.

Yocum, C. and R. Dasmann, 1967. The Pacific Coastal Wildlife Region. Naturegraph Company, Healdsburg, California.

Young, L.B., 1976. Environmental Problems in Extra High Voltage Transmission; in Proceedings of the First National Symposium on Environmental Concerns in Rights-of-Way Management, R.T. Tillman (Ed.) pp. 125-133.

AGENCIES AND PERSONS CONTACTED

Socioeconomics/Aesthetics/Land Use

- William E. Reany, staff memo to Gregory Newhouse, June 10, 1980.
- Richard A. Carter, Testimony, Geysers Unit 16, August 8, 1980, p. 7.
- Robert F. Van Horn, G.R.I.P.S. Commission. Letter to Board of Supervisors July 30, 1980, Attachment F.
- Pacific Gas and Electric Co., Application for Certification: Geysers Unit 18. CEC catalog 79-AFC-3 (1979) p. 5-106.

Waste Management

- Central Valley Regional Water Quality Control Board
- California Department of Health Services
- Barney Simonsen, Vice President, IT Corporation, letter dated 9/10/79
- W.T. Kritikos, General Manager, Geothermal, Inc., letter dated 7/16/79
- PGandE Geysers Unit 17, Application for Certification, 1979
- PGandE Geysers Unit 16, Application for Certification, 1979

Biology

- Frank Cahn, PGandE horticulturist, 10/6/80

Geology

- October 25, 26, 1979 - Seismic Hazards Evaluation Methodology Workshop, sponsored by CEC with participation by:

  U.S.G.S.: G.R.I.P.S.: SMUD: PGandE; Union Oil; NCPA; Earth Science Assoc.; Department of Water Resources; California Division of Mines and Geology; California Division of Oil and Gas; CNEN, Italy; and the consulting services of: Converse Ward Davis Dixon; Cooper Clark and Associates; Dames and Moore; Harding-Lawson; McCulloch Geothermal Corporation; Ruth and Going; SAI Engineers; SLC; Stone and Webster

Water Quality

- California Department of Health Services, Hazardous Materials Management Section, phone conversation from Lloyd Batham re: classification of geothermal fluids and wastes, 1979.
- Central Valley Regional Water Quality Control Board, Order No. 78-184, "Waste Discharge Requirements for Aminoil USA, Inc., Ford Flat, Castle Rock Springs, and Davies Estate Geothermal Leaseholds," Lake County
- Crawford, Ed. CVRWQCB letter, signed by Ed Crawford, re: acceptability of reinjection techniques, 1979, for Bottle Rock EIR
- North Coast Regional Water Quality Control Board. Order No. 74-151, "Spill Contingency and Containment Plan," 1944; Order No. 78-17, "Waste Discharge Requirements for Aminoil USA, Inc., Federal Lease Unit No. 7, Sonoma County," 1978
- SMUD Interrogatories, 2nd set, dated 23 April 1980, response to Hydrology - Water Quality
- State Water Resources Control Board. Letter dated 9/25/78, re: impermeable layer for pad of NCPA #2 geothermal power plant; (identical letter on DWR Bottle Rock, dated 12/11/78) and (to DWR So. Geysers dated 1/8/80).

Transportation

1. Don Pape, Lake County's Environmental Officer, 1980.

2. Lake County Department of Public Works, July 1980.

3. Lake County's Comments on the Draft Environmental Impact Report for SMUDGEO #1.

4. Lieutenant J. Flin of the California Highway Patrol, Lakeport, December 1980.

5. Ron Nickel, Sonoma County Department of Public Works, January 1981.

6. Officer Gardner of the California Highway Patrol, Santa Rosa, December 1980.

7. Eugene Collins, Road Commission, Lake County, 1981.

8. Mr. Carmiggelt, Assistant Road Commissioner, Lake County (Telephone Conversation, July 1979).

GLOSSARY

ALGAE	Simple plants containing chlorophyl and having no true root, stem, or leaf, and typically found in water or damp places.
ALLUVIATED	Refers to sediments deposited by, and/or landforms originated by, streams or rivers.
ANADROMOUS FISH	Spending most of their life in the ocean, but returning to fresh water to spawn.
ARCHAEOLOGICAL SITE	Any location where people have done something in the past and left something from which useful information can be derived. An archaeological site consists of artifacts, debris, and soil in contexts.
ARTIFACT	Any portable object used and/or modified by man. (Particularly during prehistoric times.)
BODY BURDEN	The amount of a specified toxicant present in an animal or human body at a specified time.
BUS	An electrical conductor which serves as a common connection for two or more electrical circuits. A bus may be in the form of rigid bars, either circular or rectangular in cross section, or in form of stranded-conductor overhead cables held under tension.
CORE	A stone from which flakes have been struck. Often retouched and/or used as a hammer, chopper or plane.
CUT AND FILL	Construction term referring to earth removal at a site (cut) and disposition of the excess dirt (fill).
DECIDUOUS	Vegetation that loses its leaves annually, generally in fall or winter.
EARTH FLOWS	Downslope movements of a discrete mass of soil and/or highly weathered near-surface bedrock; commonly show a spoon-like bowl at the top of the mass and a tongue-like bulge at the toe.
ELECTROMAGNETIC FIELD	A field of force that is made up of associated electric and magnetic components that result from the motion of an electric charge.
ELECTROSTATIC FIELD	A field of force surrounding a charged object.
ENDANGERED SPECIES	Any species or subspecies of plant or animal threatened with extinction.
ENDEMIC	A species restricted to a given geographic location. Species native to a given locale.

EXPANSIVE SOIL — Clay rich soil which swells when wetted and shrinks upon loss of water by percolation, evaporation, etc. Commonly shows large open "shrinkage" cracks during the dry season.

ETHNOGRAPHIC SITE — A site or location which is known to (or is ethnographically recorded) as a habitation, sacred, ceremonial, prehistoric, or resource procurement place important to the preservation and perpetuation of Native American cultural identity.

FAULT — A fracture or fracture zone in the earty's crust along which parallel slippage of adjacent earth material has occurred.

FAUNA — Animals of a specified region.

FLAKE — A chip knocked off a stone during production of a tool. Flakes are often "retouched" (i.e., flaked along the edges) to form cutting and scraping tools.

FLORA — Plants of a specified region.

GENOTOXIC — Causing tumors, congenital birth defects, or a permanent change in cellular hereditary material.

GEOTHERMAL STEAM — Steam created by the heat of the earth.

GEYSER — Spring that throws forth continuous or intermittent jets of heated water and steam.

GROUNDWATER RECHARGE — The process by which water is added to groundwater within the voids of subsurface soil and/or rock units.

HABITAT — The environment where a plant or animal lives.

HERBACEOUS — Like or pertaining to herbs (any seed plant whose stem withers away after each season's growth).

HERBICIDE — A toxic substance capable of killing vegetation.

HISTORIC SITE — An archaeological site as discussed herein is historic if it represents for the most part occupation or use by any population after the general missionization of the study area at the end of the 18th century.

HOLOCENE — An interval of geologic time; an epoch. Generally used to refer to the time between the present and about 10,000 years ago.

INACTIVE FAULT — A fault considered not capable of generating earthquakes or rupturing the ground surface. Commonly refers to faults which have not been active during the last 1.8 million years.

INTERMITTENT STREAM — A stream flowing only during the wet season.

INTERSPERSION	The spatial relationship to other habitats or life requirements.
INVERTEBRATE	An animal having no backbone or spinal column.
KILOWATT (KW)	1,000 watts.
KILOWATT-HOUR (KWH)	The basic unit of electric energy equal to one kilowatt (1,000 watts) or power supplied to or taken from an electric circuit steadily for one hour.
LATERAL FAULT GROUND RUPTURE	Ground rupture in which one block of ground moves horizontally with respect to adjacent ground across a generally vertical fault.
LIQUEFACTION	A general term to describe severe loss of strength of susceptible saturated granular soils, usually in response to strong earthquake ground shaking; in the extreme case the liquefied soil behaves as a fluid mass.
MEAN MONTHLY FLOW	Daily stream flows averaged over a period of one month.
MEGAWATT (MW)	1,000 kilowatts, 1 million watts.
MESIC	Requiring a moderate moisture content to carry out life functions.
MIDDEN	Many California archaeological sites are "middens": areas of rich organic soil full of food debris, artifacts, fire-cracked rocks, etc. Technically, a midden is a garbage heap, decomposed into rich, usually dark-colored soil.
PALEONTOLOGICAL SITE	Geologic phenomena in the form of fossil-bearing formations.
PERENNIAL STREAM	A stream flowing year-round.
PETROGLYPH	A picture incised on a rock. In archaeology, the term is often used to describe any drawing, inscription, or incision on a rock by early man.
PLEISTOCENE	An interval of geologic time; an epoch, generally used to refer to the time between about 10,000 years and 1.8 million years ago.
POTENTIALLY ACTIVE FAULT	A fault considered to have been active during the last 1.8 million years and which could become active in the future.

PREHISTORIC	A prehistoric site is one that was apparently occupied for the most part prior to missionization. By definition, prehistoric sites in the study area are sites utilized by California Native American populations.
RAPTOR	Birds of prey such as hawks, eagles, and owls.
RARE SPECIES	Generally considered, a species or subspecies which although not presently threatened with extinction is in such limited numbers throughout its range that it may become endangered if its environment worsens.
RIPARIAN	Associated with or adjacent to a water source.
ROOKERY	A colonial nesting site.
RUNOFF	That portion of precipitation on the land that ultimately reaches streams; water from rain or melted snow that flows over the surface.
SEDIMENTATION	The settling out of solids in a liquid.
SEISMICITY	The phenomenon of earth movements. All that relates to earthquakes, their locations, periodicity, size, effects, etc.
SERPENTINE	A rock or mineral consisting essentially of a hydrous magnesium silicate, usually having a dull green color and often found along fault zones and landslide areas.
SIGNIFICANT	Within the context of the California Environmental Quality Act, "significant" refers to an adverse environmental impact of consequence. Per the National Environmental Policy Act, "significant' impact means any major environmental impact, whether adverse or beneficial.
SOIL COMPACTION	The process by which soil particles are packed more tightly together to form a denser mass; can be caused by loading soil (i.e., with additional soil, concrete footings or mats, etc.) and in some cases by strong earthquake shaking.
SOIL CREEP	Slow, more or less continuous downslope movement of soil in response to gravity and/or seasonal shrinkage and swelling of the soils.
TAP LINE	A short electrical transmission line connecting a power plant to a main transmission line.
TERATOGENICITY	Causing birth defects or malformations.
THREATENED	Any species or subspecies of plant or animal likely to become endangered within the foreseeable future throughout all or a significant portion of its range.
TOPOGRAPHY	Physical features of a district or region such as are represented on maps; the relief and contour of the land.

TRANSMISSION LINE	Structures and conductors that carry bulk supplies of electrical energy from power generating units for system needs. By definition, transmission voltage is 50 kV or above.
UNCONSOLIDATED SEDIMENTS	Soil particles and/or rock fragments that are loosely arranged and not cemented; generally a surficial or near surface deposit.
VERNAL POOL	A small seasonal water body.

IMPACT IDENTIFICATION MATRIX

Environmental Category: CULTURAL RESOURCES

Potential Impact	Significance	Source
<u>WELL FIELD</u>		
Disturbance or destruction of cultural resources due to exploration, drilling and construction related to development of geothermal resources.	None	AFC, pages 5-105 thru 5-106 and "<u>Cultural Resource Survey of the Aminoil 7 West Geothermal Leasehold</u>", <u>Sonoma and Lake Counties</u>, by Dr. David Fredrickson, 11/79.
Disturbance or destruction of paleontological resources resulting from construction.	None	Same
Disturbance or destruction of historical resources.	None	Same
Destruction of valuable resources by on-going power plant maintenance and operation and visitors.	None	Same
Increased access and resulting disturbance of cultural or historical resources.	None	Same
<u>POWER PLANT</u>		
Possible disturbance or destruction of archaeological resources resulting from construction.	None	Same

IMPACT IDENTIFICATION MATRIX

Environmental Category: CULTURAL RESOURCES

Potential Impact	Significance	Source
POWER PLANT (cont.)		
Disturbance or destruction of paleontological resources resulting from construction.	None	Same
Disturbance or destruction of historical resources.	None	Same
Disturbance or destruction of educational, religious, scientific or other cultural resources.	None	Same
Destruction of valuable resources by ongoing power plant maintenance and operation and visitors.	None	Same
Increased access and resulting disturbance of cultural or historical resources.	None	Same
TRANSMISSION LINES		
Possible disturbance or destruction of archaeological, paleontological, historical, educational, religious, scientific or other cultural resources, resulting from construction and operation/maintenance activities.	None	Same

IMPACT IDENTIFICATION MATRIX

Environmental Category: WATER QUALITY

Potential Impact	Significance	Source
POWER PLANT (Cont.)		
Potential deleterious effects of wastewater disposal on ground and surface waters.	Insignificant - all wastewaters are to be reinjected.	AFC, Sections 1.2.5; 1.3.12; 1.3.13; 1.3.7.2; and 5.4.2.2.
Degradation of water quality (surface and ground) from discharge of chemical effluents (demineralizer regeneration wastes, biocide and blowdown from steam generators, heating boilers and closed cycle cooling systems) in receiving waters.	Significant - any spill of chemicals or waste streams at the power plant could pollute streams and impact aquatic life and vegetation.	DFG/RWQCB compilation and records on spill incidents in the Geysers KGRA.
Change in the temperature of receiving waters from thermal effluents.	Insignificant - controlled by RWQCB - no discharges to streams.	AFC, Section 5.4.2.3 (see waste disposal item) and RWQCB requirements of no discharge.
Degradation of ground water quality from spills and leakage of oils, toxic chemicals, liquid wastes, etc.	Insignificant - power plant pad will be completely paved and bermed to contain spills, also minimal groundwater at area.	AFC, Sections 1.3.1.1.2; 5.4.1.4; 5.4.2.2; and 5.4.2.3.
Degradation of ground water quality from liquid waste disposal on the facilities site.	Insignificant - see above, other liquids are reinjected far below any groundwater and into the steam reservoir.	See above, and Section 1.3.8.

IMPACT IDENTIFICATION MATRIX

Environmental Category: WATER QUALITY

Potential Impact	Significance	Source
WELL FIELD		
Increased levels of suspended solids in surface waters due to increased erosion.	Significant - (under the control of Sonoma County, the NCRWQCB, and CDF&G)	Experiences in KGRA area, and Geysers KGRA EIRs.
Discharge of geothermal fluids to surface waters.	Significant - see above.	
Potential groundwater pollution.	Insignificant - minimal groundwater in the area, not generally enough for beneficial uses.	AFC, Sections 5.4.1.4;1.2.2.2; and other KGRA EIRs.
Increased water pollution due to damage caused by environmental hazards.	Significant - by erosion, landslides, spills, discharges - (under Sonoma County, NCRWQCB, and CDF&G jurisdiction.)	Other KGRA EIRs.
Potential deleterious effects of wastewater disposal on ground and surface waters.	Insignificant - all wastes to be contained in lined sumps or disposed at approved sites.	NCRWQCB requirements on Aminoil, (Steam Developer), Order No. 78-17.
Degradation of water quality (surface and ground) from discharge of chemical effluents (demineralizer regeneration wastes, biocide and blowdown from steam generators, heating boilers and closed cycle cooling systems) in receiving waters,	Not applicable - no such systems used in well drilling.	
Change in the temperature of receiving waters from thermal effluents.	Insignificant - no discharges to surface waters.	NCRWQCB requirements and SWRCB Basin Plans.

