# CUMULATIVE BIOLOGICAL IMPACTS OF THE GEYSERS GEOTHERMAL DEVELOPMENT

## STAFF REPORT

DO NOT MICROFILM
COVER

OCTOBER 1981

CALIFORNIA
ENERGY
COMMISSION

P700-81-021



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## DISCLAIMER

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P-700-81-021

ACKNOWLEDGMENTS

The author would like to acknowledge contributions made to this report by division staff, particularly Gary Gomby for the preliminary analysis of impacts and preparation of the draft for the impacts portions of the report and contributions by Richard Anderson, Jim Nelson, and Marc Sazaki. Graphics were provided by Tino Flores and Thom Lewis and maps by Alan Taylor and Yorick Lutes.

The report was critically reviewed and suggestions for improvements in the text were made by Bob Haussler, Biology and Water Resources Unit Manager; Bob Therkelsen, Office Manager, Environmental and Health Office; and Bill Durkee, Deputy Division Chief.

The original report was typed by Tracy Werhan, with report revisions and final draft typed by the Word Processing staff.

## Preface

This report reviews studies on both current and potential future cumulative biological impacts that may result from development of the dry steam resource at The Geysers-Calistoga KGRA and identifies the CEC staff position on related issues and their proposed solutions.

## ABSTRACT

The cumulative nature of current and potential future biological impacts from full geothermal development in the steam-dominated portion of The Geysers-Calistoga KGRA are identified by the California Energy Commission staff. Vegetation, wildlife, and aquatic resources information have been reviewed and evaluated. Impacts and their significance are discussed and staff recommendations presented.

Development of 3,000 MW of electrical energy will result in direct vegetation losses of 2,790 acres, based on an estimate of 11.5 percent loss per leasehold or 0.93 acres/MW. If unmitigated, losses will be greater. Indirect vegetation losses and damage occur from steam emissions which contain elements (particularly boron) toxic to vegetation. Other potential impacts include chronic low-level boron exposure, acid rain, local climate modification, and mechanical damage.

A potential exists for significant reduction and changes in wildlife from direct habitat loss and development influences.

Highly erosive soils create the potential for significant reduction of aquatic resources, particularly game fish. Toxic spills have caused some temporary losses of aquatic species. Staff recommends monitoring and implementation of mitigation measures at all geothermal development stages.

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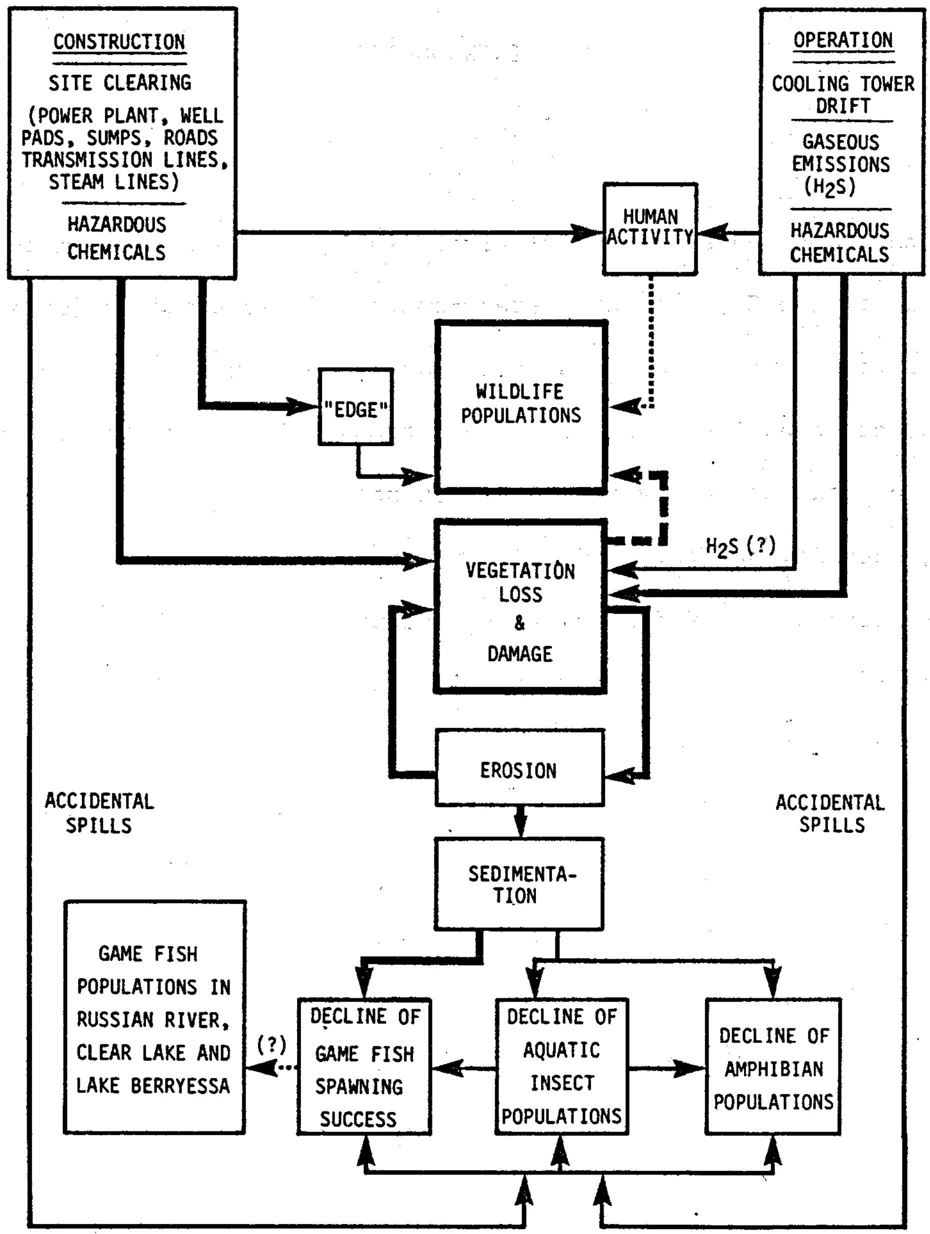
# INTRODUCTION

## PURPOSE

This report documents the cumulative biological resources impacts that have occurred in The Geysers KGRA steam-dominated area and projects the impacts that will occur if development proceeds according to three projected energy development scenarios. Rather than attempting an exhaustive categorization and discussion of every real and potential cumulative biological resource impact, this investigation identifies those impacts on land, air, and water which in turn affect flora and fauna (Figure 1). The discussion of biological resource impacts focuses on the following areas: (1) direct habitat loss (i.e., vegetation) due to construction; (2) indirect vegetation loss and damage due to cooling tower emissions; and (3) wildlife and aquatic resource (particularly game fish) impacts due to construction and operation activities. The report summarizes relevant literature, identifies problem areas that will require additional information for resolution, identifies issues which should be addressed by geothermal policy makers, and presents the Commission's biological resources staff position on these concerns.

This report is the first product of a three-phase program to address the cumulative biological resource impacts in The Geysers steam resource area. The second phase is a series of biological constraints maps covering the geothermal area. The third phase will involve development of regional mitigation, compensation, and management plans. Each of the products is likely to be used by developers to plan projects and by federal, state, and local permitting agencies to provide guidance in policy and siting decisions. If implemented, these plans will reduce the potential for cumulative biological




| | |
|---|---|
| MAJOR INCREASE | ▬▬▬ |
| MINOR INCREASE | ——— |
| MAJOR DECREASE | ▪ ▪ ▪ ▪ |
| MINOR DECREASE | ........ |

FLOW CHART DEPICTS IMPACTS TO BIOLOGICAL RESOURCES STEMMING FROM GEOTHERMAL DEVELOPMENT. CONSTRUCTION AND OPERATION ACTIVITIES HAVE AN INCREASING EFFECT OR DEPRESSING EFFECT ON BIOLOGICAL RESOURCES: E.G., CONSTRUCTION ACTIVITIES INCREASE VEGETATION LOSS AND DAMAGE, WHICH IN TURN INCREASES EROSION. QUESTION MARKS (?) INDICATE THAT THE EFFECT OF THE ACTIVITY IS UNCERTAIN.

