MASTER

Comprehensive Air Monitoring Plan for the Geysers Geothermal Region of California

CONSULTANT REPORT

June 1980

California Energy Commission
P500-80-030

9512462

G.R.I.P.S. COMMISSION

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COMPREHENSIVE AIR MONITORING PLAN

GENERAL MONITORING

REPORT

MARCH 31, 1980

PREPARED UNDER CONTRACT WITH

CALIFORNIA ENERGY COMMISSION

Contract #500-068(8/9)

Cal. Energy Comm.
950 8632

Geothermal Research, Information and Planning Services / A California Joint Powers Agency

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ABSTRACT

The Comprehensive Air Monitoring Plan (CAMP) Report provides recommendations for general monitoring of hydrogen sulfide (H_2S) in ambient air in parts of Colusa, Lake, Mendocino, Napa and Sonoma counties potentially impacted by emissions from geothermal development projects in The Geysers-Calistoga Known Geothermal Resource Area. The report was prepared by GRIPS Commission consultants with assistance from a Project Coordinating Committee representing the concerned local, state and federal regulatory agencies, geothermal steam producers and power plant operators.

Recommendations for types, placement, performance guidelines, and criteria and procedures for triggering establishment and termination of CAMP monitoring equipment were determined after examination of four factors: population location; emission sources; meteorological considerations; and data needs of permitting agencies and applicants. Three alternate financial plans were developed.

Locations and equipment for immediate installation are recommended for: two air quality stations in communities where the State ambient air quality standard for H_2S has been exceeded; three air quality "trend" stations to monitor progress in reduction of H_2S emissions; two meteorological observation stations to monitor synoptic wind flow over the area; and one acoustic radar and one rawinsonde station to monitor air inversions which limit the depth of the mixing layer.

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EXECUTIVE SUMMARY

The Geothermal Research, Information and Planning Services (GRIPS) Commission is a focal point for data collection and for sharing of information on the local, state and federal levels regarding geothermal development in the Geysers-Calistoga KGRA. In March, 1979, the GRIPS Commission approved the submission of a proposal to the California Energy Commission (CEC) for funding the development of a Comprehensive Air Monitoring Plan for those parts of Colusa, Lake, Mendocino, Napa and Sonoma counties potentially impacted by emissions from geothermal development in the KGRA during the next five years. The proposal was accepted and approved by the CEC in mid-June, 1979. During July, a Project Coordinator was appointed and by August 1, 1979, the Work Plan had been approved.

The goal of the Comprehensive Air Monitoring Plan (CAMP) was to establish recommendations for monitoring requirements and allocation of monitoring costs. Suggested sites are oriented toward the monitoring of ambient air characteristics and not toward site-specific requirements for new source review. CAMP monitoring locations will only reinforce and supplement site-specific monitoring activities.

At the beginning of the program, a Project Coordinating Committee was established to provide guidance by those concerned with air quality issues in the area. The Committee included representatives from the Northern Sonoma County and Lake County Air Pollution Control Districts, California Air Resources Board, California Energy Commission, Bureau of Land Management, other state and federal agencies, geothermal steam producers and power plant operators.

The Report begins by describing the topography of the CAMP Study Area, climate, and air pollution meteorology. In general, the introductory descriptive material emphasizes the unique status of the Study Area as one of unusual and complex terrain. Much effort was made in the past to describe transport and diffusion in the known area of geothermal resources in Sonoma and Lake counties. The Plan has referenced previous, significant air quality studies. It was noted that most of these studies were site-specific and not truly oriented toward monitoring data over a wide area or characterizing the local weather.

Establishment of the factors which would influence placement of air quality monitoring equipment required study in depth and analyses of the Study Area, population distribution, emission sources and meteorological characteristics.

The population analysis indicated limited growth during the next ten years in the CAMP Study Area. No new population centers are expected to emerge which would create new and unusally large receptor areas where geothermal development is projected. The principal value of the population analysis was the locating of population centers within the CAMP Study Area. Population projections based upon state and federal census data provided the Plan with an insight into where future geothermal power developments might have an impact.

Analysis of emission sources (current and projected) included a presentation of the types of emissions and their impact on the Study Area population (receptors). Pollutants addressed were methane, hydrogen sulfide, ammonia, nitrogen, hydrogen, and ethane. The general conclusion was drawn that, of the noncondensable gases emitted and considered to be regulated pollutants, hydrogen sulfide was the only one for which monitoring would be recommended. It was recognized that among particulates emitted at the Permitted Geothermal Facilities (PGFs), boron has sufficient potential to bear observations. However, studies of the effects of boron on vegetation which are currently underway show that the impacts of boron particulates in the emissions appear to be limited to the immediate area of the PGFs. Consequently, no recommendations have been made for monitoring of this pollutant at this time.

Recommendations for types, placement, performance guidelines, and the procedures for establishment and termination of the CAMP monitoring equipment were determined by examination of four major areas of interest and concern. These areas included population location and emission sources, both current and projected. In addition, meteorological considerations, both from the standpoint of climatological and topographic influence had to be weighed in the development of the recommendations. Finally, the data needs of permit applicants, local Air Pollution Control Districts, concerned state and federal agencies, and modelers had to be considered.

Seven air quality stations are recommended, including two mobile stations. In addition, two of a proposed seven meteorological stations are recommended for immediate installation with final determination on the remaining five being dependent on analysis of the data from the discontinued Lake County eighteen-station meteorological system. The recommended stations will observe wind speed, wind direction and temperature.

The report includes triggering mechanisms which are a part of an orderly and clearly defined process for justifying the establishment of monitoring stations recommended herein as well as for future monitoring stations. In addition, procedures are recommended which would govern the termination of stations when their existance is no longer justified.

Meteorological data are used to determine pollutant sources and transport, and are required for air quality modeling. Data are also used in forecasting short-term episodes and for interpreting trends over a multi-year period.

Because knowledge of the boundary layer over the CAMP Study Area has been lacking, further recommendations include an acoustic radar for morning soundings, and a rawinsonde for afternoon soundings during six months of the year. These meteorological soundings will provide much needed data on the temperature and air movement from the ground up to 1,000 meters (approximately 3,000 feet). Meteorological instrumentation to be chosen for the CAMP should provide data which must meet high quality standards (NRC 1.23, EPA/PSD) or forthcoming California Air Resources Board (ARB) standards.

Completion of the technical review established that the need for air quality monitoring activities during the next five years will probably be limited to areas of Lake and Sonoma counties. The monitoring program has been designed to meet that need. There was no information developed during the study which suggested that populations in the parts of Colusa, Mendocino and Napa counties located in the Study Area would be impacted by current or projected development in the Geysers-Calistoga KGRA.

Development of alternate financial plans for the project involved consideration of various rationales and premises on which an allocation of financial responsibility could be placed. Potential sources of funds and possible contributors suggested by these rationales were analyzed. Two of the three alternative financial plans provide for the local APCDs to share financial responsibility with the industry and the third plan assigns total financial responsibility to the industry.

A major role for industry in financing the program is recognized. A method was developed for allocating that share of the costs which may be assigned to industry based on their level of contributions to air emissions. It is noted that the funding program developed herein does not provide for the costs of establishment of site-specific monitoring stations since location and funding of such stations will be worked out between various applicants and regulatory agencies.

The primary responsibility of the local Air Pollution Control Districts in the subject of air quality was acknowledged. This provided the basis for development of a suggested method for the public agencies to share cost responsibilities based on the relationship between emissions and those places and people impacted by the emissions.

Three viable alternate financial plans were developed, each incorporating a projection of costs over the first three years of the CAMP. Initiation of the program will be dependent upon early action by the decision-making agencies in selecting an appropriate financing plan and taking the steps necessary to carry the program into operation. It is recommended that the local Air Pollution Control Districts give strong consideration to raising permit fees to support at least part of the CAMP.

COMPREHENSIVE AIR MONITORING PLAN

1. INTRODUCTION

The Geothermal Research, Information and Planning Services (GRIPS) Commission is a focal point for data collection and for the sharing of information on the local, state and federal levels. Approval of a Joint Powers Agreement, which established the GRIPS Commission, required dealing with twenty elected County Supervisors, four County Administrators, four County Councils and eight staff members, and has received a unanimous vote in all counties. Implementation provided a means for co-funding needed environmental and technological studies by regulatory agencies, utilities and developers, without conflict of interest or anti-trust issues being raised. GRIPS provides a focus for an interagency effort to obtain environmental data and analysis needed for timely permit decisions and a focal point for federal and state activities' support in the Known Geothermal Resource Area (KGRA).

The Geysers-Calistoga KGRA has a potential for geothermal power generated many times the current 663 megawatts on-line; however, institutional and environmental issues may be the determining factors in the ultimate capacity of the region. Environmental considerations know no boundaries and are not constrained by them. County boundaries are official; environmental considerations simply cross them. Hydrogen sulfide also crosses them as do power lines and transmitting facilities.

There are a variety of approaches available to deal with these issues.

GRIPS, which encompasses the four counties which make up the KGRA, was formed to organize the existing environmental data base, identify gaps in that data base and to try to alleviate the gaps so identified. GRIPS is unique in that it is a voluntary association of the four local governmental entities attempting to address the issues that transcend their county boundaries with participation by both the state and a federal agency regulating this type of development.

1.1 History and Background of the Comprehensive Air Monitoring Plan

Late in 1978, the geothermal industry association, Geysers Geothermal Environmental Committee (GGEC) informed the Northern Sonoma County Air Pollution Control District (NSCAPCD) that the industry (utilities and developers) funding of the eight-station Stanford Research Institute (SRI) Air Monitoring Network would be discontinued early in 1979. The SRI network was originally proposed to be operated for two years only, and had already been extended for one full year at the request of the Districts.

After consultation with the administrators of the two affected APCDs, representatives of the steam producers, utility companies and members of the California Energy Commission (CEC) staff, a three element "package" was developed to deal with the planned expiration date. The package provided short-term monitoring from March to June 1, 1979, interim monitoring to June 30, 1980, and development of a comprehensive plan for monitoring beyond June 30, 1980. The industry agreed to provide for the cost of the short-term interim monitoring. In March, 1979, the GRIPS Commission approved the submission of a proposal for planning a Comprehensive Air Monitoring Plan to CEC for funding.

On May 9, 1979, the CEC approved its contract with GRIPS for a Comprehensive Air Monitoring Plan (CAMP) totaling $35,978 and the contract cleared the state control agencies on June 13.

On June 8, 1979, the Project Coordinating Committee, established in the proposed contract, met to discuss the role and scope of that Committee. At this time an Executive Committee was established. Committee membership is listed in Table 1-1. John T. Walser was subsequently selected to fill the position of CAMP Coordinator beginning the first week of July. On July 25, 1979, the Executive Committee approved the Work Plan for the program.

1.2 Purpose of CAMP

The goal of the Comprehensive Air Monitoring Plan is to establish a list of recommendations to serve as a basis for monitoring requirements and costs to be imposed in developing geothermal power resources. The reason for establishing this goal is that there is an ongoing air emissions problem which has not been satisfactorily mitigated. The Plan contains supporting information developed in its preparation and specific actions required by the concerned Air Pollution Control Districts and other agencies to carry out the Plan, projected costs and recommendations and/or specific actions, and a timetable for carrying out the Plan.

TABLE 1-1

COMPREHENSIVE AIR MONITORING PLAN
PROJECT COORDINATING COMMITTEE
FEBRUARY 1, 1980

Membership List

Name	Organization
Robert Maxwell	California Air Resources Board
*Jeff Anderson	California Energy Commission
David Hill	California Energy Commission
Larry Perry	California Department of Health Services
Linda Ferguson	California Division of Oil and Gas
*Robert Reynolds	Lake County Air Pollution Control District
Michael Tolmasoff	Northern Sonoma County Air Pollution Control District
*Warren Smith	Steam Suppliers (Union Oil)
*J. T. Holcombe	Steam Utility (Pacific Gas & Electric)
*Norm Ritchey	U. S. Bureau of Land Management
Cal Jackson	U. S. Department of Energy
Steve Body	U. S. Environmental Protection Agency

*Indicates Executive Committee

It is recognized that an air monitoring program must be planned to satisfy the needs for maintaining and supplementing existing air quality and meteorological monitoring networks. The available data must then be integrated and interpreted in the terms suitable for the requirements of environmental impact assessment, both for individual and cumulative analyses. Subsequently, using these data, air quality predictive models may be attempted which would permit the impact projection of potential releases at future development sites. Meteorological data are required for air quality modeling. Data are used to determine pollutant sources and transport. Meteorological data are also used in forecasting short-term episodes and for interpreting whether trends are desirable over a multiyear period.

The purpose of CAMP is to provide the guidance needed to establish a data base and general understanding needed so that individual developers and regulatory agencies will have sufficient information upon which to base sound development decisions. Particular attention has been given to those phases of CAMP whose immediate urgency is such that work must be carried out and preliminary information obtained during the first period of the program. In some cases, the relative importance of some of these phases may become more significant as additional knowledge of the area is gained during the first two years of the program.

1.3 Description of Study Area

The CAMP Study Area is an integral part of the North Coast and Lake County Air Basins which occupy the northwest corner of California. The two air basins extend for 400 kilometers from Sonoma County in the south to the Oregon border. The area is comprised of two major topographic units, the Klamath Mountains and the Coast Range provinces. Both provinces are marked by large areas of rugged mountainous terrain. Figure 1A is a vicinity map, showing the location of the CAMP Study Area in relation to principal towns and cities in a radius of 145 km.

Encompassing nearly two-thirds of the North Coast Air Basin, the Coast Range topographic unit is characterized by elongated northwest trending ridges and valleys. The mountains are not generally as high as in the Klamath region of the North Coast Basin, but the terrain has a more weathered and rounded appearance. The Lake County Air Basin lies entirely within the Coast Range province and constitutes one of the major terrain depressions of the region.

The Study Area lies in the folds of the California Coast Range on the west edge of the Sacramento Valley. A relief map of the local area serves as the Base Map and is shown in Figure 1B.

The CAMP Study Area is about 60 km at its widest point, east to west, and about 70 km long, north and south. It includes major portions of Sonoma and Lake Counties and parts of Colusa,

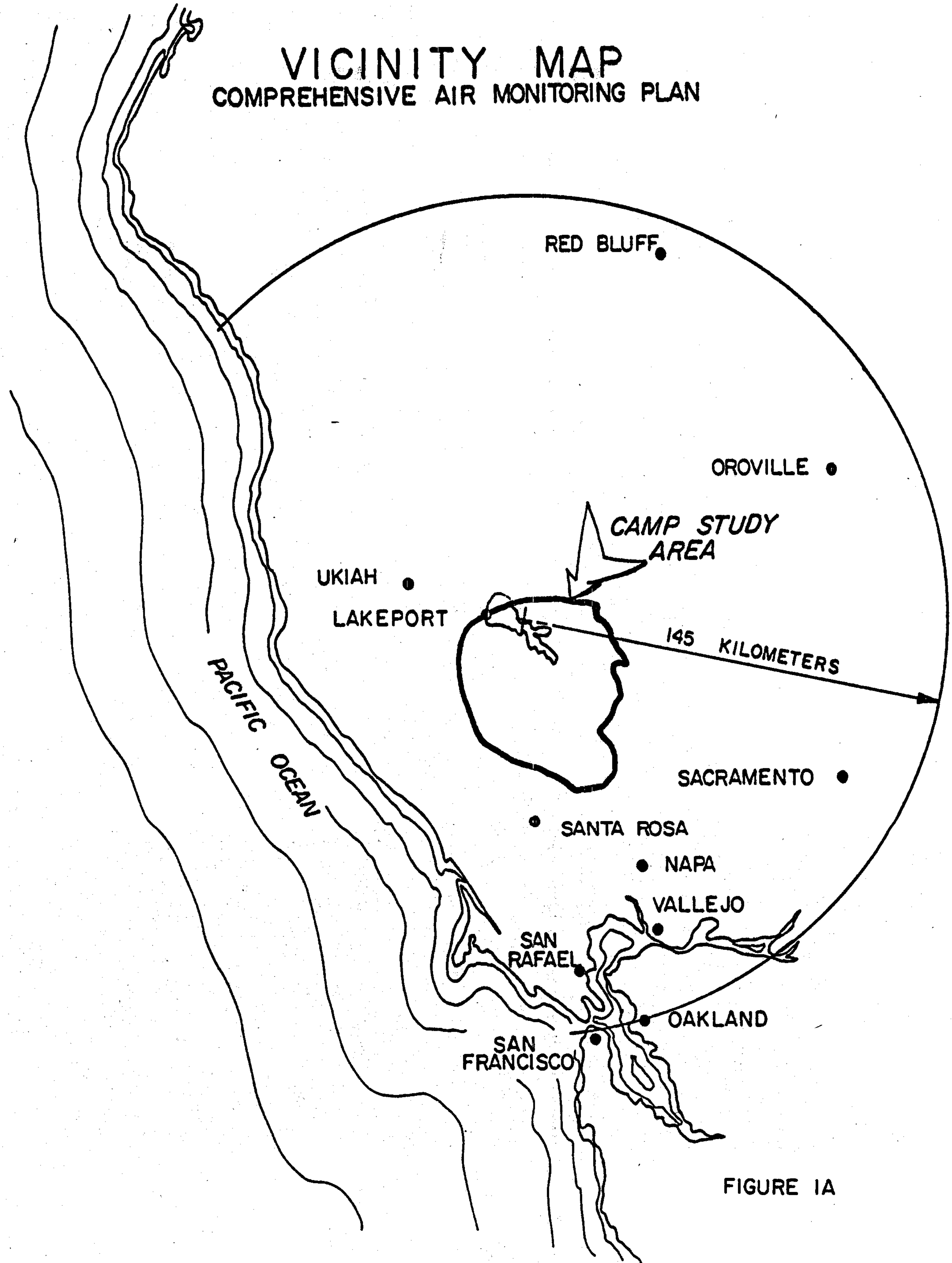
VICINITY MAP
COMPREHENSIVE AIR MONITORING PLAN
RED BLUFF
OROVILLE
CAMP STUDY AREA
UKIAH
LAKEPORT
145 KILOMETERS
PACIFIC OCEAN
SACRAMENTO
SANTA ROSA
NAPA
VALLEJO
SAN RAFAEL
OAKLAND
SAN FRANCISCO

FIGURE 1A

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Scale 1" = 6 miles

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FIGURE 1B
BASE MAP

Napa, and Mendocino counties. Figure 1C shows the boundaries of the CAMP Study Area, the KGRA, and the county boundaries. The CAMP Study Area includes all of the KGRA except small portions at its northern and southern extremities. However, the Study Area has been extended in the Plan beyond most of the KGRA boundaries to insure the consideration of the effects of possibile future permitted geothermal facility activity. Approximately one-third of the total land area involved is of federal and state ownership.

The Study Area is characterized by alternating northwesterly oriented valleys and ridges. Overall relief is about 1,372 meters, but the local relief in the mountainous portion is generally on the order of 600 meters. The northeastern three-fourths of the area drains to the Sacramento River via Cache and Putah Creeks, while the southwestern quarter drains to the Russian River and thence to the Pacific. A major feature of the drainage pattern is Clear Lake, which occupies some 210,000 square kilometers in the northern part of the area, and discharges to Cache Creek.

Steam characteristics of the CAMP Study Area were discovered in 1847. By the 1880s, there were numerous spas and health resorts attesting to the value of the geothermal activity. However, it was not until 1960 that the first geothermal power plant came on-line in Sonoma County, with a capacity of 11 megawatts. Currently, there are 663 megawatts with another 765 megawatts either under construction or in the regulatory processes.

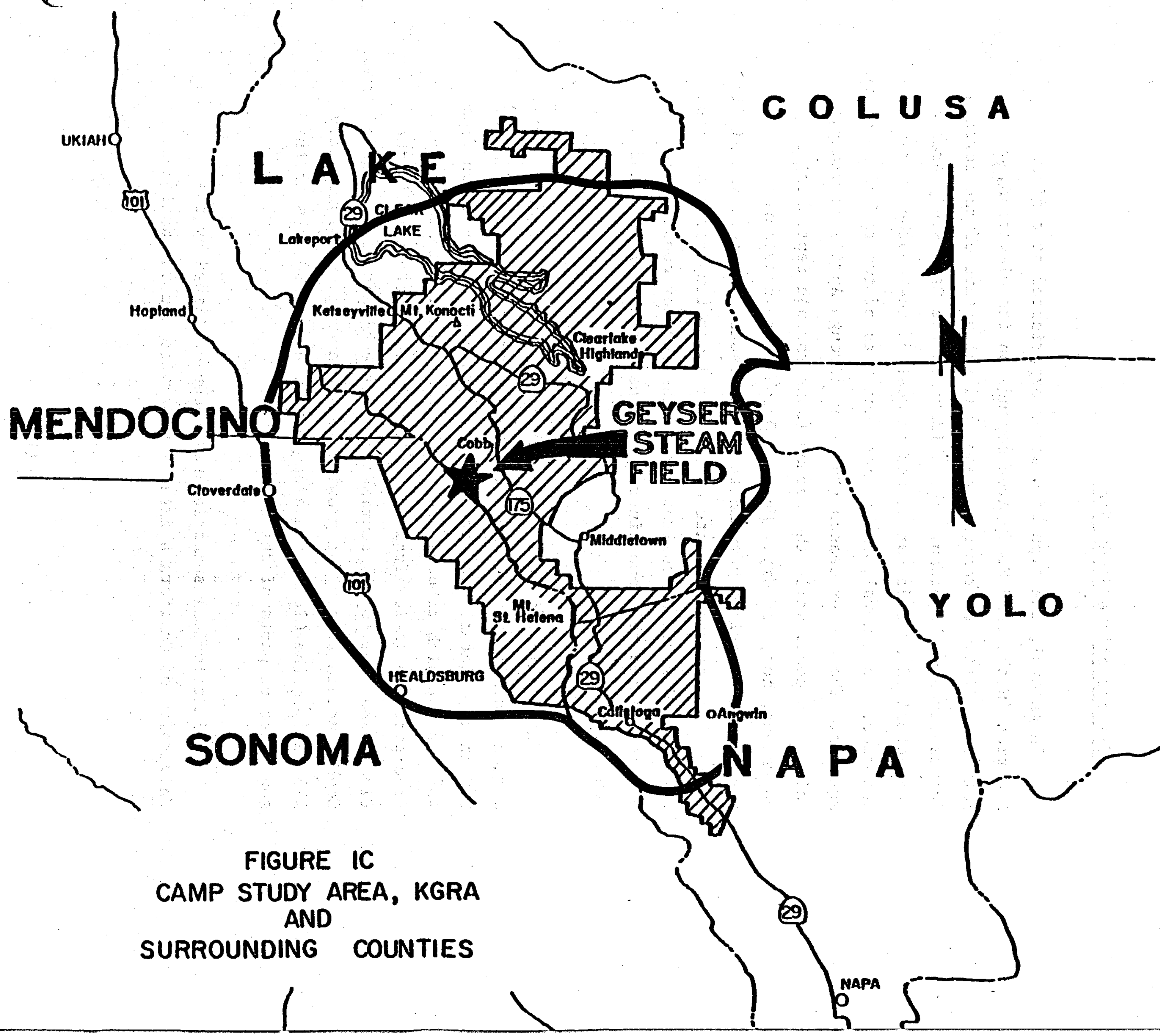

FIGURE IC
CAMP STUDY AREA, KGRA
AND
SURROUNDING COUNTIES

1.4 Climate of the Study Area

In general, the type of weather experienced at a given location in the CAMP Study Area depends on its elevation, latitude, distance from the ocean, and the nature of the terrain between it and the ocean. The climate of the CAMP Study Area is characterized by wide variations in most of the weather parameters recorded. In general, the climate consists of two rather opposite seasons. The winter season (November through April) is windy, rainy, and cool, while the summer (June through September) is quiescent, hot, and dry. May and October are considered transitional periods between the two seasons. Winters are similar to a marine coastal climate except for lower temperatures. Since the area is somewhat sheltered from the shallow cooling oceanic effects by coastal mountain ranges, the summers are more of a continental type.

Climate in the Study Area is fairly constant, ranging from a mean maximum of about 35°C in the summer to minimums of about 0°C in the winter. The greatest temperatures observed run from 43°C as the high temperature to -12°C as the low temperature. Precipitation varies from approximately 58 centimeters in the Clear Lake area to 165 centimeters in the higher elevations of the Cobb Mountain area. The growing season averages approximately 195 days in the Clear Lake area to well above 200 days in the southwestern parts of the Study Area.

Climatological summaries have been published by the University of California Extension Service and the National

Weather Service. A special climatic report on Clear Lake is available. Additional climatic data are available for several stations in the area of interest. Some of these data are available in current serial climatic publications while others are in summarized form. Most of the federal publications are available in the public libraries and at local National Weather Service offices. APPENDIX B is a listing of climatological data sources and current and former climatological data stations in the CAMP Study Area.

a. Winter

As in all of Northern California, the principal control on weather in the CAMP Study Area is the Pacific high pressure cell which is nearly always present along the west coast in North America. This is a broad region of descending air which is normally warm, dry, and stable. The cell tends to migrate seasonally, so that in the winter it generally is located far south of the CAMP Study Area.

Because of the wintertime southward shift in the Pacific high pressure cell, the North Coast is subject to a series of frontal systems which sweep across the region frequently. The weather is such that the region experiences the greatest frequency of clouds and precipitation of any place in California. Most of the precipitation occurs during the winter season and falls primarily as rain. Annual totals are from 100 to 150 centimeters in the Eel and Russian River Basins.

Maximum annual precipitation on record in California is 390 centimeters in 1909 at Monumental, Del Norte County (elevation 838 meters). The greatest monthly total ever observed in the Continental United States was 182 centimeters (71.54 inches) at Helen Mine, Lake County (elevation 841 meters) in January, 1909. Helen Mine is approximately two kilometers south of Power Plant Unit #16.

A typical winter storm situation brings intermittent rain over a period of 2-5 days followed by 7-14 days of dry weather. On occasion, periods of stormy weather persist for as much as two weeks. This situation usually occurs when a frontal system stagnates in the vicinity of the CAMP Study Area. This occurrence is usually the result of the temporary northward displacement of the Pacific high pressure cell which may join with a strong surface ridge of high pressure over the Great Valley. This synoptic pattern acts to block the passage of fronts into central California. If this regime persists for several days, the Study Area may experience rains while the remainder of the state is enjoying fair weather or variable high clouds.

Between storm periods, nighttime cooling usually leads to the formation of ground fog in sheltered inland valleys. Considerable air stagnation causes these radiation fogs to persist for several days. These conditions are more pronounced in Lake County where storms are less frequent than in the extreme northern parts of California. This weather type ordinarily brings clear conditions with good visibility to northern California. On occasion, gusty, strong northerly winds occur during this regime. Compared to much of the rest of California, the winter weather types over the CAMP Study Area generally bring favorable ventilation conditions.

b. Spring

With the onset of spring, there is a northward shift of the semi-stationary Pacific high pressure cell. The cell steadily strengthens through the period and acts to weaken and, in some cases, blocks the passage of frontal storms into northern California. As a result, winter storms steadily decline in frequency and intensity through the spring months. The direction of the prevailing winds shifts from southeast to west or northwest.

As the days progressively lengthen, heating of the surface air layers becomes more intense. Since the air aloft is relatively cold in the spring months, the atmosphere tends to become unstable. This instability is conducive to vertical motion and generally favorable ventilation.

c. Summer

The Pacific high pressure cell effectively blocks all northern Pacific low pressure storms from entering the CAMP Study Area in the summer. The resulting winds are moderate and generally from the west or northwest. Warm airflows aloft, coupled with cold ocean currents (due to upwelling), result in the formation of a moist marine stratus cloud deck capped by a stabilizing air temperature inversion layer during the summer months. This deck of clouds usually extends inland farther during the night and then recedes to the vicinity of the coast during the day. The mixing layer is typically 450 meters thick or less. Thermal inversions (300 to 600 meters thick) act as a barrier against mixing the cool, moist marine air below and the dry, warm air aloft. The Mayacamas Mountains act as a partial barrier to direct sea breezes and inhibit penetration of the moist marine layer. Summer skies in Lake and northern parts of Napa County are generally cloudless and of low moisture content. This results in nighttime radiational cooling and further limits the ability of marine air to descend down the east slopes of the Mayacamas and to ventilate valleys in Lake and northern Napa County.

d. Fall

Radiation inversions with accompanying ground fog occur during the periods of clear skies and light winds during the fall season. Pressure gradients are generally weak at this time of the year, with the result that the lowest mean wind speeds over the CAMP Study Area occur in September to December.

1.5 Air Pollution Meteorology

Transport and diffusion of air contaminants depends largely upon wind speed, turbulence and atmospheric stability. Once an air pollutant is released into the atmosphere, it is simultaneously transported by wind and diffused by the smaller components of these air motions called turbulent eddies. In general, the stronger the winds and the more unstable the air, the faster the pollutant cloud will travel and disperse.