211

IMPACT IDENTIFICATION MATRIX

Environmental Category: WATER QUALITY

Potential Impact	Significance	Source
TRANSMISSION LINES		
Degradation of water quality, resulting from construction and/or operation of transmission line facilities.	Significant - potential for short-term erosion, etc.	
Cumulative impacts upon water quality.	Significant - short-term impacts of field development and power plant construction, and long-term impacts of added sediments and any spills which can occur from the power plant or the materials and waste disposal transportation.	Geysers KGRA EIRs, KGRA and RWQCB experiences, PG&E studies.

Impact Identification Matrix

Environmental Category - SAFETY

Potential Impact	Significance	Source
POWER PLANT		
Possibility of accidents associated with construction of power plant facilities	Insignificant: Isolated construction location, relatively small work force.	SMUDGEO #1 AFC Sec. 9. Staff Analysis
Possibility of accidents associated with use of explosives, heavy equipment operation	Insignificant: Relatively small use of heavy equipment. No blasting expected.	SMUDGEO #1 AFC Sec. 9 Staff Analysis Sec. 1.3.1.1.3.
Possibility of accidents associated with operation and maintenance of generation system equipment	Insignificant: Control room will monitor plant deviations, equipped with automatic and manual shut-offs.	SMUDGEO #1 AFC Sec. 1.3.3.
Possibility of accidents associated with transportation systems constructed as a direct adjunct to the power plant (examples: new supply road)	Insignificant: Minimal, 2/3 mi. will be required to provide access.	SMUDGEO #1, AFC Sec. 1.2.6.
Possibility of security problems associated with general operations and maintenance of the plant	Insignificant: Isolated location, relatively low hazard level, automatic and manual shutdown provisions.	SMUDGEO #1 AFC Sec. 1.3.3. Staff Analysis

IMPACT IDENTIFICATION MATRIX

ENVIRONMENTAL CATEGORY

Political Impact	Significance	Source
WELL FIELD		
Possibility of accidents associated with well drilling and steam or hot water extraction.	Insignificant: No unusual risk or hazard.	Staff Analysis
Emissions may be caused by accident hazard during well operations.	Insignificant: There has been only a single incident where a well has failed and steam is escaping freely.	Staff Analysis: Geysers 16 EIR

Impact Identification Matrix

EARTH RESOURCES

Environmental Category - HYDROLOGY

Concern	Significance	Source
POWER PLANT		
Change in currents, flows, temperature, chemical constituents, etc. of the receiving waters from discharge of cooling waters, blowdown discharge, treated service water systems, or accidents.	Insignificant - Discharges are allowed only during high flow periods.	Page 5-37, AFC
Increased overland flow, storm runoff. Increased discharge from cleared areas (especially vegetated areas). Increased flood potential and channel erosion, increased stream water temperature, volume and velocity.	Insignificant - Slight increase in overland flows and storm runoff due to site clearing and paving.	Page 5-22, AFC
Disruption of groundwater movements by cuts for access roads or facility sites. Change in groundwater and recharge areas due to impervious surfaces (increased surface areas impervious to water infiltration) and site dewatering.	Insignificant because no groundwater aquifers exist in The Geysers area except along fracture zones.	Page 5-23, AFC

Impact Identification Matrix

EARTH RESOURCES

Environmental Category - HYDROLOGY

Concern	Significance	Source
POWER PLANT (Continued)		
Potential destruction from flooding, either natural or intensified by construction activities.	Insignificant - Flooding of the site is not considered to be a problem due to its physical location.	Page 5-22, AFC
Impacts from consumptive use of water in generating plant operations.	Insignificant - Condensed geothermal steam will be used for cooling water supply.	Page 1-26, AFC
Modification of existing stream flows and infiltration patterns due to the location and construction of reservoirs, lakes, ditches, pipelines, towers, cooling ponds, etc. Includes stream channel relocation or diversions and altered site drainage characteristics.	Insignificant - The power plant site will be located on a ridge. There will be no modification to the natural drainage pattern.	Page 5-20, AFC
Potential for flooding from reservoirs and ponds if dams or levees break.	Insignificant - Power plant site will be located on a ridge high above the natural drainage channels. Also, no dams or levees exist upstream from the plant site area.	Page 5-20, AFC (personal knowledge of the area)
Cumulative impacts on the geothermal reservoir from consumptive use of condensed geothermal steam for power plant cooling.	(See geology)	

Impact Identification Matrix

EARTH RESOURCES

Environmental Category - HYDROLOGY

Concern	Significance	Source
WELL FIELD		
Potential damage to well or pipeline facilities from flooding.	Insignificant - Well pads will be located well above the natural drainage channels.	Figure 1.2-2
Increased overland flow, storm runoff. Increased discharge from cleared areas. Increased flood potential and channel erosion. Increased stream water temperature, volume and velocity.	Insignificant - Small areas will be cleared but they are small in comparison with the watershed. Revegetation of all cut and fill slopes will take place prior to the wet season.	Page 1-7, AFC
217 Disruption of groundwater movements by cuts for access roads or facility sites. Change in groundwater and recharge areas due to impervious surfaces (increased surface areas impervious to water infiltration) and site dewatering.	No known groundwater basin exists in the area. Groundwater exists in the interstice of the fracture rock in minor amounts. Therefore, disruption or alteration of groundwater movements is insignificant.	Page 1-11 & 12, AFC
Alteration of groundwater hydrology	(See above)	
Modification of existing stream flows and infiltration patterns due to the location and construction of reservoirs, lakes, ditches, pipelines, towers, cooling ponds, etc. Includes stream channel relocation or diversions and altered site drainage characteristics.	There will be no modification or relocation of any stream channel for well pad construction.	Figure 1.2-2
Potential destruction from flooding, either natural or intensified by construction activities.	Insignificant - Well pads construction will result in minor increase of runoff due to land clearing and paving.	Page 1-7

Impact Identification Matrix

EARTH RESOURCES

Environmental Category - HYDROLOGY

Concern	Significance	Source
TRANSMISSION LINES		
Alter existing flow patterns (water courses, overland flow, groundwater recharge) by placement of tower pads and substation and switchyard facilities.	Insignificant - Minor alteration of flow patterns and groundwater recharge is caused by placement of tower pads and substation and switch yard facilities.	
Potential loss of tower, transmission lines, or other facilities due to flooding.	Unknown at this time. Proper placement of tower pads showed minimize potential loss due to flooding.	

IMPACT IDENTIFICATION MATRIX

Environmental Category: WATER QUALITY

Potential Impact	Significance	Source
POWER PLANT		
Potential degradation of water quality related to:		
• Increased surface runoff increasing erosion potential, siltation, turbidity.	Significant	Work experience with RWQCB and the Geysers area.
• Discarded or discharged construction materials, fuels, fluids.	Insignificant - minimal practice	
• Herbicides used to retard vegetative growth, pesticides.	Insignificant - unresolved.	
• Wastewater (construction, sanitary).	Insignificant - portables to be used, reinjection during operation	Work experience and AFC, Section 1.3.12, page 1-34.
• Dredging and spoil disposal	Not applicable	
• Nutrient loading from fertilizers	Insignificant - minimal amount applied.	
• Increased water temperatures due to increased turbidity.	Insignificant - unresolved, high background temperature data.	AFCs in-house for other like project in KGRA.
• Soil additives (such as lime, fly ash, asphalt, phosphoric acid, sodium, and calcium, chlorides).	Insignificant - not applicable, minimal application.	
• Temperature increase due to removal of vegetation.	Insignificant - not relative to project.	
• Disturbance of stream bed for road, pipeline, and cable crossing.	Insignificant - none planned.	
• Construction of 2/3 mile of access road	Significant	Experience in Geysers KGRA

Impact Identification Matrix

EARTH RESOURCES

Environmental Category

Potential Impact	Significance	Source
POWER PLANT FACILITIES		
Hazards		
Seismic shaking/fault rupture	Insignificant - Good design and construction practices can prevent unacceptable damage.	AFC, pages 5-41-42
Mass wasting or general slope instability	Insignificant - Normally a critical concern in power plant design for the Geysers area, however, the SMUDGEO proposed site area appears to be free of unstable slopes.	AFC, page 5-42
Liquefaction	Insignificant - Liquifiable soils are not known to occur in the leasehold.	AFC, page 5-42
Differential settlement	Insignificant - Low probability of causing facility damage using good construction and maintenance practices.	AFC, page 5-44
Volcanism	Insignificant - Low probability of occurrence.	AFC, page 5-43
Subsidence	Minor significance: Induced subsidence from withdrawal of subsurface fluids may result in a minor hazard to the facility, but the potential for operational difficulties is considered low.	AFC, page 5-43

Impact Identification Matrix

EARTH RESOURCES

Environmental Category

Potential Impact	Significance	Source
<u>Impacts</u>		
Unique geological features	Insignificant - There are no unique geological resources of historical, scientific or recreational interest within the boundaries of the leasehold.	AFC, page 5-44
Mineral resources	There are no significant mineral resources on the leasehold other than the geothermal steam.	AFC, page 5-44
<u>STEAM FIELD</u> (wells, well pads, roads and pipelines)		
<u>Hazards</u>		
Fault rupture	Probably insignificant	AFC, page 5-42, 8-8
Seismic shaking	Probably insignificant - Wells, pipelines, and roads are generally insensitive to shaking. Pipelines and roads can usually be easily repaired. Good construction and maintenance practices will reduce hazard to all facilities.	AFC, page 5-41
Resource reliability	Probably insignificant - The leasehold appears capable of supporting 55 MWe of electric power generation for a period of at least 30 years.	SMUDGEO Reference Document Page 1

Impact Identification Matrix

EARTH RESOURCES

Environmental Category

Potential Impact	Significance	Source
Volcanic activity and subsidence	Insignificant - The probability of either of these phenomena damaging the facilities is remote.	AFC, page 5-43 and Harding-Lawson Associates Report dated March 28, 1980.
Slope instability	Insignificant - Generally in the Geysers area, this hazard is particularly acute, however, at the SMUDGEO site there are no active or potentially active landslides or unstable slopes which could affect the wells, well pads, roads, or even pipelines.	NOI, page 5-42 and Harding-Lawson Associates, dated March 28, 1980; Aminoil Plan of Development Operation.
<u>TRANSMISSION LINES, CONSTRUCTION AND OPERATION</u> (lines between roads)		
<u>Hazards</u>		
Slope instability/surface fault rupture	Significant - Only to the extent that the siting of towers must take into consideration such potential hazards. Easily mitigatable through avoidance or by good construction and maintenance procedures.	AFC, pages 8-7, 8
Seismic shaking/subsidence	Insignificant - Due to normal construction practices.	AFC, pages 8-7, 8

Impact Identification Matrix

IMPACT CATEGORY — Fiscal

Potential Impact	Significance	Source
POWER PLANT (continued) Conformity with the CERCDC biennial forecast of electrical demand.	Insignificant; CEC Preferred Outlook calls for about 3000 MW of new geothermal capacity by 1991. This unit is 55 MW.	AFC P. 1-1
Impact of constructing project on national capital supplies.	Insignificant; it will increase SMUD capital investment by 7%. Nationally, California utilities represent less than 1% of the total US Credit Market.	AFC P. 3-3 Memo to Dave Morse from Dorothy Ward (3/[illegible]) discussing Utility/Capital Market Relationships.
Impact of proposed project on "average" residential, commercial and industrial rate schedule.	SMUD's electricity rates will increase in 1984 and future years, but the impact will be small. Incremental costs of the project are $.0046/kWhr. Present (1978) system average price for SMUD approximately $.02/kWhr. Impacts on each sector will depend on the extent time of day, seasonal rates and marginal cost pricing is used as future rate structure.	AFC P. 3-1 and 3-3

IMPACT IDENTIFICATION MATRIX

ENVIRONMENTAL CATEGORY - NOISE

Political Impact	Significance	Source
TRANSMISSION LINES		
Exposure to noise in excess of 90 dB(A) for 8 hours for workers,	Insignificant, workers are protected by DOSH safety orders.	1) CEC staff analysis 2) Experience of numerous Geothermal siting cases.
Potential radio and television interference.	Near term impact anticipated to be insignificant due to proximity and quantity of noise receptors.	CEC staff analysis.
Corona caused audible noise.	Near term impact anticipated to be insignificant due to proximity and quantity of noise receptors.	CEC staff analysis.

IMPACT IDENTIFICATION MATRIX

ENVIRONMENTAL CATEGORY - SAFETY

Political Impact	Significance	Source
TRANSMISSION LINES		
Possibility of accidents associated with the electric transmission system.	Insignificant, few or no safety accidents would be expected due to excellent safety record of 230 kV lines.	1) CEC staff analysis. 2) Report on utility accidents and Administration of General Orders Nos. 95 and 128. (1972 thru 1979)
Possibility of induced shock from electric field	Insignificant, Applicant will ground fences.	1) CEC staff analysis. 2) Experience on numerous geo-thermal siting cases.

IMPACT IDENTIFICATION MATRIX

ENVIRONMENTAL CATEGORY --NOISE

Political Impact	Significance	Source
WELL FIELD		
Exposure to noise in excess of 90 dB(A) for 8 hours for workers or in excess of 55 dB(L_{dn}) to sensitive environmental receptors.	Insignificant: Project noise levels are below standards.	SMUD Geothermal #1 AFC.
POWER PLANT		
Exposure to noise during construction in excess of 90 dB(A) for 8 hours for workers or in excess of 55 dB(L_{dn}) to sensitive receptors.	Insignificant: Project noise levels are below standards, the Applicant will supply hearing protection to mitigate exposure to workers.	SMUD Geothermal #1 AFC pages 1-32 and Section 5.8.
Exposure during operation of power plant to noise in excess of 90 dB(A) for 8 hours for worker or in excess of 55 dB(L_{dn}) to sensitive receptors.	Insignificant: Project noise levels are below standards, the Applicant will supply hearing protection to mitigate exposure to workers.	SMUD Geothermal #1 AFC pages 1-32 and Section 5.8.

Impact Identification Matrix

Environmental Category - Soils

Potential Impact	Significance	Source
WELL FIELD		
Potential for landslides or mass soils movement - (Geology Section)		
Potential for significant erosion from road cuts, drilling pads, blowouts, etc.	Significant	Soils technical staff experience in KGRA
Loss of prime agricultural soils	Insignificant	SCS Determination
Potential for accelerated erosion rates as a result of construction and operation activities.	Significant	Soils technical staff experience in KGRA
POWER PLANT		
Increased erosion potential due to construction activities	Significant	Soils technical staff experience in KGRA
Loss of prime agricultural soils	Insignificant	SCS Determination
TRANSMISSION LINES		
Increased erosion potential due to construction activities	Significant	Soils technical staff experience in KGRA
Loss of prime agricultural soils	Insignificant	SCS Determination
CUMULATIVE IMPACTS		
Increased soil loss and consequent sediment yield to streams in KGRA	Indeterminate	Soils technical staff experience in KGRA

Impact Identification Matrix

Environmental Category BIOLOGICAL RESOURCES

Potential Impact	Significance	Source
POWER PLANT		
Loss of vegetation (native or agricultural) and wildlife habitat (food cover, nesting locations, breeding ground, winter ranges, etc.), resulting from construction	Insignificant- Chaparrel is major vegetation type in area and is the type to be cleared for power plant.	AFC, p. 5-76, p. 5-88.
Increase fire hazard caused by workmen and equipment resulting from construction	Insignificant-Is appropriate precautions are followed.	
Potential loss of flora and fauna related to the increased fire hazard caused by operation and maintenance of the facility	Insignificant- Power plant site cleared of vegetation. Chaparrel can recover from fire.	AFC, p. 5-82.
Potential for harm to flora and fauna from liquid and gaseous effluents discharged during operation of geothermal facilities	Unresolved - Cooling tower drift may cause local damage to vegetation.	AFC, p. 5-81.
Potential loss of agricultural production	DNA- No agriculture production on site.	AFC, p. 5-47, p. 5-54.