FIGURE 1: FLOW CHART OF ENVIRONMENTAL DISRUPTION DUE TO GEOTHERMAL DEVELOPMENT

impacts in The Geysers. At present, staff has concentrated on the geothermal steam resource area, but the need is recognized for future study to include the hot water resource area.

## BACKGROUND

The Geysers-Calistoga KGRA (Figure 2) is located approximately 80 miles north of San Francisco in the north central California Coast Ranges. The 586 square mile KGRA has been characterized as a "scenic region of mountains, steep canyons, hilly uplands, terraced valleys, and flat lake-basins terrain" (SRI, 1978). The area is unique in that it contains subsurface geothermal resources that can be used for electrical power generation and other energy applications.

Geothermal electrical production is currently limited to a small region in the KGRA underlain by geothermal steam (Figure 3, 4). In 1960, the Pacific Gas and Electric Company began generating 11 MW of power using this resource. PGandE's current geothermal electrical generating capacity is 908 MW from 15 generating units. These units are supported by a network of steam wells, steam pipelines, access roads, and transmission lines. Nine additional power plant proposals made by several utility and geothermal development companies have either been approved or are being reviewed in the Energy Commission's power plant licensing process. If constructed, these facilities will increase the electrical generating capacity of the area to 1,669 MW.

The current geothermal steam resource development is occuring over a large area and requires the construction of numerous facilities dispersed over the entire area to obtain the maximum energy production from the resource. This development requires vegetation removal and disturbance of wildlife habitat