Transport and diffusion of pollutants released into the atmosphere near the ground depends largely upon the vertical temperature structure of the air in which the pollutants are released. Due to expension, air that rises to lower pressure will cool at a rate of 10°C each kilometer (the dry adiabatic rate). If the actual lapse rate (temperature change with height of the ambient air) exceeds the adiabatic rate (unstable), upward mixing of pollutants will be unimpeded. Lesser lapse rates than adiabatic (stable) will resist upward mixing; and in the case of an inversion where the temperature increases with height, vertical transport and diffusion is virtually negated. Inversions provide effective lids for pollutants that are emitted in or beneath them, unless sufficient bouyancy (mechanically or thermally induced) is present to allow the plume to penetrate the inversion.

There are essentially two types of inversions that affect the CAMP Study Area. The most prevalent type is the radiational (or nocturnal) inversion which forms during cloudless nights year round from cooling of the lowest 200 to 300 meters of the atmosphere by the heat radiating earth. In complex terrain, inversions formed by radiation are reinforced by cooling air that drains downslope into the valleys. In general, this type of inversion is conducive to destruction by heating during the daylight hours. However, morning "heating of drainage associated inversions can at times concentrate the pollution even more by lowering the inversion as heating releases air from the sides."*

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*Ayer, H.S., "On the Dissipation of Drainage Wind Systems in Valleys in Morning Hours", J of Meteorol., 18, pp 560-563 (1961).

The second type of inversion is known as a subsidence inversion, and is caused by heating of downward moving air on the outer fringes of the semi-permanent Pacific high pressure cell. Its effect is most prevalent during the warm half of the year over California and frequently leads to "worst-case" pollution. In essence, its effect is superimposed upon a radiation inversion, causing a stronger resultant inversion during the warm half of the year.

Data* in and near the CAMP Study Area indicate that low level (equal to or less than 300 meters) inversions occur on the average of 95 percent of the time in the early morning hours. Although there is little difference in frequency of occurrence from month-to-month throughout the year, there are about twice as many strong low-level inversions each month during the summer than the winter. This is principally due to reinforcement of radiation inversions by subsidence which operates extensively during the warm months.

Data on afternoon mixing heights also indicate that these inversions are generally destroyed by solar heating by mid-afternoon. As expected, this lifting of inversions is slower and less extensive during the winter. These low inversions would trap pollutants released into or under them during the night, allowing only the horizontal spreading by the wind. As the sun rises, and the day wears on, heating would allow upward mixing which would deepen to an afternoon maximum.

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*Lehrman, Don, Draft, Supplemental Studies to the Cobb Valley Geothermal Development Impact Program, July 3, 1978, submitted to Environmental Systems and Services, Kelseyville, California.

Another aspect of lessening pollution concentration is wind motion in the horizontal direction. Winds are mostly terrain oriented and influenced with speeds generally lighter during the evening due to nocturnal cooling at ground level.

The combination of a stable atmosphere and light winds during the hours of darkness presents the greatest potential for the production of high pollution concentrations at ground level in the CAMP Study Area. Since wind transport of pollutants is weak in these cases, pollution is usually localized. This is mostly applicable to the longer canyons on the western side of the Mayacamas Mountain Range, while trapped pollutants may escape from the shorter canyons on the eastern slopes and affect a larger area. In general, nighttime pollution potential would be more widespread in the hilly country east of the Mayacamas ridge because terrain there is not as conducive to impeding horizontal transport of a pollutant cloud.

As the sun begins to heat the air next to the ground during the mornings, atmospheric instability and wind speed generally increase. These reactions disperse air pollution, resulting in decreased concentrations. Isolated incidence of increased ground level concentrations can occur from fumigation of pollutants released aloft in a stable atmosphere that are brought to the surface by mid-morning convective thermals that have reached the level of maximum concentrations. High concentrations may be brought down to the ground in puffs; this phenomenon is called "fumigation". Fumigation is short-lived because of the rapidly changing vertical temperature distribution.

By mid-day, the mixing layer usually should have deepened to the point where ground level pollutants are minimal. Most pollution released in canyons and deep valleys remains rather localized even during the day, since the upper wind flow should not significantly affect the bottom half of these features. However, wind flow up a valley might be effective in transporting pollution over the blocking ridge line. Down-valley basic flow would most certainly transport pollution out of the shorter valleys into the surrounding countryside, but in diluted concentrations.

It should be mentioned that pollutants released near or on top of mountain ridges will not readily stagnate any time of the day or night, since any undisturbed basic wind flow that exists would act as a continuously effective transportation mechanism. Fortunately, these same winds would dilute pollution concentration, although increases in ground concentrations can temporarily occur in downwind areas under downwash conditions.

During periods of storminess in winter, pollution concentration will be minimal day and night, since dispersal by gusting winds and unstable air and scavaging by precipitation will act at optimum effectiveness in the dispersion and ventilation of the ambient air.

It is concluded that, due to infrequent rainfall, weak wind regimes and stable nighttime conditions during the summer and fall months in the CAMP Study Area, the air pollution potential is probably significantly higher during this period than the remaining months of the year, but atmospheric conditions can result in local pollution episodes during any month. Additionally, what is known of the diurnal wind and atmospheric stability regimes suggests that the pollution potential is quite a bit higher during the hours of darkness plus a few hours after sunrise the year around throughout the CAMP Study Area.

On the basis of the analysis of the topographic features already discussed in Section 1.3, and the influence of the air pollution meteorological characteristics herein presented, the CAMP Study Area was divided into 10 air drainage basins. These air drainage basins are shown in Figure 1D on the following page.

An air drainage basin is analogous to a water drainage basin. The analogy to the water drainage is that relatively cold air, like water, will flow downward from any location within the basin toward the lowest point in the basin. The numbers and names of the drainage basin identified for the CAMP are indicated in Table 1-2 on Page 22. Most of the air drainage basins can be meteorologically, clearly defined. However, Basins 1, 8 and 9, consisting of Upper Lake, Lower Lake and Long Valley, could probably be called a single air drainage basin. Nevertheless, there are some weakly defined topographic features which allowed for this relatively large area to be subdivided as indicated.

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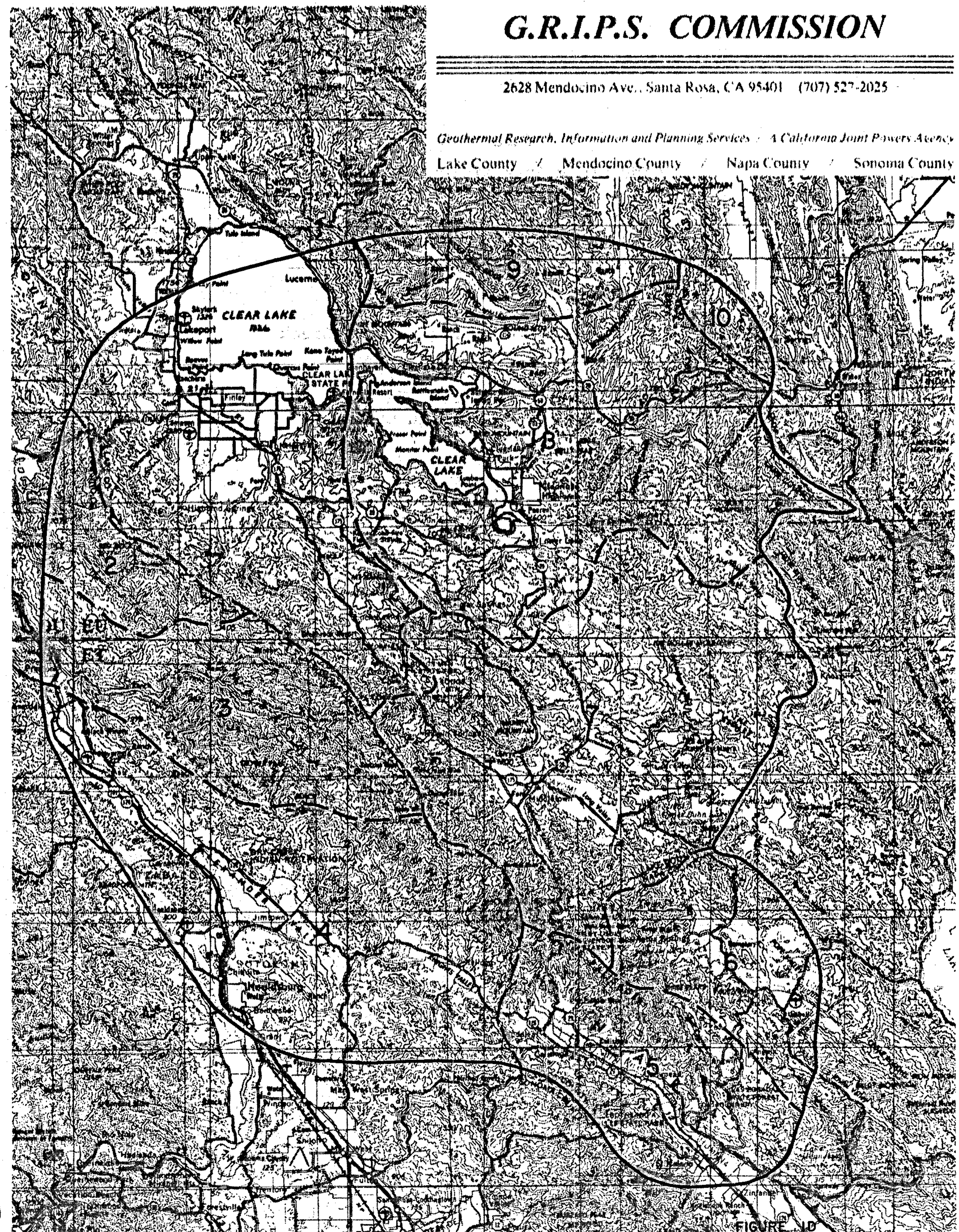

FIGURE 1D
CAMP AIR DRAINAGE BASINS

TABLE 1-2

CAMP Study Area Air Drainage Basins
February 1, 1980

Number	Name
1	Upper Lake
2	Pieta Creek
3	Big Sulphur Creek
4	Russian River
5	St. Helena Creek
6	Pope Valley
7	Putah Creek
8	Lower Lake
9	Long Valley
10	Wilbur Springs

1.6 Previous Data Gathering Efforts in CAMP Study Area

Prior to the advent of the construction of power plants in the CAMP Study Area, persons visiting the region complained of sulfurous odors. Hence, it must be conceded that ambient concentrations of hydrogen sulfide (H_2S) from fumaroles and hot springs must have exceeded the State standard.

The first air quality study made in the CAMP Study Area began in July, 1970, and continued until November, 1972. The results of this survey were published in a report by PG&E entitled "Geysers Air Monitoring Program, July, 1970 - November, 1972, Progress Report" #7485.4-72, dated May 11, 1973. During this study, a number of sampling stations were established to measure the average hourly concentration of hydrogen sulfide.

The next significant air quality study was also conducted by PG&E. This program was initiated in August, 1974. The California Air Resources Board had requested PG&E to monitor hydrogen sulfide over a wide area, including upper Kelsey Creek. The procedure used by PG&E was to use Colortec hydrogen sulfide tag-type detectors. The Colortec is a chemically-treated tag which develops a brown stain on exposure to hydrogen sulfide. The shade of stain developed is dependent upon the dosage of hydrogen sulfide. A color grade of 1.0, developed after overnight exposure, is usually associated with odor complaints.

Other than site-specific studies, the next major air quality study was established by PG&E and its steam suppliers using the Stanford Research Institute (SRI) as a contractor in January, 1976. SRI set out a group of eight weather and air quality observation stations from which has been gathered a significant amount of data over a period of 3½ years ending in May of 1979. Several important analyses of these SRI data have been completed. Among these analyses are those made by SRI, Environmental Research and Technology (ERT), and Meteorological Research, Inc. (MRI). Within the ERT report is included a fairly comprehensive listing of many meteorological and air quality data gathering stations in and around the CAMP Study Area during 1976 and 1977.

The most thorough and comprehensive listing of data gathering efforts in the CAMP Study Area has been completed by Environmental Systems and Services (ES&S) under the direction of Mr. J. Regis Trainor. This index covers the period 1970 to mid-1979 and is included in APPENDIX C.

In addition to the air quality and meteorological data gathering studies and analyses completed for the development of geothermal resource facilities, federal, state and local agencies have, through the years, also collected meteorological data within and near the area of interest. The federal agencies from which climatological data are available are the National Weather Service, the Forest Service, and the Federal Aviation Agency. State agencies which have gathered climatological data in the area of interest are the Department of Water Resources, the Air Resources Board, and the Department of Forestry.

An additional study, which is significant from the point of view of the overall CAMP Study Area data gathering programs, is the Atmospheric Studies in Complex Terrain (ASCOT) program. This was initially known as the Complex Terrain Modeling Program. The long range goal was to develop methods for the use of models, improve physical understanding, and field programs to help assess the impact of developing energy sources in areas of complex terrain. The ASCOT program officially began in October, 1978. It is largely a multi-laboratory, Department of Energy-sponsored program with the Lawrence Livermore Laboratory as the lead laboratory.

After its first year of operations, the ASCOT program redirected its efforts and is now focusing on the study of nocturnal drainage winds. Basic efforts were expended in reviewing the literature related to previous atmospheric studies in complex terrain and to modeling activities concentrated in three major areas. The major areas were: diagnostic wind field models; second order closure models, and; application of finite element methods to atmospheric boundary layer modeling. In addition to the literature review and modeling activities, a major effort is being made in actual field measurements. The Anderson Creek area, in the northern Putah Creek drainage basin, was chosen as the location for the major field program activities of ASCOT.

Data obtained during initial ASCOT field programs are currently being processed for entry into a central data base system at the Lawrence Livermore Laboratories, where the data will be distributed to each participating organization. ASCOT data will not be released to the public for a year or so; thus it is not available for ongoing impact studies. Analysis of the data will take place to assist in the design of further field studies planned for the fall of 1980. These field observations will include a series of tracer experiments involving a simultaneous release of multiple-gas tracers, and supported by an array of meteorological measurement systems.

2. POPULATION DISTRIBUTION

A population analysis was requisite in the development of the CAMP. People are our greatest concern and constitute the receptors which may determine the final site approval of a geothermal facility. Study was made in depth to determine the current and projected population distribution in the CAMP Study Area.

2.1 Population Analysis and Projections

Available population data differ from county to county in terms of age, origin, reliability and adequacy. In order to establish reliable and comparable data for each county, a three-stage analysis was conducted:

a. The best existing data were gathered and analyzed. For some counties, these were 1970 census data (Colusa, Lake and Mendocino); for others, 1975 special census data were available (Napa and Sonoma). These data were then: (1) updated to 1979, and; (2) adjusted to the boundaries of the CAMP Study Area. These steps were undertaken with the assistance of local planners. Baseline projections were then made using California Department of Finance, as well as local, estimates of anticipated growth rates in the CAMP Study Area.

b. Independently, a distribution map was prepared for the GRIPS Commission by PG&E. This map plots the location of domestic customers within the CAMP Study Area for winter, 1979. The PG&E digitized, graphic computer analysis provided data which indicated a density of approximately 4 households per 10 km^2. These data were applied to the number of persons per household for each county (supplied by the California Department of Finance). The resultant data showed an average density of approximately 5 persons per 4 km^2. The CAMP population centers analyzed and shown in Figure 2A each include a minimum of 40 km^2, or approximately 50 persons. The map identifies the location of the population and residential zones within the CAMP Study Area.

c. Finally, the results of the first two analyzed stages were integrated, summarized and displayed in Tables 2-1, 2-2, and in APPENDIX D.

As might be expected from the geography of the CAMP Study Area, the largest share of the population is located in Lake County. Almost fifty-four percent of the total CAMP population is located there and is distributed primarily around Clear Lake. Sonoma County contributes close to one-fourth of the CAMP Study Area population in the developed Cloverdale-to-Healdsburg corridor east of Highway 101. The final twenty-two percent is divided between Napa, Colusa, and Mendocino counties, with Napa contributing the major share. Two of Napa County's urbanized areas, Calistoga and St. Helena, are included in the CAMP Study Area. Mendocino and Colusa counties contribute almost negligibly to the total population, Mendocino bringing less than four-tenths of one percent and Colusa contributing only five one-hundredths of one percent.

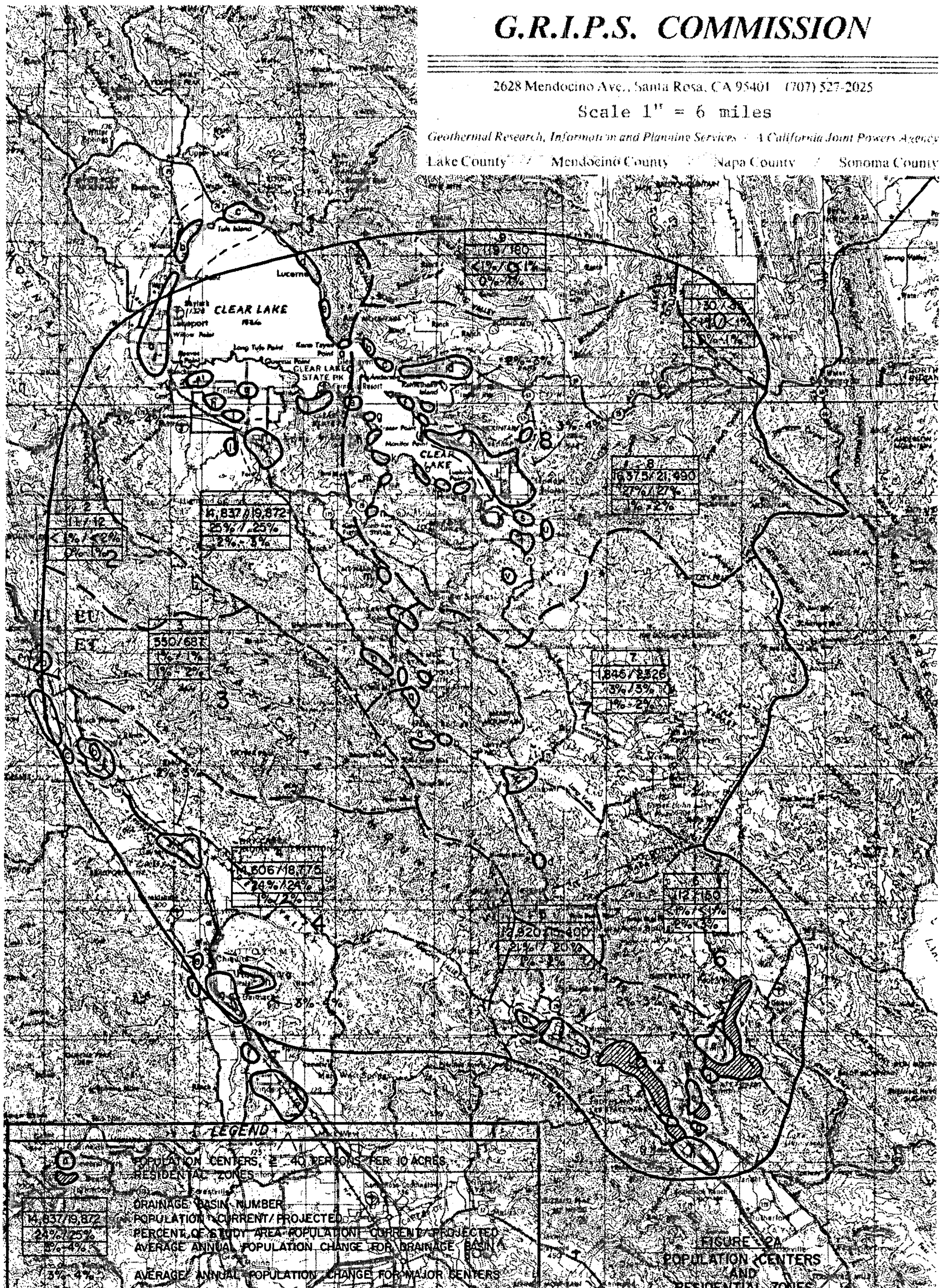

FIGURE 2A
POPULATION CENTERS AND RESIDENTIAL ZONES

These percentages are expected to continue virtually unchanged through 1990, although Lake County will gain a slightly larger share (by one percentage point) of the entire CAMP Study Area, with a corresponding drop in that of Napa County.

The total CAMP Study Area population is approximately 61,000. By 1990, it will be approaching 80,000, for a gain of close to 30%. It is anticipated that the major increases in population will occur in presently developed areas, with proportionally smaller increases in rural areas. This is due, in part, to the historical tendency for population growth to occur in areas where needed services (water, sewer, utilities) already exist and, in part, to local land use policies which will be considered in the next part of this section.

2.2 Land Uses

This section deals with six related land use issues. Examination of these will be useful in: projecting population growth and density; identifying areas zoned or designated for geothermal development; and determining the processes by which approval is obtained for air quality monitoring stations within the CAMP Study Area. Data on two of these topics is shown in Figure 2A on the preceding page.

The two types of information presented on the map are:

- Air Quality Drainage Basins and Population Centers
- Unincorporated Areas Zoned for Residential Development

The four strictly narrative divisions of this section deal with:

--- Areas where subdivisions have been approved. Approved is used here to identify those subdivisions where improvements are in or where construction bond has been posted.

--- Unincorporated areas zoned to allow geothermal development.

--- The use permit process for geothermal development in areas other than those specified in item above.

--- The use permit process for siting air quality monitoring stations.

Sections of five (5) counties comprise the CAMP Study Area: Colusa; Lake; Mendocino; Napa; and Sonoma. Individual comments have been prepared (see APPENDIX E) for each of the counties since existing land use conditions are unique and policies different.

The County Zoning Ordinances, Zoning Maps, General Plan Elements, draft geothermal ordinances, and other written documents used in the preparation of this section are listed in APPENDIX A, <u>REFERENCES</u>, and are available for review at the G.R.I.P.S. Commission Office.

TABLE 2-1

TOTAL COUNTY POPULATION, POPULATION PROJECTIONS, AREA AND DENSITIES

FEBRUARY 1, 1980

County	Current[1] Population 1979	Projected[2] Population 1990	Percent Increase[3]	Area[4]	Densities[5] Current Population	Densities[5] Projected Population
Colusa	13,000	14,541	11.85%	737,920	.018	.020
Lake	33,000	42,212	27.92%	803,840	.041	.053
Mendocino	64,400	80,806	25.48%	2,244,480	.029	.036
Napa	93,900	125,733	33.90%	485,120	.194	.258
Sonoma	274,300	354,807	29.35%	1,010,560	.271	.351
TOTAL	478,600	618,099	29.15%	5,281,920	.111	.144

[1]California Department of Finance, Report 79E-1, 1979. Data are as of January 1, 1979.

[2]California Department of Finance, Report 77-P-3, Series E-150, 1977. Data are as of July 1, 1990.

[3]Percent increase is the total increase expressed as a percent of the 1979 population.

[4]California Department of Water Resources. Land area only in acres.

[5]Population divided by area, expressed as persons per acre.

TABLE 2-2

CAMP STUDY AREA POPULATION*, POPULATION PROJECTIONS, AREA AND DENSITIES

FEBRUARY 1, 1980

County	1979[1] Current Population	1990[2] Projected Population	Annual[3] Average Change	Area[4]	Densities[5] Current Population	Densities[5] Projected Population
Colusa	30	33	0.91%	12,816	.002	.003
Lake	33,057	43,400	2.84%	414,727	.080	.105
Mendocino	273	305	1.07%	31,136	.009	.010
Napa	13,500	16,500	2.02%	122,837	.110	.134
Sonoma	14,657	18,958	2.67%	168,404	.087	.113
TOTAL	61,517	79,196	2.61%	749,920	.082	.106

*Those portions of the five counties which fall within the CAMP Study Area boundaries.

[1] Summarized from Table 2-3 (this report); adjusted to county boundaries by discussion with County Planners.

[2] Projections developed by application of growth rates to current data, or by adjustment of County projections to Study Area. Growth rates derived from California Department of Finance county projections; applicability confirmed in consultation with County Planners.

[3] Annual average change is total increase divided by the number of years (11) and expressed as a percent of the 1979 population.

[4] Digitization by SEA of Santa Cruz. Area is expressed in acres.

[5] Population divided by area, expressed as persons per acre.

APPENDIX F contains a listing of airports located in or near the CAMP Study Area. In siting air quality monitoring stations in or near these airports, it will be necessary to comply with Part 77 of the Federal Aviation Regulations entitled, "Objects Affecting Navigable Airspace". This document sets forth the regulations concerning the height of buildings allowed near airports. County ordinances, where they exist, enforce the provisions of Part 77. Part 77 is on file at the GRIPS Office.

3. EMISSION SOURCES

3.1 Emissions

A pollutant is considered to be any substance that has a detrimental effect on people, animals, vegetation or land. Many of the materials emitted as the result of geothermal development are potential pollutants, but only a few of these substances pose actual problems. Water vapor and carbon dioxide which are emitted in relatively large quantities from the permitted geothermal facilities in the CAMP Study Area are not considered pollutants. Most of the substances are emitted in such small quantitites that it has been assumed that they do not produce detrimental effects. Tables 3-1 and 3-2 list the concentrations of gases and solids. Of the noncondensable gases, carbon dioxide, nitrogen and hydrogen would not be considered pollutants. Methane and ethane are not emitted in sufficient quantities to produce ozone nor are other compounds which are likely to react with oxides of nitrogen; therefore, they do not pose an oxidant air quality problem. H_2S is the primary regulated pollutant of concern to date. However, efforts are being made by geothermal developers and others to better characterize and quantify emissions and ambient concentrations of various unregulated pollutants found in geothermal steam.

Mercury, arsenic and boron have been detected in the condensate of the geothermal steam. These particulates may produce a site-specific air quality or water pollution problem. Emissions of boron have caused damage to vegetation in the vicinity of older power plants in the Study Area, primarily because of deposition of cooling tower drift. However, data

TABLE 3-1
CONCENTRATIONS OF NONCONDENSABLE GASES IN STEAM FROM WELLS*

Gas	Concentrations, ppm		
	Average	High	Low
Carbon dioxide (CO_2)	3260	30600	290
Hydrogen sulfide (H_2S)	222	1600	5
Methane (CH_4)	194	1447	13
Ammonia (NH_3)	194	1060	9.4
Nitrogen (N_2)	52	638	6
Hydrogen (H_2)	56	218	11
Ethane (C_2H_6)	---	19	3

TABLE 3-2
SOLIDS IN CONDENSED STEAM FROM WELLS*

Solid	Concentrations, ppm		
	Average	High	Low
Mercury (Hg)	0.0050	0.018	0.00031
Arsenic (As)	0.019	0.050	0.002
Boron (B)	16	39	2.1

*Reference: PG&E Report No. 7485 (1974), Emissions of Noncondensable Gases and Solid Materials from the Power Generating Units at the Geysers Power Plant.

on particulate emissions from normal operating geothermal plants are scarce.

In summary, the two main categories of emitted pollutants in the CAMP Study Area are those emitted as gases or vapors, of which H_2S is an example, and those emitted with cooling tower drift droplets of which boron is an example. Research relevant to a specific pollutant in one of these categories should be relevant to any other pollutant in the same category.

Emissions themselves are unique from those resulting from conventional types of electric power generation. Instead of one or two well-defined point sources, the geothermal development in the CAMP Study Area has resulted in a number of point sources of varied emission magnitude. Initial emissions occur when wells are drilled. Upon the completion of well drilling, valves are installed and the flow is restricted to minimum bleed until a power plant is constructed. After a power plant is constructed and placed in operation, venting still continues at a number of locations along the steam supply lines. Emissions from the Study Area include natural sources, the power plants, gas ejector lines and cooling towers. The rates, temperature and exit velocities of the emissions vary from source to source, and may vary in time for a given source. An air quality analysis must, therefore, account for these complicated spatial and temporal variations of H_2S submissions discussed above; it is highly desirable to resolve the contributions to ground level H_2S concentrations of each emission source.

In a normal operating plant, the major point of emission into the atmosphere is the cooling tower. At least two important aspects of emissions from cooling towers affect downwind concentrations of pollutants near the ground:

1. The elevated heights at which pollutants are injected into the atmosphere and;

2. The rapid dilution with ambient air that occurs inside the cooling tower and immediately after ejection from the cooling water.

The cooling towers in the CAMP Study Area are all mechanical draft type approximately 15 meters high; they consist of up to 10 towers each about 9 meters in diameter. The efflux from the cooling tower is ejected into the atmosphere at an appreciable upward velocity and elevated temperature. The elevated temperature applies positive buoyancy which tends to accelerate the emissions upward. The net effect is that cooling tower emissions move upward and are suspended over a height interval that depends on properties at the top of the cooling tower and on atmospheric stability. Vapor or gaseous pollutants tend to rise and be transported with the plume. Pollutants from drift droplets have an additional component of motion as a result of the falling of the droplets in the plume. The terminal velocity of the drift droplets depends primarily on the droplet size; the size changes as a result of condensation, evaporation, and coalescence.

It is difficult to estimate the emissions of H_2S from the current geothermal development. One estimate* indicated that the power plants account for approximately 88% of the total H_2S emissions. Sources other than power plants amount to about 12% of the total. An important emission source is major venting (sometimes referred to as stacking). Stacking is discussed in detail in Section 3.3.