Impact Identification Matrix

Environmental Category BIOLOGICAL RESOURCES

Potential Impact	Significance	Source
POWER PLANT (continued)		
Change in species composition (both floral and faunal) due to habitat changes (e.g., degradation of water quality) resulting from construction.	Insignificant- Loss of chaparral from site clearing. Earth moving not planed for rainy season.	AFC, p.5-47, p. 5-54.
Potential harm to vegetation and wildlife from the degradation of water quality from wastewater systems	Insignificant- Mitigation proposed to retain spills on-site and for reinjection of geothermal fluids.	AFC, p. 5-88, p. 5-32
Permanent loss of vegetation and wildlife habitat due to project facilities	Insignificant- Site specific losses are not significant. Mitigation	AFC, p.5-76, p. 5-85
. Loss of displacement of wildlife supported by the habitat	Insignificant- Some loss of wildlife habitat.	AFC, p. 5-77, p. 5-87.
. Loss of rare, endangered, unique or unusual species of plants and wildlife, communities or habit ts.	Insignificant- No loss for power plant site identified.	AFC, p. 5-77, p. 5-88.
Loss of wildlife from construction activities from lack of available habitat after displacement.	Insignificant- Site specific loss not of large magnitude. Mitigation proposed.	AFC, p. 5-77, p. 5-87.
Direct loss of wildlife from construction activities:		
. Loss of aquatic communities if a stream is relocated	Unresolved - Calm spring may be impacted by road construction.	AFC, p. 5-80, p. 5-87.
. Loss of aquatic organisms (fresh water)		AFC, p. 5-80, p. 5-23.

Impact Identification Matrix

Environmental Category	BIOLOGICAL RESOURCES	
Potential Impact	Significance	Source
POWER PLANT (continued)		
Loss of rare, endangered, unique or unusual species or habitat resulting from construction activities	Insignificant- No rare or endangered species identified .	AFC, p. 5-77.
Accumulation of harmful substances in some species due to uptake of pesticides, herbicides, construction chemicals, etc.	Unresolved- Cooling tower drift contains toxic materials.	AFC, p. 5-82.
Change in wildlife species composition species number in vicinity of generating facility	Insignificant- Changes will occur.	AFC, p. 5-82.
Deleterious effects on aquatic organisms and other wildlife from surface water contamination from cooling tower or pond drift or cooling pond leakage.	Insignificant- No deleterious effects on aquatic organisms or wildlife have been identified. Mitigation proposed.	AFC, 5-82, 5-88/
WELL FIELD		
Vegetation damage and destruction	Unresolved - Can be mitigated but no conditions established.	
Potential loss of agricul-ural production	DNA- No agriculture use identified.	AFC, p. 5-54

Impact Identification Matrix

Environmental Category BIOLOGICAL RESOURCES

Potential Impact	Significance	Source
<u>WELL FIELD</u> (continued)		
Potential for harm to flora and fauna from liquid and gaseous effluents discharged during operation of geothermal facilities.	Insignificant- Normal venting impacts are localized. Potential significant impacts from accidental spills.	
Loss of wildlife habitat or significant habitat components	Unrelolved- Can be mitigated but no conditions established.	
Disturbance of wildlife by human activity and noise	Insignificant- Temporary disturbance during construction and some displacement of sensitive species.	The Geysers KGRA wildlife Study, 1979.
Hazards to fish and wildlife from sumps, disposal of drilling muds, releases of geothermal fluids, etc.	Significant- If accidental spills occur, materials are toxic to fish.	
Creation of new habitat features and availability of new habitat areas after abandonment	Unresolved- areas may be returned to near natural conditions but no conditions established	
Potential for loss of flora and fauna from fire	Insignificant-Generally localized; chaparral, the major vegetation type, is a fire associated community.	

Impact Identification Matrix

Environmental Category	BIOLOGICAL RESOURCES	
Potential Impact	Significance	Source
TRANSMISSION LINES		
Increased human access (secondary impact on and near transmission corridors such as increased hunting (increased loss of animal species and disturbance and destruction of habitat), increased recreation potential)	Insignificant- Area already has numerous access roads; relatively short line, approx. 3,000 ft.	AFC, p. 8-2
Disturbance, expecially of sensitive species from human encorachment (sensitivity depends on species, time of year, life history stage, etc.)	Insignificant- No sensitive species identified.	AFC, p. 8-4.
Restriction of migration routes and daily movement corridors	Insignificant- No routes have been identified	AFC, p. 8-3.
Collision mortalities, especially in waterfowl migration routes, between birds and towers, cables or other facilities	Insignificant - Not in a flyway area.	AFC,p. 8-3.
Loss of vegetation and supported wildlife by selective thinning of vegetation during maintenance activities	Insignificant- Limited vegetation clearing required	AFE, p. 8-3.

Impact Identification Matrix

Environmental Category BIOLOGICAL RESOURCES

Potential Impact	Significance	Source
<u>TRANSMISSION LINES (continued)</u>		
Potential damage to lines and towers from fire supported by vegetation beneath the lines	Insignificant- Vegetation of low height.	
Electrocution of large birds on towers and cables	Insignificant- Design factors will minimize impacts.	AFC, p. 8-1
Permanent loss of habitat under tower footings, paved access roads, switch-yard and substation facilities. Loss of rare and endangered and unique or unusual species or habitat. Loss of wildlife species supported by habitat permanently lost (if adjacent areas unable to support displaced wildlife)	Insignificant- Clearing for pads of about 30 feet radius	AFC, p. 8-1, p. 8-5.
Change in species composition and in food and cover value of transmission right-of-way	Insignificant- Minor disturbance indicated	AFC, p. 8-1, p. 8-5.
Loss of vegetation and wildlife habitat through "clean" maintenance of access roads and facility sites	Insignificant- Minimal clearing of right-of-way required	AFC, p. 8-1.

Impact Identification Matrix

Environmental Category BIOLOGICAL RESOURCES

Potential Impact	Significance	Source
TRANSMISSION LINES (continued)		
Potential for loss of agricultural production	Insignificant- No agricultural use identified in righ-of-way	AFC, p. 8-3
CUMULATIVE IMPACTS		
Loss of vegetation and wildlife habitat due to full field development	Significant- Mitigation is not being implemented on site specific basis nor is mitigation proposed to off-set full field development	Comments received from USFWS, and CDFG

Impact Identification Matrix

Environmental Category SOCIOECONOMICS

Potential Impact	Significance	Source
POWER PLANT		
Project area will experience increased employment and income directly attributable to construction of power plant and related facilities (Primary employment)	Not Significant - Total peak employment is 125 workers	AFC, p. 5-10.
Power plant construction will compete for workers with other projects or existing economic sectors.	Non Significant- Historical unemployment rates exceed those of the State as a whole	AFC, Table 5.10-4 and 5.10-5, California Employment Development Department Statistics.
Project area will experience increased employment and income directly attributable to operation and maintenance of power plant	Not Significant- Operating Contingent consist of only 20 employees	AFC, p. 5-116.
Project area population will increase due to increases in direct and indirect employment	Not Significant-Total population increase will reside in the area of 110 each in Lake and Sonoma Counties. Cululative impact is potentially significant upon Lake County.	AFC, pp. 5-111-B.
Possible changes in community structure, lifestyle	Not Significant- Total population growth is small relative to existing population.	AFC, pp. 5-111-113, 5-108.

Impact Identification Matrix

Environmental Category SOCIOECONOMICS

Potential Impact	Significance	Source
POWER PLANT (continued)		
Possible changes in community structure, lifestyle	Not Significant- Total population growth is small relative to existing population.	AFC, pp. 5-111-113, 5-108.
Housing units will be required to accommodate households of construction and secondary workers	Not Significant- Total population impact is small. Cumulative effects will strain housing supplies in Lake County	AFC, p. 5-114.
Operation and maintenance of power plant may result in new households in project area	Not Significant- Operating contingent consist of only 20 employees	AFC, p. 5-116.
Presence of power plant may diminish employment in other sectors	Not Significant - No existent employment will be supplanted by the proposed facilities. Site is currently undeveloped.	AFC, p. 5-107.
Change in basic economic activities of affected region, primarily rural/agricultural and recreation areas.	Not Significant- Project is continuation of existent geothermal development in the area	AFC, p. 5-107

Impact Identification Matrix

Environmental Category SOCIOECONOMICS

Potential Impact	Significance	Source
POWER PLANT (continued)[1]		
Impact of additional population on adequacy of commercial services	Not Significant- Population increase is small relative to that already in the area	AFC, pp 5-111-113; p. 5-108.
WELL FIELD		
Population increase attributable to development of the geothermal resource required for the proposed facilities (direct and induced in-migration)	Not Significant- Workers migrate from site to site. (Addition of further crews would contribute to adverse cumulative impacts in Lake County)	
Impact on supply of labor available to other sectors in the local economy	Not Significant- Historical unemployment rates are high, indicating adequate supply of labor	AFC, Tables 5.10-4 and 5.10-5. California Employment Development Department Statistics
TRANSMISSION LINES		
Population and housing effects due to construction of transmission lines	Not Significant - Employment required is only a single 10 person crew for one month	Interrogatory response, April 23, 1980. Socioeconomics - Question 1.

Impact Identification Matrix

Environmental Category: PUBLIC SERVICES

Potential Impact	Significance	Source
POWER PLANT		
Adequacy of community services/facilities due to plant requirements, e.g., waste water, solid waste, police, fire	Not Significant- Applicant will have to supply own water, provide for disposal of solid waste outside of venue of local government. Fire, police, will be required only on rare occasions.	AFC, p. 5-113-114
Adequacy of community services/ facilities due to increased population (construction and operation work force). Services/facilities demanded could include: . Sewer . Water . Transportation . Police protection . Fire Protection . Solid waste . General government . Schools . Medical care . Electrical and gas utilities . Parks and recreation . Flood control and drainage . Telephone and communications . Housing	Not Significant- Population increase is small relative to existent local population. Cumulative impacts are known significant for the Middletown Unified School District, and may be significant for other public services as well in Lake County	AFC, pp. 5-111-113, p. 5-108 Staff memo from William Reany to Greg Newhouse, May, 1980.

Impact Identification Matrix

Environmental Category Potential Impact	Significance	Source
POWER PLANT (continued)		
Change in capitoal requirements, operating costs and revenues of local service providers	Not Significant- Small population impact. Significant cumulative effect upon Middletown School District	AFC. p. 5-111-113, p. 5-108, and staff memo from William Reany to Greg Newhouse, May, 1980.
Adequacy of local transportation systems to accommodate construction and operation	Significant- Lake County roads are deemed inadequate to handle substantially increased traffic.	AFC, p. 5-114.
Potential depletion of municipal water supplies by heat dissipating system	Not Significant-No Municipal Water sources will be used	AFC, p. 1-26.

Impact Identification Matrix

Environmental Category LAND USE

Potential Impact	Significance	Source
POWER PLANT		
Consumption of land for generating plant and related facilities	Insignificant- Designation Compatible.	AFC, p. 5-107
Compatibility with nearby existing and planned land uses, and/or land use designations including General Plan.	Compatible	AFC, p. 5-107
Change in land use due to waste disposal requirements	Not Significant- Facility will contribute to demand for storage facilities for Stretford wastes only if output cannot be sold.	AFC, p. 1-31
WELL FIELD		
Change in land use due to exploration and extraction	Not Significant- Consistent with present uses.	AFC, p. 5-107
Change in land use due to transportation needs	Not Significant- No additional roadways proposed	AFC, pl 5-114
Change in land use required for fill disposal	Not Significant- All fill materials will be utilized on the project leasehold	AFC, p. 1-3
Compatibility with nearby existing and planned land uses (including General Plan) and/or land use designations	Compatible	AFC, p. 5-107, Sonoma County General Plan.

Impact Identification Matrix

Environmental Category LAND USE

Potential Impact	Significance	Source
<u>TRANSMISSION LINES</u>		
Utilization of land for electric transmission	Not Significant- Corridor is short, fully contained within Geothermal area as designated by Sonoma County	AFC, Section 8, <u>Sonoma County General Plan</u>
Compatibility of transmission lines with a-jacent land uee	Not Significant- Right-of-way will cross only other geothermal lease-holds	AFC, p. 8-1

Impact Identification Matrix

Environmental Category AESTHETICS

Potential Impact	Significance	Source
POWER PLANT		
Alteration or disruption of aesthetic attributes of viewscape and/or site due to construction of power plant and related facilities	Not Significant- Although a ridgetop site, facilities will entail only remote views to affected populaces	AFC, p. 5-117
Aesthetic impacts upon nearby residents: . Visual . Noise . Odors	Not Significant- Nearest residences are in excess of two miles distance, with intervening land forms preventing visual intrusion. Occasional detection of odors may occur. See Environmental Categories: Noise, Publich Health and Air Resources.	AFC, p. 5-107, and p. 5-117
WELL FIELD		
Alteration or disruption of visual attributes of site by exploration and production of geothermal resource	Not significant- Impacts related to drilling activities will be experienced only at times during facility construction, and for only short periods of time.	Ecoview, Final Impact Report for Geothermal Leasehold of the Union Oil CO., Sonoma County. February, 1975, pp. 16-18.

Impact Identification Matrix

Environmental Category AESTHETICS

Potential Impact	Significance	Source
TRANSMISSION LINES		
Accessibility to new vantage points allowing people easier access to areas, thereby effecting aesthetic attributes	Not Significant- No new access will be promoted by transmission system	AFC, p. 8-1
Alteration or disruption of aesthetic attributes of viewscape and/or route for transmission system	Not Significant- Line will not be visible from area outside of the KGRA	AFC, p. 8-8

Impact Identification Matrix

Environmental Category ENERGY AND MATERIAL RESOURCES

Potential Impact	Significance	Source
POWER PLANT		
Use of resources and energy in the preparation of the site and construction of the various facilities including the generating plant	Insignificant - fuels and materials employed on short-term basis; insignificant in comparison to energy made available by the project.	Professional judgement of California Energy Commission staff.
Depletion of the geothermal resource for power generation	Unresolved	
Resource and energy uses associated with project facilities including the generating, service water, and waste heat dissipating systems (e.g., coolant pumps, cooling tower blowers) plus other internal uses	Insignificant - quantity of equipment and fuels required are minor.; insignificant in comparison to energy made available by the project.	Professional judgement of California Energy Commission staff.
Use of chemicals, materials, fuel and electricity for facilities operation and maintenance	Insignificant - any minor quantities of fuels and electricity are required by the power plant. Insignificant in comparison to energy made available by the project.	Professional judgement of California Energy Commission staff.

Impact Identification Matrix

Environmental Category

Potential Impact	Significance	Source
Steam Field and Supply Lines Emissions during normal operation may present a health hazard to workers or the public.	Workers: Insignificant	See Public Health Attachments # 1 & # 2.
	Public: Insignificant - Normal operation (excluding stacking) of steam field contributes 5-6% of the total H_2S emissions in the Geysers KGRA. The resulting potential impact on ambient pollutant concentrations in populated areas is insignificant relative to total power plant emissions.	SRI International, May 1977. Environmental Analysis in the Geysers Region Vol. 1: Summary. SRI Project EGH-5554, CEC Consultant Report P500-77-005.
Emissions during stacking operation may present a health hazard to workers or the public.	Workers: Insignificant Public: Unresolved	See Public Health Attachment # 1. See Public Health Attachments # 2 & # 3.

HEALTH AND SAFETY IMPACTS MATRIX

Attachment No. 1

Emissions from steam field and power plant operations may present a health hazard to workers.