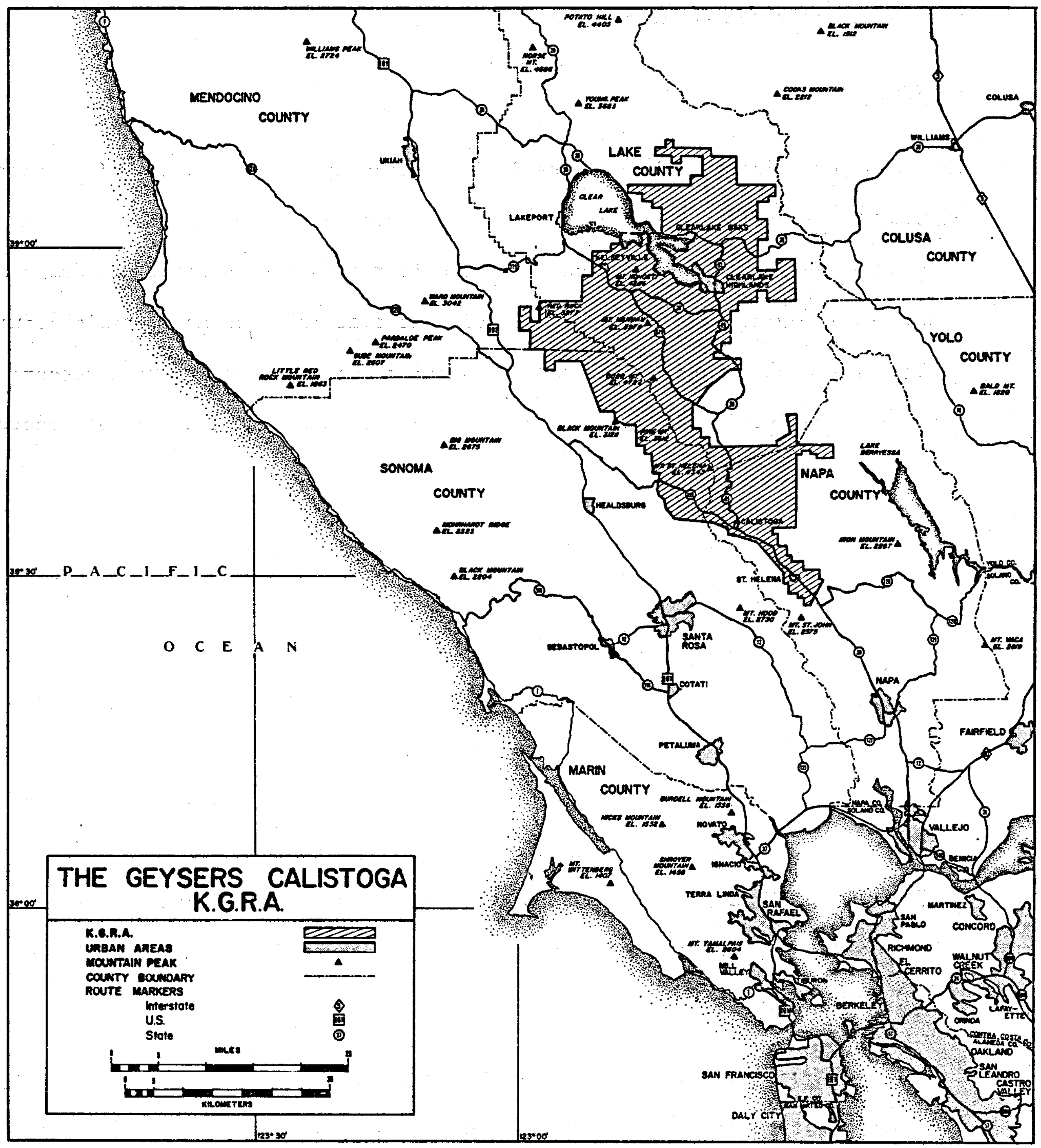



FIGURE 2: KGRA AND SURROUNDING COUNTIES

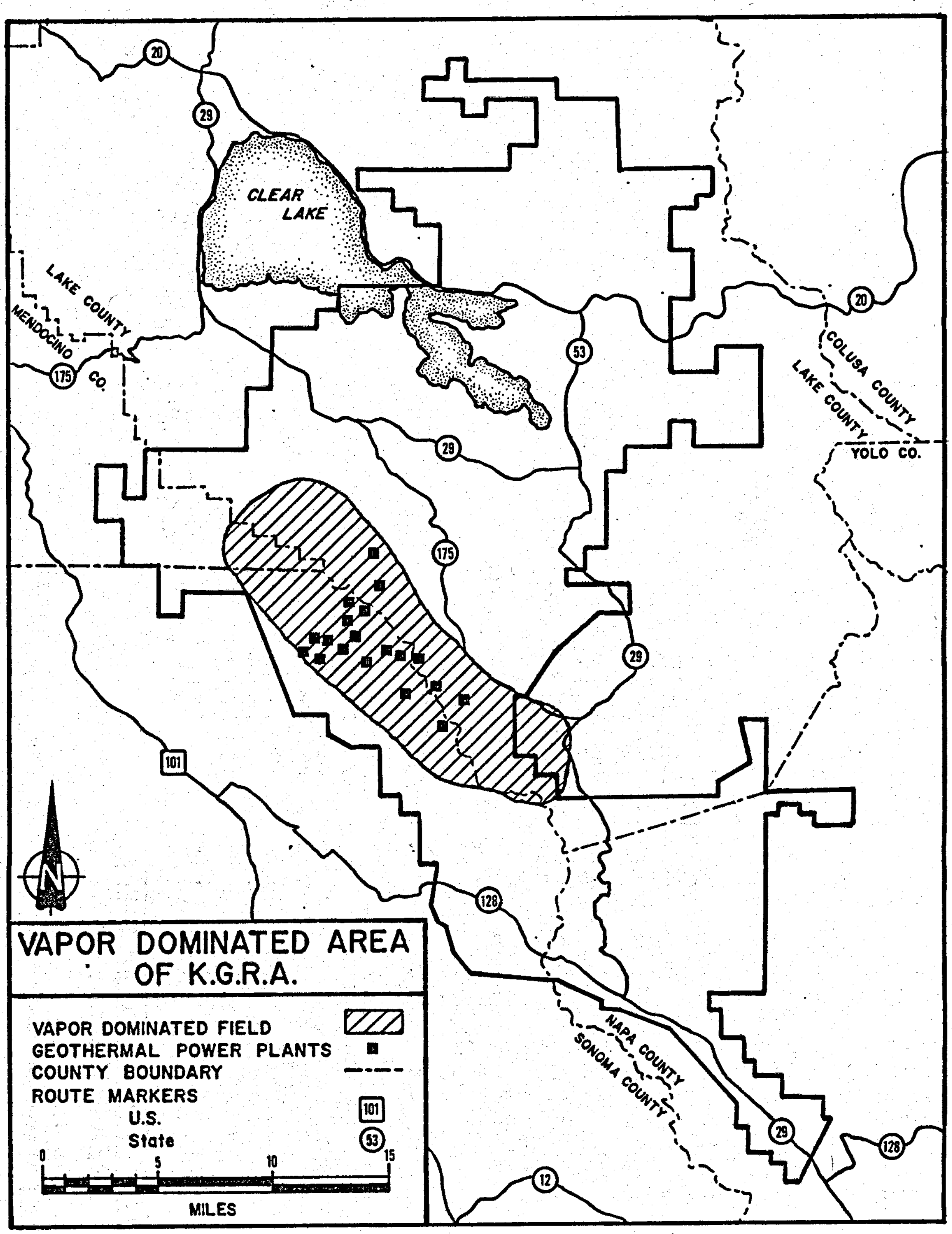



FIGURE 3: DRY STEAM RESOURCE AREA

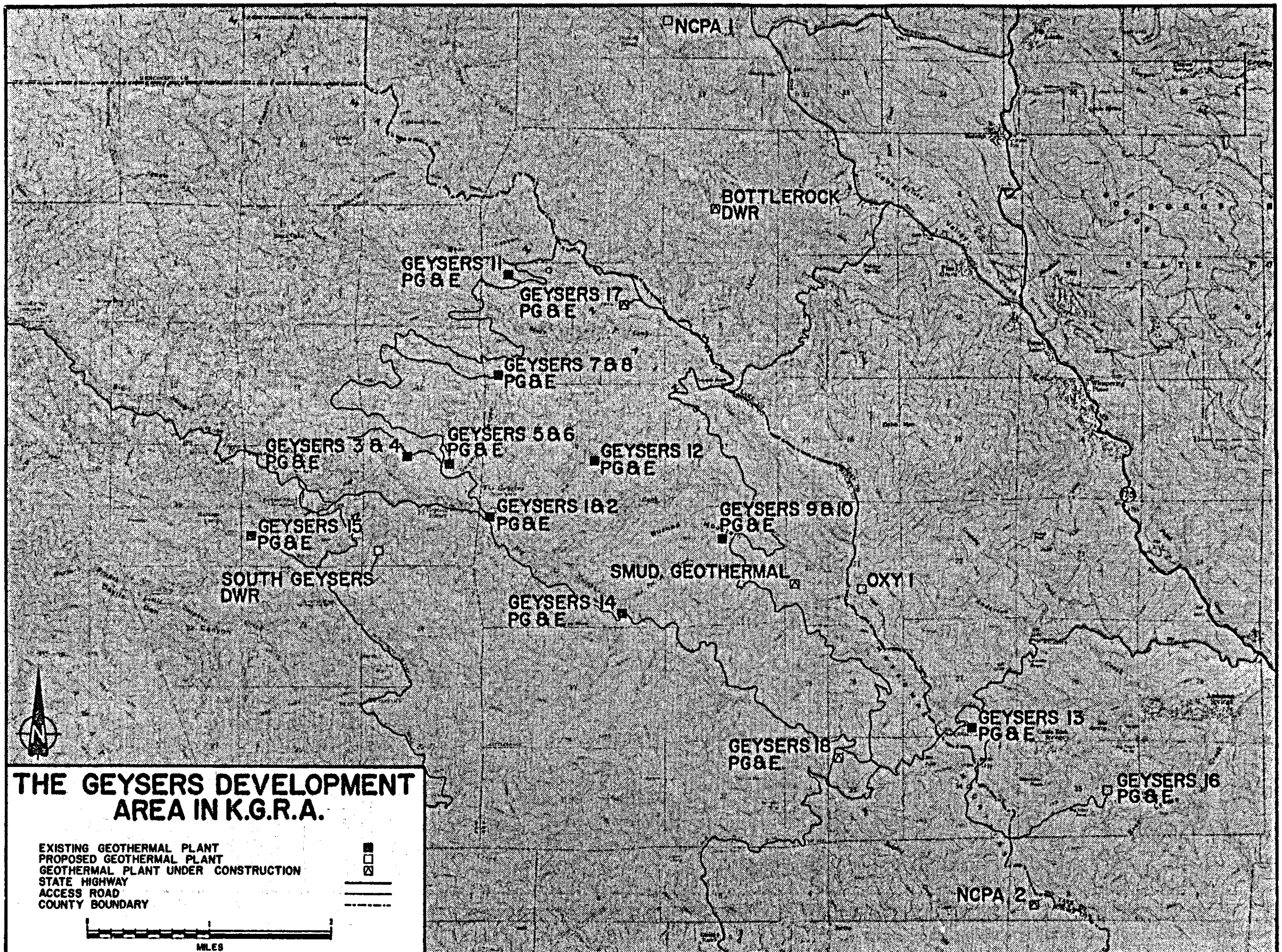



FIGURE 4: THE GEYSERS DEVELOPMENT AREA

resulting from exploration and construction of the steam wells, steam pipelines, roads, power plants, electrical transmission systems, sumps, storage yards, and other facilities.

The biological impacts from initial geothermal developments were considered on an individual project basis and not as impacts from regional geothermal resource development. The significance of each of these individual developments and their impact on biological resources was investigated and reported in various environmental impact documents. Often the conclusion reached when each project was considered by itself was that the biological impacts were insignificant. However, as geothermal development has expanded with an increasing number of power plants sited in relatively undisturbed areas of high wildlife value, cumulative impacts on biological resources in The Geysers have become an issue. The expanded development is perceived by agencies and public groups concerned with biological resources management as causing a major wildlife habitat loss and associated disturbances in an area that, due to the type of terrain and remoteness, was previously thought as unlikely to be disturbed by an industrial "energy park" type of development. Prior to geothermal development, limited logging and cattle grazing were the only activities that had presented potential conflicts with wildlife use of the area.

Comments concerning the cumulative effects to biological resources in The Geysers area have been received from the California Department of Fish and Game and the United States Fish and Wildlife Service. According to the California Environmental Quality Act (CEQA, State of California, 1978), "Cumulative impacts refer to two or more individual effects which, when considered together are considerable or which compound or increase other environmental impacts" (14 Cal. Admin. Code, Section 15023.5). Such impacts should be "...viewed in connection with the effects of past projects, the effects of other current projects, and the effects of probable future projects" (14 Cal. Admin. Code, Section 15082). Letters of comment regarding changes in the area's biological resources have also been received from various intervenor groups and area residents. These groups are concerned about geothermal development which is changing their previously secluded lifestyles.