3.2 Study Area Fumarole Activity

Although several early reports have been made on natural fumaroles in the CAMP Study Area, it was not until 1975 that a concerted effort was made to determine natural emission sources and the possible hydrogen sulfide emission rates ejected into the atmosphere. The initial natural emission source study in 1975 conducted under the supervision of M. Tolmasoff, NSCAPCD, and concentrated on Sonoma County, noted that fumarole openings or vents vary greatly in size and shape. Some vents may be roughly circular and only a few centimeters in diameter while some vents are apparently ground surface cracks extending as much as a meter in length. Sometimes vents are closely connected, thereby plugging one vent at times, causing another to increase its exhaust rate.

*Stanford Research Institute, Enviromental Analysis for Geothermal Energy Development in the Geysers Region, Volume I: Summary, May, 1977, SRI Project EGH-5554, prepared for the California Energy Resources Conservation and Development Commission.

Very active fumaroles in the CAMP Study Area are few. However, there are many hundred from which steam is noiselessly escaping. Also steam is often seeping through the ground surrounding fumaroles. The ground is usually rather muddy, and with temperatures as high as 97°C. The term "seam seepage" is used to denote such hot ground and vents less than two centimeters in diameter.

Fumaroles in the Big Sulphur Creek drainage basin are usually clustered together in large areas, as large as 1/2 hectare (within these areas, fumaroles are less than 30 centimeters apart). These areas are referred to as "fumarole fields" and are characterized by a lack of vegetation and ground coloration due to mineral deposits. In the Sulphur Creek Region, eight significantly active fumarole fields were found by Tolmasoff. Other such areas with ground discoloration and active vent holes were evident, indicating previous activity. A few small fields were also located but were ignored by Tolmasoff's study group; activity was very minor (they would emit less than 1/4 kilo of hydrogen sulfide per day).

The conclusion of Tolmasoff's report indicated that the fumarole fields emit about 54 kilos of hydrogen sulfide per day. However, the inaccuracy involved in locating and source testing these fumaroles made it necessary to merely state in his report the range of the emission rates. Therefore, the amount of hydrogen sulfide emitted lies within the range of 34 to 113 kilos per day (during the summer of 1975).

Without a doubt, the amount of hydrogen sulfide emitted from fumaroles in the Geysers Area is negligible compared to the amounts emitted in the local geothermal power generating plants. However, natural emission sources close to the monitoring equipment could impact the H_2S levels observed at those stations. Current allowable emissions, with 90% abatement plus all other venting, probably total about 320 kilos of H_2S per hour; although total emissions are higher because of variances granted PG&E by NSCAPCD.

Fumarole ground seepages are not the only natural source of contributing hydrogen sulfide to the ambient air. Several hot streams are located in the CAMP Study Area. Geothermal streams often contain parts-per-million concentrations of hydrogen sulfide.

Studies to determine if the fumarole activity is subject to fluctuation could be accomplished by repeat testing of individual vents or by field inspecting the inactive vents for new activity. No such studies have been made or any planned.

In 1978, a far more extensive study, covering the entire CAMP Study Area, was conducted by Tom Sperling of ES&S, Kelseyville, California, under the sponsorship of the GGEC. Sperling's study showed a total of 45 natural H_2S emission sources including sources reported by Tolmasoff in 1975. Sperling made no attempt to measure the emission rates from these natural sources. Table 3-3 and Figure 3A shows the Natural Fumarole Activity researched by Sperling.

TABLE 3-3

NATURAL FUMAROLE ACTIVITY

FEBRUARY 1, 1980

Map #	Name	Location
1.	Anderson Springs	Located about 0.4 km northwest of the last house in the Anderson Springs Community on Hot Springs Creek.
2.	Aetna Springs	Located about 6.4 km northwest of Pope Valley.
3.	Borax Lake	Located down Country Club Drive, northwest of Clear Lake Highlands.
4.	Clear Lake Riviera	On the shoreline of the Clear Lake Riviera Yacht and Golf Club Marina.
5.	Geysers Geothermal Area (Bath House Fumarole Field)	This field is directly across Sulphur Creek from the Geysers Bath House. The area covers about 0.4 hectares of the creek bank. There is visible steam and some water seepage in three areas which produce a flow of about 11 liters per minute.
6.	Geysers Geothermal Area (Big Sulphur Creek) Fumarole Field)	This field is about 91 meters downstream from Geyser Canyon. One area of activity is 3 meters by 9 meters and about 3 meters from the creek bed on the north side of Big Sulphur Creek. There are four vents producing dry steam.
7.	Geysers Geothermal Area (Fumarole Fields 1 & 2)	Fumarole Field No. 1 is a small field located about 9 meters north of the main road, one-quarter mile up from the Power Plant Unit No. 1. There are about 24 small vents and one large fumarole located at the bottom of a slight slope. This fumarole produces about 2/3 of the total emission. Fumarole Field No. 2 is adjacent to Fumarole Field No. 1, and is a bit more active than the first.

TABLE 3-3 (cont.)

Map #	Name	Location
8.	Geysers Geothermal Area (Geyser Creek)	This field of emissions is located in Geysers Canyon south of Power Plant Unit No. 5 and No. 6. Two hot streams flow at about 76 liters per minute from the south side of Geyser Canyon directly into Geyser Creek.
9.	Geysers Geothermal Area (Little Geysers)	Little Geysers is a fumarole field about 3.2 km east of Power Plants 1 and 2 on a southwest facing slope below Anderson Ridge. The field is about 91 meters across by 274 meters long. There are vents and mud pots. There is a man-made pond fed by the creek.
10.	Geysers Geothermal Area (Sulphur Bank)	Sulfur Bank Fumarole Field is located downhill about 274 meters from the PG&E Mess Hall. The area covers about 0.2 hectares.
11.	Geysers Geothermal Area (Wild Well Area)	A blow-out occurred while drilling Magma Thermal Well No. 4, 1957, causing what is now a 0.8 hectare fumarole field of high activity. The most active area in the field is located near the original hole.
12.	George Nunnemaker, Sr. Spring	Located on the Binkley Road off Bottle Rock Road about 1.6 km past Mr. Nunnemaker's house.
13.	Gordon Springs	Located on the far side of Kelsey Creek in back of Pine Grove.
14.	Harbin Hot Springs	Located 5.6 km north of Middletown.
15.	Highland Springs	9.6 km southwest of Kelseyville.
16.	Horseshoe Bend	Small bay between Soda Bay and Buckingham, about 91 meters of it shoreline, it emits numerous gas bubbles.
17.	Howard Springs	Located 14 km southwest of Lower Lake.
18.	Kelseyville (Gas Hill)	Abandoned well off the east end of Main Street, Kelseyville, CA.

TABLE 3-3 (cont.)

Map #	Name	Location
19.	Konocti Harbor Inn	At the end of the dock area next to the shore on the left side of the Marina looking toward the Lake.
20.	The Narrows	The Narrows is a small stretch of Clear Lake at the tip of Buckingham Peninsula. There are three rows of emerging bubbles, each approximately 9 meters long, running parallel to each other.
21.	Mr. Wright's Spring	Located on Sulphur Creek.
22.	Old Cox Ranch	3.2 km south of Kelsey Creek Highway 29 Bridge.
23.	S Bar S Quarry	Located in a sulfur mine on the south side of Highway 29 just southeast of Bell Mine on Konocti Mountain.
24.	Seigler Springs	Located at Vision Mound Sanctuary and is inaccessible to any outside agency; 3.2 km northwest of Howard Springs near the junction of Seigler Springs North Road and Loch Lomond Road.
25.	Sulphur Bank Mine	Located on the eastern arm of Clear Lake on the southeastern shore.
26.	Soda Bay Springs	91 meters offshore of the right tip of Soda Bay looking toward the Lake.
27.	Tantarelli Springs	Located at Glenn Brook off Bottle Rock Road in the Cobb Mountain Area.
28.	Warm Spring	Located on the Yellow Creek in Sonoma County, 0.4 km east of Little Geysers Fumarole Field.
29.	Wilbur Springs Area (Sites 1,2,3,4,5)	Five natural emission sites, including a geyser which erupts every 40 minutes Excess water flows into Sulphur Creek, and thence into Bear Creek, from all the natural emission sources.

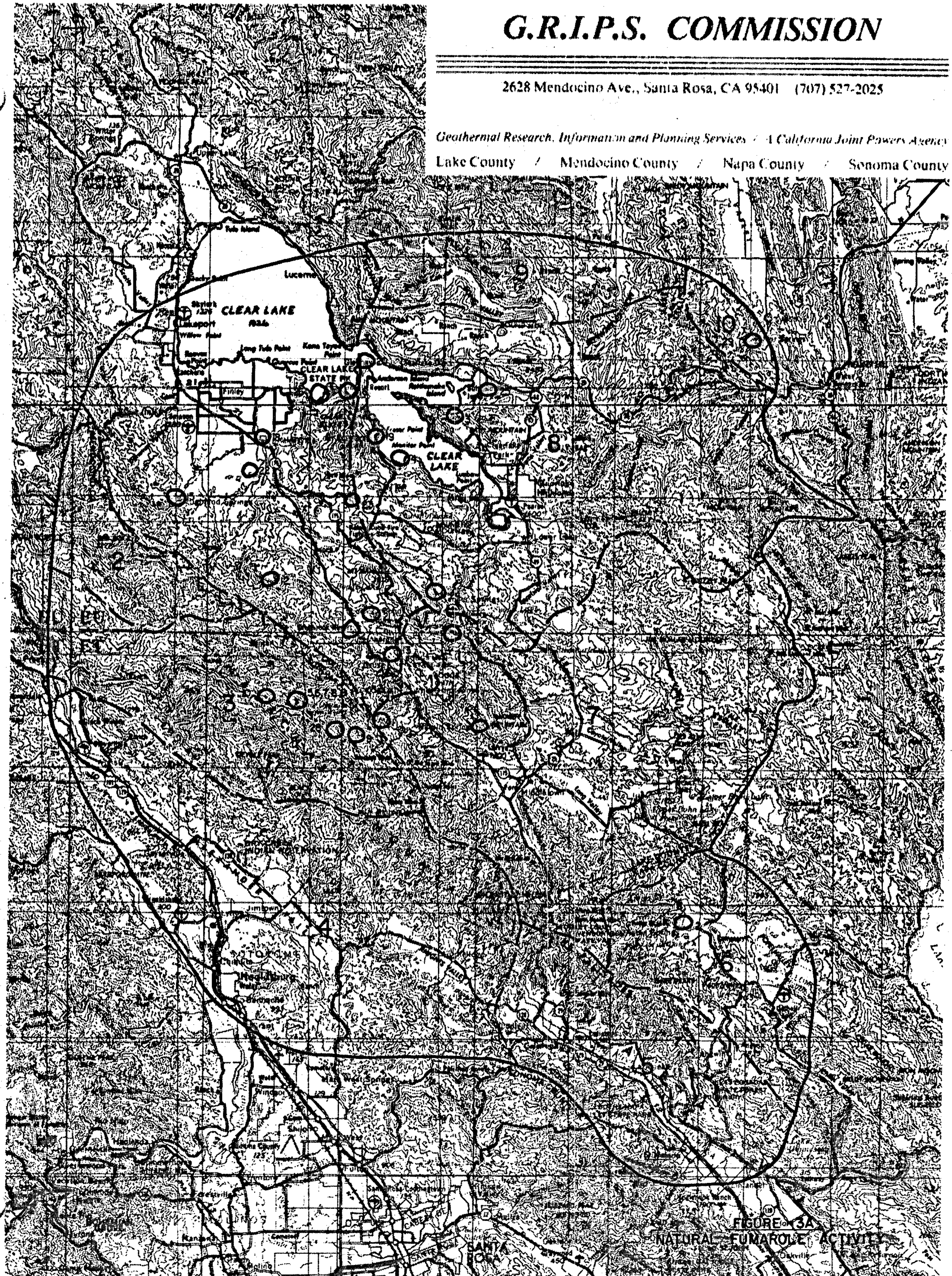

FIGURE 3A
NATURAL FUMAROLE ACTIVITY

3.3 Current Emission Sources

Approximately 250 production wells have been drilled in the CAMP Study Area. Thirteen permitted geothermal electric generating plants, with a producing capacity of 663 megawatts, are in operation. Presently, two additional plants are under construction in Sonoma and Lake counties.

Figure 3B is a map showing the current emission areas in the CAMP Study Area. Including the areas shown on Figure 3B are all sources capable of current emissions, These include drilling producing wells, shut-in or idle steam wells, and, of course, power plants.

Initial H_2S emissions occur when wells are drilled. As drilling progresses into the geothermal zone, it is necessary to drill with compressed air because the hydrostatic pressure is too low to support mud drilling. Thus, the geothermal fluid provided with a path to the surface is released to the atmosphere. Releases during well drilling typically continue for as long as three weeks. Normally, only one well drilling operation is at a depth where geothermal fluids are being released. Sometimes two or, perhaps, three wells are at this stage. After a well drilling operation is completed, valves installed and the well tested, the flow is restricted to a minimum bleed. The size of the bleed pipe is determined primarily by the wetness or rate of condensation within the well. The bleed pipe diameter is normally about 1 centimeter, but may be as large as 6 centimeters. The diameter of a well is typically 25 centimeters.

After a well is drilled, it is allowed to bleed from 1,000 to 15,000 pounds steam per hour until a power plant is constructed. It may remain in this condition for several years, although most production wells are drilled during the latter stages of plant construction.

After a power plant is constructed and placed in operation, venting routinely occurs at several locations along the steam supply lines from the wells to the power plant. However, in operating plants, most of these vents have been connected to a vent collection system, and the condensed geothermal fluid is now reinjected into the ground. These vents are all small, one centimeter or less, and are connected at the particle separators that remove particles at the wellhead, at the flow meters along the steam lines, at low spots along the line where condensate is periodically removed, and at the dust particle separator near the plant entrance. All these do release the entire geothermal fluid without removal of any potential pollutants.

The major release associated with the steam supply occurs when a power plant shuts down. When a malfunction is detected in the plant, the supply of steam to the turbine is shut off. This causes pressure to build up quickly in the lines. This pressure buildup in the transmission line actuates relief valves sequentially, and the full flow of geothermal fluid is vented directly into the atmosphere through a muffler that reduces noise. Some suppliers have developed procedures for use in the event of power plant outages to curtail production from the geothermal wells. Such curtailment reduces emissions by throttling down wells and/or re-distributing steam into adjacent operating power plants.

Under normal operating conditions, approximately 80% of the water from the geothermal steam, after passing through the turbine that turns the generator, is emitted into the atmosphere. However, approximately 20% is reinjected into the ground. Again, in a normally-operating plant, the major point of emission into the atmosphere is the cooling tower. This is true even for the noncondensable gases, because the noncondensable gas ejector system is normally injected into the cooling tower.

3.4 Projected Emission Sources

It is recognized that there are many uncertainties attended in the description of the H_2S emissions inventory during the next ten years. Among these unknown are the following:

a. The location, number and size of operating geothermal facilities.

b. The operating characteristics of permitted geothermal facilities:

  (1) Frequency of major venting

  (2) Variation in power production

  (3) H_2S abatement efficiency and reliability

c. The extent of which new and existing permitted geothermal facilities comply with existing emissions control regulations scheduled to be in effect during the period.

d. The extent of which existing regulations may either be relaxed or made more stringent in the intervening years.

e. The degree of control of H_2S emissions (both upstream and in the expended geothermal fluid) achieved as a consequence of technological advances.

f. Variations in H_2S concentration in steam.

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FIGURE 3B
CURRENT EMISSION AREAS

A projection of the number of producing wells which will be developed during the next five years has been incorporated in Table 7-4. This projection was based on current production figures which show an average of ten wells producing approximately 450,000 kilos of steam per hour for each 55 megawatts of power production. Figure 3C shows the outlines of the areas in which drilling has taken place and in which emission sources could occur.

One worst-case scenario could be envisioned as a severe subsidence stagnation episode occurring at a time when most, if not all, the producing wells are venting. The probability of simultaneous venting of all manifolded wells is finite; however, such a situation is an extremely unlikely event. It would be extremely difficult to assess the future background levels under the numerous worst-case meteorological conditions and the determination of what the incremental impacts from a proposed new permitted geothermal facility would be.

An approach to establishing source-receptor relationships might be through the use of deterministic air quality dispersion models. By this method, the relevant physical and chemical processes that occur in the atmosphere are represented in mathematical form; and relationships among these processes are expressed in terms of one or several important advantages over other methods. It is possible with this model type to obtain concentration estimates over a broad range of meteorological and emission conditions. These include historically observed events as well as hypothesized conditions. Dispersion models permit examination of the impact of a particular source on one or several receptors as well as examination of the impact of

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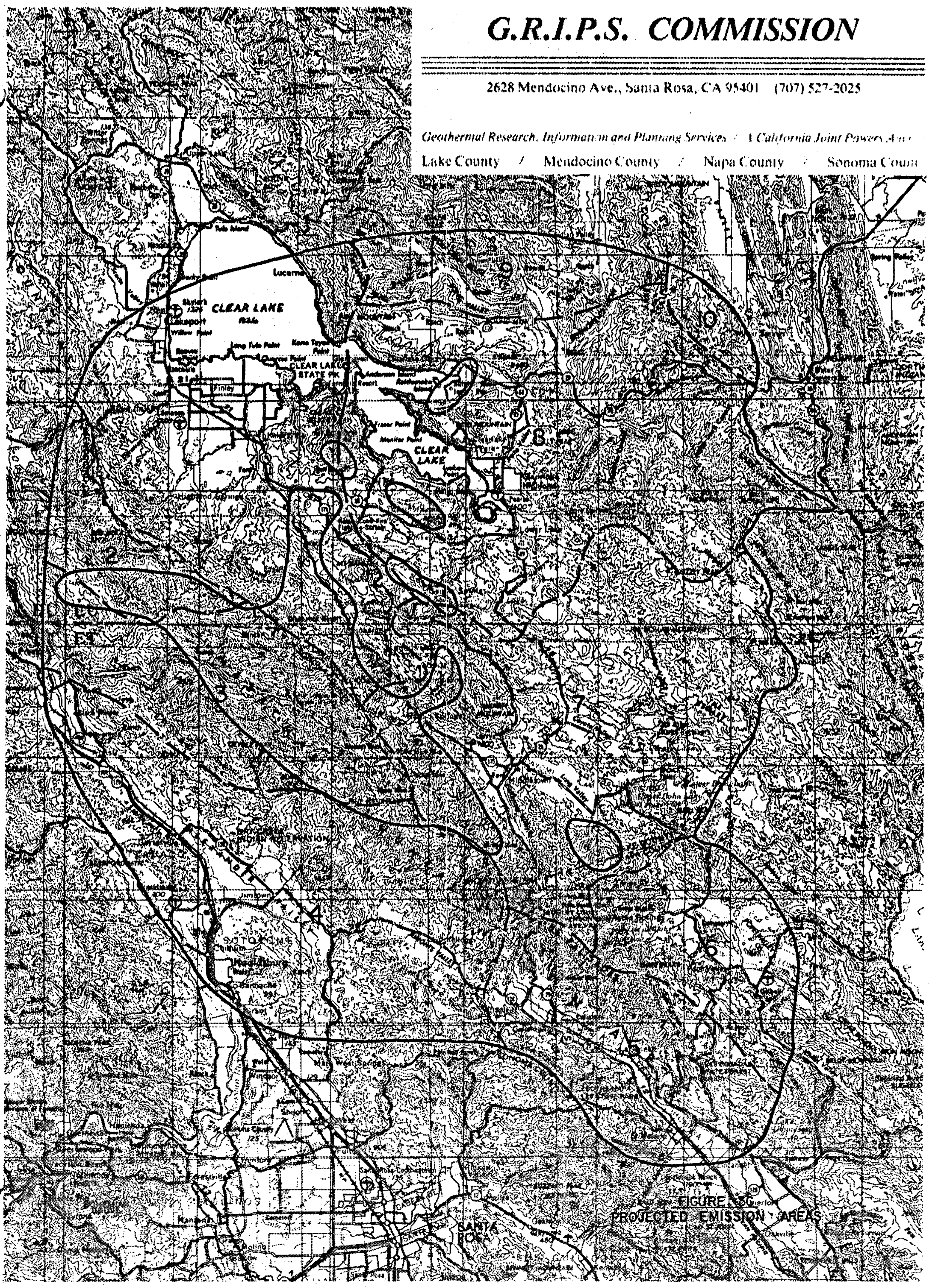


FIGURE 5C
PROJECTED EMISSION AREAS

several existing (or proposed) sources on a single receptor. Modeling has been employed as an approach in air quality analysis in some previous projects in the CAMP Study Area. However, because of the current lack of demonstrated adequate performance in complex terrain, modeling is not widely used.

Field measurement programs constitute perhaps the best way to establishing source-receptor relationships. The most effective programs involve atmospheric releases of tracer materials. Tracer experiments provide fact relationships between emissions and resultant air quality for the conditions examined. Extrapolation of the results to other conditions induce uncertainties in the concentration levels that, in some cases, cannot be resolved without recourse to modeling or repetition of the test under a different set of conditions. Tracer studies do not provide a suitable approach to estimate future background levels because a large number of tests are required to establish source-receptor relationships to the numerous sources under several meteorological regimes.

Although emission levels have been diminished from those recorded prior to 1978, as a consequence of improved emission controls, several conclusions can be drawn from CAMP Study Area meteorological analyses:

1. Cooling tower emissions represent the largest H_2S source category.

2. H_2S emissions under major venting are much larger than those occurring during power plant operations.

3. H_2S emissions from natural sources are insignificant.

4. Emissions of types other than H_2S probably do not have to be considered because detrimental effects have not been identified beyond the immediate vicinity of the power cooling towers.

Table 3-4 shows the estimated H_2S emission rates for the year 1975. The estimated rates are annual average rates in lbs/hour, and do not represent the pollution potential of the emissions which is related to the instantaneous rate of emission.

TABLE 3-4
ESTIMATED* H_2S EMISSION RATES (1975)

	Lbs/Hour	Percent of Total
Power Plants	1574	(4%)
Uncontrolled Well	73**	(3%)
By-Passing	61	(3%)
Pipeline Vents	31	(2%)
Well Testing & Clean-Out	28	(2%)
Well Drilling	9	(<1%)
Well Bleeds	7	(<1%)
Natural Fumaroles	5	(<1%)

Table 3-5 on the following page (53) shows the drainage basin in which a Permitted Geothermal Facility (PGF) is located, the PGF type and number of units, output, developer, and the on-line date. These data are significant because it permits the reader to have an idea of the pounds per hour of H_2S emitted from those air drainage basins containing the most PGFs.

Figure 3D, following Table 3-5 shows the power plants and wells situated in each of the air drainage basins. The symbols on the figure indicate both the PGFs currently in operation and those projected with the on-line dates shown in Table 3-5.

*Stanford Research Institute, Environmental Analysis for Geothermal Energy Development in the Geysers Region, Volume I; Summary, May, 1977, SRI Project EGH-5554, prepared for the California Energy Resources Conservation and Development Commission.

**Most recent estimate is 35 lbs per hour (1980)

TABLE 3-5

DRAINAGE BASINS, PGFs, OUTPUT, DEVELOPER AND ON-LINE DATES

February 1, 1980 ***

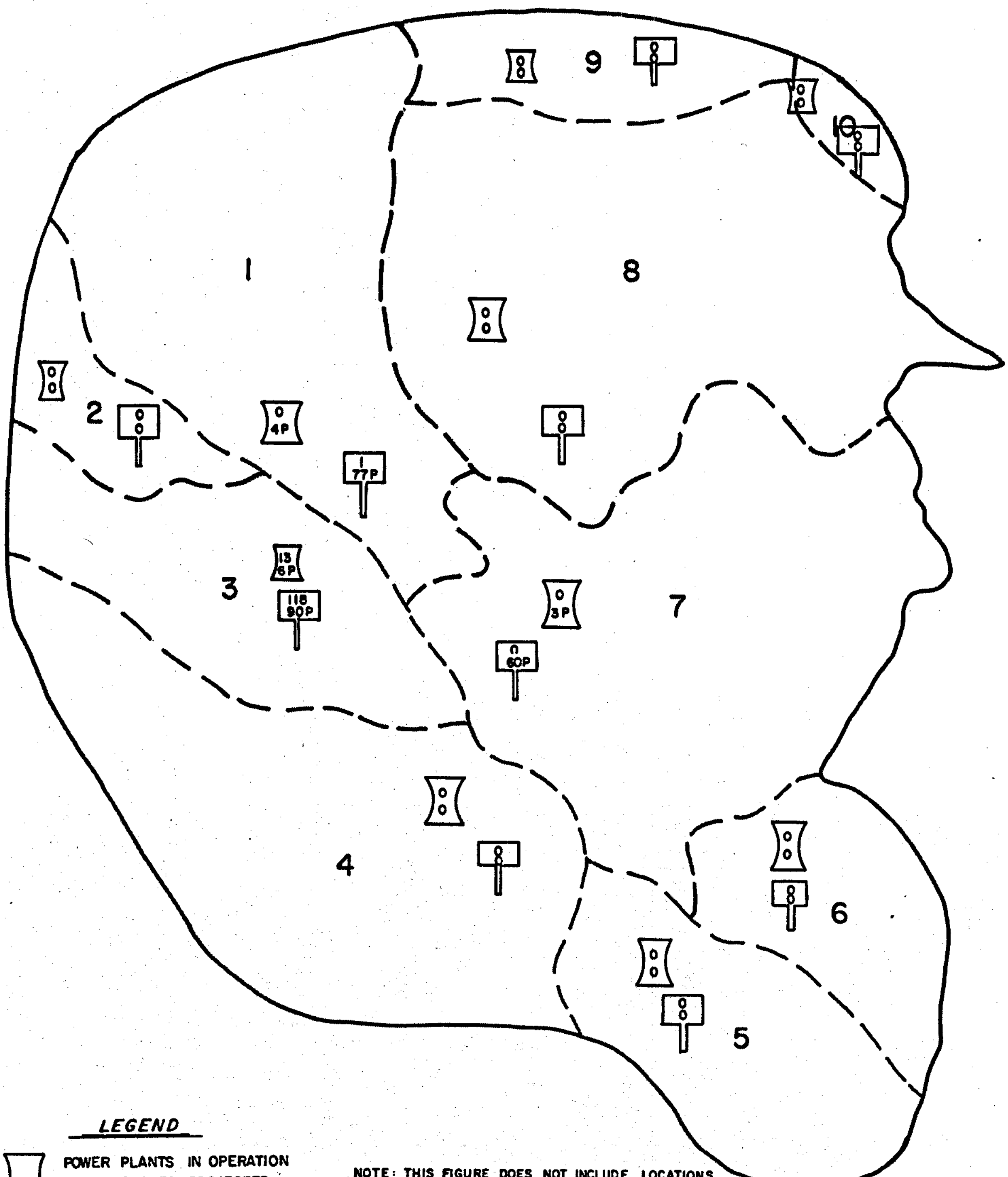
Corresponding Drainage Basin No. to Power Plant Unit *	Power Plant Unit	MW	Steam Lbs per Hr. Per Unit	Numbers** of Wells Serving Each Unit	Developer	When On-Line
3	PG&E 1	11	200,000	17	Union	1960
3	PG&E 2	13	236,000		Union	1963
3	PG&E 3	27	491,000	21	Union	1967
3	PG&E 4	27	491,000		Union	1968
3	PG&E 5, 6	53/53	964,000/964,000	10	Union	1971
3	PG&E 7, 8	53/53	964,000/964,000	15	Union	1972
3	PG&E 9, 10	53/53	964,000/964,000	21	Union	1973
3	PG&E 11	106	1,927,000	14	Union	1974
3	PG&E 12	106	1,927,000	10	Union	3/1979
3	PG&E 15	55	1,000,000	10	Thermogenics	7/1979
	Proposed Units					
7	PG&E 13	135	2,455,000	-	Aminoil	4/1980
3	PG&E 14	110	2,000,000	-	Union	8/1980
3	PG&E 17	110	2,000,000	-	Union	8/1982
7	PG&E 16	110	2,000,000	-	Aminoil	1/1983
3	NCPA 2	55/55	933,000/933,000	-	Shell	1981/82
1	DWR/Bottle Rock	55	1,000,000	-	McCulloch	1983
3	PG&E 18	110	2,000,000	-	Union	10/1982
1	NCPA 1	33/33	600,000/600,000	-	RFL	12/1983
7	PG&E 19	110	2,000,000	-	Aminoil	1983?
1	PG&E 20	110	2,000,000	-	Union	198?
1	PG&E 21	110	2,000,000	-	Union	198?
3	DWR/ S. Geysers	55	1,000,000	-	Geothermal Kinetics	1984
3	SMUD 1	55	1,000,000	-	Aminoil	1984
?	DWR/Unnamed	55	1,000,000	-	Unknown	?
?	SMUD 2	55	1,000,000	-	Unknown	?

* See Figure 3D.

** These numbers are approximate and include injected wells. Data were taken from the California Division of Oil and Gas Map, The Geysers G3-1, 9/1979.

*** Information on PGFs, output, developer and on-line date was taken from the California Energy Commission's Geothermal Update, November, 1979.