A. Hydrogen Sulfide and Benzene: Insignificant

The Applicant will institute a program to comply with Cal/OSHA occupational health and safety requirements (California Administration Code, Title 8, Industrial Relations, Chapter 4). This program will be developed with the assistance of the Cal/OSHA Consultation Service and should insure the protection of worker health (AFC, p. 6-6m).

B. Radon-222: Insignificant

Although emissions may at times exceed the California emission standard for ^{222}Rn, workers' doses can be controlled by the amount of time spent in the affected work area (LFE, 1975; Anspaugh, 1978). The Applicant has agreed to implement a radiological monitoring/reporting plan approved and enforced by the Department of Health Services, Radiologic Health Section (DOHS/RHS) (CAC, 1976; AFC, p. 6-4 and Appendix G). This program should ensure adequate protection of worker and public health.

C. Ammonia, Arsenic, Boron, Mercury, ADA and Vanadium: Insignificant

Emission of these pollutants is not expected to produce levels exceeding occupational standards or recommended safe levels of exposure (see Public Health Impacts, Table 13).

Attachment No. 2

Emissions from the steam field and power plant operations may present a health hazard to the public.

A. Hydrogen Sulfide: Unresolved

The NSCAPCO has not made a determination of compliance. Few studies have been conducted to determine health effects from low-level, long-term exposure to hydrogen sulfide (H_2S) at levels likely to be encountered in the communities surrounding the plant; thus, this is a controversial issue (NAS, 1979).

B. Radon-222: Insignificant

See Attachment No. 1, Radon-222.

C. Ammonia, Arsenic, Benzene, Boron, Mercury, ADA and Vanadium: Unresolved

See Hydrogen Sulfide in A above. The Applicant has agreed to provide a new analysis of steam from the existing well on the leasehold. The submittal date is June 1, 1980, and the analysis will also include benzene. The Applicant has agreed to periodically monitor the steam supply for ammonia, arsenic, boron, benzene, H_2S, and percent noncondensibles. The Applicant has also agreed to conduct a limited-term preoperational monitoring study to establish baseline data for ammonia, mercury, arsenic, boron, and vanadium background ambient concentrations.

Attachment No. 3

Stacking operations are a minor source of environmental pollutants, typically releasing to the atmosphere 4.4 percent of the total steam produced in PGandE Units in 1977 at The Geysers KGRA (Accurex, 1980). SMUD has proposed a bypass system to eliminate steam stacking emissions.

Impact Identification Matrix

Environmental Category Potential Impact	Significance	Source
POWER PLANT		
Emissions incurred during construction may present a health hazard to workers or the public.	Workers: Insignificant - Compliance with occupational health standards and requirements should ensure adequate protection of worker health.	Staff Analysis
	Public: Insignificant - Emissions from construction equipment, and dust should not increase ambient pollutant concentrations in the nearby communities, or in the air basin, to levels which would affect public health.	Staff Analysis
Emissions from generating operation may present a health hazard to workers of the public.	Workers: Insignificant Public: Unresolved	See Public Health Attachments # 1 & # 2.
Cumulative emissions from generating operation may present a health hazard to workers or the public.	Workers: Unresolved - Resolution is pending Determination of Compliance submittal by NSCAPCO.	See Air Quality Section.

Impact Identification Matrix

Environmental Category

Potential Impact	Significance	Source
HAZARDOUS WASTES		
Emissions and spills of hazardous pollutants from power plant sludge and abatement chemicals may present a health hazard to workers or the public.	Workers: Insignificant – Compliance with occupational health standards and requirements should ensure adequate protection of worker health.	Staff Analysis
	Public: Resolved – Compliance with hazardous waste disposal and hazardous chemical transport regulations should ensure adequate protection of public health.	Staff Analysis

APPENDIX B
POTENTIAL HEALTH EFFECTS OF GEOTHERMAL POLLUTANTS

Geothermal steam contains contaminants which, when inhaled or ingested in sufficient quantities, can adversely impact human health. These include regulated pollutants such as hydrogen sulfide (H_2S), radon-222 (^{222}Rn), particulate matter, and nonregulated pollutants such as ammonia (NH_3), mercury (Hg), arsenic (As), and boron (B). Abatement systems can also emit varying amounts of pollutants such as vanadium (V), anthraquinone disulfonic acid (ADA), hydrogen peroxide (H_2O_2), iron (Fe), sodium carbonate ($NaHCO_3$), sodium sulfate (NA_2SO_4), and sodium thiosulfate ($NA_2S_2O_3$). Some of these pollutants can react in the ambient air to form secondary pollutants such as sulfur dioxide and sulfates.

The potential for adverse impacts to public health depends on: 1) the toxicity of the emitted contaminants, 2) the concentration or quantity to which the public is exposed, and 3) the duration of exposure. Exposure to these pollutants can occur from inhalation of air, or ingestion of contaminated drinking water or food. The following discussion addresses potential adverse human health impacts associated with these contaminants.

REGULATED POLLUTANTS

Hydrogen Sulfide (H_2S)

Hydrogen sulfide is a toxic gas which can be fatal to humans when inhaled in concentrations of 1,000 ppm and above for several minutes (NIOSH, 1977). Longer exposure to lower concentrations can also be fatal. In concentrations above the state occupational standard of 10 ppm (8 hour average), H_2S can cause irritation of the eyes and respiratory tract, damage to the lungs, and loss of consciousness. H_2S levels below 10 ppm may induce decreased corneal reflex, nausea, insomnia, headaches, loss of sleep, and other symptoms (Walton and Simmons 1978). The effects of exposure to various concentrations are summarized in Table B-1, Appendix B.

Relatively few studies examine adverse health effects from exposure to H_2S at low concentrations (less than 0.1 ppm) such as those measured in populated areas around The Geysers KGRA. Because of the lack of studies and questions concerning the validity of results from some of those studies, controversy exists regarding the potential for adverse effects from H_2S at low concentrations.

Some experts do not believe that exposure to concentrations below 1 ppm adversely affects human health (Simmons, 1979). The State of Montana recommends an H_2S standard of 0.05 ppm based on reported health effects (MAQB, 1980). The Canadian Ambient Air Quality objectives include a proposed maximum desirable level for H_2S of 0.66 ppb (1 hour average), and proposed maximum acceptable levels of 3.6 ppb (24 hour average), and 10.8 ppb (1 hour average) (Katz, 1980). The lowest concentrations accepted by other experts as inducing adverse health effects is 0.08 ppm (IIEQ, 1974), almost three times greater than the California ambient air quality standard for H_2S; nausea, fatigue, loss of appetite, dizziness, blurred vision and increased incidence of mental depression may result from chronic exposure to this concentration.

TABLE B-1

HUMAN HEALTH EFFECTS OF HYDROGEN SULFIDE

ppm*	Health Effects	Reference
0.00047-0.0045	Odor threshold	Leonardos, 1969 Wilby, 1969
0.007-0.03	Slight odor	Gurinov, 1952
0.03	California ambient air quality standard for one-hour average (concentration based on the odor threshold)	ARB, 1970
0.04-0.13	Clear definite odor	Gurinov, 1952
0.08	Increased incidence of mental depression, dizziness and blurred vision	IIEQ, 1974
0.30	Increased incidence of nausea, insomnia, shortness of breath and headaches with chronic exposure	Indiana APCD, 196
0.7-7	Incidence of decreased corneal reflex with chronic exposure	IIEQ, 1974 Rubin, 1975
4.6	Readily apparent, offensive odor	Simson, 1971 Yant, 1930
10	Threshold limit value for 8-hour exposure at the work place	ACGIH, 1977
10-50	Threshold for irritative action with prolonged exposure: eye irritation such as conjunctivitis and at the higher concentrations dry throat. Fatigue, loss of appetite and insomnia with chronic exposure	Ahlborg, 1951 Gurinov, 1952 NIH, 1941
20-30	Very strong, but not intolerable odor	IIEQ, 1974 Yant, 1930
70-150	Eye irritation after several hours of exposure; conjunctivitis, keratitis and photophobia. Threshold for olfactory paralysis occurring within minutes	Devege, 1956 Evans, 1967 Mitchell, 1925 AIHA, 1963
200-300	Serious local irritation to eyes and respiratory tract caused upon inhalation for one hour, with possible subsequent pulmonary edema. This is the maximum concentration which can be inhaled for one hour without serious consequences.	Mitchell, 1925 Haggard, 1925

Adapted from Walton and Simmons, 1978

Some studies report adverse health effects at levels below 0.08 ppm; the validity of these low level studies, however, is questionable (Weres, 1977; Walton and Simmons, 1978). Nevertheless, the possibility that these low levels can induce adverse health effects calls for further investigation.

Exposure to H_2S may be more harmful to certain groups of individuals than to the general population. These H_2S sensitive groups include infants, individuals with anemia, eye or respiratory problems, schizoid or paranoid tendencies, and those who have recently consumed alcohol (IIEQ, 1974; Walton and Simmons, 1978).

Hydrogen sulfide gas has a characteristic odor of rotten eggs which can be detected at low concentrations. The odor threshold varies with individual sensitivity; thresholds have been reported as high as 0.14 ppm and as low as 0.00047 ppm (Walton and Simmons, 1978). Different experimental techniques, subject training, and difficulties in accurately preparing very dilute hydrogen sulfide concentrations may contribute to the wide discrepancy between reported thresholds. At high concentrations (70 - 150 ppm) hydrogen sulfide causes olfactory paralysis--loss of sense of smell (Weres, 1977; Walton and Simmons, 1978).

The California State Ambient Air Quality Standard for H_2S is 0.03 ppm (1 hour average). Although public health protection was considered, this value was based on the average H_2S odor threshold obtained in a study conducted by the California Department of Public Health (CARB, 1970). In that study H_2S odor thresholds for 16 individuals ranged from 0.012 to 0.069 ppm; the average was 0.029 ppm H_2S. A report prepared by Lawrence Berkeley Laboratories states that if the standard is to be based on known odor threshold, "...then the standard should be lowered by a factor of 3 to 5 to the more recently accepted value for the odor perception threshold."(Case, 1977)

<u>Radon-222 (^{222}Rn)</u>

The noncondensable gas fraction of steam originating from natural fumaroles and developed geothermal wells contains the inert radioactive gas, ^{222}Rn. When the steam is used to produce electrical energy, ^{222}Rn and its daughter products remain in the cooling tower sludge, in the steam condensate released to the atmosphere from the cooling tower, and at various locations with the workings of the plant itself (i.e., the steam exhaust ducts and condensers).

The primary health hazard associated with ^{222}Rn and its short-lived daughter products is inhalation and possible deposition in the lung. ^{222}Rn itself is usually inhaled and exhaled without disposition on lung tissue. However, the short-lived daughter products of ^{222}Rn (especially those which emit alpha particles), have a high probability for deposition. Deposition of an alpha-emitting substance on the lungs provides a greater potential for temporary or permanent tissue damage through the natural destructive action of the alpha energy.

Standards for ^{222}Rn set by the California Department of Health Services (DOHS) (Section 30355 of Title 17 of the California Administrative Code), are 100 pCi/l in air for a controlled area and 3 pCi/l in air for an uncontrolled radiation area at the point of release to the environment. Federal standards are set at 3 pCi/l for ^{222}Rn alone, and at 1 pCi/l for ^{222}Rn in combination with its daughters. These standards are for concentrations in the air above natural background radiation. A controlled radiation area means an occupational area which is designated as a hazardous radiation area, and an uncontrolled area means any area to which workers or the general public would have unlimited access.

NONREGULATED POLLUTANTS

Geothermal steam contains pollutants for which there are no Federal or California standards, including mercury, arsenic, benzene, silica, boron, and ammonia. Abatement systems emit ADA, vanadium, hydrogen peroxide, iron, $NaHCO_3$ and $Na_2S_2O_3$. These substances could cause adverse public health impacts if present in sufficient concentrations. Suggested standards and safe levels for these pollutants in air are listed in Table 20, Public Health Impacts.

Ammonia

Ammonia is primarily an irritant to eyes, mucous membranes, and the upper respiratory tract. The lowest concentration reported to cause irritation in humans via inhalation is 20 ppm (EPA, 1977), and barely noticeable eye irritation may occur at 5 ppm (NIOSH, 1974). EPA believes that exposure to low levels of ammonia does not cause permanent adverse health effects (EPA, 1977). The odor threshold for ammonia ranges between approximately 0.7 ppm and 50 ppm (NAS, 1977).

Mercury

Inhalation of mercury compounds can induce cough, fever, bronchitis and pulmonary edema. Chronic poisoning results from the accumulation of mercury in the brain, kidneys, and hair, and causes symptoms such as headaches, dizziness, and fever. Children are especially susceptible to mercury poisoning (Britt and Hushon, 1976). Certain mercury compounds have the potential to cause cancer or birth defects (EPA, 1977).

Organisms, particularly those in aquatic environments, can absorb, concentrate, and transform trace elements. Mercury may transform to more hazardous forms (such as methyl mercury), and accumulate in various links in food chains, particularly in higher trophic levels. Fish can contain high mercury levels since they take up mercury compounds both through consumption of food and through their gills (Britt and Hushon, 1976). Ingestion of mercury in contaminated food or water can result in adverse health effects such as headaches, blurred vision, loss of muscular coordination, and death (Waldbott, 1973). To protect public health from hazards of mercury ingestion, the U.S. Food and Drug Administration recommends 1.0 ppm mercury in fish as a safe level for human consumption.

Arsenic

Arsenic and arsenic compounds emitted from geothermal steam may occur in varying forms such as suspended particulate or vapor. Depending on concentration and form, acute exposure to arsenic may cause headaches, dizziness, numbness, chills and fever, nausea, vomiting, abdominal pain, pulmonary edema, jaundice, and leukocytosis. Chronic exposure may cause irritation to nose and throat, hair loss, tremors, anemia, and cancer of the skin, lung, or liver (Britt and Hushon, 1976).

Boron

Compared with other atmospheric pollutants, the medical literature on boron and its compounds is sparce (Waldbott, 1973). Boron and most boron compounds are not highly toxic (Waldbott, 1973; Durocher, 1969), although boron hydrides are rated as highly toxic (Durocher, 1969). Chronic exposure to boron and boron compounds can result in reduced appetite, nausea, weight loss, increased risk of lung infection, central nervous system depression, and kidney injury (Britt and Hushon, 1976). Inhalation of boric acid and boron oxide in the form of dust can cause respiratory irritation but is not likely to induce permanent damage (Waldbott, 1973). Inhalation of boron hydrides (boranes) can result in severe central nervous system damage with symptoms including headache, dizziness, drowsiness, convulsions, fever, cough and pneumonia (Wilcox, 1973; Waldbott, 1973); death or permanent damage may also result from such exposure (Durocher, 1969).

Vanadium

Exposure to excessive concentrations of vanadium can result in conjunctivitis, skin irritation, chest pain, cough, asthma, pneumonia, nausea and vomiting, headache, and tremor. Long range effects include hypertension, cardiovascular disease, kidney damage, anemia, emphysema, and pulmonary fibrosis (Britt and Hushon, 1976). There is no evidence of genotoxicity due to vanadium. In fact, studies suggest that vanadium may be an essential element for some animals, including man, at certain concentrations (WHO, 1973).

Anthraquinone Disulfonic Acid (ADA)

Stretford solution contains anthraquinone 2:7 disulfonic acid (PGandE, 1979b), an aromatic compound most commonly used in the dye industry (Stern, 1977). Few sources describe health effects from exposure to ADA. Anthraquinone is a naturally occurring mutagenic compound, although the contribution to human cancer remains to be evaluated (Ames, 1979). It has low systemic toxicity to humans, but may cause skin irritation sensitization (The Merck Index, 1968). Anthraquinone 1:5 disulfonic acid and anthraquinone 1:8 disulfonic acid are suspected to have low toxicity (The Condensed Chemical Dictionary, 1972).