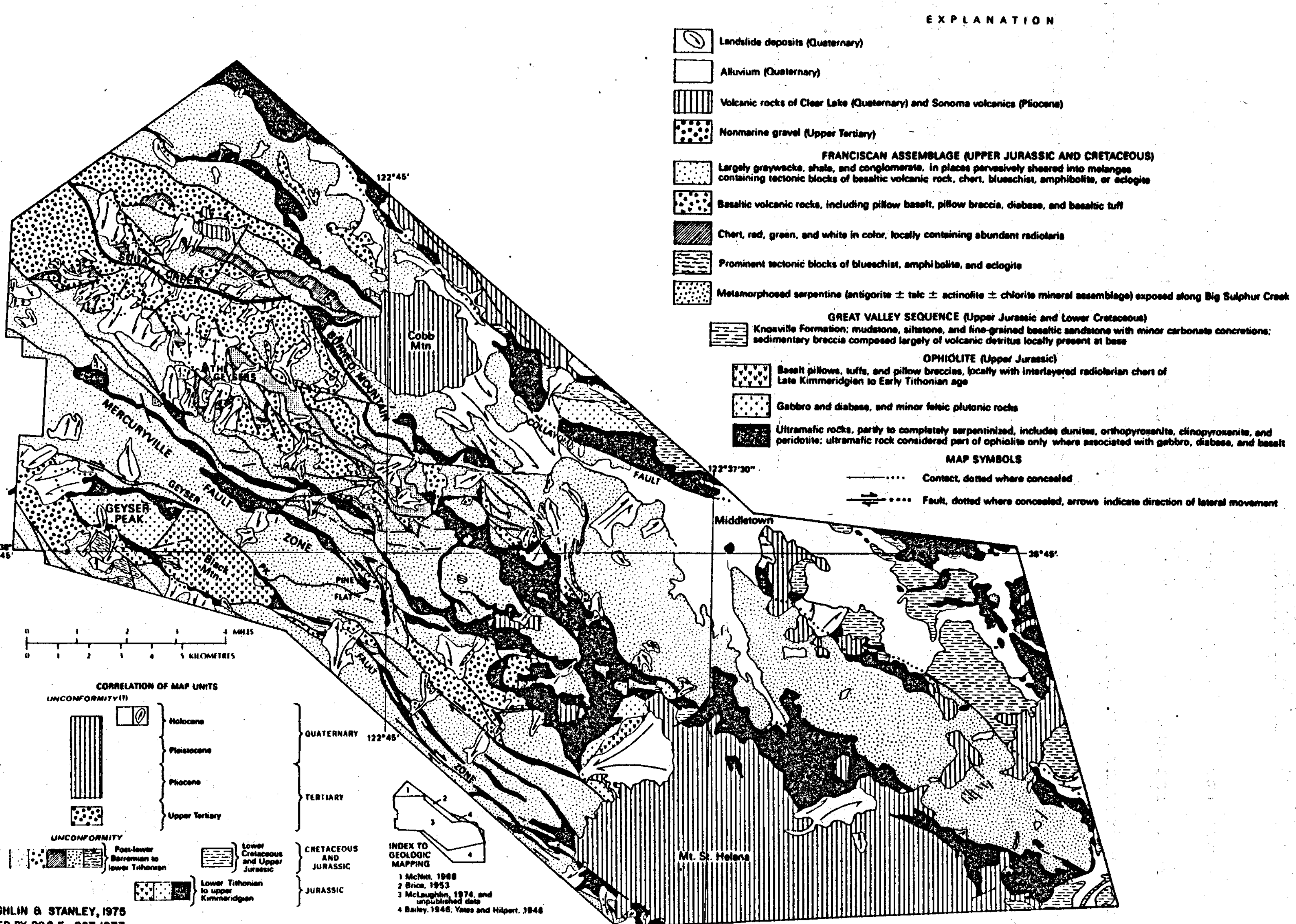
The flow chart in Figure 1 illustrates the consequences of construction and operation of geothermal power plants and their associated support facilities (roads, pipelines, transmission lines, well pads, mud sumps, etc.) on biological resources. Due to the interrelationships between components of a biological community, impacts to one component may ramify throughout the community. Figure 1 reflects this characteristic and represents what are believed to be the most serious cumulative impacts of geothermal development, by virtue of their potential magnitude for environmental disruption. Both direct vegetation removal for site clearing and indirect impacts from spills and power plant emissions result in an increase in loss and damage to vegetation. These effects on vegetation in turn lead to decreases in wildlife populations and increases in soil erosion and sedimentation. Increased sedimentation reduces aquatic biological resources. Therefore, an apparent site-specific impact can combine with other development impacts to result in significant cumulative biological resource impacts.

## OVERVIEW OF GEOTHERMAL RESOURCE

Biological impacts in The Geysers area are associated with the nature of the geothermal resource and the methods required to utilize this resource. This section provides an overview to the area's geology and development methods, so that the nature of the biological impacts and potential mitigation can be better understood.

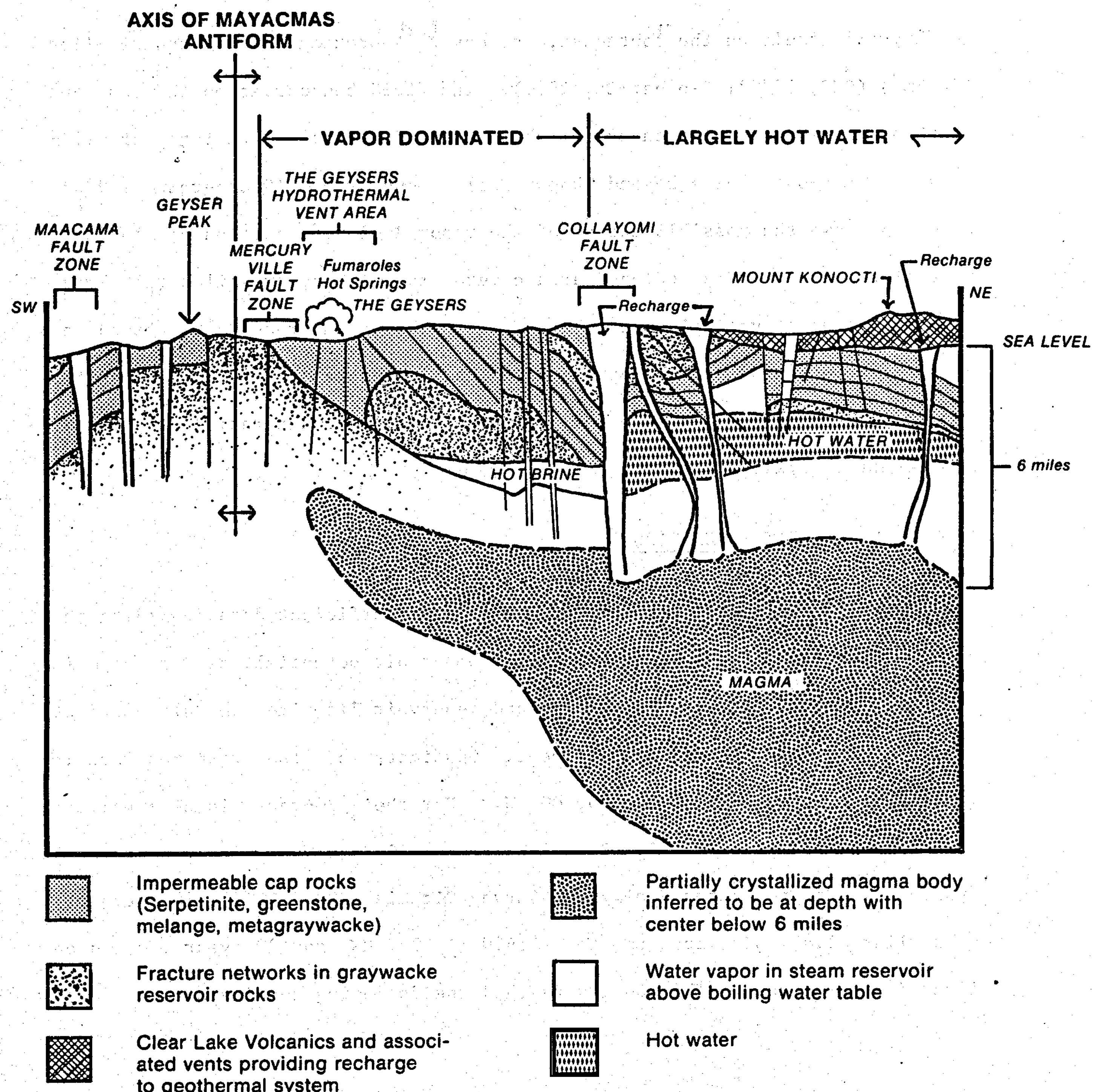
The Geysers region is underlain by intensively deformed and faulted sedimentary, igneous and metamorphic rocks of the Franciscan Formation (GeothermEx, 1980) (Figure 5). The geothermal reservoir rock is formed of fractured, very dense and impermeable Franciscan graywacke sandstone. Steam flow occurs only when open fractures are intersected by drill holes (Lipman et al., 1977). The reservoir rock is capped by relatively impermeable Franciscan rock types which inhibit descending cold groundwater from entering the reservoir rocks rapidly enough to quench steam formation (CEC, 1979d). The ultimate heat source for the geothermal system is believed to be a molten magma body, which may cover as much as 100 square miles (240 $km^2$) and lie only 13,000 to 16,000 feet (4-5 km) below the surface (GeothermEx, 1980) (Figure 6).