Note: Basin #3 is in Sonoma County, and Basins #1 and #7 are in Lake County.



LEGEND

POWER PLANTS IN OPERATION
POWER PLANTS PROJECTED

PRODUCING WELLS
PROPOSED WELLS

NOTE: THIS FIGURE DOES NOT INCLUDE LOCATIONS FOR DWR/UNAMED OR SMUD 2 BECAUSE THEY WERE NOT SITED AT THE TIME THIS REPORT WAS MADE.

FIGURE 3D
POWER PLANTS & WELLS
PER DRAINAGE BASIN

4. TYPE AND LOCATION OF MONITORING EQUIPMENT

4.1 Background

Meteorological and H_2S monitoring conditions in the CAMP Study Area have largely been confined to the eight-site Stanford Research Institute (SRI) network. This network was jointly funded by PG&E, Union Oil, Pacific Energy, and Aminoil, and included various mobile laboratory programs. In addition, 18 limited parameter weather stations were operated by the Lake County Air Pollution Control District (LCAPCD) from November 1976, through April of 1979. Only one station (Middletown), in the LCAPCD network, monitored ambient H_2S concentrations.

The SRI network provided considerable information on airflows in the lower portion of the boundary layer in the vicinity of the existing dry steam regions. However, none of the work done thus far has provided the simultaneous upper air data desired to more fully characterize the airflows in the region.

Table 4-1 shows meteorological and air quality sites in operation during the fall of 1979. Most of these stations were established for site-specific purposes and have been in operation since August of 1979, but are scheduled for removal in March, 1980.

Additional stations related to the needs of specific developers have been implemented but do not have a long enough period of record for meaningful analysis. These stations are generally site-specific and not well suited to the purpose of the CAMP which requires long-term, audited data.

TABLE 4-1

METEOROLOGICAL AND AIR QUALITY STATIONS

OPERATING FALL, 1979

SPONSOR	SITE NAME	OLD #	INSTRUMENTS
* SHELL	UPPER		W_R, W_D, R/H
* SHELL	LOWER		W_R, W_D, R/H
* DWR	BOTTLE ROCK		W_R, W_D, R/H, H_2S
* DWR	SO. GEYSERS		W_R, W_D
* DWR	POCKET PEAK		W_R, W_D
* DWR	GEYSER ROCK	SRI #1	W_R, W_D, H_2S
* DWR	BIG SULPHUR CR.	SRI #8	W_R, W_D, H_2S
* DWR	GEYSERVILLE		W_R, W_D, H_2S, A.R.
**NSCAPCD	PINE SUMMIT ESTATES	SRI #4	W_S, W_D, H_2S
**NSCAPCD	HEALDSBURG CITY HALL		W_R, W_D
* SMUD	ANDERSON SPRINGS	SRI #6	W_R, W_D, H_2S
* SMUD	SAWMILL FLATS	SRI #7	W_R, W_D, A.R.
* SMUD	DIAMOND D		W_R, W_D, A.R.
* SMUD	SOCRATES MINE		W_R, W_D
* SMUD	SMUD #1		W_R, W_D, R/H
* SMUD	JIMTOWN		W_R, W_D, H_2S
* SMUD	ACADEMY (FORMERLY HOBERG'S)		W_R, W_D, H_2S
* PG&E	UNIT #13		W_S, W_D, T, D.P.
* PG&E	UNIT #16		W_S, W_D, T, D.P.
* PG&E	UNIT #19		W_S, W_D, T, D.P.
* PG&E	UNIT #20		W_S, W_D, T, D.P.
* AMAX	LIVERMORE RANCH		W_S, W_D
* AMAX	TAMAGNI RANCH		W_S, W_D
* AMAX	CALISTOGA		W_S, W_D
* AMAX	BLANCHARD RANCH		W_S, W_D
**LCAPCD	MIDDLETOWN		W_R, W_D, T, H_2S
**LCAPCD	ANDERSON SPRINGS (MOBILE)		W_S, W_D, T, R/H, H_2S
**LCAPCD	LAKEPORT		W_S, W_D

W_R = Wind Run

W_S = Wind Speed

W_D = Wind Direction

T = Dry Bulb Temperature

R/H = Relative Humidity

H_2S = Hydrogen Sulfide

A.R. = Acoustic Radar

D.P. = Dew Point

* Site Specific Monitoring Station

**Equipment owned by districts

Meteorological data are required for air quality modeling. They are used to determine pollutant sources and transport. Meteorological data are also used in forecasting short-term episodes and interpreting whether trends are desirable over a multiyear period. While the meteorological data collected under this plan will not be adequate to support rough terrain modeling, it must be available to make H_2S monitoring data meaningful and useful.

In summary, the history of major, significant sources of meteorological and air quality data in the CAMP Study Area are the nine stations in the SRI network and the eighteen stations in the LCAPCD mesometeorological network. All of these data collected by these two networks are essentially surface measurements; wind instruments on ten-meter towers. An acoustic radar has been situated at one of the SRI sites for measuring vertical stability and inversion heights. Many of the stations in both networks were located where local terrain influenced the observations.

Attempts to construct a generalized description of the surface wind pattern over the CAMP Study Area on the basis of data collected by the SRI and LCAPCD networks have not been very successful. The complexity of the terrain and an insufficient number of stations have contributed to this lack of success.

Upper air data are completely inadequate to provide guidance in determining how the upper level gradient wind flow by which the emitted pollutants are primarily transported. The only upper air data available in the CAMP Study Area are acoustic radar data at one SRI site and an a.m. and p.m. pibal released at Lakeport every six days. This lack of meteorological data in the lowest kilometer above the ground also prohibits any meaningful verification of flow fields predicted by modeling studies.

In conclusion, the surface data collected in the CAMP Study Area are useful, but are inadequate to provide a reliable description of the airflow at the surface or to permit the verification of modeled flow fields. Upper air data are almost totally lacking.

4.2 Factors Impacting Site Selection

The CAMP Study Area includes a major part of the Lake County Air Basin, and parts of the North Coast, Sacramento Valley and the Bay Area Air Quality Basins. The Study Area has been divided into a number of air drainage sub-basins (see Figure 1D) for the purposes of the CAMP. The rationale applied to the division of the CAMP Study Area into air drainage sub-basins has been described in detail in Section 1.5. However, the principal factor used to subdivide the Study Area was the hydrologic drainage. In some cases, the hydrologic basin itself was subdivided. Air drainage, particularly in the early morning worst-case conditions, follows the water drainage pattern. The climatology of the Study Area suggests that the synoptic or macroscale meteorological pattern is moderately uniform throughout its length and breadth. Except for a unique rainfall pattern and micrometeorological, areal discontinuities, the inter-sub-basin air mass characteristics can be considered uniform.

Because the CAMP Study Area is an area of complex terrain features, it is generally recognized that ideally it would require hundreds of meteorological stations to determine the local characteristics of the many air drainage sub-basins. However, in recognition of financial limitations, the CAMP provides for the collection of only the amount of meteorological data which should be sufficient to meet the needs for developing and utilizing H_2S monitoring data.

The effects of mountainous (complex) terrain on atmospheric flow are well known. Orographic lifting and downwash, with or without flow separation, is a result of either normal (right angle) or oblique airflow against a mountain barrier. Canyons and valleys tend to channel the ground-level flow in a direction that is aligned with the local terrain. Bifurcation, or splitting, is another feature observed in complex terrain when airflow approaches a terrain obstacle. Flow around Cobb Mountain, for example, is likely to be of a bifurcated character and has led to the difficulty in assessing source-receptor relationships. Another kinematic effect produced by complex terrain is the acceleration of windflow through mountain passes, saddles or cols, as they are sometimes referred to, and then the deceleration of the airflow on the downwind, downslope side of the mountain. These effects create considerable deformation of the air stream.

4.3 Types of Data Gathering Equipment

Two type groups of data collection equipment are proposed. One group consists of meteorological (ambient atmospheric) data collection equipment. The second type group consists of H_2S detectors and meteorological sensors.

a. Type Group I - Meteorological Data Collection

1) Fixed 10-meter, guyed, triangular tower with wind velocity measured at the 10-meter level and temperature and relative humidity measured at the 3-meter level. These data will be used by the APCDs and concerned meteorologists in the determination of inter-air basin synoptic wind flow (and H_2S trajectories) and low level air mass characteristics.

2) Acoustic Radar, semi-portable turbulence detector. These data will be used to verify the capability of the atmosphere to mix pollutants, validating dispersion models, assessing layering including the top of fog and low clouds.

3) Rawinsonde, semi-portable upper-atmospheric sounding detector. Data gathered from the rawinsonde is essential (wind velocity and temperature) up to heights of 2 or 3 kilometers to understand and simulate the transport of pollutants. Interaction between the terrain-controlled surface flows and the unperturbed upper level flow must be measured since it is at these levels that the emitted H_2S is transported. The rawinsonde data may also be used to verify acoustic radar data, especially if the two instruments are co-located.

b. Type Group II - H_2S Data Collection Equipment

1) Established Exceedance Receptor Station (EERS)
Data sensors will include a continuous H_2S analyzer located in a small, insulated, air-conditioned building. Wind velocity and temperature will be observed from a 10-meter triangular tower in the immediate vicinity. These data will be utilized by the APCO to monitor and verify impact on local receptors in addition to estimating trajectories of suspected H_2S sources.

2) <u>Interim H_2S Sampler Station (IHSS)</u>

These stations consist of an expendable Colortec tag protected from precipitation and wind and mounted on a one-meter pole or side of a tree. Data will show integrated levels of H_2S over 24-hour periods and will be used to verify and select locations for EERS.

3) <u>Trend Station (TS)</u>

This type of H_2S monitoring station includes the same equipment as an EERS. However, this station is not necessarily receptor oriented and the APCO utilizes the data principally for his development and analysis of control strategy.

4) <u>Mobile H_2S Station</u>

This station, too, involves the same analyzer and meteorological sensors as the EERS. However, the wind and temperature data may be observed from a weather station mounted on a 3-meter pole attached to the mobile, air-conditioned trailer which houses the H_2S analyzer. The Mobile H_2S Station may be used at the discretion of the APCO as a substitute for an EERS, IHSS, or TS, depending upon the immediate needs.

5) <u>Site-Specific Station (SS)</u>

This station minimally includes wind speed (or wind run) and wind direction. In addition (see Table 4-1), a site-specific station may include temperature, relative humidity, or dewpoint, and H_2S sensors. SS stations are required in the permitting process, and the data are used by the concerned agencies for baseline information.

4.4 General Guidelines for Locating Meteorological Stations

A recommended meteorological network is a compromise of station spacing and direction orientation to minimize the impact of local kinematic effects. Climatological data suggests that the CAMP Study Area is most frequently under the influence of homogeneous air masses. There may be an infrequent occasion when the Study Area west of the Mayacamas Ridge is influenced by a marine air mass, and the balance of the Area may be dominated by a relatively dry, continental air mass. However, these instances are not sufficient to justify the installation of more than one or two observation sites sensing air mass moisture in the meteorological station network.

Based on the assumption of relatively uniform air mass characteristics, particularly as related to the uniformity of boundary layer characteristics, a network of 7 meteorological stations is recommended. The recommended network, designated by circles on Figure 4A and Table 4-2 on the following page, is located along the Mayacamas Ridge, normal to the west-east prevailing wind flow. Two of the 7 stations, however, are located at high elevations on a line normal to the Mayacamas ridgeline. Such a right angle configuration of meteorological wind data stations should provide the best resultant wind data.

Guidelines for locating a meteorological station are listed as follows:

a. Synoptically oriented

b. Located on elevated terrain

c. Properly exposed

  1) 10-meter tower

  2) Away from abrupt escarpments

d. Monitoring wind speed, wind direction and temperature

TABLE 4-2

Proposed Meteorological Network*
February 1, 1980

Station #	Location	Elevation	Parameters
1	St. Helena 3.5 W	2000	W_S, W_D, T
2	Red Hill	2156	W_S, W_D, T
3	Old ES&S #24	3000	W_S, W_D, T, R/H
4	Old ES&S #21	3200	W_S, W_D, T
5	Hopland Summit	2500	W_S, W_D, T
6	Queens Peak	1948	W_S, W_D, T
7	Brushy Sky High	3200	W_S, W_D, T

W_S = Wind Speed   T = Temperature

W_D = Wind Direction   R/H = Relative Humidity

* Limited meteorological data will also be collected by some of the proposed air quality stations.

This network will permit the characterization of the synoptic wind flow pattern over the total CAMP Study Area.

G.R.I.P.S. COMMISSION

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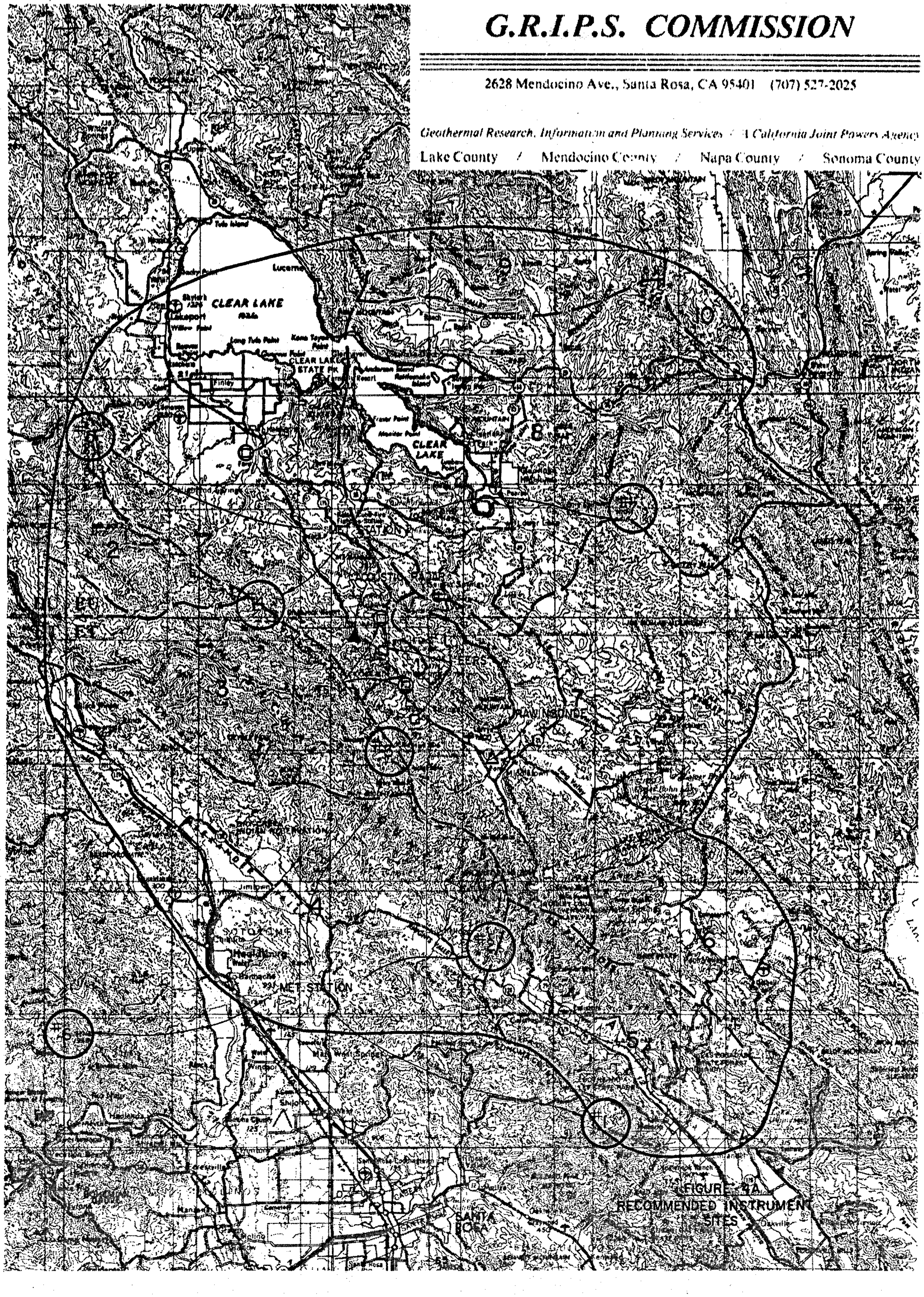

Station #3, Old ES&S #24, would be the only meteorological monitoring station to observe relative humidity. Each station was selected to allow a reasonable assessment of the winds when coupled with measurements of winds at adjacent stations. Analysis of data after a statistically representative period of collection may indicate that stations should be eliminated, relocated or increased in number. The trade-off between increased maintenance cost due to accessibility and combining the stations should be considered.

4.5 Justification for Locating Acoustic Radars and Rawinsondes

The mixing height is the distance above ground to which relatively free vertical mixing occurs in the atmosphere. When the mixing height is low, entrapped pollutants are prevented from dispersing upward if the pollutants are contained in the mixing layer. Mixing height data are generally derived from surface temperatures and from the twice-daily upper air soundings which are obtained by means of rawinsondes. However, more accurate determinations of the critical morning period depth of the mixing layer can be obtained by means of acoustic radars. Acoustic radars provide information on the vertical thermal structure of the atmosphere, including heights of inversion layers and the top of the convective mixing layer. It is recommended that an acoustic radar, mounted on a trailer for mobility among the air drainage basins, be available for use within the CAMP Study Area.

Data obtained from an acoustic radar loses its definition in the afternoon as vertical mixing becomes very active and the inversions lift. Therefore, an alternative way of obtaining upper air data in the afternoon is with rawinsonde observations.

These soundings should correspond in time (for synoptic scale correlation) with those taken by the National Weather Service at 0000 Greenwich Civil Time (1600 PST). An added advantage of the rawinsonde is that it provides a measure of the moisture content of the air mass dominating the area of interest. The rawinsonde provides observations of the wind speed and direction to heights well above the mixing layer. However, temperature and relative humidity are limited in resolution and accuracy in the lowest few hundred meters because the data profiles have substantial gaps. Also, wind direction is sometimes not well defined in the very low levels due to tracking errors under very light wind conditions. However, a relatively inexpensive air-sonde type of balloon may resolve these problems.

The initial locations of an acoustic radar and a rawinsonde are shown on Figure 4A. An acoustic radar mounted on a trailer might initially begin operation in Cobb Valley. It then may be moved to other sites as sufficient data are gathered to allow establishing correlations among air quality sub-basin mixing height characteristics.

4.6 General Requirements for Locating H_2S Stations

a. Data Needed

The placement of additional instrumentation to sense the impact of proposed and Permitted Geothermal Facilities (PGF) on the CAMP Study Area environment poses a complex problem. H_2S stations should provide accurate data needed to:

1) Assess the strategy for emission control as related to ambient air standards;
2) Measure the exposure of populated areas to H_2S for public health and air quality analysis;

3) Develop impact statements;
4) Provide a framework for conduct of site-specific studies;
5) Assess transport of pollutants;
6) Complete the data base to achieve the goals of CAMP.

The fulfillment of the requirements to gather data to assess and gauge the strategy of emission control and the exposure of populated areas to H_2S has only been partially determined through the use of formerly-established networks and previous air quality studies. However, the installation of one or more complex and costly H_2S stations in every one of the CAMP Study Area sub-basins cannot be justified.

Interim H_2S (IHSS) samplers are small, chemically-treated tags to be used at the discretion of the APCO to verify and establish suspected violative sites in populated areas. The tag develops a brown stain proportional in intensity to the amount of H_2S experienced during a 24-hour exposure period. Color standards representative of known dosages are printed around the treated tags. The exposed tags are compared visually with the color standards for immediate evaluation of the dosage. Although the chemically-treated interim detector tags provide limited information, this information would allow for a determination of whether or not a continuous H_2S monitoring station should be located in that vicinity.

To meet the guidelines for H_2S "trend" measurements, and to monitor H_2S at "EERS" sites, continuous H_2S gas analyzers should be installed. EERS sites are those locations in populated areas where violation of ambient air standards have been found through previous studies. There are two EERS locations in the CAMP Study

Area: the Upper Cobb Valley on Kelsey Creek; and Anderson Valley in the upper Putah drainage. Trend sites are H_2S stations established within selected air drainage basins to gather data needed for trend analysis. These trend site locations have been previously determined by the NSCAPCO and LCAPCO as sites they consider requisite for development and analysis of control strategy.

b. Guidelines for Locating H_2S Stations

1) Located immediately adjacent or in the geographical center of (significant) population areas within the CAMP Study Area (IHSS and EERS).
2) Not be situated immediately within or adjacent to a point or area emission source unless the source is adjacent to a population center (EERS only).
3) Located near a reliable source of alternating electric current.
4) Easily accessible.
5) Monitor H_2S ambient air temperature and wind velocity (EPA/ARB Guidelines).
6) Trend Stations (TS) will be located with due consideration given to historical data base, if possible.

"Establishing and Terminating Monitoring Stations", Section 6, deals specifically with the time when an interim, chemically-treated tag H_2S monitor should be installed. Likewise, Section 6 discusses when a continuous H_2S station should be established or terminated.

Frequently, due to physical obstructions, the location of an H_2S station is not a desirable site to measure meteorological parameters. However, compromise sites can be selected with bias toward the requirement for the measurement of the H_2S parameter. The wind direction is an aid in approximating the direction of transport of the plume. The variability of the direction of transport over a period of time is a major factor in estimating ground level concentrations averaged over that period of time. Wind velocity, therefore, should be measured at or near each H_2S station at the 10-meter level.

Figure 4A shows the proposed locations of two EERS H_2S monitoring stations to monitor population center levels and are designated by triangles. The recommended location of the Cobb Valley H_2S station is near Pine Grove. The Anderson Valley location recommended is at the intersection of Anderson and Bear Canyon Creeks in Anderson Springs.

In order to allow flexibility for determining the exact location of Trend Sites (TS) and, perhaps, as an aid in verifying Established Exceedance Receptor Stations (EERS), one or more mobile H_2S stations are recommended. These mobile stations would be sited following the guidelines established for EERS and TS siting.

Table 4-3, on the following page, lists the proposed locations for EERS and TS. There are no currently proposed areas for locating IHSS.

TABLE 4-3

PROPOSED H_2S MONITORING LOCATIONS
FEBRUARY 1, 1980

Station Type	Location
EERS	Cobb Valley (Pine Grove)
EERS	Anderson (Anderson Springs)
TS	Hoberg (Presently SRI #4)*
TS	Whispering Pines 0.5 SE
TS	Kelseyville 1 S
Mobile	(To be selected by NSCAPCO)
Mobile	(To be selected by LCAPCO)
IHSS	(To be selected by NSCAPCO & LCAPCO)

*Until correlations can be established with the Hoberg site.

Guidelines for locating site-specific monitoring stations will, generally, follow EPA/ARB Guidelines. However, no further recommendations are made in the CAMP concerning site-specific monitoring station locations or numbers because these determinations are made by the permitting agency as part of the permitting process.

5. INSTRUMENT PERFORMANCE

In order to provide the data base and general understanding needed so that individual developers and regulatory agencies will have sufficient information upon which to base sound development decisions, meteorological data and air quality data must be available in the CAMP Study Area. The credibility of the data base is a function of the instrumentation performance, including data logging, maintenance and processing. These functions are addressed in the following paragraphs.

5.1 Instrument Standards

a. Wind Velocity - mounted on 10-meter towers:

1) Wind speed - Threshold, < 0.5 M/S
Range, 0.5 to 50 M/S
Accuracy, for time averaged values $\pm$ 0.25 M/S

2) Wind direction - Threshold, recovers to $\pm 5^{\circ}$ of actual for a 10° deflection in a 0.5 M/S wind field.
Range, 001° to 360°
Accuracy, $\pm 5^{\circ}$

b. Temperature - mounted on 10-meter towers:

1) Vane aspirated thermistor;
2) Range, -12° C to 46° C;
3) Accuracy, $\pm 1.0^{\circ}$ C;
4) Time constant, 10 seconds to 63% in still air.

c. Relative Humidity

1) Range 10% to 99%;
2) Accuracy, $\pm$ 4% Full Scale.

d. Hydrogen Sulfide

1) Continuous Analyzer (ARB accuracy);
2) Threshold, 5 ppb.

5.2 Quality Assurance

To insure the quality and performance of the CAMP, the Air Monitoring Quality Assurance Plan of the State of California Air Resources Board should be followed explicitly. Standard operating procedures are provided with guidelines for maintaining and operating air monitoring stations and to provide detailed instruction for testing, maintaining and trouble-shooting and calibrating specific types of analyzers and support equipment. The validity and/or accuracy of data obtained from equipment depends upon equipment performance and operating efficiency. Equipment which produces data which consistently does not meet the ARB performance criteria should not be used in the CAMP. Deviations from the recommended procedures set forth in the ARB manuals, as well as in the manufacturer's instruction manual, may result in the collection of invalid data. Therefore, the monitoring station operator must become familiar with the information contained in the ARB Air Monitoring Quality Assurance Plan manual, as well as each manufacturer's instruction manual, in order to be at the minimum level of competence and an acceptable level of data quality.

The ARB Air Monitoring Quality Assurance Plan manual specifically outlines the routine tasks to perform each time an air monitoring station is serviced. It, also, defines the responsibility and techniques for data reduction.

Because maintenance, operation checks, calibration dates and other activities which may affect the data quality are important facets of an air monitoring network, specific care and maintenance of documentation is critical. Items such as instrument logs, station logs, and equipment relocation notifications or sight identification reports must be carefully maintained. All these items have a direct impact on quality, and must be strictly adhered to.

5.3 Data Logging

It is recommended that all recording be done on analog strip chart recorders and, in parallel, in digital format in nonvolatile memory at the field locations. The microprocessor in the field should be programmed not to record wind speeds less than 0.5 meters/sec. Chart speeds should operate at not less than 2.5 cm (1 inch) per hour with not less than 25 cm (10 inch) width charts for H_2S and 12 cm (5 inch) width for wind speed, wind direction (540^o format), temperature and relative humidity. The field-recorded nonvolatile memory should be finally translated into 1.25 cm (1/2 inch) magnetic tape or floppy discs for archiving and future analysis.

5.4 Data Retrieval Processing and Archiving

Data retrieval and processing can be undertaken by private contractor. One contractor could handle system maintenance, repair, calibration, data retrieval and validation. However, another contractor may very well handle data processing under a separate contract. However, it is important under all circumstances, that the data be processed and made available to the public as rapidly as possible.

The Comprehensive Air Monitoring Plan should follow the ARB Air Monitoring Quality Assurance Plan, and, hence, data retrieved will be of high quality. However, the processing of all data should follow an established quality assurance plan. A quality assurance program must be submitted by a data processing contractor as part of his work plan.

All data should be archived on 1.25 cm (1/2 inch) magnetic tape in a format acceptable to the ARB. In addition, all data gathered in the CAMP should be integrated into the GRIPS Data Archive and Retrieval System. This information management system provides for the assembly, classification and cataloging of all existing documentation in the development of the CAMP Study Area.

In general, the specifications for all stations are as follows:

a. Valid data captured to be representative of the period for which it is applied (approximately 90 percent).

b. The equipment, quality assurance program, operating and maintenance of each station must conform to ARB standards.

c. All meteorological and air quality data collected should be sampled at 15-minute intervals and reduced to hourly averages and recorded on a format acceptable to the local APCD.

6. ESTABLISHING AND TERMINATING MONITORING STATIONS

Early planning* by the CEC accented the need for air quality monitoring. A short-term program was suggested for the period March through May, 1979, followed by an interim program from June 1, 1979, to June 30, 1980. The CAMP was then to follow beyond June 30, 1980.

Subsequent development did not allow for the implementation of the short-term and interim programs starting in March and June of 1979. The interim monitoring program should be established at locations dictated by specific triggering guidelines. In addition, during the interim program, solicitations should be made for a contractor(s) to procure, establish and maintain the recommended meteorological and air quality monitoring network and the recommended rawinsonde and acoustic sounder.

It is the responsibility of the individual industrial developer to obtain site-specific meteorological and air quality measurements and studies. These studies and measurements should be obtained through the use of models, tracer studies, and the on-site installation of stack-monitoring sensors and grade-level meteorological towers. Because individual developers and regulatory agencies must have sufficient information upon which to

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*Consultation among administrators of the local APCDs, representatives of the steam producers and the utility companies, and members of the CEC staff.

base sound development decisions, the CAMP should be complimented by geothermal facility site-specific monitoring stations. Site-specific monitoring stations should be established using most of the same siting guidelines as set forth in Section 4.

Except as otherwise defined by local APCD regulations, site-specific ambient monitoring stations should be established one year prior to actual power plant construction. Termination of a site-specific monitoring station should not occur until mitigation has reached some specific reasonable and obtainable level defined by the concerned APCD.

6.1 General Guidelines

Guidelines which may trigger the need for placement of meteorological and air quality monitoring stations are essentially the basis for fulfilling the recommendation of the CAMP. The CAMP should provide a means to: assess the effectiveness of ambient control or mitigation strategy; measure the exposure of the population to hydrogen sulfide when confirmed complaints have been received; provide supplemental data for development of impact statements for projected PGFs; provide a framework for conduct of any site-specific studies which may be needed as a result of ambient air quality regulation changes; provide a unified data base and fill data gaps over the Study Area.