Hydrogen Peroxide

Exposure to hydrogen peroxide fumes represents a traditional occupational worker concern rather than a public health concern. Hydrogen peroxide is nonflammable but, since it is an oxidizing agent, it helps to support combustion. Hydrogen peroxide, by itself, is not as toxic as when it is in combination with other pollutants such as ozone. Studies by Svirbely found that ozone (1 ppm) combined with hydrogen peroxide at concentrations above 1.5 ppm was lethal to some animals; whereas hydrogen peroxide by itself, in a concentration of 200 ppm, produced only slightly toxic responses (Svirbely et al., 1961).

Iron

Exposure at high concentrations to iron oxide fine particulates results in conjunctivitis, chronic bronchitis, pulmonary fibrosis, and emphysema. Iron oxide can penetrate the walls of the lung bronchi and alveoli without damage to the mucous or ciliary barrier. In this way it can transport the carcinogenic combustion product, benzo(a)pyrene, into the lungs (Waldbott, 1973). Ingestion of ferric sulfate at very high concentrations causes vomiting, tachycardia, liver insufficiency, and capillary damage.

Sulfates

High concentrations of sulfates are associated with increased attack frequency in asthmatics, worsened symptoms in cardio-pulmonary patients, decreased ventilatory function in school children, and symptoms of acute and chronic diseases in children and adults (Bachman, 1975).

Benzene

Chronic exposure to benzene may result in poisoning characterized by blood disorders (leukemia), changes in body organs, chromosomal aberrations, and cancer; acute exposure to benzene has a narcotic effect (EPA, 1977). Benzene can be absorbed through the skin, but inhalation is the usual mode of exposure.

Silica

Exposure to high concentrations of silica, especially crystalline free silica, can cause silicosis, a serious disabling lung disease which may affect the heart.

APPENDIX C

ASSUMPTIONS FOR PUBLIC HEALTH CUMULATIVE IMPACT ANALYSIS

The following assumptions were used by CEC staff in the Public Health Impacts section.

1. Concentrations of pollutants in incoming steam were based on:

   a) Utilities estimates where available;

   b) Exploratory well data, where available; or

   c) Average concentrations from 61 producing wells at The Geysers.

2. The total quantity of steam contaminants is released to the atmosphere through the cooling tower.

   Note: This is an over estimation. In reality, some portion of incoming steam contaminants is reinjected with excess condensate or accumulates in sludge. The percentage that exits through the cooling tower varies depending on the volatility of the pollutant. This assumption allows for a worst case analysis only; it is not precise.

3. The analysis assumes that all geothermal pollutants are transported in the atmosphere in the same manner as gaseous H_2S. This may not be entirely accurate, since some pollutants, particularly arsenic compounds, are likely to behave more like a particulate than a gas. Gaseous pollutants are more extensively dispersed than particulate pollutants.

4. The analysis for nonregulated pollutants is based on the cumulative impact study for H_2S. A similar set of assumptions used in the H_2S analysis applies:

   a) Background pollutant levels assumed for nonregulated pollutants are lacking or outdated and may not apply in 1983 when the facility is scheduled for commercial operation.

   b) It assumes that all nonregulated pollutants are emitted during normal operation and steam stacking, so there would be no increase during steam stacking or reduced H_2S abatement efficiency.

5. As meteorological conditions, this cumulative impact analysis assumes those conditions which result in the maximum impact of the project emissions on ambient pollutant concentrations in Anderson Springs (the nearest population center). These meteorological conditions do not necessarily cause the maximum impact from other units' emissions in this area. In addition, this analysis does not identify the maximum possible impact of these other units on Anderson Springs. Rather, it identifies the impact on pollutant concentrations in Anderson Springs when the project emissions have a maximum impact, given:

a) All incoming pollutants are emitted through cooling towers and dispersed in the same manner as H_2S, and

b) Limited emission and background and concentrations data.

APPENDIX D

COMMENTS AND RESPONSES TO COMMENTS ON THE DRAFT JES

LCAPCD COMMENTS

On The SMUDGEO #1 DEIR

1. Page 5 ... Comment under Steam Supply wells indicating that the USGS is the permitting authority should be clarified further in that many other agencies will have permits to issue.

2. Page 81... Comment indicates that figure 14 lists sites as a source of data applicable to the proposed development (SMUD & DWR). However, the referenced figure only depicts SMUDGEO #1 and Geysers 17. The latter (Geysers 17) is not directly applicable to the proposed development due to the intervining action of Cobb Mountain on meteorological conditions.

3. Page 83... Some clarification should be offered for the large difference in temperature indicated between the NCPA 2 site and the SRI 2 site. It would normally hold true that the SRI 2 site could be expected to be cooler since it is nearly 600 feet higher in elevation.

4. Page 85... Reference is made to the wind rose pattern on page 87 as having no predominate direction, but the westerly component is somewhat significant when the 1976-78 SRI data is compared. Also the reference to western and southwestern winds could be more properly called westerly and southwesterly.

5. Page 86... The label on the wind rose indicates (SRI 2) Socrates Mine Road is incorrect in as much as the road is approximately 1.5 miles south of the SRI 2 site.

6. Page 88... Earlier in the Text SRI 2 is indicated as applicable to project site, but a comparison of SRI 2 and SMUD-1 wind roses reveals significant differences.

7. Page 91... In as much as well characteristics change with time, and most of the 61 referred to wells have probably been reworked the validity of the data in this table from 1972 to 1974 is questionable.

8. Page 110.. Under Projected Impacts drainage is indicated as producing significantly less impact than limited mixing or downwash, but the ER-T study indicates drainage as the worst case.

9. Page 120.. Under climate section the annual average windspeed is given as 11 MPH. Where was this value for, and what is the source?

10. Page 129.. Section on PSD needs updating as EPA letter of November 26, 1980 requires that SMUD obtain a PSD permit for H_2S prior to the beginning of construction.

LCAPCD GENERAL

COMMENTS

On The SMUDGEO #1 DEIR

11. Since a violation of the CAAQS for H_2S of .03ppm is predicted for Anderson Springs when stacking occurs under worst-case conditions, and the background levels are above 5-10 ppb further clarification on the expected frequency of stacking and performance reliability to the proposed turbine bypass system should be included.

12. Additionally, the added impact of more than one power plant in the nearby locale stacking concurrently with SMUDGEO #1 should be addressed. As this happens on occasion in the geysers complex, it is reasonable and rational to assume the same could or will occur in the Anderson Spring area when the PG&E Units 13, 16, 18, and potentially 19; NCPA #2; SMUDGEO #1; and the OXY plant are on line.

13. The DEIR and the NSCAPCO's Conditional Determination of Compliance both address the background levels expected due to emissions from existing PG&E Geysers Units, NCPA, DWR and SMUD. Additionally Occidental Petroleum will propose to construct up to a 80 MW unit approximately .8 miles northwest of SMUDGEO #1. The added emissions and resultant impact of this development on an already marginally impact scenario (SAI and NSCAPCD) must be addressed and accounted for in the justification for the 5#/hour versus 8#/hour emission limitation of SMUDGEO #1 under normal operating conditions.

RESPONSES TO LCAPCD COMMENTS

Comment #:

1. Comment accepted. See amended text.

2. Comment accepted. See revised Figure 14 in text.

3. The temperature shown for the NCPA 2 site and the SRI 2 site were taken from two different years; hence, comparison should only be made on a gross basis.

4. See amended text.

5. Figure title amended accordingly.

6. No such reference was found in the text by staff. However, staff does agree that there are significant differences in the wind roses although magnitudes are roughly comparable.

7. See amended Table 12.

8. The staff's conclusion is based upon the tracer tests and modeling studies conducted specifically for the SMUDGEO #1 project, under the expected meteorology and site terrain of the proposed project. Although the ERT study findings show drainage as the worst case, it is not clear that the findings are applicable to the proposed project site.

9. See amended text.

10. See amended text.

11. TURBINE BYPASS SYSTEMS

    It is the staff's opinion that the components of the turbine bypass system should be as reliable as similar components currently in use on geothermal facilities (i.e., the bypass valve is similar to the existing main turbine stop valves). The turbine bypass system is not currently in use on geothermal power plants, although these systems have been used successfully on other power generating facilities. The staff does not expect that the turbine bypass system will affect normal plant operations or partitioning efficiency, although the effects on normal plant operations or partitioning have not been evaluated. The staff expects the turbine bypass to operate reliably. However, the successful abatement of stacking emissions will depend on the availability of the Stretford and secondary abatement systems. The availability of the Stretford system has been estimated to be greater than 90 percent. Perhaps 3 percent of the unavailability would be due to forced outages, and of that 3 percent only a relatively small fraction will result in total loss of abatement efficiency. It is the staff's opinion that with proper maintenance and with automatic well throttle controls stacking events will be reduced to a minimum.

12. CONCURRENT STACKING EVENTS

The potential impacts of concurrent stacking events would be significant. However, the turbine bypass system will reduce the number of stacking events from the SMUDGEO #1 facility and therefore the number of concurrent stacking events also. If proposed facilities in the site area also used the turbine bypass system, the potential cumulative impacts from the facilities would be reduced.

13. IMPACTS ON FUTURE DEVELOPMENT

This subject, to a limited degree, has been discussed in the JES, under Cumulative Effects. The existing units in The Geysers are contributing the majority of the H_2S to the existing impacts. The SMUDGEO #1 facility's contribution is minor compared to the existing units' contribution, at either the 5 lbs/hr or 8 lbs/hr emission rate. Requiring BACT controls on SMUDGEO #1 and on future developments is not as likely to ensure the attainment and maintenance of CAAQS as control of existing units (see JES section, Cumulative Effects, Air Quality Mitigations).

80-AFC-1

ENERGY COMMISSION
RECEIVED

JAN 5 1981

EUGENE P. COLLINS
Road Commissioner
County of Lake
255 No. Forbes Street
Lakeport, CA 95453
707/263-2367

STATE OF CALIFORNIA

STATE ENERGY RESOURCES
CONSERVATION AND DEVELOPMENT COMMISSION

In the Matter of:

SACRAMENTO MUNICIPAL UTILITY DISTRICT'S SMUDGEO UNIT 1 POWER PLANT

DOCKET NO. 80-AFC-1
LAKE COUNTY'S COMMENTS ON THE DRAFT ENVIRONMENTAL IMPACT REPORT FOR SMUDGEO #1

I

The transportation section of the Draft EIR does not contain a traffic study analysis. This analysis should include a traffic volumn study, accident statistics, highway design standards, and cumulative volumns for all projects using the road.

II

The traffic section does not include a cumulative impact description or analysis. This section should include a discussion of all roads used by the project which would include, but not limited to Socrates Mine Road, Ford Flat Road, and Butts

Canyon Road.

III

Socrates Mine Road is a 4.4 mile long, narrow, winding mountain road. The surface of the road consists of 1.6 miles of asphalt and 2.8 miles of gravel and dirt. The widths in the road range from 22 feet of paved road to approximately 13 feet of dirt road. There are 26 curves with sub-standard sight distances. The paved portion of the road does not have adequate structural base. This is witnessed by the fact that a large portion of the surfacing has failed because of excessive and repeated loads. The edges of the paving are failing due to inadequate shoulders and roadside drainage. The grade of the road exceeds minimum standards in many places, this is particularly true of the unpaved sections of the road. The road is too narrow to allow installation of proper guard rail where needed along its entire length. Roadside ditches are subject to excessive erosion due to the steep terrain. There are two bridge crossings which have widths of 16 feet and 18 feet respectively. Both bridges are located on short radius curves. The guard rails have been knocked out of position on these bridges because the truck traffic cannot negotiate the turns. Both of the bridges have suffered deterioration because of excessive use.

County road studies indicate a 50% increase in traffic over the last three years. These studies indicate that approximately 20% of the traffic consists of trucks. These trucks have difficulty negotiating the short radius curves and must use the full width of the road in doing so. This creates a hazard for other road users. The shoulders and edges of the road are experiencing excessive wear because of the narrowness of the road. The heavy traffic is causing dust problems which requires above normal dust control. The gravel portions of the road and the dirt sections of the road when wet do not have proper traction. There are not sufficient turnouts on the narrow road to allow vehicles to pass.

A reconstruction project for Socrates Mine Road should include improved alignment, structural section, drainage, guard rails, traffic control and safety signs, and bridges.

IV

We are currently conducting negotiations with all the road users for a collective reconstruction and maintenance program. We are optimistic that these negotiations will provide an answer to our current road problems. However, after several months the County has failed to receive a firm commitment from the road users. It is our opinion that no additional traffic should be added to Socrates Mine Road until the alignment is improved, with adequate structural section, guard rail, roadside drainage, surfacing, and proper signing.

The traffic studies have shown that some of the geothermal workers are using Ford Flat Road as their commute route. Ford Flat Road is a 2.87 mile long narrow, winding, dirt mountain road. It is a short cut from Socrates Mine Road to the residential area in Cobb. This commute traffic is causing dust and noise problems for the residences along the road. In our opinion no further commute traffic should be allowed on this road. Any power plant approvals should prohibit use of this road by the permittee or his agents.

In addition to Socrates Mine Road, we are concerned about Butts Canyon Road, the access road to the geothermal disposal site. Butts Canyon Road has experienced heavy geothermal disposal truck traffic to the point where the surface and roadbed are totally failing. The road does not have adequate structural section or drainage for this type of traffic. Again we would recommend that no additional traffic be added to Butts Canyon Road until it has been properly reconstructed. The document does not specifically discuss disposal of waste developed during the operating life of the plant. The County feels that there is a high probability that the Middletown disposal site will be used for this disposal operation, via Butts Canyon Road.

Lake County does not believe the mitigation measures for road construction as set forth on Page 65 are sufficient. We believe that, as an additional mitigation measure, the road problems cited above should be corrected before the project construction is started. We are willing to work with the applicant for a cost sharing program for reimbursement.

We believe the social economic section is incomplete. The document should include a chart which shows project related revenues and cost. The immediate costs will far exceed the immediate revenues. This would create a major financial impact on Lake County that the document does not discuss.

Respectively submitted

DATE

EUGENE P. COLLINS
Road Commissioner

266

RESPONSE TO LAKE COUNTY'S COMMENTS

The entire Transportation section of the JES has been revised, giving more thorough coverage to the issues raised in your comments. See amended section.

In reference to the final paragraph of comments from Lake County, no specific itemization of costs is available at this time. Text unchanged.

SMUD COMMENTS

	PAGE	PARAGRAPH	COMMENT
1.	i	Project Features	Based on final civil plans, 8.8 acres should be 10.5 acres and 2.5 acres should be 2.2.
2.	ii	first	It will be a four flow machine, not dual flow.
3.	ii	second	Suggest rewording of last sentence as "and allows a greater portion of the environmentally undesireable hydrogen sulfide to be captured with the noncondensable gases. Hydrogen sulfide in this form is more easily treated than it is if it dissolves in the condensed steam.
4.	ii	third	The condenser will have titanium, not steel tubes.
5.	ii	fourth	Startup water will be supplied by Aminoil from condensed steam, but not necessarily from within lease 1862.
6.	ii	fifth	There are a decreasing number of H_2S exceeds in the area, see JES p. 100.
7.	iii	first	Request adding a sentence after 1983. "Based on the estimated impacts SMUD does not believe that reducing the allowable emission rate from 8 lbs/hr to 5 is warranted.
8.	iii	second	There are no solids in the non-concensible gas stream.
9.	iii	Air Quality	"The SMUDGEO #1 project will contribute an immeasureable increment to an existing..."
10.	iii	Air Quality	"Conditional Determination of Compliance for SMUDGEO #1 since it may contribute..."
11.	iv	first	"since existing unabated power plant emissions are the major contributors to these violations and the existing plant emissions will not be reduced significantly until 1985 and 1986 when further emissions reductions from existing units will occur"
12.	iv	Public Health	"albeit in non-measureable amounts, to..."
13.	iv	Public Health	There is no evidence that emissions of nonregulated pollutants have caused any adverse health effects at The Geysers.