Size of the Steam Reservoir--The reservoir system at The Geysers has two portions: a shallow reservoir underlying an area on the north side of Big Sulphur Creek where surface hydrothermal activity (fumaroles, hot springs) is apparent and a much larger and deeper regional reservoir system as shown on Figure 3 (Crow, 1978). Most of the steam produced at The Geysers comes from wells that tap the large reservoir system, which extends at least 2.8 miles north and 5.3 miles southeast of the original wells in the Big Sulphur Creek Canyon area (Crow, 1978). The known field is elongated northwest-southeast, appears to be bounded by the Collayomi fault on the northeast and the




SOURCE: McLAUGHLIN & STANLEY, 1975
AMENDED BY PG&E, OCT-1977
CEC, 1979d

FIGURE 5: GEOLOGICAL MAP OF THE GEYSERS - CLEAR LAKE REGION




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

Source: AAPG, 1979.

FIGURE 6: CROSS-SECTION THROUGH THE GEYSERS -- CLEAR LAKE REGION

Mercuryville fault on the southeast, and covers approximately 20 square miles (50 $km^2$) (CEC, 1979d, GeothermEx, 1980). The field boundaries on the east and southeast have probably been established through success and failure of wildcats or step-out wells beyond known field boundaries (GeothermEx, 1980). Figure 3 shows the possible extent of the vapor dominated portion of the geothermal resource. The enclosed area covers about 100 square miles (160 $km^2$). However, recent evaluation of the size of the steam reservoir, based on existing information about depth of wells at first steam entry, indicates the portion of the field available for practical electrical generation is about 25 square miles (Dykstra, 1981).

## GENERATING CAPACITY SCENARIOS

As the previous discussion indicates, there is insufficient data regarding the nature and size of the steam reservoir. Reservoir potential, as reflected in MW-years (MWy) of extractable energy, and reservoir lifetime are also subject to considerable debate and disagreement. Estimates of the steam resource in The Geysers range from 1,200 to 5,600 MW.* For their 20-year planning period, PGandE assumes approximately 2,000 MW from a 30 square mile area will be available. United States Geological Survey Circular 790 (USGS, 1979) projects a similar level of development: 1,630 ± 770 MW for 30 years based on identified resources. The CEC has reached the following conclusions:

*Estimates are calculated as follows: Total steam reserve (MWy) ÷ power plant amortization period (30 - 35 yrs), e.g., 70,000 MWy ÷ 35 yrs = 2,000 MW (See Ramey, 1978).

> Assume a range of 2,000 - 3,000 MW . . . for total electric generating capacity at The Geysers using presently commercialized technology, i.e., exploitation of the dry steam resource. Given the conflicting testimony, the fact that much of the exploration data are proprietary and the uncertainties surround eventual exploitation of other resources (e.g., hot water), it is not possible to state at this time the ultimate generating capacity which will be placed on line at The Geysers or the time frame within which resources will be developed (CEC, 1978b).

For purposes of discussion, three alternative generating capacity scenarios are proposed: High Development Scenario (4,000 MW), Middle Development Scenario (3,000 MW), and Low Development Scenario (2,000 MW).* In each case, geothermal development continues until the scenario generating capacity ceiling is achieved. Ceiling capacity is maintained as long as steam reserves permit.

Because steam reserves are considered finite and are declining as geothermal development proceeds, the lower the final scenario ceiling, the longer that level can be sustained.** Generating capacity is assumed to increase at the rate of 200 MW/year, the average rate projected by utilities for the next 10 years (Table 1). If this occurs, the Low Scenario (2,000 MW), a 220 percent increase over the current level of 908 MW, would be reached in 1985, the Middle Scenario (3,000 MW) in 1991, and the High Scenario (4,000 MW) in 1997.

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*The 4,000 MW figure is basesd on testimony by Ramey (1978), who suggested that steam recovery in other portions of the steam field would be on the same order of magnitude as the 2,000 MW presently assumed to exist. USGS Circular 790 projects 1,630 ± MW 770 and notes that the undiscovered resource base may equal the discovered resource base (CEC, 1979b). Capacity estimates greater than 4,000 MW, e.g., 5,600 MW (SRI, 1978) appear too speculative to consider at this time.

**Under best case assumptions, natural and artificial recharge of the steam reservoir probably does not exceed one-third of steam production. (GeothermEX, 1980). Courts have held that the geothermal steam resource at The Geysers is finite [454f.2d1157 (1972)]. Other discussions of the exhaustible nature of the steam resource include: GeothermEx, 1980, Isherwood, 1977; Lipman, 1977; Ramey, 1978.

## TABLE 1

## GEOTHERMAL POWER PLANT DEVELOPMENT IN THE GEYSERS AREA 1960-1990

| Unit Name | Year on Line | Capacity (MW) | Cumulative Capacity (MW) |
|---|---|---|---|
| PGandE 1 | 1960 | 11 | 11 |
| PGandE 2 | 1963 | 13 | 24 |
| PGandE 3 | 1967 | 27 | 51 |
| PGandE 4 | 1968 | 27 | 78 |
| PGandE 5 | 1971 | 53 | 131 |
| PGandE 6 | 1971 | 53 | 184 |
| PGandE 7 | 1972 | 53 | 237 |
| PGandE 8 | 1972 | 53 | 290 |
| PGandE 9 | 1973 | 53 | 343 |
| PGandE 10 | 1973 | 53 | 396 |
| PGandE 11 | 1974 | 106 | 502 |
| PGandE 12 | 1979 | 106 | 608 |
| PGandE 15 | 1979 | 55 | 663 |
| PGandE 13 | 1980 | 135 | 798 |
| PGandE 14 | 1980 | 110 | 908 |
| Wild Well Geothermal (PGandE) | 1981 | 5 | 913 |
| PGandE 17* | 1982 | 110 | 1,023 |
| NCPA 2* | 1982 | 110 | 1,133 |
| PGandE 18* | 1982 | 110 | 1,243 |
| PGandE 16* | 1983 | 110 | 1,353 |
| SMUDGEO #1* | 1983 | 65 | 1,418 |
| DWR Bottle Rock* | 1984 | 55 | 1,473 |
| Occidental* | 1984 | 80 | 1,553 |
| NCPA #3 | 1984 | 55 | 1,608 |
| PGandE 20 | 1984 | 110 | 1,718 |
| Modesto Irrigation District | 1985 | 110 | 1,828 |
| NCPA #1* | 1985 | 66 | 1,894 |
| DWR South Geysers* | 1985 | 55 | 1,949 |
| SMUD 2 | 1987 | 55 | 2,004 |
| Occidental (PGandE) | 1987 | 55 | 2,059 |
| PGandE 19 | 1988 | 55 | 2,114 |
| PGandE 22 | 1988 | 110 | 2,224 |
| PGandE 21 | 1988 | 110 | 2,334 |
| PGandE 23 | 1989 | 110 | 2,444 |
| PGandE 24** | 1990? | 110 | 2,544 |
| PGandE 25** | 1990? | 110 | 2,664 |
| PGandE 26** | 1990? | 110 | 2,774 |
| PGandE 27** | 1990? | 110 | 2,884 |
| PGandE 28** | 1990? | 110 | 2,994 |

| | | | |
|---|---|---|---|
| Total number of units: | PG&E | 29 | 2,288 MW |
| | SMUD | 2 | 120 MW |
| | NCPA | 3 | 231 MW |
| | DWR | 2 | 110 MW |
| | Occidental | 2 | 135 MW |
| | Modesto Irrigation District | 1 | 110 MW |