The additional requirement for mobile air quality monitoring stations has long been recognized as a requisite component of the CAMP. The flexibility afforded by air quality stations which can be easily and quickly moved to different sites within the CAMP Study Area will permit the responsible agencies to respond in three important categories:

a) Population densities in some parts of the CAMP Study Area fluctuate markedly with the season. It may be important to have the flexibility of a mobile air quality station to monitor a population center during season, high-density population periods should the population center meet the guidelines for locating an air quality station.

b) A mobile air quality station can be particularly useful for validating a site initially suspected of exceedances by a large number of complaints and/or the interim Colortec studies.

c) The mobility of an air quality station would be particularly valuable to verify air quality impact in the various air drainage sub-basins due to seasonal variations in the local climate.

Although the aforementioned general guidelines may be met, a monitoring station will not be established within the CAMP Study Area unless specific, contingent guidelines are also fulfilled. All the data obtained in the analyses of current and projected population and permitted geothermal facilities has been applied to the determination of triggering guidelines which are detailed as follows:

6.2 Specific Guidelines

a. For establishing interim H_2S samplers (Colortec)

1) All of the following conditions exist:

   a) Population density equals or exceeds five (5) resident adults per acre over 10 or more contiguous acres (per 0.4 hectares over 4 or more contiguous hectares).

   b) Not closer than 600 meters to a Permitted Geothermal Facility (PGF) unless otherwise determined by the Air Pollution Control Officer (APCO).
      1) Current PGF
      2) Newly PGF

   c) At least two (2) concurring adult complaints.

b. For terminating interim H_2S samplers (Colortec)

1) Twelve (12) months with no PGF traceable exposures exceeding Colortec range #1 (5 ppb) for 24 hours unless the APCO determined otherwise; or

2) No concurrent complaints from two (2) or more adults in the prior 12 months.

c. For establishing a continuous H_2S gas analyzer

1) Colortec range #1 (5 ppb) for 24 hours has been equalled or exceeded 3 or more times per year; or

2) Previous H_2S studies have shown exceedances at the location; or

3) Air quality modeling acceptable to the APCO shows an air quality impact equal to or greater than 20 ppb; or

4) Large number (< 5) of adult, concurring complaints; or

5) To obtain baseline data required for new source review in prospective development areas as determined by APCO; or

6) Need to measure accurate level of receptor exposure as determined by the APCO; or

7) Need to assess transport to a receptor exposure area as determined by APCO.

d. For terminating continuous H_2S gas analyzer site

1) One year of valid observations indicating less than 15 ppb H_2S.

2) No exceedances of state standard in two-year period.

e. For establishing meteorological monitoring sites

1) Need for macroscale temporal and areal data characterization measurements during period of geothermal facility development.

2) As needed in conjunction with air quality monitoring.

f. For terminating meteorological monitoring sites

1) Completion of characterization, subject to annual review; or

2) At completion of related air quality monitoring.

g. For establishing mobile acoustic sounder

1) Need for characterizing a.m. mixing layer data.

h. For relocating or terminating mobile acoustic sounder

1) Obtained one (1) year of data.

2) More desirable site in same air quality basin.

3) No longer needed.

i. For establishing mobile rawinsonde receiver

1) Need for characterizing p.m. mixing layer data and upper level moisture and wind velocity.

2) As needed in conjunction with air quality monitoring.

3) To assess accoustical radar data.

j. For establishing or terminating mobile rawinsonde receiver

1) More desirable site in or outside of CAMP Study Area.

2) Sufficient data to determine its value.

7. PROGRAM FOR FUNDING

7.1 Background

The Contract for preparation of the CAMP provides that the Preliminary Final Draft Report shall include alternative methods for financing the CAMP. Development of the alternatives described herein include the following steps:

-- A review of potential funding resources including: permit fees, direct industry contributions, BLM Mineral Lease payments, CEC, ARB, DOE, DOG, and other appropriate local, state and federal agencies.

-- The funding of prior air monitoring activities was reviewed to determine what methods have been used in the past.

-- The funding of the existing ambient air stations described in Table 4-1 were also reviewed.

-- Representatives of government and industry working in the CAMP Study Area were contacted.

-- Functions and purposes of proposed monitoring equipment were analyzed to: establish the responsibility for the conditions which led to the need for placement of equipment; and to determine the benefits to be derived from the placement of equipment.

It should be noted that the funding program developed herein does not provide for the costs of establishment of site-specific monitoring stations since location and funding of such stations will be worked out between various applicants and regulatory agencies.

The discussions with public agency and industry representatives clearly established that there are a variety of opinions and positions and that the determination of responsibility and benefits to be derived is quite subjective. However, there was a general concensus that the geothermal industry will have to bear a significant part of the cost. There is no clear-cut agreement on which approach or combination of approaches should be used to facilitate industry contributions. The alternatives include permit or fee payments, permit conditions and direct contributions.

The Alternative Funding Rationales described in Section 7.2 reflect an attempt to identify the major alternative approaches which were identified during this study process. The Alternative Financial Plans described in Section 7.6 are based on a staff evaluation of the viability of the elements of the Funding Rationales.

7.2 Alternative Funding Rationales

An orderly funding of the system should be based on a rationale or combination of several rationales for assignment of funding sources to cover the various cost elements. In recognition that such assignment is a subjective exercise, this section includes five alternative rationales for assignment of funding responsibilities.

These rationales only suggest assignment of responsibilities to the major parties involved: the Industry (utility companies and steam suppliers); Public Agencies (the local APCDs and the CEC); and the Public (citizens who are served by the monitoring system). The alternative methods for obtaining money from these sources are discussed in Section 7.3, Funding Sources.

Each rationale is based on a basic premise or set of premises. These premises reflect varying biases, and are frequently in conflict.

One basic premise is suggested for application to all of the alternatives. This premise is that the Air Pollution Control Districts shall, singly or through a joint mechanism, have the administrative responsibility for the establishment and operation of the proposed monitoring system (the system does not include site-specific monitoring activities). This involves preparation of a site, acquisition and installation of equipment, supervising analysis of retrieved data, station maintenance, and assuring that the operations are audited (the ARB may assume responsibility for the actual audit activity). This designation of responsibility for establishment and operation allows for the greatest possible continuity, assuring one clearly identifiable direction for all phases of the CAMP program in each county.

The alternative rationales developed herein are based on premises which attempt to incorporate the range of positions taken by the various participants in the interviews and the PCC discussions. The following titles were established for the alternatives: Regional/Local; Equipment/Operation; Air Drainage Basin; Responsible Party; Beneficiary.

a. Regional/Local

This alternative is based on the following PREMISES: 1) Meteorological (MET) Stations are a regional management issue and, thus, are the financial responsibility of public agencies; 2) Air Quality Stations are a localized issue and, thus, are the financial responsibility of industry.

This approach suggests that since MET Stations are concerned with the overall air movement (direction, speed, and temperature) in the area encompassing all of the air drainage basins, this regional nature makes them the financial responsibility of the entities concerned with the Air Resource management — local Air Pollution Control Districts. It suggests that the H_2S monitoring stations are concerned with a particular pollutant in a particular area (air drainage basin) and should, consequently, be the financial responsibility of the entities who produce the pollutant — the geothermal industry.

b. Equipment/Operation

This alternative is based on the following PREMISES: 1) Since equipment will be acquired for long-term use for varied applications, it should be a public agency financial responsibility; and 2) annual operating costs are incurred to measure specific industry activities and should, therefore, be an industry responsibility.

This alternative recognizes that the public agency which acquires the equipment for the program should have the freedom to use the equipment as it interprets the need. Locational needs will shift from year to year. Equipment will have a "life" (and resale value) which may well extend beyond the time required to provide an analysis of particular emissions or particular receptor locations. However, on a short-term (year-to-year) basis, the operation of the equipment will be directed toward dealing with questions raised by specific emission issues. Industry, therefore, should have the financial responsibility for covering the costs of those issues since they are responsible for the emissions.

c. Air Drainage Basin

This alternative is based on the following PREMISES: 1) MET and H_2S monitoring are joint financial responsibilities of regulatory agencies and industry. These responsibilities are shared on an air-drainage-basin to air-drainage-basin basis; and 2) the industries in each air drainage basin which produce the greatest amount of steam should have the greatest share of cost in each air drainage basin.

Under this approach, the cost of operating the CAMP would be divided among the various air drainage basins, based upon the equipment serving each drainage basin. The responsibility for paying these costs would then be assigned to the industry operating in or impacting on the air basin.

The Air Pollution Control Districts would have the financial responsibility for setting up the monitoring stations in this alternative. Subsequently, costs for operating the system would be allocated among the industries operating within or impacting on each air drainage basin. The allocation of costs to industry would be based on the individual industry contribution to the air pollution "problem". The quantity produced at the wellhead and steam entering the utility property would be used to establish the proportion of costs assigned to each industry within each air drainage basin.

d. Responsible Party Alternative

This Alternative is based upon the following PREMISE: industry, since it created the necessity for air quality control, is solely responsible for the costs incurred in the CAMP.

This approach suggests that an air monitoring system would not be required if this industry did not exist in the area and, thus, industry should be considered totally responsible for financing the system.

e. Beneficiary Alternative

This alternative is based on the following PREMISE: The areas in which the air monitoring system is located should share financial responsibility with industry which receives permits for development and operation of facilities.

This approach suggests that a method be developed that would allow for those people who live in the areas in which air monitoring occurs to contribute to an air monitoring program, and for this contribution to be shared with assignment of financial obligations to the industry operating in the area.

7.3 Funding Sources

In reviewing potential funding resources, consideration must be given to several factors which bear on the suitability of a resource to meet the projected program funding requirements. These include:

-- $ Available: It is important to consider this factor in determining what resources should be related to specific costs.

-- Continuity: Funding sources are either available at only one time or are available in varying amounts from one time to another. Others are subject to special conditions or limitations which prevent the assurance of continued or repetitive use of the source.

-- Legal Process: Acquisition of funds involves significantly varying processes such as: revision of fee structures; incorporation as conditions in use permit processes; incorporation as part of the budget process of a local government; execution of an agreement, Memorandum of Understanding or contract; processing of a grant; etc. These alternatives each have a bearing on both the feasibility of obtaining funds and the time required to obtain them.

-- Time Factors: The legal processes described above have varying lengths of time for completion, and some of them can be initiated only during certain times of the year. They also have varying frequencies of availability, particularly if related to an annual budget process.

The following is an enumeration and brief analysis of the funding sources most frequently mentioned during interviews and during the meetings of the PCC.

a. Industry

1) Permit Fees

$ Available: There are no specific limitations other than reasonableness and a need for any expenditures to be related to the purposes of the permit.

Continuity: The APCDs issue annual permits and, thus, funds from this source would be available on an annual basis as long as the permitted use continues. This will allow previously-permitted power plants and wells to contribute to the project. Permit fees established by the CEC are charged on a one-time basis and are of limited potential.

Legal Process: The revision of permit fees is accomplished through a hearing process before the APCDs' Boards of Directors. Subsequently, the funds obtained must be allocated to the monitoring system through the budget process. This would generally involve incorporation in the annual budget which is adopted effective July 1st each year.

Time Factors: The time required for revising the APCD permit fee structure is 60-90 days. This must be completed prior to formal action on a budget. Incorporation in the annual budget would have to be initiated prior to its adoption July 1st.

2) Use Permit Conditions

$ Available: The money available under this procedure is limited to the reasonableness and relationship of the use permit conditions to the proposed activity.

Continuity: Use permit conditions are generally established to accomplish a specific objective, and that would have a time limit. Such a time limit could certainly extend beyond a single year of funding, but this source could not be considered a permanent funding resource.

Legal Process: Use permit conditions can be attached only during the permitting process and at the time of formal action approving the permit.

Time Factors: The time required to complete this process depends upon the delays encountered in processing the permit request. A "normal" time for an APCD permit procedure would be 30-60 days. The CEC process involves 270-365 days.

3) Volunteered Industry Contributions

$ Available: The number of dollars available through this method is totally dependent upon industry's perception and acceptance of the justification for the program.

Continuity: While industry commitment to this process to date has been excellent, it does not carry with it the kind of assurance of continuity which is provided by a legally-established procedure. There are no sanctions, such as loss of use permits, in the event a decision is made to discontinue funding such activities.

Legal Process: If such a resource were to be used, it would seem that there should be a contract or Memorandum of Understanding executed between the industries involved and the jurisdictions responsible for operation of the facilities.

Time Factors: If this method is used, time factors would vary dependent upon who decided to contribute: individual industries, a small group of industries or a larger group of industries such as the Geysers Geothermal Environmental Committee. The larger the number of organizations contributing, the more time-consuming will be the process.

b. Public Agencies

1) APCDs - Local Property Tax

$ Available: It would appear to be difficult, if not impossible, to obtain more than a minimal amount of money from this source because of the limitations established through Proposition 13, which cut back on the local property tax, and Proposition 4, which set a ceiling on expenditures which can be made with property taxes.

Continuity: If funds can be obtained from this source, they should become available on an annualized basis since they would be a part of the annual budget of the APCDs.

Legal Process: Utilization of this resource would be through one of two methods: incorporation in the annual budget; or the carrying out of a special election to authorize the increase of property taxation above the levels set as a result of Proposition 4.

Time Factors: If incorporated in the annual budget, funding could become available on July 1st. Action to place a tax increase to a special election would have to occur 120 days before the election. Property taxes to be realized from such a special election would not be available until the tax was added to the next property tax billing.

2) CEC Budget

$ Available: It has not been determined whether the CEC would have the legal powers to expend funds for these purposes. If such authority exists and if the Commission determined that this is a desirable expenditure, it is likely that significant amounts of money could be provided. However, the passage of the Jarvis II State Income Tax Reduction Initiative in June would, for practical purposes, eliminate this alternative.

Continuity: Such funds could be made available either as one-time contributions for specific projects or ongoing contributions to a specific facet of a program. In the latter case, continuity would most likely be maintained.

Legal Process: This action could be accomplished either through execution of a contract for services between the Energy Commission and a local entity or through incorporation of an Energy Commission contribution in the Energy Commission budget.

Time Factors: Execution of a contract would require a minimum of 4 months from the time negotiations are commenced to approval by the CEC and subsequent clearance by the state control agencies. Incorporation in the budget would require initiation of the process by October of the year prior to the July in which funds would be obtained. There is the possibility that a first-year contribution could be made from reserve funds. Such action would probably take a minimum of 3 months to accomplish.

3) Air Resources Board

$ Available: ARB Subvention Funds are allocated on the basis of a state-wide formula, and the APCDs are already receiving the maximum amount available from Subvention Funds. The only way these funds could be increased would be through a reorganization which resulted in a consolidation of the two APCDs.

These funds are presently allocated in both the Lake County and Sonoma County budgets. The ARB Research Division has monies available for research projects which meet state-wide needs, and have a potential for development of information which would have to be based upon development of a project which would produce more information and analysis than is necessary for the basic monitoring to be provided within CAMP. Limited services are available from the Technical Services Division of ARB for such activities as auditing and calibration of the instruments used in the monitoring program.

Continuity: Subvention and Technical Services funds are available on an annualized basis as a part of the ARB budget. Research funds would be available on a one-time basis.

Legal Process: Use of Subvention Funds would require a decision by the APCD Boards of Directors since the funds are automatically allocated as a part of the annual state budget process. Research funds are obtained through a grant/contractual process from monies allocated for research in the ARB budget.

Time Factors: Subvention Funds would be subject to the time constraints related to a budget decision by the APCD which occurs during the several months leading up to the July 1st new budget year. Generally, research projects are identified at the time the state budget is prepared, approximately

9 to 10 months prior to the start of the July 1st fiscal year. On occasion, funds from cancelled projects, or projects which do not utilize the full amount, are made available during the year. Negotiations for such funds, and completion of the grant process, would probably emcompass 3 to 4 months. Technical Services Funds are allocated annually, and use of such funds would generally have to be negotiated prior to submission of the budget, 9 to 10 months prior to the July 1st fiscal year start.

4) Bureau of Land Management Mineral Lease Payments

$ Available: While $8 million has been returned to the State of California by the Bureau of Land Management, the State Legislature has not acted upon a method of allocating those funds. The number of dollars available for this project will be dependent upon how much of this money is allocated to geothermal resource activities. However, it is anticipated that a substantial number of dollars will be made available to Lake and Sonoma counties.

Continuity: BLM revenue funds are based upon sales of mineral leases at this time and, thus, cannot be considered for use in activities in the immediate future which require an annual rebudgeting. It will be 5 to 7 years before the leases start producing any substantial sums of money from production royalties.

Legal Process: This cannot be defined until the legislation is approved allocating funds.

Time Factors: This issue is also dependent upon the decisions on where the funds go and what requirements will be established for using them.

5) Grants from Other Agencies

$ Available: There is no clear indication as to how much money, if any, may be available from other state or federal agencies through grants. Grants from EPA are generally limited to work on Criteria Pollutants. H_2S is not presently so designated. DOE grants and contracts are primarily focused on development activities, and recent policy positions have reduced the opportunities for use of funds for environmental purposes.

Continuity: There do not appear to be any programs that provide funds for ongoing activities. Grants would generally be available for one-time expenditures.

Legal Process: This would be dependent upon the particular source of funds. Various programs have different procedures. Grants and contracts generally involve a negotiated process which results in either an offer of the funding by the source agency or an execution of a contract between the source agency and the recipient.

Time Factors: Time required for the process would vary dependent upon the program followed. There are varying requirements for timing of submission of proposals or applications. The length of time for negotiations and the point at which grants or contracts are awarded also varies.

c. Local Property Owners

A member of the PCC reported that several property owners had offered to participate in development of monitoring activities. Such participation might take the form of provision of property for location of monitoring stations, provision for power, and even some modest financial contributions.

$ Available: There would be a limited amount of money available in this manner.

Continuity: Since this would be a voluntary program, there would be no way of assuring or guaranteeing permanence of contributions.

Legal Process: It would be desirable, under these circumstances, to execute an agreement or contract covering agreed-upon conditions for the participation.

Time Factors: Negotiation and execution of agreements would probably be accomplished in a short period of 30 to 60 days.

7.4 Equipment, Maintenance, Service, and Data Processing Costs

Requests for proposals should be prepared so as to reflect ways to lease, lease-purchase, or outright-purchase equipment. Outlined in Table 7-1 are two suggested options for equipment procurement. The figures given in the options are conservative and may be improved upon by competitive biddings.

The equipment described in this Section complies with the equipment recommended in Section 4, "Location and Type of Equipment". Costs shown under the Lease and Outright Purchase columns in Table 7-1 are freight-on-board, site destination. Costs shown under Installation are for "turn-key" operation, and include all copies of operation manuals and systems maintenance handbooks for each and every site, including extra copies for the operator's base station. Local, state and federal taxes are not included. Title to leased equipment will be transferred to the client after the designated lease period.

Cost estimates indicated under Installation should be increased if a contractor is to be additionally engaged to participate in the actual physical search and selection of a site. Normally, the client has already located the site and procured the necessary permits, easements, etc.

Costs estimated in Table 7-1 in the Service Calibration and Maintenance column are the annual costs per site. These costs do include estimates of labor, supplies (less tax), and mileage estimate included in the costs is based upon an average of the distances from the sites to a service center located within the

CAMP Study Area. For the capability to respond rapidly, it would be requisite that a service contractor maintain a field office within the CAMP Study Area.

Annual costs for tabulating and archiving data from each of the various types of stations are also shown on Table 7-1. These costs include man-hours required for processing (digitizing and/or tabulating) analog records and processing magnetic tapes.

TABLE 7-1

ESTIMATED COSTS PER SITE
FEBRUARY 1, 1980*

Description	24 Month Lease Annual Cost	Outright Purchase	Installation	Annual Service Maintenance	Annual Tabulation, Archiving
Air Quality Site	13,944	22,780	1,915	11,760	780
Mobile Air Quality	14,148	23,120	150	11,760	780
Colortec	N/A	12	30	1,800	
Meteorological Site	5,952	9,730	850	4,140	180
Meteorological Site with R/H	7,224	11,810	1,425	4,140	180
Acoustic Radar	8,952	14,625	150	6,360	600
Rawinsonde	14,400	12,000	750	24,000	5,400

*Revised March 31, 1980.

7.5 Projected Total Developmental and Operation Cost

The total developmental cost of the CAMP includes the following items:

- Field survey man-hours and mileage
- Land leases (if required)
- Use permits (if required)
- Hardware
- Installation

Operational costs include monthly service calibration, maintenance, and data processing. Field survey costs may be in the order of $150 per day, one-time minimum, if aid is to be requested outside a governmental agency. Land leases could require $50, more or less, per month. One-time use and building permit costs are addressed in Section 2 of this Report.

Tables 7-2 and 7-3, on the following pages, summarize the costs for the development and operation of the CAMP. An arbitrary estimate of 10 Colortec units was integrated into the costs to show the financial impact of some Colortec monitoring. The only costs not estimated in the development of the data on Tables 7-2 and 7-3 are those related to field surveys (man-hours + mileage), land leases, and permit fees. These aforementioned costs may vary so widely and their percentage impact on the total costs be so low, that no attempt was made to estimate them.

TABLE 7-2
PROJECTED TOTAL COSTS UNDER OUTRIGHT PURCHASE PLAN
FEBRUARY 1, 1980 ****

	ACQUIRE			OPERATE			TOTAL
	A	B	C	D	E	F	G
Description	Purchase Price	Installation Cost	Total A + B	Annual Service and Maintenance	Annual Tabulation and Archiving	Total D + E	Total 1st Year Cost, C + F
1. Three (3) Air Quality Stations**	$68,340	5,745	$74,085	$35,280	$ 2,340	$ 37,620	$ 111,705
2. One (1) Mobile Air Quality Station***	23,120	150	23,270	11,760	780	12,540	35,810
3. Colortec (10)	120	300	420	18,000	42	18,042	18,462
4. (Subtotal 1, 2, 3)	($91,580)	($6,195)	($97,775)	($65,040)	($3,162)	($68,202)	($165,977)
5. Six (6) Meteorological Sites (a)	58,380	5,100	63,480	24,840	1,080	25,920	89,400
6. One (1) Meteorological Site with R/H (a)	11,810	1,425	13,235	4,140	180	4,320	17,555
7. One (1) Acoustic Radar	14,625	150	14,775	6,360	600	6,960	21,735
8. One (1) Rawinsonde	12,000	750	12,750	24,000	5,400	29,400	42,150
9. (Subtotal 5, 6, 7, 8) (a)	($96,815)	($7,425)	($104,240)	($59,340)	($7,260)	($66,600)	($170,840)
10. TOTAL (a)	$188,395	$13,620	$202,015	$124,380	10,422	$134,802	$336,817

* Annual costs subsequent to first year would be based upon the data in column F plus 10% increment for cost-of-living increases.

** Five (5) stations are recommended but NSCAPCD and LCAPCD both own air quality stations currently sited at SRI #4 and Middletown.

***Two (2) stations are recommended but LCAPCD owns one mobile air quality station currently sited at Anderson Springs.

****Revised March 31, 1980

(a) Revised recommended costs shown in note (a) on Table 7-6, Page 114.

TABLE 7-3
PROJECTED TOTAL COSTS UNDER LEASE PURCHASE PLAN
FEBRUARY 1, 1980 *****

	ACQUIRE			OPERATE			TOTAL	
	A	B	C	D	E	F	G	H
Description	Lease Price	Installation Cost	Total A & B	Annual Service and Maintenance	Annual Tabulation and Archiving	Total D + E	Total 1st Year Cost, C + F	Total 2nd Year Cost, A + F*
1. Three (3) Air Quality Stations**	41,832	5,745	47,577	35,280	2,340	37,620	85,197	83,214
2. One (1) Mobile Air Quality Station***	14,160	150	14,310	11,760	780	12,540	26,850	27,954
3. Colortec (10)	120****	300**	420	18,000	42	18,042	18,462	19,966
4. (Subtotal 1, 2, 3)	(56,112)	(6,195)	(62,307)	(65,040)	(3,162)	(68,202)	(130,509)	(131,134)
5. Six (6) Meteorological Sites (a)	35,712	5,100	40,812	24,840	1,080	25,920	66,732	64,224
6. One (1) Meteorological Site with R/H (a)	7,224	1,425	8,649	4,140	180	4,320	12,969	11,976
7. One (1) Acoustic Radar	8,952	150	9,102	6,360	600	6,960	16,062	16,608
8. One (1) Rawinsonde	14,400	750	15,150	24,000	5,400	29,400	44,550	46,740
9. (Subtotal 5, 6, 7 & 8) (a)	(66,288)	(7,425)	(73,713)	(59,340)	(7,260)	(66,600)	(140,313)	(139,548)
10. TOTAL (a)	$122,400	$13,620	$136,020	$124,380	$10,422	$134,802	$270,822	$270,682

(Column A is based on 24-month lease purchase plan)

* Annual operating costs subsequent to first year are based upon the data in Column F plus 10% increment for cost-of-living increases.

** Five (5) stations are recommended but NSCAPCD and LCAPCD both own the quality stations currently sited at SRI #4 and Middletown.

*** Two (2) stations are recommended but LCAPCD owns one mobile air quality station currently sited at Anderson Springs.

****Purchase only.

*****Revised March 31, 1980

(a) Revised recommended costs shown in note (a), Table 7-6 on Page 114.

7.6 Alternative Financial Plans

a. Introduction

The monitoring plan provided herein is designed to meet the air monitoring needs for current and projected emission conditions in the Geysers-Calistoga KGRA. This includes methodology for future expansion of monitoring activities based upon patterns of complaints or projections of potential problem developments. Equipment recommended in the earlier sections, and for which costs have been compiled in Subsection 7.5, will adequately meet the needs during the first three years of the program. The alternate financing programs included herein provide alternate methods for carrying the program for this first three-year period. At completion of the second year, the financial program should be reviewed to determine whether revisions are required.

Development of the alternate financial plans has involved staff review of the information in the earlier parts of this section, as well as consideration of several other factors:

- The suggested alternatives must be administratively feasible.
- The availability of funds from the recommended resources must be clearly evident.

Initiation of the program will involve both one-time costs and ongoing costs. The acquisition and placement of equipment requires one-time expenditures; and the annual operation, maintenance and analysis of data requires annual budgetary allocations. These costs have been enumerated in Tables 7-1, 7-2, and 7-3 in Sections 7.4 and 7.5.

b. Questions for Regulatory Agencies

Initiation of the CAMP will be dependent upon development of the financial resources necessary to carry out the CAMP. This is dependent, in turn, primarily upon a series of decisions which must be made by the Northern Sonoma County and Lake County Air Pollution Control District if they accept the financial plan alternatives presented herein. These plans are based upon a recognition that the two local Air Pollution Control Districts have the statutory responsibility for air quality issues in this area, subject to guidelines established by the ARB. The CEC will not be a direct participant in the decisions on the financial program, but may be called upon to support these decisions as the utility companies submit Notices of Intent and Applications for Certification for future power plants.

The questions concern determinations among the alternative funding rationales and alternative funding sources described in Sections 7.2 and 7.3. They are as follows:

(1) How shall funding responsibility be divided between public agencies, industry and beneficiaries?

(a) How shall funding responsibility be divided among public agencies?

(b) How shall funding responsibility be divided between utility companies and steam producers?

(2) What funding sources should be used?

(3) Should equipment be obtained through direct purchase or through a lease-purchase program?

c. Proposed Alternate Financial Plans

The following comments include discussion of the issues related to the questions outlined in Subsection (b) above. Acceptance of a recommended alternate plan will provide the answers to the questions.

A review of the alternative funding rationales discussed in Section 7.2 in the context of the qualifying questions in Subsection (a) above has resulted in the selection of three of the five rationales for the basis for alternate financial plans. The three selected are: Alternate A - Regional/Local; Alternate B - Equipment/Operation; and Alternate C - Responsible Party. The other two were considered unworkable for financing the comprehensive plan proposed herein.

The Air Draninage Basin Alternative would be extremely difficult to carry out because of the lack of sufficient data on which to measure impact on an air basin by a specific industry as compared to another industry. Additionally, there is clear evidence that industries in one air basin provide emissions which on occasion impact on other air drainage basins. Furthermore, the conditions would change periodically, requiring adjustment to the charges made against the industries within a particular basin.

The Beneficiary Alternative rationale has no basis in practical application because of the limited amount of money which could be obtained from the residents of the areas in which air monitoring equipment is located. It will certainly be possible for the Air Pollution Control Districts to solicit this participation by property owners, particularly in the utilization of the Colortec System, which is initiated in response to complaints by citizens. However, the level of expenditures required for the program, and the necessity to assure continuity of expenditure sources, limits the potential value of contribution by property owners.

Consideration of the question of which public agencies should be responsible for the financing of public agency contributions focuses on one basic point: this is a program for air quality monitoring. On that basis, it appears appropriate for the two local Air Pollution Control Districts to assume primary responsibility to obtain any funding which is deemed the responsibility of public agencies. This does not preclude the APCDs seeking funding from other levels to meet their responsibilities.