14.	iv	Public Health	There is no record of "evident public concern" in the JES.
15.	iv	Public Health	SMUD will not "assess the health state of local residents". SMUD's contribution to the emissions inventory is negligible and the resident population, ~~the population~~ is not large enough to yield significant statistics from an epidemiological study that would attempt to measure effects from the very low level of pollutants present. The results of such a study, if undertaken, would not be available for many years, ~~certainly years.~~
16.	iv	Growth Inducing Impacts	SMUD will support in some fashion its fair share of maintenance for the roads, but will not necessarily "enter into an agreement with both counties."
17.	v	Wastes	"Berms" should be curbs. The Stretford system will produce 350 cu yd/yr, not 125. The peroxide secondary abatement system will produce about 3.5 cu yd/yr, not "4160".
18.	v	Cultural	The comment about a buffer zone around Little Geysers is unnecessary. It is not impacted by this project and such action is not within SMUD's power to accomplish.
19.	xvi	first	net normal operating capacity should be gross.
20.	3	fourth	Should South Geysers be included?
21.	5	first	SMUD will construct a secondary abatement system; the commitment is not qualified as to Stretford system performance.
22.	5	second	H_2 and CO_2 are not abatement system chemicals. H_2O_2, $FeSO_4$, and HAA are.
23.	5	Water Supply	Initial startup water will be steam condensate, but not necessarily from within the leasehold.

24.	12	Earthquake Mitigation	SMUD is now using a dual level approach to seismic design. Suggest replacing second paragraph with "SMUD proposes to use a dual level approach to seismic design. Those structures and components that are very costly or cannot be repaired or replaced within one year will be designed to withstand a peak bedrock acceleration of 0.28g; all other structures and equipment will be designed to withstand a peak bedrock acceleration of 0.15g. Based on probabilistic seismic hazard analyses performed for other generating units at The Geysers (e.g., Cooper-Clark, 1979), the probabilities that these values may be exceeded during the 30-year facility lifetime are 5 percent and 50 percent, respectively.
25.	14	Steam Reservoir	Has the summary report that was to be available in June 1980 been issued?
26.	16	first	There will be an earthmoving, not a construction moratorium during the rainy season. In addition, partly to control erosion, SMUD is going to pave the site, pave the access road, and upgrade and pave the fire road down to Socrates Mine Road.
27.	17	The KGRA	All of the 1625 acres of development is not in the Big Sulphur Creek watershed, for example at least Units 13, 16, 19, 21, NCPA 1 and 2, and Bottle Rock are not. Also, 36 acres is about 2.2% of 1625, not 1.1%.
28.	23	Losses Related to Construction	Power plant acreage is 10.5, not a 8.8.
29.	24	third	"impacts on vegetation also are affected by the amount of boron in the steam supply, which determines the amount of boron in the circulating water."
30.	25	Operation	A detailed monitoring program was submitted to the CEC for review in December 1980.

31.	29	last	Erosion into Calm Creek is not likely. The access road is about 1155 feet from the spring and the majority of the water intercepted by the road will be diverted to the Cobb Creek drainage. Neither is it likely that construction of the road will diminish the waterflow in the spring. The road is at the crest of the hill, and will divert a small fraction of the rain which falls on the hill. In addition, there is no evidence that surface recharge in the immediate area supplies the water bearing strata at the spring.
32.	30	fifth	It is physically impossible for cooling tower drift to directly cause an increase in water temperature in Cobb or Calm Creek. It is unlikely that drift will cause a decrease in vegetative cover sufficient to allow a measureable increase in the water temperature due to solar heating.
33.	31	first	Black bear have probably already abandoned the area. No signs of bear have been sighted in recent reconnaissances of the leasehold.
34.	31	fourth	It is not likely that drift will affect the purple martins. The SMUDGEO #1 drift levels are two order of magnitude <u>less</u> than those in the cited study.
35.	31	fifth	Drift will not impact the Calm Creek spring. It is highly unlikely that project activities will disrupt the water source or fill the spring with sediment.
36.	32	first	Drawings for the well pad have been submitted to the CEC. The contours are such that rain that falls on the well pad and associated fill slope will drain away from the SMUD plant site to an area where it will be controlled by Aminoil. All slopes will be revegetated.
37.	32	fifth	SMUD submitted a revised mitigation plan addressing these concerns in December 1980.
38.	33	5	The entire road will be paved in the summer of 1981.

39.	39	fifth	There is no retention area around the basins other than the curbed plant pad itself. The plant site is sloped toward two catch basins, from which water is pumped to the tower basins.
40.	39	seventh	Systems will be equipped with alarms for malfunctions, but not spills. The instrumentation will warn of high levels, or pressures, etc. but will not detect a spill per se.
41.	60	a.	SMUD is including a performance requirement of 85 dBA at three feet, but is not including it as a separate specification.
42.	67	first	Construction will start in April, not February.
43.	76	first	Sludge from the secondary abatement system will amount to about 3.5 cu yd/yr.
44.	79	first	4160 cu yd/yr should be 3.5 cu yd/yr.
45.	82	Figure	Wrong figure - monitoring stations not shown.
46.	84	first	Stretford solution should be maintained above 50°, not 60°.
47.	84	first	Analysis submitted by SMUD shows that maximum impacts at Anderson Springs occur under limited mixing conditions.
48.	85	first	Boron is a particulate, not a water soluble gas.
49.	89	Air Quality	Geothermal steam is 99.8 percent water vapor and 0.2 percent noncondensible gases and solids.
50.	100	Mitigation Measures	Evaporation is the primary means of cooling the circulating water. It is not possible to economically reduce water vapor emissions.
51.	100	Air quality	Steam is 99.8 percent water vapor and 0.2 percent other.

52.	101	Particulate Sources	The majority of the particulates in the gas stream will be scrubbed by the Stretford system and will not be emitted from the Stretford cooling tower.
53.	102	last	The secondary abatement system will not result in significant particulate formation and will not result in an emission of <u>0.6</u> lb/hr. The air flow should be 9,240,000 cu ft/min.
54.	103	first	SMUD is designing a balanced abatement system consisting of a Stretford system and condensate treatment. It does not make much difference which stream carries what percentage of H_2S. Sufficient H_2S will be removed to meet the emissions limitations.
55.	106	fourth	SMUD has committed to use hydrogen peroxide with ferrous sulfate and hydroxyacetic acid for condensate treatment.
56.	108	last	CEC has data from Unit 15. The majority of data on the Stretford system is proprietary. In addition, SMUD is using a Stretford system from a different supplier than Unit 15.
57.	108	second	SMUD has already agreed to use secondary abatement, see p. 105 of the JES.
58.	108	third	Amount of solids formed with the secondary abatement system SMUD will use is insignificant, 3.5 cu yd/yr. Solids removal is not necessary.
59.	120	Mitigation Measures	It is not clear what is desired from a cooling tower emission program. Quantifying water vapor would not produce any useful information, and the minor changes in humidity cannot produce observeable changes in the field, and it is not economically feasible to reduce water vapor emissions.
60.	121	seventh	Where has the ARB made the determination that 25 ppb is a violation of the 30 ppb standard?

61.	122	Figure 28	This figure is referred to in the text as Figure 29, and on p. 123 Figure 29 is concluded. If it is Figure 29, there is no Figure 28.
62.	127	Mitigation Measures	Did this BACT determination include a cost/benefit analysis?
63.	128	Compliance	SMUD will use a turbine bypass to reduce stacking. There is no mention of this here. Even without the bypass, Aminoil intends to throttle back the wells if necessary to reduce emissions. See AFC Section 1.2.2.3.
64.	129	fourth	With the bypass, Aminoil does not need to reduce flow to 35 percent.
65.	142	---	Arsenic, boron, mercury, and silica are not gases and are not emitted from the cooling tower in anything near the quantities stated. The majority of these contaminants are retained either in the sludge in the cooling tower basin or go with the reinjection stream down the well. See AFC Table 5.3-2 for calculated emission rates for SMUDGEO #1. For instance, arsenic is emitted at a rate of $0.01x10^{-2}$ tons/year or $0.2x10^{-4}$ lb/hr, not 0.2 lb/hr.
66.	143	footnote e	Add to the end of the footnote - "but are not intended for use as regulations."
67.	147	Monitoring	At the concentrations involved, mass balance measurements for arsenic and mercury will not yield meaningful results.
68.	154	EIC Process	Under unknown aspects add: d) costs, including steam penalties
69.	160	Population	Construction will start in April, not February.
70.	164	Public Health	Health effects at the concentrations anticipated would be impossible to determine with any degree of confidence, thus monitoring health status provides no useful information.
71.	168	Waste Management	SMUDGEO #1 will produce 3.5 cu yd/yr from secondary abatement, not 80 cu yd/wk.

72.	175	Biology	56 acres is not a significant portion of The Geysers KGRA.
73.	175	Safety	All roads used by trucks for SMUD plant will be paved.
74.	195	-	Add a definition of significant.
75.	203	Degradation of Water Quality	Impact cannot be significant. All spills from plant will be contained.
76.	241	Attachment 3	This does not appear to pertain to SMUDGEO #1.
77.	250	2	This assumption is in error. A conservative assumption is one that takes the extreme of range of what is physically possible. An assumption that is beyond the range of physical reality is not a suitable tool to use in drawing policy conclusions. A considerable amount of money has been spent by the nation in actually measuring cooling tower drift and its effects, including research sponsored by SDGandE and in the CEC's Sundesert NOI record. SMUD is investing additional money to keep drift below 0.001 percent, but the CEC analysis has been performed as if the cooling tower is completely uncontrolled.

ADDITIONAL COMMENTS ON
SMUDGEO #1 - DJES

	Page	Paragraph	Comment
78.	i	First	Past tense is appropriate. We propose the following: "... demand capability was 1896 MW."
79.	iii-iv	Last-First	The actual value is currently under reconsideration, therefore, we suggest the following word changes: "... concentration <u>of H_2S is below acceptable levels</u> (this monitoring ..."
80.	iv	Second	Radon is a radioactive gas with inert chemical characteristics. It is the radon "<u>daughters</u>" which have deposition potential.
81.	iv	Growth Inducing Impacts	As currently worded, it could be misinterpreted. The last sentence should read "SMUD will enter into an agreement with both counties regarding <u>their proportionate share of</u> compensation for maintenance of county roads"
82.	1	Economics (first)	Addition of the words "...(existing system is composed of hydroelectric, nuclear and purchased power)" is confusing when related to the rest of the sentence. Suggest either deleting or making a new sentence.
83.	1	Economics (Second)	SMUD's system wide cost of generating electricity is given as 6.6 cents per kilowatt hour. Initial efforts to verify its accuracy indicate it may be high by a factor of at least two. If considering it as a levelized cost for 1983-2010, it may still be high. The source of this number and/or its methodology of development should be given.
84.	3	Second	Aminoil's current plans are to reroute steam transmission pipelines to avoid crossing portions of nonfederal leases.
85.	4	First	Suggest clarification of the 9-26 wells by specifying approximately 9 will be required for initial operation, but that over the life of the project, replacement wells may increase the nu[illegible] to a total of 26.

	Page	Paragraph	Comments
86.	12	Earthquake Mitigation	The last sentence of SMUD's DJES Comments submitted on December 23, 1980, should be modified to read: "... at the Geysers (e.g., Shah, May, 1980), the probabilities that these values may be exceeded during the 30-year facility lifetime are five (5) percent and 25 percent, respectively.
87.	16	Second	SMUD has agreed to provide the information to CEC and USGS only.
88.	17	Big Sulphur Creek Watershed	The 0.50 acre/MW and 72 MW for determining a vegetation loss value is not valid for SMUDGEO #1 because of the higher plant efficiency. Using 55 vs 72 MW as the multiplier would be more representative.
89.	17	The KGRA	The same comment given in the above paragraph applies here.
90.	32	1.	For various reasons discussed at numerous Public Workshops, combining the power plant pad and well pad, erosion control is not possible.
91.	34	Second	We believe that spring monitoring is no longer a recommendation of the staff. This paragraph should be deleted.
92.	63	Ethnography-Mitigation	A buffer zone around Little Geysers is unnecessary. It is not impacted by this project and such action is not within SMUD's power to accomplish.
93.	67	Fourth	For clarification we recommend the following wording addition: "... counties to determine its proportionate share of maintenance costs ..."
94.	75	Construction Wastes	Typo "years" should read "yards"
95.	76	First	This paragraph should reflect the secondary abatement sludge infomration provided in a SMUD filing on the subject docketed December 19, 1980.
96.	104	Fifth	The SMUDGEO #1 Stretford supplier is Peabody - not Parsons. Nonetheless, removal efficiency should be similar.
97.	106 and 108	Last-First	The NSCAPCD has access to analytical information from Unit 15. SMUD does not! SMUD will submit all available test data on its own systems, but it will be up to the NSCAPCD to determine the applicability of Unit 15 data to that of SMUDGEO #1

	Page	Paragraph	Comments
98.	108	Fifth	See sludge discussion submitted and docketed by SMUD on December 19, 1980. No major solids removal system is contemplated. Solids collection will occur in the cooling tower basin.
99.	141-142	Last-Table 21	See SMUD submittal on major steam constituents docketed on December 23, 1980.
100.	147	Mass Balance Measurements	See SMUD submittal on Major Steam Constituents docketed on December 23, 1980.
101.	156	First	Wording does not properly reflect the proposed design. Suggest the following word changes: "SMUD proposes to use double circuit, steel lattice ..."
102.	157	First	Alternative A is shorter than Alternative C in overall length. The text should be corrected.
103.	160	Population	There is no known reason to believe that the construction schedule as defined in the AFC will be delayed or altered in any way.
104.	160	Population	Type: "... the total population increase in each county attributable to ..."
105.	161	Figure	The Figure should be labeled with a number. It is assumed that the "Figure 32 below" words at the bottom of page 160 refers to the Figure on page 161.
106.	162	Sixth	Typo: "Impacts will be insignificant upon Sonoma County."
107.	162	Sixth	The growth inducing impacts described in this entire section may not occur if the current recession-economy continues into the 1981-82 time frame. Currently, there are 1100 fewer people employed in the construction trades in the two county labor market than there were one year ago. This possibility should be reflected in the text.
108.	163	Fiscal Impacts	The steam field improvements (Aminoil) associated with the project will be subject to local property taxation by Sonoma County.
109.	163	Fiscal Impacts	Further clarification is needed for words in the last sentence. Specifically: "... and miscellaneous expenses."

	Page	Paragraph	Comments
110.	165	Erosion and Drainage	Estimates should be based on a 55 MW not 72 MW plant. The difference is associated with plant efficiency not larger facilities.
111.	167	Vegetation	The total development lost acreages values are too large for the same reasons stated above.
112.	169	Transportation	Typo: "... from Middletown via State Route 175 ..."
113.	170	Vegetation and Wildlife	Estimation of lost vegetation should be based on 55 MW not 72 MW. Project being penalized for its higher efficiency.
114.	172	Long-Term Productivity	Typo: "... reliable long-term source for electrical power, ..."
115.	174	Land Use and Aesthetics	Typo: "... inevitably alter the character of the landscape ..."
116.	175	Erosion and Sedimentation	All of the 1625 acres of development is not in the Big Sulphur Creek watershed. For example at least Units 13,16,19,21, NCPA 1 and 2 and Bottle Rock are not.
117.	175	Biology	56 acres is based on 72 MW. This acreage is an overestimate because of the higher efficiency of the project.
118.	175	Biology	SMUD and others are expanding a large sum of money to assure that there is a net benefit to vegetation, water and animal habitats. The words "... may be narrowly successful, ..." are not supportable or justified!!