*Application for licensing these power plants have been submitted to the CEC.
**If steam supply available.
?Dates are not firm at present for these units.
SOURCE: CEC 1981

These three energy development scenarios estabish the basic framework around which further discussion of cumulative impacts is developed. Each scenario entails different levels of environmental impacts because each requires different uses of three resources: energy, time and space. The energy represented by the steam resource is recoverable, but the rate and duration of recovery differ for each scenario, as does the surface area or spatial extent of the development process. Cumulative impacts in The Geysers are assessed using the three scenario format. In this way, the potential ranges of such impacts are bracketed between high and low estimates.

However, while examining these scenarios, it is noted that basic decisions concerning the pattern of energy use for The Geysers geothermal resource have not been established. Presently unanswered questions include: (1) Will the geothermal resource be used for maximum short-term (30 - 35 year) energy production? (2) Will it be managed for long-term (40 to 100 or more years) production at a lower production rate?

Unless a regional plan of energy production is adopted, the possibility exists that the High Scenario impacts from steamfield development will occur even though the High Scenario electric power production levels are not attained. Economic and other advantages to the steam developers for early establishment of steam fields and rapid extraction of steam from the resource may lead to the inability of the steam reservoir to support all the electrical generating facilities. This could occur due to uncertainty about the extent and lifetime of the steam resource and the fact that steam resource development precedes by several years the production of electrical power.

## CUMULATIVE VEGETATION IMPACTS

### INTRODUCTION

The KGRA is a mix of forest, chaparral, and grassland; location and species composition is determined by the interplay of climate, topography, soil type, and other factors (Ornduff, 1976, SRI, 1977). At least 12 vegetation communities exist in the KGRA, each distinguished by the presence of characteristic species (Appendix A). These communities include grassland, oak savannah, oak woodland, chaparral, mixed evergreen forest, yellow pine forest, knobcone pine forest, Douglas fir forest, cypress forest, riparian, aquatic (vegetation growing in or around springs and ponds), and weedy (ruderal).

The development of geothermal power plants and related roads and well fields in The Geysers may have significant cumulative impacts on unique vegetation resources such as riparian, meadow, forest areas, and those occurring on serpentine soils. The abundance, distribution, and mix of these unique vegetation resources, areas of critical concern, are an important aspect of The Geysers biological community. Maintaining the diversity of plant community associations in The Geysers area is necessary to preserve the integrity of the area's biological community as a whole.

### RARE AND ENDANGERED PLANTS

Because of the complex arrangement of vegetation, soils, and topography, The Geysers region supports a relatively large number of endemic plant species which are rare or endangered.

SRI (1977) lists over 60 plant species in the KGRA as rare and endangered, the majority of which are herbs found on serpentine outcrops. The SRI inventory includes plant species found in the entire 586 square mile KGRA, not just those found in the approximate 100 square mile vapor-dominated portion of the steam field. The completeness of the list is uncertain because field surveys have been primarily restricted to leaseholds within the 20 square mile section of the steam field undergoing geothermal development.

CEC staff has reviewed the California Native Plant Society (CNPS) listing of rare and endangered plants (Smith et al., 1980) and prepared a summary which lists the status of rare plants known or suspected to occur in The Geysers KGRA, Appendix B. This summary separates species which have been identified as rare and endangered (CNPS List 2) from those which are recognized as rare but not endangered (CNPS List 3). Rare and endangered species are those which require a high level of protection in most instances. Species which are rare but not endangered may be indicators of special biological areas and may also require preservation under specific circumstances.

<u>Staff Position</u>--The potential impacts on rare and endangered plants have been raised as a concern by CEC staff in all regulatory cases, both as site-specific and cumulative impacts. Staff views impacts on rare plants as a serious constraint to the development of geothermal facilities in some areas. Rare plants designated as legally protected on state and federal lists as well as candidate species such as those designated by the California Native Plant Society are given consideration in regulatory cases.

<u>Proposed Solutions</u>--CEC staff recommends that all areas which represent potential habitat for rare plants be identified early in the regulatory process,

preferably during the planning stages. Appropriate surveys should be conducted at the project site and in the site vicinity for these species, particularly in areas subject to disturbance by the project. If rare plant species exist in an area, the area, including an appropriate surrounding buffer area, should be avoided and/or excluded from development. The species involved will dictate the size of this area. It is essential that accurate and complete information be available for the species involved in order to make informed and appropriate decisions. If this information is not available, it must be developed through specific field research to provide adequate data on a case-by-case basis. Staff recommendations for each case will be developed following a thorough study of the species, the site, the potential impacts, and all alternatives. Much more field work is required in order to determine the number and precise location of rare and endangered species found in the KGRA areas most likely to be developed.

## DIRECT VEGETATION LOSS

In the literature, estimates of nonsite-specific vegetation removal ("loss") range from 8 - 20 percent (51.2 - 128 acres) for an "average" 640 acre leasehold.* Actual total vegetation loss experienced in The Geysers KGRA is unknown, although site-specific estimates exist. A 1975 study of habitat loss in the Big Sulphur Creek Watershed estimated 1,024 acres (4.0 percent) of a total 25,900 acres had been lost due to the development of 502 MW of geothermal capacity. This is the equivalent of 2.04 acres lost/MW. A breakdown of acreage losses for each phase of a typical geothermal development is given in Table 2.

*8 percent: Suter, 1978; 10-20 percent: SRI, 1977; 20 percent: Reed and Campbell, 1975, USFWS, 1978.

Table 2

LAND USE REQUIREMENTS FOR A TYPICAL GEOTHERMAL DEVELOPMENT SITE

| Phase | Surface Area |
|---|---|
| **Exploration and Testing Phase** | |
| Road Construction | 3 to 4 miles (5.1-6.8 acres) |
| Drill Pads | 2.5 acres each, cleared and compacted 1/ |
| Mud Sump | Each one requires an area 100' x 125' x 10' deep to temporarily store up to 1,000,000 gallons of effluent and cuttings (.29 acres) |
| **Full Field Development** | |
| Road Construction | Acreage varies. Access roads may be built to drilling pads, mud sumps, building for housing equipment and storage. Average road width is a function of slope, and varies from 15-36 feet 2/ |
| Pipelines | Each pipeline is 10" to 30" in diameter, raised on supports rising no more than 12 feet. The area temporarily cleared for the pipeline is 30 feet wide, but may be wider depending on whether access roads are constructed. 2/ |
| Power Generation Facilities | Approximately 10.5 acres are required. 3/ |
| -turbine generators and condensers | Each is 150' x 65" x 60' high |
| -cooling towers | Each is 360' x 65' x 60' high |
| -transformer | Each is 100' x 100' x 55' high |
| Transmission Lines | Lines consist of towers or poles at a height of 80 to 120 feet, with concrete bases 40' apart. Approximately 0.2 acres must be cleared for each tower. Access roads to each tower are required. Existing roads are used where possible. |

Notes:

1/ ECOVIEW, 1975a
2/ Eaton, 1980
3/ Average of loss estimates for PG&E Units 16-18; NCPA 1, 2; DWR Bottle Rock, DWR South Geysers; SMUDGEO 1.