The plans outlined below recommend that the Northern Sonoma County and Lake County Air Pollution Control Districts share equally the financial responsibility for the public agency contribution. Figure 7A shows that the H_2S monitoring equipment is located primarily in Lake County where the impacted population is located and that the emission sources are primarily located in Sonoma County. Figure 2A shows the population distribution, and Table 7-4 provides a breakdown of power plants and wells located in Lake and Sonoma counties.

It is recommended that the industry contribution be obtained through increasing the permit fees charged by the Air Pollution Control Districts. The present fee schedules for the two Air Pollution Control Districts are provided in Table 7-5. The use of volunteer contributions by industry is a lengthy and cumbersome procedure which cannot be guaranteed to provide a prompt enough response and the amount of money necessary to meet the time schedule included in Section 8.3. It also cannot provide the kind of assurance of continuity which is necessary for the annual ongoing costs of operation of part, or all of the system. Utilization of Use Permit conditions would be of limited value because it would most likely be applicable on new Use Permits only.

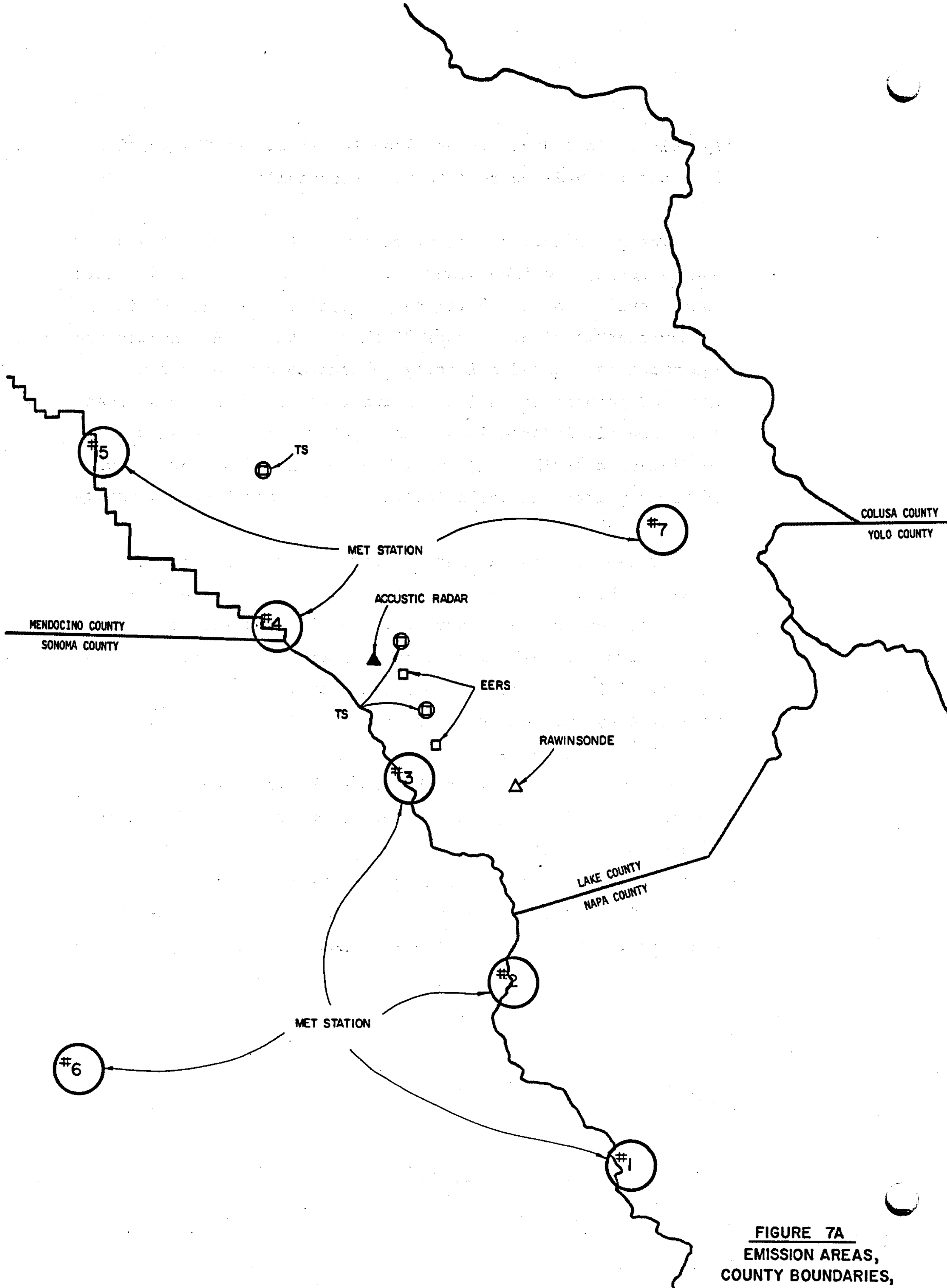


FIGURE 7A
EMISSION AREAS,
COUNTY BOUNDARIES,
INSTRUMENTATION

TABLE 7-4

GEYSERS, CALISTOGA KGRA
EXISTING, IN PERMIT PROCESS & PROJECTED
POWER PLANTS AND PRODUCTION WELLS

February 1, 1980

	Lake	Sonoma	Total
Existing Production			
Plants/MW/(Steam)*	0	13/663	13/663/(120)*
Wells/(Steam)*	1[(a)]	117	118/(120)*
In Permit Process			
Plants/MW/(Steam)*	4/366	5/495	9/861/(156)*
Wells[(b)]/(Steam)*	77[(c)]	80[(c)]	157/(156)*
Projected			
Plants/MW/(Steam)*	3/330	1/55	6/495[(d)]/(90)*
Wells[(b)] / Steam*	60	10	90[(d)]/(90)*
Total			
Plants/MW/(Steam)*	7/696	19/1,213	28/2019[(d)]/(366)*
Wells/(Steam)*	138[(e)]	207[(e)]	365[(d)(e)]/(366)*

(a) Serves Sonoma County power plants.

(b) Estimated figures based on projection of an average of 10 wells per 55 megawatts.

(c) Estimate 10 Lake County wells will serve Sonoma County power plants.

(d) Includes 2 power plants (SMUD & DWR) and related 20 wells which are projected but for which final site has not been negotiated or contracted.

(e) Does not include exploratory wells beyond those developed for projected power plants.

* 100,000 lbs of steam per hour.

TABLE 7-5

CURRENT APCD PERMIT FEES

February 1, 1980

	Wells	Well APC Device	Trans. Lines	Power Plants
Sonoma County				
Initial Permit	$ 300	$ 40	-	-0-
Renewal	$ 175	-0-	-	$2,830
Lake County				
Authority to Construct	$ 800	-	$1,000	$3,000
Renew Authority to Construct	$ 600	-	$ 800	$1,000
Permit to Operate	$ 300	-	$1,000	$1,200

APC - Air Pollution Control

Power plants and producing steam wells are both established under design criteria with a common unit of measurement — pounds of steam per hour. It is recommended that 100,000 pounds per hour of design capacity be used as the base unit in establishing the charge to be paid by the utility companies and steam developers. Charges would be in increments or multiples of that unit. Fees for exploratory wells could be established at a flat rate which reflect the ratio of successful production wells to the total number of exploratory wells. This would relate the cost of monitoring to the design level for production and to income.

The alternative financial plans include cost figures for both direct-purchase and lease-purchase acquisition of equipment. The primary benefit to the lease-purchase option, if acquisition of equipment is the responsibility of public agencies, would be that the public agency would be able to spread the cost over a two-year period. If funds can be obtained for initial purchase, there would be a considerable savings in the use of the direct-purchase approach. If the industry is given responsibility for acquisition of part or all of the equipment, then the lease-purchase approach would allow for a lowered impact on the permit fees and, thus, would allow more opportunity for new permits which are initiated during the second year to participate in the acquisition cost.

It should be noted that all of the cost figures reflect the current ownership of equipment by the two APCDs. Northern Sonoma County APCD owns a Trend Station (TS), now located at the former SRI Site #4. The Lake County APCD owns a mobile facility at Anderson Springs and a Trend site at Middletown.

ALTERNATE A -- REGIONAL/LOCAL

Under this Alternate, the local APCDs have the responsibility for all costs related to the establishment and operation of the meteorological system. The geothermal industry would be responsible for all costs for the development and operation of the air quality system.

The APCDs would have to develop funding sources other than permit fees for both the capital outlay for purchase of meteorological equipment and the annual operating costs of the meteorological system.

The utility companies and steam producers would have the same requirements for the air quality system. If permit fees are used as recommended, there would be a large increase in fees during the first year's operation (and second year, if lease-purchase is used). This would be reduced in the second (or third) year.

The total cost breakdown and cost per 100,000 pounds of steam per hour for the first three years are shown in Table 7-6. The cost per 100,000 pounds of steam has been established by dividing the total costs by the combined number of 100,000 pounds units of steam used by

TABLE 7-6
ALTERNATE A - REGIONAL/LOCAL FINANCE PLAN
DISTRIBUTION OF COSTS
FEBRUARY 1, 1980 ***

	Acq. & Install.		Operation	Total					
				1st Year		2nd Year*		3rd Year*	
	Outright Purchase	Lease Purchase		Outright Purchase	Lease Purchase	Outright Purchase	Lease ** Purchase	Outright Purchase	Lease Purchase
Meteorology System (a)									
Sonoma Co. APCD	$ 52,120	$ 36,857	$ 33,300	$ 85,420	$ 70,157	$ 36,630	$ 69,774	$ 40,293	$ 40,293
Lake Co. APCD	52,120	36,857	33,300	85,420	70,157	36,630	69,774	40,293	40,293
Total	$104,240	$ 73,714	$ 66,600	$170,840	$140,314	$ 73,260	$139,548	$ 80,586	$ 80,586
Air Quality System									
Utility Companies	$ 48,888	31,154	34,101	82,989	65,255	37,511	65,567	41,262	41,262
Steam Producers	48,888	31,154	34,101	82,989	65,255	37,511	65,567	41,262	41,262
Total	$ 97,776	$ 62,308	$ 68,202	$165,978	$130,510	$ 75,022	$131,134	$ 82,524	$ 82,524
Cost/10^5 lbs/hr steam				301	236	136	238	150	150
Grand Total - 1st Year (a)	$202,016	$136,022	$134,802	$336,818	$270,824				
- 2nd Year						$148,282	$270,682		
- 3rd Year								$163,110	$163,110

* 2nd and 3rd year each reflect 10% cost of living increases for operating costs.

** Installation cost eliminated in 2nd year.

*** Revised March 31, 1980

(a) Costs reflect full 12-month operation of all seven of the meteorological stations. Revisions made in final review recommend installation of 2 stations when the program is initiated and later consideration of the remaining five. The original two stations are: one meteorological site; and one meteorological site with R/H. It also recommends operation of stations on a six-month basis during the first year to determine whether 12-month operation is required. These changes will reduce first-year costs by the following amounts: Acquisition and installation by Outright Purchase - $52,900; Acquisition and installation by Lease Purchase - $34,010; First year Operating Costs - $18,000 (includes minimal maintenance during 6 mos. downtime).

the power plants and the number of 100,000 pounds units of steam produced by wells (see Table 3-4). For purposes of this projection, it was considered that the units of steam produced by the wells is equal to the units used by the power plants.

Projections of costs on Table 7-6, based on units of steam, reflect the number of power plants on-line and in the permitting process as of February 1, 1980 (see Table 3-4). No adjustment has been made in second and third year projections for new plants which may enter the permitting process.

ALTERNATE B -- EQUIPMENT/OPERATION

Under this Alternate, the local APCDs have the responsibility for acquisition of all equipment used in the program. The geothermal industry would have responsibility for all operational costs.

The APCDs would have a one-year (or two-year if lease-purchase is used) large expenditure, but all subsequent costs would be borne by the industry.

The utility companies and steam producers would have to make annual payments to cover operating costs based on the units of 100,000 pounds per hour of steam, using the same methods as described for Alternate A. Table 7-7 provides the tabulation of total costs and the estimated charge to industry per 100,000 pounds of steam per hour.

TABLE 7-7

ALTERNATE B - EQUIPMENT/OPERATION FINANCE PLAN

DISTRIBUTION OF COSTS

FEBRUARY 1, 1980 **

	Meteorology	Air Quality	Total 1st Year	Total 2nd Year	Total 3rd Year
Equipment: Acquisition & Installation (a)					
Outright Purchase:					
Sonoma County APCD	$ 52,120	$ 60,523*	$112,643*	$ -0-	$ -0-
Lake County APCD	52,120	37,253*	89,373*	-0-	-0-
TOTAL	$104,240	$ 97,776	$202,016	$ -0-	$ -0-
Lease Purchase:					
Sonoma County APCD	$ 36,857	$ 39,084*	$ 75,941*	$ 68,274	$ -0-
Lake County APCD	36,857	23,224*	60,081*	54,126	-0-
TOTAL	$ 73,714	$ 62,308	$136,022	$122,400	$ -0-
Operation Costs (a)					
Utility Companies	$ 33,300	$ 34,101	$ 67,401	$ 74,141	$ 81,555
Steam Producers	33,300	34,101	67,401	74,141	81,555
TOTAL	$ 66,600	$ 68,202	$134,802	$148,282	$163,110
Cost/100,000 lbs/hr steam			$ 244	$ 269	$ 295
GRAND TOTAL					
1st Year: Outright Purchase			$336,818		
Lease Purchase			270,824		
2nd Year: Outright Purchase				$148,282	
Lease Purchase				270,682	
3rd Year: —					$163,110

* Totals reflect the fact that Sonoma and Lake county each own one TS and Lake County owns one Mobile Station.

** Revised March 31, 1980

(a) Revised recommended costs shown in note (a), Table 7-6, Page 114.

ALTERNATE C -- RESPONSIBLE PARTY

Under this Alternate, the geothermal industry would have the total responsibility for all costs related to the program. These costs and projected costs per 100,000 pounds of steam per hour are shown on Table 7-8.

TABLE 7-8

ALTERNATE C - RESPONSIBLE PARTY

FEBRUARY 1, 1980 *

	Total					
	1st Year		2nd Year		3rd Year	
	Outright Purchase	Lease Purchase	Outright Purchase	Lease Purchase	Outright Purchase	Lease Purchase
Utility Companies (50%)- - -	$168,409**	$135,412**	$ 74,141	$135,341	$ 81,555	-
Steam Producers (50%)- - - -	$168,409**	135,412**	74,141	135,341	81,555	-
TOTAL - - -	$336,818**	$270,824**	$148,282	$270,682	$163,110	-
Cost Per 100,000 lbs Steam/Hour - - - -	610	491	269	490	295	-

*Revised March 31, 1980

**Revised recommended costs shown in note (a), Table 7-6, Page 114.

8. CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusions

Conclusions are stated in three parts: Part a. addresses the Technical aspects of the CAMP; Part b., the Administration; and Part c., the Financial.

a. Technical

In general, there is a lack of baseline ambient air quality data for the region outside the developed dry steam area and its immediate area of influence. However, for proper analysis of air quality, the existing monitoring programs require a higher degree of coordination than is now evident. Standardization and instrumentation, data collection, analysis, and reporting are needed.

Available information is sufficient to begin the development of a CAMP Study Area emissions inventory, defining locations, magnitude, frequency, pollutant concentrations and relative contribution of geothermal emissions. However, the existing meteorological data base is insufficient for regional analysis of air pollutant transport and diffusion.

Correlation of emission sources with population centers generated the conclusion that for the next five years ambient air quality monitoring can be limited primarily to specified areas of Lake and Sonoma counties. If commercially exploitable geothermal resources are found in adjoining areas, additional monitoring may be needed.

The current climatic conditions throughout the CAMP Study Area need to be known in order to determine the influences of future geothermal development on climatic factors. In addition, it must be determined what impact climatic factors may have on known geothermal emissions. Even with a 90% reduction in emissions, the air pollution potential of an expanded geothermal field may exceed the capacity of the air basin to dilute abated H_2S emissions to levels below the California Ambient Air Quality Standard.

In surveying available climatological data, it becomes evident that data are inadequate in principle zones which appear to be prime targets for geothermal development. These are: high elevations of the Mayacamas Mountains, and mountainous areas southeast of Clear Lake.

Except for agricultural and populated areas, temperature data are limited throughout the region and wind data are severely lacking. The only long-term wind stations recording wind movement are located in Santa Rosa and Ukiah. Several short-term (ARB) stations have been identified, but these were discontinued after as little as a month of operation. The remaining recording stations of note are Forest Service Stations in the area. Records prior to 1973 were not retained. Due to this lack of data, available wind records have little value for analysis of air movement and air pollutant transport.

b. Administration

It is concluded that the administration of the project proposed by CAMP can be most effectively administered by the local APCDs. It is mandatory that the entire project be coordinated and operated in a uniform way throughout its period of existence.

c. Financial

Purchase of all of the equipment required for establishment of the monitoring plan recommended herein will require a substantial outlay of between $136,020 ($102,020) (if lease purchased) and $202,015 ($149,115) (if outright purchased). It will also require an annual operating budget expenditure of $134,802 ($113,202) for the first year, with projected cost of living increases at ten percent per year. The reduced costs in the final recommendations described in Section 8.2, Recommendations, Page 123 are shown in parentheses.

If the program is to be established in a timely manner, it will have to be funded by resources which can be committed with little or no delay. There will have to be at least one source which can be called upon for annual contributions. These factors should be taken into account when it is determined how much should be paid by industry and/or public agencies.

The Northern Sonoma County and Lake County Air Pollution Control Districts are legally responsible for dealing with air quality issues in the parts of the CAMP Study Area currently impacted and projected for impact within the next five years. It is appropriate, therefore, for the two APCDs to assume the responsibility for the public agency share of program costs.

Since the emissions are predominantly in Sonoma County and the populated areas currently impacted and proposed air monitoring equipment locations are predominantly in Lake County, it appears logical to divide their respective financial responsibilities on a 50%-50% basis. Credit should be given for equipment already purchased by each district.

The expenditure ceiling limits established for the APCDs by passage of Proposition 4, approved in November, 1979, prevent them from using tax monies for expenditures as large as those projected herein. However, the limitation does not apply to fees which are established to cover the costs of services provided by the districts. This allows the revision of the fee schedules to provide a means for collecting the funds required for the industry contribution to the program.

Furthermore, the Proposition 4 ceiling does not apply to monies received from the federal or state levels in the form of grants or pass-through funds such as the Bureau of Land Management Mineral Lease Revenues. Such one-time funds are logical sources for one-time expenditures such as the acquisition and installation of equipment.

Establishment of a method for allocating costs to industry should involve a unit of measurement which: is common to both steam suppliers and utilities; has some relationship to the emissions produced; and, if possible, relates to income realized. The number of pounds of steam per hour represents such a unit.

Each alternate financial plan includes cost estimates for both outright purchase and a 24-month lease purchase. The latter approach allows for a reduction of the burden of acquisition of equipment if this becomes a factor in the decision process. Provision of cost estimates for three years for each Alternate on Table 8-1 allows a comparison of costs during time when equipment is being purchased and during later years when operational costs are the only financial obligation.

8.2 Recommendations

a. Technical

Recommendations to obtain the technical objectives and to integrate the results obtained from the objectives in the planned and proposed meteorological and air quality studies are:

1) Locate two (2) air quality Established Exceedance Stations (EES): one at Cobb, on Kelsey Creek; and a second at the confluence of Anderson Creek and Bear Creek in Anderson Springs.

TABLE 8-1

COMPARISON OF COSTS ALTERNATE PLANS A, B, & C

FEBRUARY 1, 1980**

		First Year			Second Year			Third Year		
		Alt.A Reg./Loc.	Alt.B Eq./Op.	Alt.C Resp.Pty.	Alt.A Reg./Loc.	Alt.B Eq./Op.	Alt.C Resp.Pty.	Alt.A Reg./Loc.	Alt.B Eq./Op.	Alt.C Resp.Pty.
APCDs										
Sonoma County	OP	$ 85,420*	$112,643*	$ -0-	$ 36,630	$ -0-	$ -0-	$ 40,293	$ -0-	$ -0-
	LP	70,157*	75,941*	-0-	69,774	68,274	-0-	40,293	-0-	-0-
Lake County	OP	85,420*	89,373*	-0-	36,630	-0-	-0-	40,293	-0-	-0-
	LP	70,157*	60,081*	-0-	69,774	54,126	-0-	40,293	-0-	-0-
TOTAL	OP	$ 170,840*	$202,016*	-0-	$ 73,260	$ -0-	$ -0-	$80,586	$-0-	$ -0-
	LP	$ 140,314*	$136,022*	-0-	$139,548	$122,400	$ -0-	$80,586	$-0-	$ -0-
INDUSTRY										
Utility Companies	OP	$ 82,989	67,401*	168,409*	37,511	74,141	74,141	41,262	81,555	81,555
	LP	65,255	-0-	135,412	65,567	-0-	135,341	41,262	81,555	81,555
Steam Producers	OP	82,989	67,401*	168,409*	37,511	74,141	74,141	41,262	81,555	81,555
	LP	65,255	-0-	135,412*	65,657	-0-	135,341	41,262	81,555	81,555
TOTAL	OP	$ 165,978*	$134,802*	$336,818*	$ 75,022	$148,282	$148,282	$82,524	$163,110	$163,110
	LP	$ 130,510*	$ -0-	$270,824*	$131,134	$ -0-	$270,682	$82,524	$163,110	$163,110
Cost for 100,000 lbs per hour of steam	OP	301*	244*	610*	136	269	269	150	295	295
	LP	236*	-0-	291*	238	-0-	490	150	295	295

OP -- Outright Purchase

LP -- Lease Purchase

* Revised recommended first year costs shown in note (a), Table 7-6, Page 114.

**Revised March 31, 1980

2) Establish three (3) air quality Trend Stations (TS): one at Hobergs, one near Kelseyville, and a third southeast of Whispering Pines.

3) Provide two (2) mobile air quality stations which may be located to satisfy the requirements of the APCDs.

4) Utilize Colortec tags to initially verify exceedance areas.

5) Establish two (2) meteorological observation sites at old ES&S #21 and #24 (one with relative humidity) upon initiation of the program. Upon completion of analysis of the data from the Lake County 18-station meteorological network, consider placement of the remaining five stations as described in Table 4-2, Page 64. All stations to be operated during the 6-month period each year when projections regarding exceedances are required.

6) Locate an acoustic radar on Kelsey Creek near Cobb.

7) Establish a rawinsonde station at or near Middletown.

8) Establishment of future monitoring stations and termination of existing and future stations shall be in accordance with the procedures outlined in Section 6, "Establishing and Terminating Monitoring Stations".

9) All equipment must meet specific, minimum performance standards.

10) Equipment testing, maintenance, and calibration must adhere to ARB Quality Assurance Plan.

11) Data logging shall be accomplished on magnetic tape cassettes and in parallel with analog recorders.

12) Data retrieval and processing shall be undertaken by private contractor(s).

b. Administration

The CAMP proposed project should be administered by the local APCDs in one or in combination of the following alternatives:

1) By contract with the other concerned APCD(s),
2) An agreement of joint responsibilities,
3) A Memorandum of Understanding,
4) By sub-contract as approved by the concerned APCD(s).

c. Financial

Table 8-1 provides a summary of the cost implications of the three viable alternate financial plans which were described in detail in Section 7.6. The contract with the CEC, under which this report was prepared, provides that the Final Report shall include alternate methods for financing the CAMP.

The three plans were submitted for review as a part of the Preliminary Draft. The only revisions to be made as a result of the review reflect the reductions in costs as shown in Note (a), Table 7-6, Page 114.

8.3 Specific Actions and Timetable

The agencies which have the authority to initiate the Comprehensive Air Monitoring Plan described herein will have to take a number of actions prior to the program getting underway. In order to have the program fully operational by January 1, 1981, it will be necessary for the responsible agencies to take prompt action within the brief period of ninety days. The time schedule for the action described herein to meet the January 1, 1981, initiation date is shown in Table 8-2. The following is a discussion of the specific actions listed on that table.

a. Review by Agencies (30 Days)

In order for the Plan presented herein to be initiated, it will be necessary for the Lake County and Northern Sonoma County Air Pollution Control Districts, the California Air Resources Board and the California Energy Commission to come to agreement on the recommendations made herein. Staff representatives from these agencies have participated in development of the Plan and will be reviewing this Plan Report prior to its submission to the California Energy Commission on March 31, 1980. Additionally, the Plan should be presented to the Boards of Directors of those agencies during the month of April with recommendations from their respective staffs. Such review is necessary in order to obtain approval from these Boards for development of the next step in the process - preparation of a Draft Memorandum of Understanding.

b. Develop Memorandum of Understanding (75 Days)

After agency review has established policy positions for the four agencies, staff can work together to develop the details of the Memorandum of Understanding which would be required to establish agreement between the agencies regarding:

1) Type and location of monitoring equipment.
2) Procedures for establishment and termination of monitoring stations.
3) Program for funding.
4) Procedures for administration of Plan.

Upon completion of drafting of this Memorandum of Understanding, it would be submitted to the respective governing bodies for their approval.

c. Revision of Procedures (120 Days)

During the months of May and June, the two Air Pollution Control Districts and the Energy Commission should take the steps necessary to revise their permitting procedures to reflect the requirements agreed upon in the Plan, the method for financing the Plan and the administration of the program.

d. Budget Revision (30 Days)

If the financing plan recommended herein is adopted, it will be necessary for the Boards of Directors of the two Air Pollution Control Districts to take the steps during the month of June to revise their 1980/81 budget to reflect the changes required in revenues and expenditures to carry out the program.

e. Equipment

1) RFP Process (75 Days)

The first step in acquisition and placement of equipment will be initiation of a Request for Proposals process based upon agreement reached in the Memorandum of Understanding.

2) Purchase and Delivery (90 Days)

It has been estimated that 90 days should be allowed for obtaining delivery of equipment once the decision to purchase has been made.

3) Installation and Calibration (30 Days)

After equipment is delivered, it will be necessary to allow a period for the setting up and calibration of the equipment.

4) INITIATION OF MONITORING PROGRAM

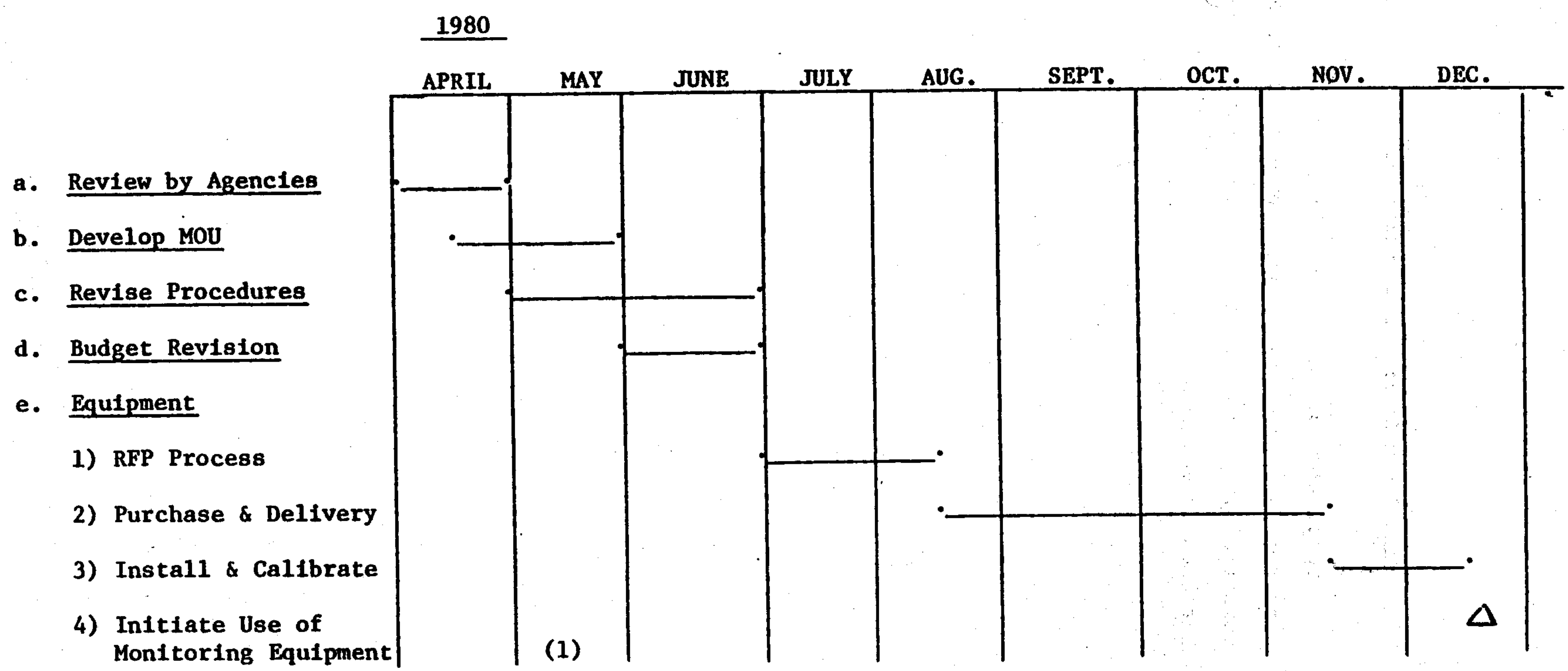
Completion of all of the foregoing steps will be required to reach this point. However, utilization of the Colortec System can be initiated in July, once the program has been agreed upon.