RESPONSES TO SMUD'S COMMENTS

1. See amended text.

2. See amended text.

3. See amended text.

4. Text amended.

5. See amended text.

6. See amended text.

7. See amended text.

8. See amended text.

9. Comment was not included in the text, based upon the staff's opinion that the modification would be misleading to the public. The issue is not whether SMUDGEO #1's impact is measurable but whether the incremental impact will interfere with the attainment or maintenance of the CAAQS for H_2S.

10. Text amended.

11. Text amended.

12. Text unchanged; see response to SMUD's comment #9.

13. Text unchanged; see Draft JES, p. 132, paragraph 7.

14. See response to comment #13 above; no change in text.

15. This is a typographical error--see page 147, paragraph 2. Given the uncertainties in assessing potential adverse health effects of chronic exposure to emissions from geothermal power plants, CEC will be examining the feasibility of conducting an epidemiological study of residents in The Geysers KGRA; if found to be feasible and if funded, the epidemiological study could be completed in 1982 or 1983. See amended text.

16. See SMUD comment number 81, i.e., "last sentence should read 'SMUD will enter...'." Since this is SMUD's latest set of comments, we have accepted them. Note addition of "upgrading," per regulatory case proceedings.

17. Text amended.

18. The comment is deemed appropriate by staff. This impact is due to cumulative geothermal development, rather than the SMUDGEO #1 project exclusively. Nevertheless, by law such an impact must be identified in the environmental study, and mitigation measures proposed. Implementation of

the buffer zone will likely be through cooperative regional planning efforts, possibly as an outcome of the pending CEC generic cumulative impacts assessment studies. Once the generic studies are complete SMUD and all other geothermal developers will be invited to participate in the hearings. The text will remain unchanged.

19. Text amended.

20. Yes, text amended.

21. Text amended.

22. Text amended.

23. Text amended.

24. The wording in this section has been amended to reflect the dual level approach. See amended text.

25. The summary report is expected in February 1981; text amended accordingly.

26. See amended text.

27. See amended text.

28. See amended text.

29. Text amended.

30. Text amended.

31. No change in text. The source water for the spring has not been identified. SMUD will monitor the area of the spring on Calm Creek for potential impacts.

32. See amended text.

33. Black bears were sighted near the leasehold in 1977 (see AFC, p. 5 - 73). No change in text.

34. No change in text. SMUD will monitor the Purple Martin nesting area (CEC SMUDGEO # 1 Regulatory Proceeding, Biology, Finding #14).

35. No change in text. SMUD will monitor water quality and flow in Calm Creek near the spring (Finding 14).

36. See amended text.

37. See amended text.

38. No comment or amendment necessary.

39. See amended text.

40. See amended text.

41. See amended text.

42. Text amended.

43. Text amended.

44. Text amended.

45. Figure amended.

46. Text amended.

47. Text amended.

48. See amended text.

49. Text amended.

50. See deletion in text.

51. Text amended.

52. See amended text.

53. See amended text.

54. See minor change in text.

55. Text amended.

56. See deletions and changes in text. To summarize, the inclusion of the
57. requirements originially listed in the Draft JES is not warranted. Page
58. 108 has been deleted and replaced with requirements which were mutually
agreed to by CEC staff and SMUD.

59. Text deleted.

60. Reference amended into text.

61. See amended figure numbers.

62. It is not clear to the staff that a cost/benefit analysis is legally required. NSCAPCD and ARB have determined that a 5 lb/hr emission rate constitutes BACT (see ARB letter from Harmon Wong-Woo to William C. Walbridge, dated August 26, 1980). SMUD estimated the cost of BACT for SMUDGEO # 1 facility to be approximately $2.9 million over the life of the plant (SMUD letter, W.S. Boxxenmaier to Michael Tolmasoff, dated November 17, 1980).

63. CEC staff agrees with comment; however, the turbine bypass and throttle back are discussed in the mitigations (on page 129) to the impacts discussed on page 128 of the Draft JES. No change in text.

64. The information provided was obtained from SMUD; see response to second section of interrogatories (SMUD letter to Ms. Pam Patterson from John Mattimoe, dated June 3, 1980).

65. See Appendix C. The steam composition and emission characteristics of geothermal power plants are currently very uncertain. Thus, staff recommends that power plant operators monitor incoming steam and perform mass balance studies (see changes for Mitigation Measures, page 147 of Draft JES).

66. See Draft JES, p. 136, paragraph 2, and p. 137, paragraph 2.

67. CEC staff has recommended that the Applicant perform mass balance studies for arsenic and mercury (see p. 147, paragraph 4). Sampling for the proposed mass balance calculations for mercury and arsenic should be performed twice during the second year of commercial operation. Samples should be collected from incoming steam, condensate, noncondensible gas to the Stretford and cooling tower, Stretford solution, cooling tower emissions and blowdown, and cooling tower sludge. Mass balance calculations should quantify the emission rate of all incoming mercury and arsenic leaving the power plant; SMUD should prepare a report on the sampling and mass balance calculations, including a discussion of assumptions and a statistical analysis, and forward this to the Compliance Audit Manager per Health Compliance Monitoring Program requirements. Based on a conversation with Dave Robertson of Pacific Northwest Laboratories, Batelle Memorial Institute (January 16, 1981), today's cost for this program's sampling and data analysis would be roughly $30,000. This is equivalent to approximately 0.05 percent of the construction cost for the entire project.

    The contaminants listed in the Draft JES are of concern because they can be cumulative toxins and possibly carcinogens. Hence, a small concentration of contaminant in a large quantity of steam can result in the movement of potentially significant quantities of these substances through the facility and into the environment via cooling tower emissions or waste discharges. In another study by Pacific Northwest Laboratories, soils in the vicinity of The Geysers power plants were found to be contaminated with mercury.

    When the SMUDGEO #1 facility becomes operational, it is reasonable to assume that monitoring and sampling techniques will have advanced past the 1979 stage of development. This will serve to reduce some of the complexities alluded to by the SMUD analysis. Sampling and mass balance calculations after the facility becomes operational will reduce current uncertainties regarding the concentration of contaminants in SMUDGEO steam, the configuration of plant generation and pollution abatement equipment, and the partitioning of steam contaminants within the facility. Results of sampling at PGandE and DWR facilities are not directly applicable to SMUDGEO, due to differences in steam source (hence, contaminant concentrations) and plant configurations. Confirmation of low levels of pollutant emissions and resultant impacts on ambient concentrations in populated areas will validate the conclusions based on necessary assumptions and calculations arrived at during this proceeding, to wit, that the operation of the proposed facility will not pose a threat to public health.

However, given a certain conservation of mass, contaminants in the steam not released through the cooling tower will be emitted elsewhere, such as process liquid and solid chemical and waste streams, or even condensation or deposition on the components of the generation system. Over time, accumulation of significant quantities of some trace substances could pose environmental (e.g., waste disposal) or occupational health and safety risks. Adequate sampling and mass balance calculations can serve to identify potential problems before the fact so that adequate measures can be taken to prevent environmental degradation or worker health risks.

In a submittal dated December 24, 1980 (received at CEC December 23, 1980), SMUD presented a draft copy of a brief annual report article by P.E. Robertson et al. of the Pacific Northwest Laboratories, Battelle Memorial Institute. It apparently had been sent to PGandE on November 19, 1979. SMUD also submitted an authorless analysis of this article and an alternative table of emission rates for steam contaminants. CEC staff analyzed the draft and final versions of the Battelle article in preparing the SMUDGEO #1 Draft JES Public Health section. Contrary to the conclusions reached in the SMUD analysis, the Battelle article, albeit out-of-date, provides justification for conducting additional monitoring and mass balance calculations for the SMUDGEO facility when it becomes operational.

The Battelle report does indeed indicate the complexity of monitoring and calculating the flow of steam contaminants through a geothermal facility (particularly as of 1979). However, the report also indicates the large variation of concentrations of trace contaminants in steam throughout the developed portions of the KGRA and even, with time, in a given steam source. In addition, the possible trapping of certain contaminants in different H_2S abatement process streams or the addition of trace contaminants into the plant environment by certain abatement process chemicals (e.g., mercury) is also stated.

Given current factual uncertainties relating to the potential for significant public and occupational health risks, two regulatory strategies are possible. Approval of the SMUDGEO facility could be delayed until more information is available from monitoring and mass balance studies on existing facilities, and PGandE and DWR facilities are approved by the CEC. Or uncertainties in current knowledge can be recognized as cause to move ahead prudently, incorporating means of reducing uncertainties and confirming assumptions along the way. CEC staff suggests the second approach.

68. Text amended.

69. Text amended.

70. See responses to SMUD's comments numbers 9 and 12 - 15.

71. Text amended.

72. See amended text.

73. Reference to "unpaved" access roads deleted.

74. See glossary addition.

75. The potential impact of this geothermal power plant without mitigation measures to prevent a direct discharge to surface waters of undiluted toxic/hazardous wastes or materials is definitely very significant. Through negotiation of adequate and proper mitigation measures, whether suggested by SMUD, CEC, or others, this potential problem can be rendered insignificant. This is the purpose of the matrix--to identify significant areas of concern, areas to be covered in the text of the environmental impact document.

76. Comment noted; see changed text.

77. See reponse to SMUD comment #65.

78. Text amended.

79. Since this comment was made, the actual value has been established. See revised text.

80. See amended text.

81. See amended text.

82. Proposed deletion accepted. See amended text.

83. The method used in calculating SMUD's systemwide generation cost is shown below:

    1. 1983 and 2000 SMUD average electricity prices were taken from the attached sheet. The source is "CEC Staff Forecast Revision Subsequent to Biennial Report Demand Hearings," September 22, 1980.

    2. Residential 1983 - 2010 growth was calculated to be 65 percent/year.

    3. GNP deflator 1983 - 2110 = 6.9 percent/year.

    4. Total escalation rate = 6.9 + 1.9 = 8.8 percent/year.

    It was assumed that the rate of increase is similar for each sector. Applying the total 8.8 percent/year increase plus a 15 percent discount rate to a mid-1983 system cost of 1.81¢/kWh (1977$) or (3.04¢/kWh in 1983$), the levelized cost is 3.04 x 2.166 (level, factor) = 6.6¢/kWh. Therefore, the paragraph will remain the same.

84. Text amended accordingly.

85. Text appears to be clear enough as is. Text unchanged.

86. See amended text.

87. Text amended.

88. The difference in area disturbed using 72 MW versus 55 MW amounts to only 8 acres, which is only .4 percent of the developed area and is considered insignificant. Moreover, the acres-to-MW ratio is used for estimation only. Text unchanged.

89. See response to comment #88.

90. See amended text.

91. See amended text, which is based on Biology Finding #14, SMUDGEO # 1 regulatory proceeding.

92. See response to comment # 18. Text unchanged.

93. Comment accepted. See amended text.

94. Typo corrected, thanks.

95. Paragraph deleted. The Draft JES was issued in November and therefore could not reflect SMUD's December submittal.

96. SMUDGEO #1 Stretford supplier, Peabody, duly credited in revised text.

97. See amended text.

98. Text revised.

99. Comment noted; see Draft JES Appendix C, also response to SMUD's comment.

100. See Appendix C; also CEC staff response to SMUD's comment #67.

101. Text amended.

102. Test unchanged. It indicates that alternative C is slightly longer than A.

103. Reference to schedule delays deleted.

104. Correction made in text.

105. Figure is now labeled #32.

106. Correction made in text.

107. See minor changes in text.

108. Text amended accordingly.

109. Requested clarification added to text. See amendments.

110. See response to comment #88. Text unchanged.

111. The estimate of 56 acres is based on Figure 8 of the AFC (p. 5 - 76); the MW of the power plant were not used to determine this value (see Draft JES, p. 17, vegetation, losses related to construction). Based on SMUD comments on p. 23, the power plant acreage is 10.5, not 8.8 acres. Therefore, the estimate of acreage loss should be increased by 1.7 acres to 57.4 acres (55.7 acres plus 1.7 acres).

112. Text corrected.

113. See response to comment #111. Total vegetation loss should be corrected to an estimated 57.4 acres.

114. Typo corrected.

115. Typo corrected.

116. See amended text.

117. Comment refuted, although this portion of the text has been amended. See response to comment #111.

118. See amended text.

80-AFC-1

ENERGY COMMISSION
RECEIVED

JAN 5 1981

JAMES P. BOTZ
County Counsel
County of Sonoma
2555 Mendocino Avenue #116A
Santa Rosa, California 95401
Telephone: 707-527-2421

Attorney for Petitioner

STATE OF CALIFORNIA

ENERGY RESOURCES CONSERVATION

AND DEVELOPMENT COMMISSION

In the Matter of the

SMUDGEO #1

Application for Certification /

Docket No. 80-AFC-1

INTERVENOR'S COMMENTS TO DRAFT EIR

Intervenor COUNTY OF SONOMA submits the following comments to the draft State/Federal Joint Environmental Study (hereinafter DEIR), dated November, 1980:

1. DEIR is inadequate in that it concludes without supporting data that the public roads that would provide access to the project site are adequate for traffic generated by the project (see DEIR pp. 64 and 159). The major Sonoma County access to the project site is the Healdsburg-Geysers road which is inadequate for truck traffic of the type and quantity to be generated by the project.

The Healdsburg-Geysers road was originally designed and in its current condition is adequate only for light passenger vehicle traffic and occasional agricultural equipment. The one bridge structure on the Healdsburg-Geysers road is inadequate for heavy loads required by the project without temporary shoring. The DEIR reaches no conclusion nor provides any analysis of the capacity of the Healdsburg-Geysers road with respect to heavy loads, road width, turning radii, or site distances. Nor does the DEIR analyse the safety of the road with respect to a mix of multi-axle vehicles and passenger vehicles under various weather conditions.

2. The DEIR is inadequate in that it does not recommend mitigation by SMUD of the impact of the project on the Healdsburg-Geysers road, but only states as a possibility that SMUD may reach agreement with the County of Sonoma with respect to such impact. The DEIR, having identified a mitigatable impact, must propose mandatory solutions.

3. With respect to workers' health and safety (see p.148) the DEIR neither raises the issue nor resolves the question of industrial safety of SMUD's workers or SMUD's contractor workers with respect to emergency medical and evacuation service.

4. The discussion of the loss of public use of the Bureau of Land Management land in connection with the project is vague with respect to public access and joint use and refers to "other land uses [being] precluded" (see p. 60-69). The DEIR should be more specific with respect to the impact of the project on current public access and rights to the Bureau of Land Management property in question.

5. With respect to the disposal of hazardous waste

(see pp. 74-79) the DEIR correctly states that the project will generate hazardous wastes in the form of sludge, but is nonspecific with respect to the method of removal of such waste. The DEIR recites SMUD's intention to contract with private disposal sites, but does not provide any assurance that such contracts will be executed nor does the DEIR investigate the problems with respect to alternative sites should SMUD be unable to dispose at the named sites.

6. The DEIR does not adequately examine the cumulative effect of the project on the need generated by the project for public services. For instance, the DEIR is conclusionary with respect to the ability of the private housing market in the Healdsburg area to provide adequate housing for construction workers. The DEIR must identify cumulative impacts of this project and future similar projects at the Geysers for the purpose of mitigation. Intervenor has and will suggest to the Commission that it retain jurisdiction of the certification of this project so that when such cumulative effects are identified appropriate mitigation measures can be imposed on SMUD and other Commission permittees.

7. The DEIR is silent with respect to the growth-inducing impact of the project on SMUD's service area.

8. The DEIR should identify the impacts on local governmental agencies because of SMUD's tax-exempt status and require appropriate mitigation measures.

DATED: December 24, 1980.