Other data from: EPA, 1977; SRI, 1977.

Published site-specific loss data are available only for PGandE Units 1 - 6 and 11, unavailable for Units 7 - 10, 12 - 15, and estimated for all other units under construction or in the licensing process (Table 3). Using available data, losses for these units are estimated to be 54 acres (6.3 percent) per average 856 acre leasehold, or 0.55 acres per megawatt of power generation. However, M.K. Eaton of PGandE (Eaton, 1981) has estimated vegetation loss for PGandE Units 1 - 18 over the 30 year life of these power plants to be 11.5 percent (1,137 acres) of the total Unit 1 - 18 leasehold area (9,896 acres), or 0.93 acres/MW.

Estimated cumulative vegetation losses in The Geysers range widely, from 1,100 acres (Low Scenario of 2,000 MW, 0.55 acres/MW) to as high as 7,040 acres (High Scenario, of 4,000 MW, 1.76 acres/MW) (Figure 7, Table 4). If the 11.5 percent estimate is assumed to accurately reflect existing and future vegetation loss, there would be a loss of 2,790 acres for the Middle Scenario of 3,000 MW; cumulative losses could range from 1,860 (Low Scenario) to 3,720 acres (High Scenario).

Several cautionary notes are necessary with respect to acreage loss figures (Table 3). Even if PGandE estimates are accepted as the best available, they are probably low, due to the nature of the estimating process. Losses for Units 1 - 6 and 11 were calculated by planimetry from aerial photographs, a technique which underestimates surface area on slopes. Secondly, acreage losses are given on a per leasehold basis, which is somewhat misleading because disturbances such as access roads, portions of steam pipelines, transmission line clearing and access roads, and construction and storage yards may occur outside of leasehold boundaries.

Table 3

ESTIMATED VEGETATION LOSS

| Power Plant | Megawatts | Total Leasehold Area (Acres) | Area of Vegetation Lost (Acres) | Percent of Leasehold | Acres Lost Per Megawatt |
|---|---|---|---|---|---|
| PG&E UNITS | | | | | |
| 1-6 1/ | 184 | 1679 | 131* | 7.8 | 0.71 |
| 7-10 | | Data not available | | | |
| 11 1/ | 116 | 989 | 88* | 8.9 | 0.79 |
| 12-15 | | Data not available | | | |
| 16 1/ | 110 | 750 | 51 | 6.8 | 0.47 |
| 17 2/ | 110 | 720 | 80 | 11.1 | 0.73 |
| 18 3/ | 110 | 730 | 48.8 | 6.7 | 0.44 |
| TOTAL PG&E | 630 | 4868 | 398.8 | 8.2 | 0.63 |
| CALIFORNIA DEPARTMENT OF WATER RESOURCES 4/ | | | | | |
| Bottle Rock | 55 | 370 | 30 | 8.1 | 0.54 |
| South Geysers | 55 | 408 | 30 | 7.4 | 0.54 |
| | 110 | 778 | 60 5/ | 7.7 | 0.54 |
| NORTHERN CALIFORNIA POWER AGENCY 6/ | | | | | |
| NCPA 1 | 66 | 1400 | 11 | 0.8 | 0.17 |
| NCPA 2 | 110 | 1120 | 47 | 4.2 | 0.43 |
| | 176 | 2520 | 58 | 2.3 | 0.33 |
| SACRAMENTO MUNICIPAL UTILITY DISTRICT 4/ | | | | | |
| SMUDGEO 1 | 55 | 396 | 22 | 5.6 | 0.40 |
| TOTAL (PG&E, CDWR, NCPA, SMUD) | 971 | 8562 | 538.8 | | |
| AVERAGE (PER LEASEHOLD) | 97.1 | 856 | 54 | 6.3 | 0.55 |

*Actual losses (Weinberg, 1978)
Source: 1/ Weinberg, 1978; 2/ CEC, 1979c; 3/ CEC 1979d; 4/CDWR, 1978, 1979; 5/ NCPA, 1978, 1979; 6/ SMUD, 1980.