TABLE 8-2

PROPOSED TIME LINE FOR INITIATION

COMPREHENSIVE AIR MONITORING PLAN

FEBRUARY 1, 1980*



(1) Colortec use can be initiated at this time.

* Revised March 31, 1980

9. ACKNOWLEDGEMENTS

More than 30 individuals were involved in the completion of this Report. Contributions from this group and, in particular the efforts of the Project Coordinating Committee participating in the plan development decisions and in the many hours spent reviewing the draft material, can be described as examplary.

Advance planning, selection of Project Coordinating Committee members and preparation of pre-plan documents by Mr. Robert F. Van Horn of the GRIPS Commission and Mr. David Hill of the California Energy Commission are acknowledged with gratitude.

The Project Coordinator, John T. Walser, C.C.M., under whose guidance and motivation the CAMP was developed, was the principal author. Mr. Walser and Mr. Van Horn effectively synthesized large quantities of complex technical and fiscal data into a coherent plan.

Substantial background data were provided by several consultants and summarized into important sections of the CAMP. Special acknowledgement must be extended to this group, and especially to Mrs. Fran Murphy, Demographic Research Analyst.

Mrs. Sue E. Bolt and Mrs. Dorothy Ross are to be commended for the arduous task of typing the many drafts required for this Report.

The GRIPS Commission would like to express special appreciation for the constructive comments received on the Preliminary Draft from the following respondents:

Jeff Anderson
California Energy Commission

H. D. Entrekin
Stone and Webster Engineering Corporation

Linda Ferguson
California Division of Oil and Gas

W. B. Goddard
C. B. Goddard
Environmental Engineering Consultants for McCulloch Geothermal

David Hill
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APPENDIX A

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APPENDIX B

SOURCES OF CLIMATIC DATA

Source	Type of Data
U.S. Government Documents	
Climatography of the U.S. No. 86-4, Supplement for 1951-1960, California (NOAA)*	Mean temperature, precipitation, and snowfall
Climatography of the U.S. No. 11-4, Supplement for 1931-1952, California (USWB)*	Mean temperature, precipation, and snowfall
Climatological Data, National Summary (NOAA)*	Upper air data, solar radiation, storm summaries, flood summaries
Climatological Data, California (NOAA)*	Daily and monthly total precipitation, daily mean temperature, evaporation, snowfall
Local Climatological Data (NOAA)*	For a few selected stations: windspeed, direction, fastest mile, percent sunshine, sky cover, hourly precipitation
State of California Documents	
Surface Weather Observations (ARB microfilm)*	Hourly airport observations for several California stations; includes wind speed and direction, precipitation, all unreduced
Hourly Weather Sequences	Hourly airport observations for many California stations; includes wind speed and direction, surface pressures, dewpoint, all in reduced forms
Surface Wind Summaries (USWB)*	Monthly and annual mean wind direction, percent frequencies of speed and directions
Inversion and Upper Wind Data (ARB)*	Daily reports of inversions and winds for selected California stations
Climate Wind Data (ARB)*	Hourly machine summary of wind speed and directions for selected California stations

*Abbreviations:
NOAA: National Oceanic and Atmospheric Administration
USWB: U.S. Weather Bureau
ARB: Air Resources Board

APPENDIX B (Cont.)
Continued
CLIMATOLOGICAL DATA STATIONS

Station	Latitude	Longitude
*Aetna Springs	38-39	122-26
Adobe Creek	38-55	122-52
Angwin PUC	38-34	122-26
*Barney	38-55	123-52
*Bartlett Springs	39-11	122-42
Calistoga	38-35	122-34
Calistoga Williams	38-35	122-34
Calistoga 4NW	38-36	122-39
Calistoga 3SW	38-32	122-38
Calistoga 9NW	38-38	122-42
Cazadero 1N	38-32	123-05
Cazanoma Lodge	38-30	123-05
Cazadero	38-31	123-07
*Cellier Place	38-47	122-42
Clearlake Highlands	38-58	122-39
*Clearlake Park	38-59	122-43
*Clearlake Oaks 7E	38-59	122-43
*Clearlake Oaks 7E	38-59	122-33
Clearlake Oaks FFS	39-01	122-39
Cloverdale 8NW	38-49	123-10
*Cloverdale	38-49	123-01
Cloverdale 3SSE	38-46	122-59
Cloverdale Rch.	38-49	122-57
Cloverdale Fire St.	38-47	123-01
Cobb	38-49	122-43
Cobb 2NW	38-50	122-46
Cold Creek Ranch Guntley	39-24	123-11
*Cordes	38-51	122-47
Cunningham	38-57	122-53
Diamond Mtn.	38-33	122-35
Elim Grove Cazadero	38-31	123-05
Finley NNE	39-01	122-52
Finley SSE	38-58	122-52
Finley 5SW	38-57	122-56

* No longer observing

APPENDIX B (Cont.)

Station	Latitude	Longitude
Geyserville 2E	38-42	122-52
*Geyserville 1NE	38-43	122-57
Geyserville HMS	38-42	122-54
Geyserville 2N	Sec.6	T10N,R9W
*Guenoc Ranch	38-44	122-30
Guerneville	38-30	122-59
*Guerneville--City	38-30	123-00
Guerneville Telemark	38-30	122-56
Guerneville 4NW	38-33	123-01
*Harbin Hot Springs	38-47	122-39
*Hardin Ranch	38-34	122-20
H Bar H Ranch	38-50	122-36
Healdsburg	38-37	122-50
Healdsburg FFS	38-39	122-52
Healdsburg 2W	38-37	122-53
Healdsburg 5E	38-37	122-45
Healdsburg 7WSW	38-36	122-59
Healdsburg 7NW	38-42	122-57
Healdsburg 7SE	38-31	122-45
Healdsburg 8N	38-43	122-51
Healdsburg 8NW	38-42	122-58
Healdsburg 2E	38-37	122-50
*Helen Mine	38-44	122-42
*Highland Springs Ranch	38-56	122-54
High Valley Mitchell	39-02	122-42
High Valley Ranch	39-03	122-41
Hobergs	38-51	122-43
Hopland 8NE	39-01	123-00
Hopland 2 SE	38-57	123-06
Hopland Field St. HQ	39-00	123-05
Hopland Coon Lake St.	39-00	123-04
Hopland Orchard St.	39-00	123-03
Hopland Largo St.	39-01	123-07
Hopland 8NE	39-01	123-00
Hot Springs Ranch	38-47	123-07
*Indian Valley	39-05	122-34
Kellogg	38-40	122-40
Kelseyville	38-58	122-49
Kelseyville 2NW	39-00	122-51
Kelseyville 2N	39-00	122-50
Kelseyville 3SW	38-58	122-54
*Kelseyville 4SE	38-56	122-53
Knights Valley	38-37	122-40
*Kono Tayee	39-02	122-45

* No longer observing

APPENDIX B (Cont.)

Station	Latitude	Longitude
Lakeport 2NW	39-03	122-56
Lakeport	39-02	122-55
Lakeport 3W	39-02	122-57
Lakeport USSC	39-02	122-55
*Lindblooms	38-44	120-37
Long Valley Garner	39-05	122-40
Lower Lake 1W	38-54	122-38
Lower Lake	38-54	122-36
Lowsville Ranch	39-09	122-26
Lundquists	38-44	122-37
Lytton 4NE	38-41	122-49
Mahnke	38-51	122-47
Middletown	38-44	122-37
*Middletown 7NW	38-47	122-42
Middletown 4WSW	38-44	122-40
Morgan Valley Stanley	38-53	122-28
Mt. St. Helena	38-40	122-38
*Mt. St. Helena	38-39	122-36
Mt. St. Helena Trout Farm	38-42	122-39
Pitts Ranch	38-55	122-51
Pope Valley 2E	38-36	122-23
Pope Valley 3NW	38-38	122-27
Potter Valley 3S	39-16	123-06
Potter Valley 3NNW	39-22	123-08
Potter Valley 3SE	39-18	123-04
Potter Valley PH	39-22	123-08
Santa Rosa 5N	38-31	122-43
Santa Rosa 6NW	38-31	122-46
Santa Rosa 8N	38-33	122-39
Scotts Valley 3	39-03	122-56
*Simons Ranch	38-47	122-44
Skaggs Springs Las Lomas	38-40	123-08
Skaggs Springs 2NE	38-43	123-00
Skaggs Springs 2WNW	38-42	123-04
Skaggs Springs 4W	38-43	123-05
*Soda Bay	39-00	122-47
St. Helena	38-30	122-27
St. Helena 7NE	38-33	122-22
St. Helena 4WSW	38-30	122-32
*Sulphur Banks	39-00	122-39
*Talmage SCS No. 13	39-08	123-09
The Geysers	38-48	122-49
*Twin Valley	39-13	122-45
Upper Lake 2NE	39-11	122-53
Upper Lake 7W	39-11	123-02
Venado	38-37	123-01
Willits SCS	38-55	122-58
Windsor	38-33	122-56
Wohler Pumping Plant	Sec. 29	T8N,R9W

*No longer observing

APPENDIX C

DATA INDEX
FOR THE
CAMP STUDY AREA
1970 - 1979

Compiled By

Environmental Systems & Service
Kelseyville, California

LOCATION	DATA TYPE	DATES	SOURCE	REPORT NAME	COMMENTS
NCPA/Shell (Shell Upper)	Surface met. data, relative humidity	4/13/78-Present	Shell Oil	Wind analysis & wind roses	Raw data held by ES&S
	Tracer study " "	1. 11/2/78 2. 11/8/78 3. 1/17/79	NCPA/ SAI Engineers	MRI 78 R-1596 NCPA/Shell H_2S Impact Study	Subsidence Inversion " Downwash
Shell Lower	Surface met. data, relative humidity	4/13/78-Present	Shell Oil	Wind roses & analysis	Raw data held by ES&S
	Tracer study	11/7/78	NCPA/SAI Engineers	MRI 78 R-1596	Nocturnal Drainage
Natomas Well	Tracer study	10/15/78	"	"	"
Briggs Creek	Aircraft soundings surface met. data	6/24/77-9/16/77	MRI/ Republic Geothermal	MRI 78FR-1536 Briggs Creek/ Knights Valley Geo. Devel. Impact analy.	
Ransom Ridge	"	"	"	"	
NCPA well #1	Surface met. data	9/14/78-4/14/79	MRI & ES&S	MRI 79DV-1670	
	Tracer study	12/4/77 2/22/78 2/23/78 4/10/78 4/11/78	NCPA	MRI 78FR-1556 NCPA Devel. Impact study	Exact Release site varied with each test Sulfur analyser was located at Windrems and Adams Ranch.
	Tracer study	9/12/78	MRI	MRI 79DV-1670 Geysers Cobb Valley Air quality impact study	Nocturnal Drainage
	"	9/22/78	"	"	Nocturnal Drainage

LOCATION	DATA TYPE	DATES	SOURCE	REPORT NAME	COMMENTS
NCPA well #1 (cont.)	"	9/30/78	"	"	SRI 4 Episodal Cond.
	"	10/17/78	"	"	Nocturnal Drainage
	"	10/20/78	"	"	Subsidence Inversion
	"	2/9/79	"	"	Downwash
	"	2/14/79	"	"	"
	"	2/23/79	"	"	"
	"	3/30/79	"	"	Drainage from NCPA site
	"	4/4/79	"	"	"
DWR	Surface met data, R/H, H_2S, Hi Vol.	9/1/78-Present	DWR & ES&S	DWR monthly site survey reports	Hi Volume samplers 24 hrs, every 6 days. Met data (9/1/78-4/15/78) in MRI 79 DV-1670
	Acoustic Radar	10/24/78-4/11/79	ES&S	-	Base and top of First two inversions
	Tracer study	6/1/78-6/2/78	ES&S	30 day power plant site survey	3 F/P Tracer tests on two DWR sites.
	Tracer study	9/11/78	MRI	MRI 79 DV-1670 Geysers Cobb Valley Air quality impact study	Nocturnal Drainage
	"	9/27/78	"	"	Subsidence Inversion
	"	10/17/78	"	"	Nocturnal Drainage
	"	10/25/78	"	"	Subsidence Inversion
	"	10/27/78	"	"	SRI 4 Episodal Cond.
	"	1/10/79	"	"	Downwash
	"	2/8/79	"	"	"
	"	2/25/79	"	"	"
	"	4/1/79	"	"	Drainage from DWR site

LOCATION	DATA TYPE	DATES	SOURCE	REPORT NAME	COMMENTS
D.W.R. (cont.)	Tracer study	4/3/79	MRI	MRI 79DV-1670	Drainage-DWR site
Anderson Creek area	F/P Tracers Tethersondes Pibal Observations Aircraft soundings Surface met. data Neutral lift balloons	7/18/79	L.L.L.	LLL data base	Part of continuing ASCOT project. Tests were conducted every other night by a number of major labs.
Thorn 7	Surface met data	7/15/79-Present	L.L.L.	LLL data base	Part of continuing ASCOT project.
T.V. Repeator	"	"	"	"	"
Lower Simmons	"	"	"	"	"
Upper Simmons	"	"	"	"	"
Larry's Hut	"	"	"	"	"
McKinley 2	"	"	"	"	"
Smith-Brazil Well Pad	"	"	"	"	"

LOCATION	DATA TYPE	DATES	SOURCE	REPORT NAME	COMMENTS
Geyser Rock (SRI #1)	Surface met data, H_2S & SO_2	1/1/79-5/31/79	SRI INT'L.	Progress & quarterly reports	
	Acoustic radar	9/8/78-4/5/79	ES&S	MRI 79DV-1670 Geysers Cobb Valley air quality impact study	
	H_2S	4/75-6/75	Lake Co. APCD	Sulfur analysis summary	Highest daily H_2S concentration & corresponding met data.
	Hi volume sampler	2/06/77-8/17/77	ES&S	High volume air sampler data	Collected every 6 days
	Pibal observations	10/3/76-11/20/76	ES&S	-	"
Anderson Ridge (SRI #2)	Surface met data H_2S & SO_2	1/1/76-5/31/79	SRI INT'L	Progress & quarterly Reports	
	H_2S	12/75, 11/77	Lake Co. APCD	Sulfur analysis summary	Highest daily H_2S concentration & corresponding met data.
	Hi volume sampler	2/06/77-8/17/77	ES&S	High volume air sampler data	Data collected every 6 days.
Kahn Ranch (S[illegible] #3)	Surface met data, H_2S & SO_2	1/1/76-5/31/79	SRI INT'L.	Progress & quarterly Re.	

LOCATION	DATA TYPE	DATES	SOURCE	REPORT NAME	COMMENTS
Kahn Ranch (SRI #3) (cont.)	H_2S	8/75-9/75	Lake Co. APCD	Sulfur analysis summary	Highest daily H_2S concentration & corresponding met data.
	Hi volume sampler	2/06/77-8/17/77	ES&S	High volume air sampler data	Data collected every 6 days.
	Pibal observations	10/3/76-11/20/76	"	-	"
Pine Summit Estates (SRI #4)	Surface met data H_2S & SO_2	1/1/76-5/31/79	SRI INT'L	Progress & quarterly reports	
	H_2S	5/77-6/77 & 7/78-8/78	Lake Co. APCD	Sulfur analysis summary	"
	Pibal observations	10/3/76-11/20/76	ES&S	-	Data every 6 days
	Surface met data H_2S monitoring	4/79-Present	N.Sonoma APCD	-	
	Hi volume sampler	2/06/77-8/17/77	ES&S	High volume air sampler data	Data collected every 6 days
Whispering Pines (SRI #5)	Surface met data, H_2S & SO_2	1/1/76-5/31/79	SRI INT'L	Progress & quarterly reports	

LOCATION	DATA TYPE	DATES	SOURCE	REPORT NAME	COMMENTS
Whispering Pines (SRI #5) (cont.)	Hi volume sampler	2/18/77-8/17/77	ES&S	High volume air sampler data	Collected every 6 days
	Pibal observations	10/3/76-11/20/76	ES&S	-	"
Anderson Springs (SRI #6)	Surface met data H_2S & SO_2	1/1/76-5/31/79	SRI INT'L	Progress & quarterly reports	
	Hi volume sampler	2/18/77-8/17/77	ES&S	Hi volume air sampler data	Collected every 6 days
	Pibal observations	10/3/76-11/20/76	ES&S	-	"
Sawmill Flats (SRI #7)	Surface met data H_2S & SO_2	1/1/76-5/31/79	SRI INT'L	Progress & quarterly reports	
	Acoustic radar	1/1/76-5/31/79	"	"	Radar data from 9/3/78 -4/7/79 is also in MRI 79 DV-1670
	Doppler Acoustic Radar	9/2/78-4/4/79	ES&S	MRI 79DV-1670 Geysers Cobb Valley air quality impact study	
	H_2S	9/75-10/75	Lake Co. APCD	Sulfur analysis summary	Highest daily H_2S concentration with corresponding met data.
	Hi volume sampler	2/18/77-8/17/77	ES&S	High volume air sampler data	Data collected every 6 days

LOCATION	DATA TYPE	DATES	SOURCE	REPORT NAME	COMMENTS
Sawmill Flats (SRI #7) (cont.)	Pibal observations	9/6/76-2/6/77	ES&S	-	Data collected every 6 days
Adlin Ranch (SRI #8)	Surface met data, H_2S, SO_2	1/1/76-5/31/79	SRI INT'L	Progress & quarterly reports	Also, see MRI 78R-1543 Transport and dispersion characteristics affecting Adlin well sites area
	Hi volume sampler	2/6/77-8/17/77	ES&S	High volume air sampler data	Collected every 6 days
Nunnemaker's	Surface met data	9/1/78-4/5/79	MRI/ES&S	MRI 79DV-1670 Geyser Cobb Valley air quality impact study	
Adams Peak	Surface met data	9/1/78-4/5/79	"	"	
N. Caldwell Pines	Surface met data	10/76-9/77	ES&S	MRI 78R-1543 MRI 79FR-1600 Transport & Dispersion characteristics affecting well sites in Sonoma Co.	Wind analysis & 6 hr roses

LOCATION	DATA TYPE	DATES	SOURCE	REPORT NAME	COMMENTS
S. Caldwell Pines	Surface met data	9/1/78-4/5/79	MRI/ES&S	MRI 79DV-1670	
	"	10/76-9/77	"	MRI 79FR-1600	Wind analysis and 6 hour roses
				MRI 78R-1543	"
	"	4/11/78-7/20/78	"	-	
Franciscan Well	Tracer study	10/11/77	MRI/ES&S	MRI 78FR-1539	Clear light winds
		10/13/77			"
	Pibal observations	9/12/78-10/27/78	ES&S	Geyser Cobb Valley air quality impact study (pibal result	An average of 15 pibal observations for each of the 1st 10 tracer tests of the MRI 79DV-1670 study.
PG&E proposed power plant #17	Tracer studies	9/23/78	MRI	MRI 79DV-1670	SRI 4 episodal cond.
		9/27/78	"	"	Subsidence Inversion
		9/30/78	"	"	SRI 4 episodal cond.
		10/20/78	"	"	Subsidence Inversion
		10/25/78	"	"	Subsidence Inversion &/or SRI 4 episodal cond.
		10/27/78	"	"	SRI 4 Episodal cond.
		1/10/79	"	"	Downwash
		2/8/79	"	"	"
		2/9/79	"	"	"
		2/14/79	"	"	"
		2/23/79	"	"	"
		2/25/79	"	"	"
		4/3/79	"	"	Drainage from PP 17
		4/4/79	"	"	"
PG&E proposed power plant #13	Tracer studies	10/19/77	MRI	MRI 78FR-1539 Cobb Valley Geo. devel. impact study	Clear, light winds stable conditions

LOCATION	DATA TYPE	DATES	SOURCE	REPORT NAME	COMMENTS
PG&E proposed power plant #13	Tracer study	10/22/77	MRI	MRI 78FR-1539	Hazy with scattered to broken high clouds
	"	11/1/77	"	"	Clear, light winds, stable conditions
	"	11/2/77	"	"	"
PG&E proposed power plant #16	Tracer study	11/9/77	MRI	MRI 78FR-1539	Clear, light winds, stable conditions.
	"	11/11/77	"	"	Overcast, ceilings lowering below ridge level, occasional rain.
	"	12/13/77	"	"	"
Seigler Mt.	Tracer study	12/9/77	MRI	MRI 78FR-1539	Clear, light winds, stable conditions
Newfields	Tracer study	10/7/77	MRI	MRI 78FR-1539	Clear, light winds, stable conditions.
	"	10/8/77	"	"	"
	"	10/9/77	"	"	"
Union Oil well sites #4,2, gully on Cobb Mt.	Tracer study Smoke release Solar radiation Precipitation H_2S Surface met data	7/26/77-7/28/79	Nalco & ES&S for Union Oil	Nalco air quality impact assessment study for geo. resource devel. on Cobb Mt.	3 F/P tracers. Data collected at various times from 2/77 thru 11/77.
Ford Flat	Tracer study	11/14/77	MRI	MRI 78FR-1539	Clear, light winds, stable conditions

LOCATION	DATA TYPE	DATES	SOURCE	REPORT NAME	COMMENTS
Ford Flat (cont.)	Tracer study	9/24/77-9/25/77	MRI	MRI 77FR-1518 Gaussian model impact calculations for the Amin-oil Ford Flat geo. devel.	
PG&E sites	H_2S, surface met data	1970-1975	PG&E	PG&E depart. of engineer-ing research Ambient air quality at & in the vicin-ity of the Geysers 1970-1975.	Data is for various locations at sample times once a month.
PG&E Units 1,3,4	Acoustic radar	8/2/77-10/12/77	PG&E	-	Heights of Inversions, plumes and mixing.
PG&E power plants 5&6	Hi volume sampler	4/16/77-5/16/77	ES&S	High volume air sampler data	Collected every 3 days
PG&E power plants 7&8	Hi volume sampler	3/08/77-8/17/77	ES&S	"	Collected every 6 days
Cobb Mtn.	Hi volume sampler	3/08/77-4/07/77	ES&S	High volume air sampler data	Data collected every 3 days

LOCATION	DATA TYPE	DATES	SOURCE	REPORT NAME	COMMENTS
Thermogenics (near Pine Mt)	Tracer study	11/8/78	ES&S	Thermogenics well impact study	
Thermogenics Wall St. Mine	Tracer study	6/21/77,6/22/77	MRI	MRI 77R-1512 Gaussian model impact calculations for thermo-genics wall st. mine.	Dry Creek area
	Hi volume sampler	5/31/77-6/18/77	ES&S	Hi volume air sampler data	Data collected every 3 days.
Thermogenics (K-1 site)	Surface met data H_2S	5/17/77-6/19/77	Thermogen-ics Inc.	-	
D-M Ranch	Surface met data, H_2S	5/23/79-8/6/79	NSC APCD	-	
Wild Horse Canyon	Surface met data	10/76-9/77	NSC APCD	MRI 78R-1543 MRI 79FR-1600 (Transport & dispersion characteris-tics affect-ing specific well sites	Including wind anal-ysis & 6 hour roses
	"	3/23/78-5/22/78	ES&S	-	"

APPENDIX C (Cont.)

LOCATION	DATA TYPE	DATES	SOURCE	REPORT NAME	COMMENTS
Ukiah F.D.	Surface met data	7/77-11/77	ES&S	-	
Borax Lake	Surface met data	11/1/76-4/30/79	Lake Co. APCD	18 micro met station wind analysis	Quarterly reports, including 3 Hr. wind roses (south Borax Lake)
	H_2S	4/76, 9/76	"	Sulfur analysis summary	
	Surface met data, R/H precipitation	4/7/76-5/1/76	ES&S	MRI 76FR-1433 Gaussian model impact calculations for Thurston & Borax Lake.	
	Pibal observations	4/30/76-5/1/76	"		
	Aircraft Soundings	9/76	"	-	18 Aircraft runs
	Pibal observation	8/76-9/76	LCAPCD/ESS	-	
	Surface met data	8/28/76-9/28/76	ES&S	-	
Thurston Lake	Pibal observations	5/26/76-5/27/76	ES&S	MRI 76FR-1433	
Clearlake Park	Surface met data, R/H, precipitation	8/30/76-9/30/76	LCAPCD/ESS	-	
	H_2S	9/76	LCAPCD	Sulfur analysis summary	Highest daily H_2S concentration with corresponding met data.
Lakeport	Pibal observations	7/77-4/78	LCAPCD	Air character study	

LOCATION	DATA TYPE	DATES	SOURCE	REPORT NAME	COMMENTS
Hobergs Airport	Surface met data	11/1/76-4/30/79	Lake Co. APCD	18 micro met station wind analysis	Includes 3 hour wind roses quarterly reports.
Pearce	"	"	"	"	"
Calistoga	"	"	"	"	"
Healdsburg	"	11/1/76-2/28/78	"	"	"
Cloverdale	"	11/1/76-4/30/79	"	"	"
Hopland	"	"	"	"	"
Lamson Airport	"	"	"	"	"
Blue Lakes	"	"	"	"	"
Upperlake	"	"	"	"	"
Vin Keeling	"	"	"	"	"
Pope Valley	"	"	"	"	"
Walker Ridge	"	"	"	"	"

LOCATION	DATA TYPE	DATES	SOURCE	REPORT NAME	COMMENTS
Rumsey	Surface met data	11/1/76-4/30/79	Lake Co. APCD	18 micro met station wind analysis	Includes 3 hour wind roses quarterly reports.
Guinda	"	"	"	"	"
Lake Mendocino	"	2/1/77-4/30/79	"	"	"
Buckinham Point	Surface met data	5/1/77-4/30/79	Lake Co. APCD	"	"
Middletown (Cal Trans yard)	"	11/1/76-3/31/79	"	"	"
	H_2S monitoring	7/1/76-3/31/79	"	sulfur analysis summary	Highest daily H_2S concentration with corresponding met data.
	Hi volume sampler	2/18/77-8/17/77	ES&S	High volume air sampler data	Collected every 6 days.
	Pibal observation	10/3/76-11/20/76	"	-	"
Livermore Ranch (Napa Co.)	Surface met data	2/19/75-Present	Amax Corp.	-	Data not available to the public
	H_2S monitoring	11/22/75-Present			
Tamagni Ranch (near Calistoga)	Surface met data H_2S monitoring	2/27/75-12/21/76	"	-	"
Aetna Springs ([illegible]e Valley)	"	6/23/76-12/21/76	"	-	"

LOCATION	DATA TYPE	DATES	SOURCE	REPORT NAME	COMMENTS
Flynn Tree Svc (near Calistoga)	Surface met data, H_2S monitoring	12/21/76-Present	Amax Corp.	-	Data not available to the public
Tarter Ranch (Pope Valley)	"	12/22/76-9/19/77	"	-	"
Blanchard Ranch (Napa Co.)	"	9/20/77-Present	"	-	"
Binkley Ranch	H_2S	6/77-7/77	Lake Co. APCD	Sulfur analysis summary	Highest daily H_2S concentration with corresponding met data.
Glenbrook	H_2S	11/77-12/77	"	"	"
Windrems	H_2S	2/79	"	"	"
Loch Lomond	H_2S	7/75	"	"	"
#2 Watson	H_2S	5/76	"	"	"

LOCATION	DATA TYPE	DATES	SOURCE	REPORT NAME	COMMENTS
SMUD I	Surface met. data, Relative humidity Tracer studies (SF_6 & $BrCF_3$)	10/1/79 - 2/1/80	SMUD	Pending Publication	Tracer test regimes to be studied. Limited vertical mixing with winds toward Lake Co. Downwash with strong westerly winds Nocturnal winds into Alexander Valley Downwash with strong easterly or northeasterly winds Nocturnal drainage down Big Sulphur Creek
Anderson Valley (SRI 6)	Surface met data H_2S monitoring	10/10/79 - 2/1/80	SMUD	Pending Publication	MRI 1071, Houston Atlas 825 R
Jimtown (Alexander Valley)	Surface met data H_2S monitoring Acoustic Radar	10/10/79 - 2/1/80	SMUD	Pending Publication	MRI 1071, Houston Atlas 825 R
Sawmill Flats (SRI 7)	Surface met data Acoustic Radar	*	SMUD	Pending Publication	MRI 1071, Aerovironment Radar

*To be placed on line in November, 1979.