James P. Botz

JAMES P. BOTZ, County Counsel
Attorney for Petitioner/
Intervenor

RESPONSE TO SONOMA COUNTY'S COMMENTS

1. The entire Transportation section of the JES has been revised in order to better address both Sonoma and Lake County's concerns. See amended sections.

2. See mitigation measures of amended text.

3. In the event of an emergency, SMUD or SMUD's contractors can call the county to trigger the county's emergency response procedure. Within the CEC SMUDGEO #1 regulatory proceeding, SMUD has agreed to reimburse the county should the use of emergency medical and evacuation service be necessary. Minor amendment to text.

4. See response to Sonoma comment #1 above. Text amended with respect to access. The use of this leasehold for the purposes of geothermal development is consistent with both the Federal Land Policy and Management Act of 1976 and with the Sonoma County General Plan for nearby lands. Note Land Use/Impacts section for discussion of recreational losses. Land Use section of text unchanged.

5. The Draft JES discusses the method of waste removal on p. 77. No change in the text is necessary.

   Regarding the county's concern that SMUD execute the necessary waste disposal contracts--CEC will not allow SMUDGEO #1 to operate if SMUD defaults in this matter. The postcertification compliance monitoring program will ensure that SMUD properly disposes their hazardous wastes.

6. Cumulative growth in Sonoma County is covered on DJES pp. 161 - 162. Staff believes this is sufficient given the current information.

7. County growth is a cause of, rather than a result of, electricity demand growth. There is no evidence which indicates that the facility would promote growth in the SMUD service area. County growth is subject to policies of the Board of Supervisors and is hence subject to CEQA review through their auspices.

8. The DEIR already specifies probable AB 1905 revenues. No more specific estimates of public service costs are currently available, and the document clearly states that relief from property taxation will not occur. Mitigation is provided for under the "agreement for compensation" mitigation item.

MEMO

DATE: January 5, 1981
TO: Ms. Karen Mathies
FROM: Michael Tolmasoff, No. Sonoma. Co. A.P.C.D.
SUBJECT: Comments on Draft J.E.S. (SMUDGEO #1 80-AFC-1)

DOCKET 80-AFC-1
DATE: JAN 5 1981
RECD: JAN 6 1981

Below are the District comments of the draft J.E.S.:

	PAGE	PARAGRAPH	COMMENT
1.	iii	Air Quality	Concur with incremental impact statement.
2.	84	first	Downwash can also occur in Spring/Summer time. (refer to SRI data analysis).
3.	89	d. Fumigation	The District consultant in the U. 18 AFC proceeding indicated fumigation was also possible in the afternoon because of valley-shadow induced circulation.
4.	92	first	Figures 18 and 19 don't reflect all the H_2S exceeds because it only considered 30 ppb and greater (not ≥ 25 ppb H_2S).
5.	101	second	Don't you mean the turbine bypass will reduce stacking occuring.
6.	102	footnote (5)	Is there enough NH_3 to produce are the $(NH_4)_2SO_4$ assumed?
7.	105	mitigation measures	Shouldn't statement say SMUD would also have to comply with future emission standards (see footnote #10 in rule 455b)?

RESPONSES TO NSCAPCO'S COMMENTS

1. No response necessary.
2. Text amended accordingly.
3. Text amended accordingly.
4. Text amended accordingly.
5. Concur. Text amended.
6. The text has been amended to explain the assumption.
7. Concur. Text amended.

Alton Winter
Anderson Springs Annex
Middletown, Calif, 95461

R/E SMUDGO # 1 Geothermal Power Plant
Sonoma County, November 1980.
State/Federal Joint Environmental Study

80-AFC-1

ENERGY COMMISSION
RECEIVED
JAN 5 1981

To: Valerie Campbell
CEC, 111 Howe Aveneue, MS-32
Sacramento, Calif, 95825

1. Page 24, 3rd Paragraph: Drift rate loss of .001% of 125,000 gal per minute circulating water mass or 1.25 gpm..... compared with
Page 41, 1st para: Drift, averaging about 625 lbs/ hour (AFC 5.3.1.2.) .001% of circulating water is emitted as Drift? " Some disagreement here "

2. Page 44, Table 3 a significant amount of Silica for Big Sulphur Creek!

3. Page 90 Calif Ambient Air Quality Standard (TSP) of 100 ug/M3 averaged over 24 hours

4. Page 99 Radon: Most of Radon passes through steam pipelines into power plant and out off-gas ejectors. " and Cooling Towers is more correct "
Ambient Air Standard of 3 PCi/Liter? (If daugthers are not present)
Question the conclusion of no evidence of accumulation of Radium 226 or Lead 210.
Variability of normal soil samples is so vast that from JUST taking a soil sample will not warrant such a conclusion. Ambient Air would need to be sampled for Lead 210 etc., to make such a <u>determination</u>.

5. Page 101: Particulates & Quantities: 5th Paragraph
The amount of particulates entering the plant is expected to be less than 3 lbs/hr.
" this is probably wrong by a factor of at least a hundred"
The condensate will eventually pass into the cooling tower where part of the particulates will be released into atmosphere in the form of drift.????
Defininition of drift needs clarifying...Here it pertains apparently to the escape of water droplets into the atmosphere AND particulates entrained in the water droplets. But does the manufacturer's specification's Meant to include particulates? In a response to interrogatories for Unit 16, it was stated that particles less than 50 microns was NOT measured. Particulates of respirable size are not easily 'washed out'.

6. Page 102 The Plant's total particulate emissions will be approximately 3.5 lbs/hr.
which includes 0.8 lbs/hr from main cooling tower and 2.6 lbs/hr from Stretford cooling tower etc....
Total concentration of all solids in steam condensate is 38 ppm
Steam condensate flow is 983,000 lbs/hr
Drift rate is .001% of hot water flow rate
Hot water flow rate is 139,260 gpm
" missing is sizes of the particulates on the most important item" _ 60% of the particudtes would be 75 micron in diatter or less and if those smaller than 50 microns are not measured, then obviously these assumptions are not valid.

7. Page 128 para 6 In contrast to the 100 ug/M3 (24-hour average) ambient air quality standard for TSP, the impact from SMUDGEO #1 appears insignificant.

8. Page 129 Prevention of Significant Deterioration (PSD)
The proposed project is located in an area presently designated as Class II.
Under PSD regulations, the maximum permissable deterioration in ambient ~~at~~ particulate levels in a Class II area is 37 ug/M3 (24 hour averaging time).
" Page 129 is in confusion with other quotes of 100 ug/M3 for TSP" Agreement needs to be shown.

9. Page 135 Suspended particulate matter??? What about the Class II area?

10. Page 141, par 6 222 Rn Cumulative effect downwind---Presently NO program for monitoring downwind.

If 16.2 PCI/Kg steam is extended for power plants 1 thru 18, NCPA 1 & 2, CCPR 1 & 2, Smud Geo, the daily emission rate would jump to about 5 Curies a day! Presently in 1980, it is about 1.6 Curies a day. When 5 Curies a day is multiplied out for at least 35 years, the amount is Tremendous!

11. Page 240 222Rn Insignificant! see attachment # 1. If the emissions may at times exceed the California emissions Standard, How can 222Rn then be insignificant? Also it says the workers doses may be controlled by the amount of time spent in the affec affected area?? Believe that this in rexlation to deposition of daughter products that emitted Gamma rays, rather than 222Rn Gas! This is also PROOF that Daughters of Radon are indeed present and that the standard then should be 1 Pico Curie Rather than 3 pico Curies per liter.

12. Page 246 Radon 222 222Rn and its daughter products remain in the cooling tower sludge, in the steam condensate released to the atmosphere from the cooling tower, or at various locations with the workings of the plant itself (steam exhaust ducts & condensers). If this paragraph is correct, then NONE of these locations are presently

being monitored. The Daughters are filtered OFF and NOT Counted! At the present PG & E ONLY monitors the Off-Gases for Radon. and so far hasn't considered that Radon Will be entrained in the Water flow

The last paragraph on page 246 contains numbers of misleading statements that are probably not intended to be...

" the primary health hazard associated with 222Rn and its short lived daughter products is inhalation and possible deposition in the lung." Two of the daughters are Lead 210 (22 years) and Polonium 210 (138.4 days) and I would not call them short-lived!

Pohl-Ruling and Scheminzky Badgastein Austria

Changing the whole paragraph around to one more correct....

The primary radiation burden is caused mainly by the inhalation of Radon-222 and its short-lived daughters. The contribution of Radon-220 (Thoron) and Lead 212 (daughter of Thoron) as well as of Lead 210 and Polonium 210 is small

The decay products of Radon 222 or 220, which are always simultaneoulsly present with their parents in the air inhaled, are filtered off in the respiratory tract, resulting in an increased dose especially in the lungs and basal cells of the bronchias. Experiments showed that part of the decay products deposited in the lungs were directly absorbed by the blood and transported to all the organs and tissues. As the solid decay-products participate in the metabolism according to their chemical properties, they are accumulated in the various organs in quite different concentrations.

Dose Rates in MRem/ yr for continous inhalation (7300 M3/yr) of Air containing 1 pCi/liter in Equilibrium several Isotopic chains.

Organ/ Tissue	Radon 222 Polonium 214	Radon 220 Polonium 216	Lead 212 Thallium 208
Lungs, alveolar	149	4.4	1930
Blood, all influences	15	.68	350
Liver	8.8	.13	220
Kidneys	34	.25	526
Adrenal glands	63	.11	53
Gonads	2.2	.02	9
Bone marrow	4.2	.11	153
Muscles	2.0	.012	10
Bones	2.8	.078	66

Blood all influences include all the additional dose received by the blood on its way through the lungs.

The lung doses given here are the mean doses for the entire lungs according to our measurements. These are also the estimated values for the alveolar tissues. It is known, however that the basal cells of the bronchias get much larger does.

From the Chart it can be seen that of a single organ affected it is the lungs, but collectively the other organs make up an equal amount Note also the amount from Lead 212 and Thallium 208 daughters of Rn 220 (Thoron) and ignored almost totally.

Note also that the Noble Gas Rn222 may enter the blood stream as easily as oxygen and does NOT inhale and exhale without deposition as purported. The Particulates ALSO enter the blood stream.

13. Page 248 Arsenic

Vanadium Exposure to excessive concentrations of Vanadium can result in - - - - - - Actually Vanadium is as Toxic as Arsenic

Arsenic	TLV	ACGIH	50 ug/M3	8 Hours
Vanadium	TLV	ACGIH	.5 Mg/M3	8 hours

And if the more finer particles of mists are considered .1 mg/M3 for 8 hours. Suggest standardization of mg/M3 or ug/M3. .5 mg/M3 is the same as 50 ug/M3, but one seems to be a smaller amount.

Radon 220 is part of the radiation burden also
Of the particulates emitted, How much will be of Vanadium?

Alton Minter
Alton Minter
Anderson Springs Annex
Middletown, Calif, 95461

RESPONSES TO ALTON MINTER

1. There is no substantial difference between the drift rate values of 1.25 gpm and 625 lbs/hr.

   The drift rate is 75.00 gallons per hour (1.25 gpm x 60 min. = 25 gph). Using 3.34 lb/gal as the weight of water, the rate would be 625.5 lbs/hr (8.34 lbs/gal x 75 gph = 625.5 lbs/hr).

2. Silica, one of the most common substances found in nature, is part of the chemical make-up of sand, is inert, and is naturally abundant to the area.

3. Comment noted.

4. Text amended in part; however, see Draft JES, p. 147, paragraph 2 and p. 246, paragraph 7. Lead-210 decays very slowly and does not emit alpha particles, although some of its decay products do. Thus, the short-lived daughters are the most important source of alpha particle exposure.

5. Although there are uncertainties in the particulate emissions, it is the staff's opinion that the estimated emissions are valid. Manufacturer's drift specifications are meant to include particulates.

6. Assumptions are valid. Particulate size distribution is not known. See Public Health section for discussion of potential impact.

7. Comment noted.

8. The ambient air quality standards for TSP (100 ug/M3) were established to protect public health. PSD regulations were established in order to ensure attainment and maintenance of ambient air quality standards. These statements are in agreement because they do not discuss the same standards.

9. See Draft JES, Air Quality, page 108, paragraphs 4 - 6. Text unchanged.

10. See Draft JES, p. 147, paragraph 2. Text unchanged.

11. See Draft JES, p. 239, item B. The applicable emission standard in this case is 3 pCi/1, since radon-222 daughters are removed by the Stretford process and not emitted from the cooling tower [personal communication with Erik Vold, DOHS/RHS, (916) 323-2750. January 25, 1980].

12. See response to your comment #4. Measurements of radon-222 and its daughters will also provide an indication of possible soil and water contamination.

    Staff is not aware of the Austrian study cited. However, radon-222 is considered to be a far more important source of natural radiation exposure than radon-220 (U.S. Radiation Policy Council Task Force, Position Paper on Radon in Structures, August 15, 1980).

Staff is also not aware of studies reporting any uptake of radon-222 by the bloodstream. Translocation of inhaled daughter products to the intestinal tract via mucous transport, however, has been suggested as a minor route of exposure to radioactivity relative to deposition of daughter products in the more sensitive broncheal tissues (United Nations, Sources and Effects of Ionizing Radiation, Report of the United Nations Scientific Committee on the Effects of Atomic Radiation, 1977 Report of the General Assembly, United Nations Publication E.77.IX.I, U.N. Publications, NY, NY).

13. See Draft JES, pages 138 - 139, Table 20 and page 142, Table 21. Notice that mg/m^3 is used throughout in Table 21.

Radon-222 appears to be a very minor part of exposure to natural radiation.

A worst-case estimate of vanadium emission rates is presented in Table 21.

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
WESTERN REGION
P. O. BOX 92007, WORLDWAY POSTAL CENTER
LOS ANGELES, CALIFORNIA 90009

NOV 28 1980

Ms. Valerie Campbell
California Energy Commission
1111 Howe Avenue, MS-32
Sacramento, California 95825

Dear Ms. Campbell:

The Federal Aviation Administration has completed its review of the Draft Joint Environmental Study on the Sacramento Municipal Utility District's proposed SMUDGED #1 geothermal power plant at the Geysers Known Geothermal Resource Area.

Our only comment at this time is that any new construction or alterations to structures meeting notice requirements under Federal Aviation Regulation Part 77 will require filing of FAA Form 7460-1 prior to such construction.

Thank you for the opportunity to review and comment on this proposal.

Sincerely,

L. Yvonne Gibson

For Royal W. Mink
Regional Planning and Appraisal Officer

RESPONSE TO DEPARTMENT OF TRANSPORTATION, F.A.A. Comment and requirement noted. No response necessary.

AUTHORS

EIR Coordinator	Valerie Campbell
Legal Counsel	Gregg Wheatland Mark Urban
Geology	Kent Murray
Seismology	Gaylon Lee
Biology	Jim Brownell
Water Quality	Lloyd Dillon
Hydrology	Larry Chee Lloyd Dillon
Noise	Rick Buell
Cultural Resources	Gary Heath
Land Use	Bill Reany
Aesthetics	Bill Reany
Transportation	Marco Farro
Waste Management	Martin Homec
Air Quality	Rick Buell/Bill Nokes
Public Health and Safety	Tom Phillips
Growth Inducing Impacts/Socioeconomics	Bill Reany
Transmission Line Engineering	Joel Klein
Transmission Line - Health and Safety	Al McCuen
Systems Engineering	Rick Buell/Rich Kishi
Reliability/Worker Safety	Darrel Woo
Soils	Marco Farro
Overall Assistance and Coordination	Ralph Kimmel (USGS) LeRoy Mohorich (USGS) Al Bellon (BLM)

Clerical Support: Nancy Baker
Cindy Johnson
Barbara Romanini