LOCATION	DATA TYPE	DATES	SOURCE	REPORT NAME	COMMENTS
Diamond "D" Ranch	Surface met data Acoustic Radar	10/10/79 - 2/1/80	SMUD	Pending Publication	MRI 1071, Aerovironment Radar
Hobergs Academy	H_2S monitoring	*	SMUD	Pending Publication	
Socrates Mine	Surface met data	10/10/79 - 2/1/80	SMUD	Pending Publication	MRI 1071, Aerovironment Radar
DWR II (Rorabaugh Leasehold)	Surface met data	8/15/79 -	DWR	Pending Publication	MRI 1071 Regimes to be studied: Cross Ridge flow Cobb Valley Nocturnal Drainage Big Sulfur Creek Fumigation - Alexander Valley Cross ridge flow - Alexander Valley
Geyser Rock (SRI I)	Surface met data H_2S monitoring	8/15/79 - 3/1/80	DWR	Pending Publication	MRI 1071 Monitor 8450
Geyserville	Surface met data H_2S monitoring Acoustic Radar	8/15/79 3/1/80	DWR	Pending Publication	MRI 1071 Meloy 285 Aerovironment A/R
Big Sulphur Creek (SRI 8)	Surface met data, H_2S monitoring	8/15/79 - 3/1/80	DWR	Pending Publication	MRI 1071 Meloy 285
Pocket Peak	Surface met data	8/15/79 - 3/1/80	DWR	Pending Publication	MRI 1071

*To be placed on line in November, 1979.

LOCATION	DATA TYPE	DATES	SOURCE	REPORT NAME	COMMENTS
Pine Summit Estates	Surface met. data Relative Humidity H_2S monitoring	4/1/79 - Present	NSCAPCD	-	MRI 1074 System Weather Measure Hygrothermograph Meloy 285 Data is being used in DWR's South Geysers Study
NCPA/Shell	Tracer Study #4	6/8, 9/79	SAI Engineers for NCPA & Shell	MRI 79FR-1712 NCPA/Shell H_2S Impact Study (Data Volume & Analysis)	#4 Nocturnal Drainage #5 Downwash/Fumigation
Tellyer	Tracer Study	9/20/79	LCAPCD & McCulloch Geothermal	Pending Publication	Nocturnal Drainage
Newfield	Tracer Study	10/4/79	LCAPCD & McCulloch Geothermal	Pending Publication	Up-valley daytime flow, northwest winds toward Pine Grove

Types of Data Monitoring and Corresponding Parameters

Data Type	Parameters
Aircraft soundings	Vertical temperature profile
Pibal observations	Wind speed and wind direction at different elevations.
Relative humidity	Hourly averaged
Surface meteorological data	Wind direction, speed and temperature at near ground level.
H_2S (Hydrogen Sulfide)	Hourly averaged H_2S concentrations in parts per billion.
High volume sampler	Total suspended particulates (TSP)
Acoustic radar	Heights of bases and tops of inversions, mixing layers, plumes, etc.
Doppler acoustic radar	Wind speed, direction, and verticle velocity at elevations of 100 meter increments (up to 500 meters).
Tethersonde	Verticle temerature profile.
Neutral lift balloons	Horizontal wind speed and direction.
Tracer study (SF_6 & $CBrF_3$ type)	Grab and bag sample summary, Aircraft soundings, Pibal observations, Surface met data, Maps of sample site locations, Isopleth maps of high concentration areas.
Grab and bag sample summary	SF_6 & $CBrF_3$ concentrations and H_2S equivalents.

APPENDIX D

AIR QUALITY DRAINAGE BASINS: HOUSEHOLDS, POPULATION AND POPULATION PROJECTIONS

Drainage Basin	Households[1]	Current Population[2]	1990[3] Projected Population	Percent of CAMP Area[4] Current Population / Projected Population
1. Upper Lake				
a[5]	1656	3858	5150	
b	292	680	955	
c	736	1714	2364	
d	852	1985	2585	
e	132	398	495	
f	48	112	144	
g	56	130	165	
h	24	56	61	
i	16	37	41	
j	204	475	575	
k	528	1230	1650	
l	16	37	41	
m	16	37	41	
n	64	149	185	
o	128	298	383	
p	52	121	153	
q	84	196	243	
r	48	112	142	
All Other	1412	3289	4439	
TOTAL	6364	14914	19862	24% / 25%
2. Pieta Creek	4	11		<1% / <1%
3. Sulphur Creek				
a	140	385	484	
All Other	60	165	203	
TOTAL	200	550	687	1% / 1%
4. Russian River				
a	1032	2632	3474	
b	16	41	43	
c	20	51	55	
d	120	306	456	

APPENDIX D (Cont.)

AIR QUALITY DRAINAGE BASINS: HOUSEHOLDS, POPULATION AND POPULATION PROJECTIONS

Drainge Basin		Households[1]	Current Population	1990[3] Projected Population	Percent of CAMP AREA[4] Current Population	/	Projected Population
	e	40	102	123			
	f	32	182	202			
	g	n.a.*	7654	9339			
	h	268	683	989			
	i	20	51	55			
	j	16	41	43			
	All Other	1195	3046	3996			
	TOTAL	2759	14789	18775	24%	/	24%
5.	St. Helena Creek						
	a	48	122	135			
	b	1567	3997	5001			
	c	356	908	1108			
	d	64	163	203			
	e	284	724	800			
	f	20	51	56			
	g	16	41	45			
	h	1420	3621	4306			
	All Other	1291	3293	3949			
	TOTAL	5066	12920	15603	21%	/	20%
6.	Pope Valley	44	112	150	<1%	/	<1%
7.	Putah Creek						
	a	100	233	262			
	b	16	37	39			
	c	164	382	458			
	d	16	37	39			
	All Other	496	1156	1528			
	TOTAL	792	1845	2326	3%	/	3%
8.	Lower Lake						
	a	32	75	89			
	b	140	326	390			
	c	36	84	98			
	d	892	2078	2740			
	e	16	37	43			
	f	20	47	55			
	g	20	47	55			
	h	16	37	43			
	i	36	84	98			
	j	16	37	43			
	k	128	298	356			

APPENDIX D (Cont.)

AIR QUALITY DRAINAGE BASINS: HOUSEHOLDS, POPULATION AND POPULATION PROJECTIONS

Drainage Basin	Households[1]	Current Population	1990[3] Projected Population	Percent of CAMP Area[4] Current Population	/	Projected Population
l	3664	8537	11682			
m	36	84	98			
n	16	37	43			
o	48	112	133			
p	24	56	66			
q	40	93	113			
r	16	37	43			
s	140	326	390			
t	132	308	368			
u	100	233	279			
v	16	37	43			
All Other	1444	3364	4214	27%	/	27%
TOTAL	7028	16374	21482			
9. Long Valley	64	149	180	1%	/	1%
10. Wilbur Springs	n.a.*	30	33	1%	/	1%
GRAND TOTAL	22321	61694	79110	100.0	/	100.0

[1]Number of residential hook-ups, PG&E distribution map, Winter, 1979.

[2]Households times population per household: (California Department of Finance) in Colusa, 2.645; Lake, 2.330; Mendocino, 2.747; Napa, 2.551; and Sonoma 2.548; plus individuals in group quarters.

[3]Current population times projected growth rate times eleven years.

[4]Sub area/drainage basin divided by total population.

[5]Letters refer to specific geographic population sectors (see overlay Map 2A).

APPENDIX E

COUNTY ZONING, APPROVED SUBDIVISIONS,
GEOTHERMAL ZONING, USE PERMIT PROCESSES

a. Colusa County

1) Areas Zoned for Residential Development

Within the CAMP Study Area, there are none (Walker, 1979). The area is zoned wholly "A-P", Agricultural Preserve. Minimum parcel size is 80 acres; uses allowed are agricultural. With a use permit, agriculturally-related uses are allowed (Walker, 1979).

2) Areas where Subdivisions have been Approved

None (Walker, 1979).

3) Areas Zoned to Allow Geothermal Development

None. However, geothermal development is allowed in an "A-P", Agricultural Preserve Zone with a use permit (Walker, 1979).

4) The Colusa County Use Permit Process: Geothermal Development

The submission of required forms along with a $25.00 permit fee is all that is necessary to request a geothermal use permit. However, the environmental review documents that are prepared by a county-contracted consultant are the financial responsibility of the petitioners (Walker, 1979).

5) The Use Permit Process for Siting Air Quality Monitoring Stations

A use permit is required; no difficulty is involved if the tower does not exceed 12 meters (Walker). The process for acquiring the permit is the same as that described in (4) above.

b. Lake County

1) Areas Zoned for Residential Development

The unincorporated area of Lake County within the CAMP Study Area is predominantly zoned "U", Unclassified (Israel, 1979). The County is in the process of revising its General Plan and conforming zoning to General Plan designations. Eventually, specific zoning will be established (Israel, 1979). Any land use, except those requiring a use permit, are allowed in a "U" district, including residential development (Section 22-10, Article III "U" - Unclassified District, Lake County Zoning Ordinance).

2) Areas where Subdivisions have been Approved

Approved subdivisions in the City of Lakeport are listed below:

a) Thirty-five (35) lots-for-sale, twelve (12) of which are under construction.

b) Ten (10) miscellaneous lot splits, two of which are multi-unit developments.

There are also the following tentatively-approved subdivisions within the City. Approval is expected in 1979:

c) Twenty-four (24) lots for individual home construction.

d) Forty-five (45) lots for condominium development.

e) Eight (8) lots for development (Tufts, 1979).

Policy for development of the unincorporated area of Lake County was recently adopted by the Board of Supervisors to guide development while the General Plan is being updated.

3) Areas Zoned for Geothermal Development

Within the "U", Unclassified Zone, a use permit will allow "drilling for and/or removal of oil, gas or geothermal production" (Section 20-10.3 (f), Article III, Lake County Zoning Ordinance).

A draft geothermal ordinance, entitled "Lake County Geothermal Resource Development Policy, Conditions, and Performance Standards" (May, 1979), specifies the following requirements with respect to siting geothermal development:

a) Wells must be at least 800 meters (1/2 mile) from any recorded subdivision unless at least 50% of the homeowners/landowners give written consent.

b) Power plants must be at least 800 meters (1/2 mile) from a recorded subdivision or five (5) or more residences located within a 400 meter (1/4 mile) radius unless at least fifty (50%) percent of the homeowners/landowners give written consent.

4) The Lake County Use Permit Process: Geothermal Development

Since the CAMP Study Area in Lake County is presently in an "Unclassified" Zone, geothermal uses are permitted with an approved use permit.

Lake County is presently revising the protocol and fees imposed for approval of a geothermal use permit (Israel, 1979).

A proposed use fee of $1,500 is being considered; other fees will be charged for environmental documents prepared.

Presently, Planning Commissioners consider use permit requests with decisions subject to appeal to the Board of Supervisors. Since the specifics of this procedure are being revised, detail is not provided.

5) The Use Permit Process for Siting Air Quality Monitoring Stations

The procedures are the same as those required for obtaining geothermal and other types of use permits. They are currently being revised, and, hence, are not presented in detail here. In Lake County, an overlay map has been prepared identifying space and height restricted areas near larger airports (Israel, 1979). This map conforms to the specifications of Part 77 of the Federal Aviation Regulations, and may be viewed at the County Planning Department Offices. The Hoberg Airport is currently unused, and the two Middletown airports are small and used mainly for agricultural operations (e.g., crop dusting) (Israel, 1979). The County Planning Department should be consulted in applying the Part 77 provisions to these airports.

c. Mendocino County

1) Areas Zoned for Residential Development

Within the CAMP Study Area boundaries, there are none (Heath, 1979). The entire area is zoned "F-C", Agricultural-Forest Conservation. The only residential use permitted is the single family dwelling "used as a residence when occupied by the owner of the area or tract of land..." (Mendocino County Zoning Ordinance No. 759 as amended). Since the minimum lot area is one hundred (100) acres, this residential use is limited. No other residential uses are allowed even with a use permit.

2) Areas Where Subdivisions have been Approved

None (Heath, 1979).

3) Areas Zoned to Allow Geothermal Development

None. However, geothermal development, i.e., "Geothermal well drilling, including the installation and use of such equipment, structures, and facilities as are necessary or convenient..." (Mendocino County Zoning Ordinance No. 357 as amended) is a use compatible with the "F-C" Agricultural-Forest Conservation District, and is allowed with a use permit.

4) The Mendocino Use Permit Process: Geothermal Development

In order to develop geothermal resources within Mendocino County, a use permit must be requested and approved. The process involves the following steps:

a) Submitting ten (10) copies of the form "Conditional Use Permit" to the Planning Department along with:

(1) Ten (10) copies of the plot plan.
(2) Ten (10) copies of a location map.
(3) Four (4) copies of architectural building elevations and sign detail if applicable.

b) After the Planning Department reviews (including an environmental review), a Planning Commission Public Hearing is held which the petitioner or a representative must attend. The environmental review conducted by the Planning Staff, as well as all initial study done by the applicant will be examined before action is taken.

c) Planning Commission decisions are final, unless appealed within twenty (20) days to the County Board of Supervisors. Board action is final.

d) The following conditions, as well as others which may be specified at the time, apply:

(1) Use permits expire one year after date of approval if not exercised.

(2) Failure to comply with conditions is a violation of the County Zoning Ordinance.

(3) A fee is required to process the application. It is currently $50.00 plus environmental review fees.

5) The Use Permit Process for Siting Air Quality Monitoring Stations

In order to be allowed to locate monitoring stations within the "F-C", Agricultural-Forest Conservation District, the use permit process described above must be initiated and a permit approved. Note that the maximum building height allowed in the "F-C" District is 10.7 meters for residential buildings.

d. Napa County

1) Areas Zoned for Residential Development

The CAMP Study Area in Napa County includes unincorporated areas as well as the cities of Calistoga and St. Helena.

Unincorporated areas are zoned predominantly "AW", Agricultural Watershed, with some "WR", Watershed Recreation areas. There are four (4) sites shown on Map 2a which are zoned for residential development:

a) Between the Sonoma County line and Calistoga, off Highway 128, zoned "RE", Residential Estate.

b) Between Calistoga and St. Helena in the west Napa Valley, zoned "RE", Residential Estate.

c) North of St. Helena, near the sanitarium, zoned "RD", Residential Double.

d) North of St. Helena, surrounding Angwin, zoned "RD", Residential Double.

2) These zones are defined in Napa County Zoning Ordinances Nos. 186 and 551 as follows:

a) "RE", Residential Estate - applied to areas of the County suited to large lot developments for single family homes. Residential uses permitted: single family dwellings on a minimum of one (1) acre (Zoning Ordinance 186).

b) "RD", Residential Double - applied in areas of the County otherwise suited for Residential Single Zoning where housing is desired for students, nurses and institutional employees. May be located near educational institutions, hospitals and similar institutions. Residential uses permitted: one (1) single family dwelling unit per legal lot; one additional dwelling unit located within a single family dwelling.

Residential development occuring with the cities of St. Helena and Calistoga is discussed below in Section 3).

3) Unincorporated Areas where Subdivisions have been Approved

None (Nelson, 1979). Within the City of Calistoga, development is limited to a maximum of 40 housing units per year. In St. Helena, there are currently twelve (12) units which are almost complete. All other development proposals are tentative (Musso, 1979).

4) Areas Zoned to Allow Geothermal Development

None. However, Napa County Zoning Ordinance No. 499, its "Geothermal Ordinance" specifies that "certain limited portions of the incorporated area of the County of Napa may be potential sites for geothermal... exploration." In order to explore for geothermal resources, a use permit is required.

5) Napa County Use Permit Process: Geothermal Development

A use permit may be obtained from the Napa County Conservation, Development and Planning Department, according to the following process:

a) Submission of an application form and fee (currently $250.00, plus $500.00 per well) along with:

(1) Ten (10) copies of a map of the site.
(2) Ten (10) copies of a plan and cost estimate of the proposed development.
(3) Other specific information, including property owners' written consent, written proof of DOG approval, etc. (see Ordinance). Requests will be approved by the Conservation, Development and Planning Commission as long as there is no danger to the "health, safety and welfare of others" implicit in the proposal.

b) A public hearing is conducted on each application by the Planning Commission, which may request further information for environmental review.

c) The following conditions, as well as others specified at the time, apply:

(1) Use permits expire after one year if not exercised.
(2) Failure to comply with specific conditions is cause for Commission revocation.

6) The Use Permit Process for Siting Air Quality Monitoring Stations

The process, specified in Napa County Zoning Ordinance No. 511, requires:

a) Submission of an application form.

b) A Conservation, Development and Planning Commission hearing (including review of Part 77 of Federal Aviation Regulation if required).

c) The following conditions, as well as any others specified at the time, apply:

(1) Use permits expire after one year if unused.

(2) Failure to comply with specific conditions is cause for Commission revocation.

e. Sonoma County

1) Areas Zoned for Residential Development

The Sonoma County portion of the CAMP Study Area includes both incorporated and unincorporated territory. Within the unincorporated area, the zoning is primarily "A-2", Secondary Agriculture, a zone used "to identify those lands suited for less intense agricultural uses or low density agricultural-residential development" (Sonoma County Zoning Ordinance No. 1928).

This zone allows the following residential uses without a permit: single family dwellings, multi-family dwellings, and group dwellings as long as there are not less than two (2) acres per dwelling unit (emphasis added). With a permit, planned developments and condominiums are permitted, subject to the provisions of not less than two (2) acres per dwelling unit (net), "unless combined with a "B" District, in which case the maximum permitted density shall be that established by the combining district" (Sonoma County Zoning Ordinance No. 1928).

The only residential areas are those located (see Map 2A) east of Highway 101 between Cloverdale and Healdsburg. They are zoned "Rural Residential", with a required density of one (1) to five (5) acres per dwelling unit (Odom, 1979).

There are two incorporated areas within the Sonoma County CAMP Study Area: Cloverdale and Healdsburg. Residential development within city limits is proceeding and will be addressed in Section 2 on the following page.

2) Areas where Subdivisions have been Approved

In the unincorporated areas, there are none (Lehtinen, 1979). Minor subdivisions have created forty-eight (48) new lots in the period 1977-1979, approximately half of which have been issued building permits (Lehtinen, 1979).

In Cloverdale, there are two subdivisions which meet approval criteria of improvements in or construction bond posted and which will result in 58 new units (Groom, 1979). In Healdsburg, two subdivisions yeilding 70 units meet the criteria, and one further subdivision planned for 1975 units should receive final map approval in 1979 (Youngblood, 1979).

3) Areas Zoned for Geothermal Development

None. However, Sonoma County Zoning Ordinance, Article XXIX, General Use, Section 26-199(i) specifies that "the removal of minerals and earth may be permitted in any district, provided no geothermal activity other than exploratory drilling or leasing shall be permitted in the A-E, Exclusive Agriculture District and provided that a use permit is first secured in each case" (emphasis added).

Sonoma County General Plan maps* identify the CAMP Study Area as primarily undeveloped or managed resource areas (agriculture, timber, and geothermal resource lands). The only designated urban and rural residential areas are Cloverdale, Healdsburg, and the Geyserville to Asti area adjacent to Highway 101.

*Plate 3: Resource and Undeveloped Areas

The General Plan itself recommends the following geothermal policy be developed by the County:

> "A specific plan for the geothermal resource be prepared and adopted; zoning ordinance provisions governing the utilization of this resource and its relationship to other ordinances be written" (Sonoma County General Plan, page 41).

A "GR", Geothermal Resource District, draft ordinance is under consideration by the County to implement this General Plan recommendation. No date for implementation of this ordinance is available.

4) Sonoma County Use Permit Process: Geothermal Development

A Geothermal Use Permit is available at the Sonoma County Planning Department. Posted price: $344.00.

Applicants for a use permit must submit the following items to the Planning Department:

a) One (1) copy of the completed application form as well as:

(1) One (1) copy of the Assessor's parcel map
(2) One (1) site plan of the property
(3) One (1) copy of a "proposal statement"
(4) One (1) United States Geological Survey Quadrangle map showing the site

b) An environmental review fee is charged for all requests not categorically exempt.

c) The request is considered by the Project Review Advisory Committee. PRAC can require further environmental reports for the project.

d) After processing by the PRAC, the Board of Zoning Adjustments holds a public hearing, and the request is either approved or denied.

e) Decisions can be appealed within 12 days to the Board of Supervisors.

f) The following conditions, as well as others which may be specified at the time, apply:

(1) Use permits expire after one year if not exercised.
(2) Failure to comply with the conditions is a resolution of the County Zoning Ordinance.
(3) Projects requiring approval by other agencies must be contacted by the applicant and approval secured.

Note that the approval of a "GR", Geothermal Resource District in Sonoma County, would undoubtedly alter this process. Its impact would have to be assessed at the time of approval.

5) The Use Permit Process for Siting Air Quality Monitoring Stations

In Sonoma County, the same use permit process described above applies to siting air quality monitoring stations. Within the unincorporated A-2 Zone, a building height of 12 meters is allowed, provided site plan approval has been received

(Sonoma County Ordinance No. 1928). Sonoma County has passed an ordinance which enforces the provisions of Part 77 of the Federal Aviation Regulations at the Cloverdale, Healdsburg, and Sonoma County Airports (Becker, 1979).

APPENDIX F (Cont.)

AIRPORTS IN OR NEAR CAMP STUDY AREA

AIRPORT	LOCATION	ELEVATION
14. Pope Valley		
a. Public	45 km northeast of the City of Napa	188 Meters
b. Private	16 km north of Pope Valley	427 Meters
15. Yountville		
a. Private	21 km north of Yountville	35 Meters
SONOMA COUNTY		
16. Cloverdale	4.8 km south of Cloverdale	83 Meters
17. Healdsburg	8 km northwest of Healdsburg	91 Meters
18. Santa Rosa		
a. Public	2.6 km southwest of Santa Rosa	30 Meters
b. Private	11.2 km northest of Santa Rosa	137 Meters
19. Sonoma County	7.4 km northwest of Santa Rosa	38 Meters
20. Sonoma-Schelleville	8 km south of the City of Sonoma	1.5 Meters
21. Sonoma Valley		
a. Private	4.8 km southeast of the City of Sonoma	6 Meters

Note: Unless otherwise indicated, all airports are public. There may be other private fields that are not listed.

Source: Airports, USA, 1979 edition, AOPA, Washington, D.C.

*Not recorded on the San Francisco Aeronautical Chart, National Oceanic and Atmospheric Administration, 1979.

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APPENDIX G

GLOSSARY

A-2	Secondary Agricultural (Sonoma County Zoning Class)
Abatement	Reduction of pollutants by chemical or mechanical processes
Adiabatic Rate	Rate of heating or cooling as a result of compression or expansion of air as it moves downward or upward
A-E	Exclusive Agriculture (Sonoma County Zoning Class)
Air mass	An extensive body of the atmosphere which approximates horizontal homogeneity in its weather characteristics, particularly with reference to temperature and moisture distribution
Air Sonde	Inexpensive means for gathering temperature, pressure and relative humidity in upper air
AOPA	Air Craft Owners and Pilots' Association
A-P	Agricultural Preserve (Colusa County Zoning Class)
APCD	Air Pollution Control District
APCO	Air Pollution Control Officer
AQCR	Air Quality Control Regions
A.R.	Acoustical Radar
ARB	California Air Resources Board
As	Arsenic
ASCOT	Atmospheric Studies of Complex Terrain
AW	Agricultural Watershed (Napa County Zoning Class)
B	Boron
B	Business (Sonoma County Zoning Class)
Bifurcated	Splitting of an air stream, for example, laterally around a hill

Boundary Layer	Layer of air in the immediate vicinity of the ground
$BrCF_3$	Bromotrifluoro-methane
C_2H_6	Ethane
CAMP	Comprehensive Air Monitoring Plan
CEC	California Energy Commission
Centigrade	5/9 (F-32)
Centimeters	Inches x 2.54
CH_4	Methane
CO_2	Carbon Dioxide
COH	Coefficient of Haze
Col	A saddle point in the topography
Colortec	Hydrogen sulfide tag-type detector
Convective	Upward moving portion of a convective circulation, such as a thermal
Criteria Pollutants	Pollutants as defined by the EPA in Code of Federal Regulations, 40CFR50
DEIR	Draft Environmental Impact Report
Diffusion	The exchange of gas parcels between regions in space in random motion
Diurnal	Daily; occurring within 24 hours
DOG	Division of Oil and Gas
DWR	Department of Water Resources
EERS	Established Exceedance Receptor Station
Emission Source	Power plants and wells
EPA	Environmental Protection Agency

APPENDIX G (Cont.)

EPA/PSD	Environmental Protection Agency/Prevention of Significant Deterioration
ERL	Environmental Research Laboratories
ERT	Environmental Research & Technology
ES&S	Environmental Services & Systems
Exceedance	Violation of State Air Quality standards
F-C	Agricultural-Forest Conservation (Napa County Zoning Class)
F/P	Florescent Particle
FS	Forest Services
Ft^3	Cubic Feet
Fumarole	Natural gas vent
Fume	Gas emission
Fumigation	Mixing of pollutants beneath an inversion
FWS	Fish and Wildlife Service
GGEC	Geysers Geothermal Environmental Committee
GR	Geothermal Resource District (Sonoma County Zoning Class)
GRIPS	Geothermal Research, Information and Planning Services
H_2	Hydrogen
H_2S	Hydrogen sulfide
Hectare	Acres x 0.4047
Hg	Mercury
Hydrologic Basin	Common water drainage area

APPENDIX G (Cont.)

IHSS	Interim H_2S Sampler Station
Inversion	Temperature departure from usual increase or decrease with altitude, usually an increase
KGRA	Known Geothermal Resource Area
Kilo	2.2 lbs.
Kilometers	Miles x 1.609
Kinematic	Moving
Lapse Rate	Decrease of temperature with height
LBL	Lawrence Berkeley Laboratory
LCAPCD	Lake County Air Pollution Control District
LLL	Lawrence Livermore Laboratory
Liter	.908 dry quart of 1.056 liquid quart
Macroscale	Large area as distinguished from meso- and microscale
Megawatts	Watts x 10^6
Mesoscale	Middle scale, between macro- and microscale
Met	Meteorological
Meters	Feet x 0.3048
Mixing Layer	Virtually isothermal (relatively free) vertical mixing
Model	Any theoretical representation of the atmosphere
MOU	Memorandum of Understanding

MRI	Meteorology Research, Inc.
M/S	Meters per second
MSL	Mean Sea Level
N_2	Nitrogen
NAAQS	National Ambient Air Quality Standards
NADB	National Air Data Bank
NAQTS	National Air Quality Trend Sites
NEDS	National Emission Data System
NH_3	Ammonia
nr	Meteorological terms for near
NOAA	National Oceanic and Atmospheric Administration
Noncondensable gas	Gas emission as opposed to particulates and steam
NRC	Nuclear Regulatory Commission
NSCAPCD	Northern Sonoma County Air Pollution Control District
OBS	Office of Biological Service
Orographic	Of, pertaining to, or caused by mountains
Pasquill G	Very stable atmospheric category
PD	Population Density
PG&E	Pacific Gas and Electric
PGF	Permitted Geothermal Facility
Photogrammetric	Of a photographic measuring technique
Pibal	A balloon used to measure the wind speed and direction in the upper air

Point Source	Single emission points, such as a single well or power plant
Pollutant	Source emission creating harmful effects on persons, animals, or vegetation
ppb	Parts per billion
ppm	Parts per million
PRAC	Project Review Advisory Committee (Sonoma County)
PUC	Pacific Union College
Radiation	Electromagnetic propagation through free space
Rawinsonde	A radio sonde tracked by a radio direction finding device to determine the velocity of winds aloft as well as temperature
RD	Residential Double (Napa Zoning Class)
RE	Residential Estate (Napa Zoning Class)
RFL	Resource Funding, Ltd. (steam developer)
RFP	Request for Proposal
RH	Radiological Health
R/H	Relative Humidity
Roses	Pattern commonly seen in a wind formation resembling a rose
RR	Rural Residential (Sonoma County Zoning Class)
Saddle	Low point through the mountain ridge
SAMWG	Standing Air Monitoring Work Group
SCS	Soil Conservation Service
SEA	Scientific and Environmental Analysis (Santa Cruz)
SF_6	Sulfur hexaflouride

SIP	State Implementation Plan
SLAMS	State and Local Air Monitoring Sites
SLID	Specimen Label Information Directory
Source-Receptor Relationship	Air trajectory between a source and a receptor
SPM	Special purpose monitoring
SRI	SRI International as of 1977 (formerly Stanford Research Institute)
SS	Site-Specific
Stability	The stability of the atmosphere with respect to vertical displacements
Stacking	Accumulation of the output of well emissions into a stack or muffler rather than into a power plant
Strategy	A means of abatement
Subsidence	A descending motion of air in the atmosphere, usually with the implication that the conditions extends over a rather broad area
Subvention Funds	Funds provided by state from legislatively-mandated sources
Synoptic	In general, pertaining to, or affording an overall view
Thermals	A relatively small-scale, rising current of air produced by local heating
Topographic	Natural or man-made physical features on the earth's surface
TRC	Research Corporation of New England
Transport	The rate of flow of air
TS	Trend Stations
TSP	Total Suspended Particulates
Turbulent Eddies	A parcel of air with a certain integrity and life history in which the instantaneous velocities exhibit random fluctuations

U	Unclassified (Lake County Zoning Class)
UIH	Urban and Industrial Health
UNAMAP	User's Network for Applied Modeling of Air Pollution
UNEP	United Nation's Environmental Program
USWB	United States Weather Bureau
Wellhead	The source of a spring or stream
WMO	World Meteorological Organization
Worst Case Conditions	Very stable atmosphere (Pasquill-Gifford stability F) and very light wind speed (1 meter/second)
WR	Watershed Recreation (Napa County Zoning Class)