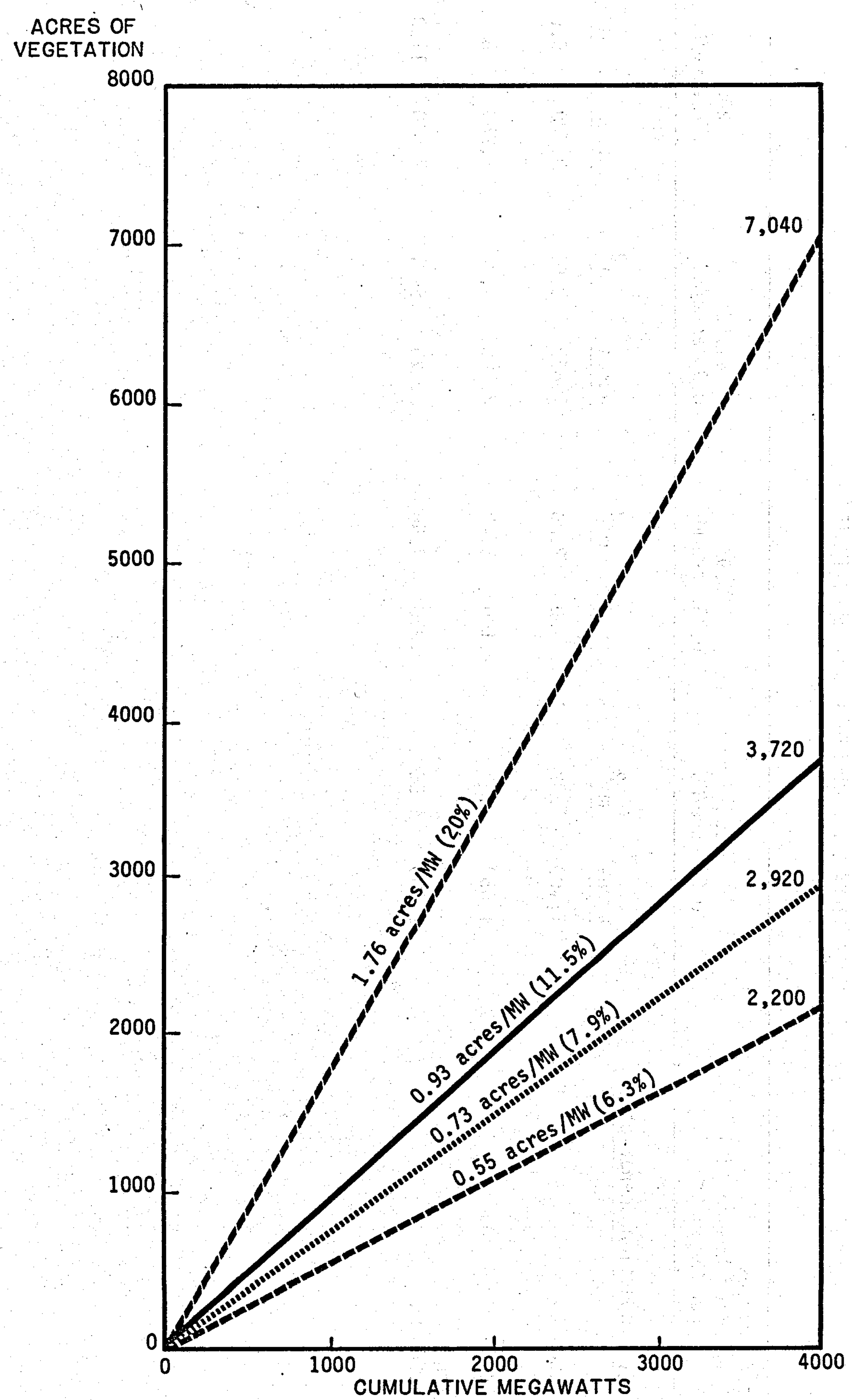


FIGURE 7: ACRES OF VEGETATION LOSS PER CUMULATIVE MEGAWATT OF POWER GENERATED

Table 4

CUMULATIVE VEGETATION LOSS ESTIMATES

| Loss Scenarios<br>Percent of Leasehold<br>Area per Megawatt | 6.3%<br>0.55 acre/MW | | 7.9%<br>0.73 acre/MW | | 11.5%<br>0.93 acre/MW | | 20%<br>1.76 acre/MW | |
|---|---|---|---|---|---|---|---|---|
| Energy Production Scenarios | acres | $mi^2$ | acres | $mi^2$ | acres | $mi^2$ | acres | $mi^2$ |
| LOW<br>2,000 MW | 1,100 | 1.72 | 1,460 | 2.28 | 1,860 | 2.91 | 3,520 | 5.5 |
| MIDDLE<br>3,000 MW | 1,650 | 2.58 | 2,190 | 3.42 | 2,790 | 4.36 | 5,280 | 8.25 |
| HIGH<br>4,000 MW | 2,200 | 4.56 | 2,920 | 4.56 | 3,720 | 5.81 | 7,040 | 11.0 |

Although it is technically correct to estimate per leasehold vegetation loss, in doing so one loses sight of the truly widespread nature of development in this region. Vegetation loss per leasehold can be estimated without noting that leaseholds are increasingly interconnected by roads, pipelines (e.g., Angwin and Toy, 1979, p. 5 - 11) and transmission lines. Percentage losses can also be estimated without noting that leaseholds are of different sizes.

Staff Position--The amount and type of vegetation loss has been raised by CEC staff, CDFG, and intervenors as a potential issue in all Geysers regulatory cases. Concerns have been voiced over both site-specific and cumulative losses of unique vegetation resources. Only the vegetation losses directly associated with power plant sites have been prevented or mitigated, while losses associated with well field and road development have not been dealt with. This potential cumulative loss, which could be as high as 5,280 acres (1.76 acres/MW), as well as the loss of unique vegetation resources, would be significant.

The CEC staff position has been to avoid development on areas of unique vegetation and to reduce vegetation disturbance and removal to a minimum. At present, sufficient detailed information about the location and abundance of unique vegetation resources and the disturbance of other vegetation communities within the geothermal resource area is not available. Without this detailed information, an effective assessment cannot be made of the cumulative impacts from projected geothermal development or about the effectiveness of site-specific mitigation measures applied to date.

Proposed Solutions--In order to prevent or mitigate potential cumulative impacts due to loss of unique vegetation in The Geysers and to evaluate and improve present mitigation measures, the following recommendations are made:

1. Develop Geysers resource maps showing detailed plant associations and the location and distribution of unique vegetation resources. These documents should be used by the Commission, counties, other permitting agencies, resource developers, and the utilities in planning, permitting, and monitoring geothermal development in The Geysers steam area.

2. Avoid or limit disturbance of unique vegetation resource areas (i.e., serpentine barrens, hot springs, fumaroles, meadows, seeps, forest, and riparian associations, etc.).

3. Require reestablishment of native vegetation on all nonuse areas which have been disturbed (i.e., cut and fill slopes).

INDIRECT IMPACTS TO VEGETATION

Indirect effects to vegetation may result from several sources including exposure to toxic materials contained in cooling tower drift, exposure to hydrogen sulfide ($H_2S$), acid rain, climate modification, and mechanical damage. Each of these potential impact sources is discussed below.

Cooling Tower Drift--Vegetation stress in the vicinity of power plants at The Geysers was first noted in 1971 and first publicly reported for vegetation near PGandE Units 1 - 6 in 1973. Since that time a considerable amount of information has been developed to determine the cause and rates of vegetation stress. The most complete information available is presented in Malloch et al., 1979, from which much of the following discussion is drawn.

Early investigators were somewhat uncertain as to the causes of foliar stress, but deposition of salts, particularly boron, carried in mists from the cooling towers was suggested (ECOVIEW, 1975b). Qualitative observations during August - December 1978 and in 1979 have verified earlier reports of marginal necrosis (tissue death along the leaf margin), interveinal necrosis, interveinal chlorosis (yellowing of tissue between leaf veins due to loss of chlorphyll) and needle tip burn and banding (conifers) for 22 species of trees and shrubs (Table 5). In general, moderate to severe vegetation damage over varying acreages has occurred around PGandE power plant Units 1 - 11.*

Foliar stress symptoms such as necrosis and chlorosis are indicative of boron toxicity. Leaf tissue analyses show greatly elevated boron concentrations in visibly damaged versus visibly undamaged samples. Vegetation grown in soils high in boron concentration near power plants develops boron toxicity symptoms. Similarly, plants exposed to cooling tower drift develop toxic symptoms. Additional support for the hypothesis that boron deposition causes foliar stress comes from two Canadian studies on the phytotoxicity of airborne boron (Temple and Linzon, 1976, Temple et al., 1978). Deposition of boron on vegetation exposed to atmospheric boron emissions from a fiberglass manufacturing plant produced injury symptoms on sensitive species. As in The Geysers, the amount and severity of foliar injury decreased with increasing distance from the source.

Cumulative stress and vegetation damage from cooling tower drift has been documented by PGandE as part of a six year (1973 - 1978) aerial photography study.** The 38.6 square mile study area lies within the Big Sulphur Creek and Kelsey Creek watersheds and encompasses the developed portion of The Geysers KGRA. The total extent of stressed vegetation in this area as of 1979 covers 247 acres (6 percent) of the total leasehold area of PGandE Units 1 - 11

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*Data for Units 12 and 15 were unavailable for inclusion in Malloch's 1979 report.

**The drought of 1975-1976, 1976-1977 could have contributed to observed vegetation stress.

Table 5

VEGETATION DAMAGED BY COOLING TOWER DRIFT

| Power Plant | Vegetation Damaged | Degree of Damage |
|---|---|---|
| PG&E 1,2 | Big leaf maple (*Acer macrophyllum*) | Severe |
| | Brutia pine (*Pinus brutia*) | Severe |
| | California bay (*Umbellularia californica*) | Severe |
| | Digger pine (*Pinus sabiniana*) | Moderate |
| | Eucalyptus (*Eucalyptus sp.*) | Moderate |
| | Interior live oak (*Quercus wislizenii*) | Moderate |
| | Valley oak (*Quercus lobata*) | Severe |
| PG&E 3,4 | Big leaf maple (*Acer macrophyllum*) | Severe |
| | California bay (*Umbellularia californica*) | Severe |
| | Digger pine (*Pinus sabiniana*) | Moderate |
| | Elderberry (*Sambucus mexicana*) | Moderate |
| | Fig (*Ficus carica*) | Moderate |
| | Interior live oak (*Quercus wislizenii*) | Moderate |
| | Madrone (*Arbutus menziesii*) | Moderate |
| | Spicebush (*Calycanthus occidentalis*) | Moderate |
| | Valley oak (*Quercus lobata*) | Severe |
| PG&E 5,6 | Big leaf maple (*Acer macrophyllum*) | Severe |
| | California bay (*Umbellularia californica*) | Severe |
| | Digger pine (*Pinus sabiniana*) | Moderate |
| | Douglas fir (*Pseudotsuga menziesii*) | Severe |
| | Interior live oak (*Quercus Wislizenii*) | Moderate |
| | Madrone (*Arbutus menziesii*) | Moderate |
| | Spicebush (*Calycanthus occidentalis*) | Moderate |
| | Valley Oak (*Quercus lobata*) | Severe |
| PG&E 7,8 | California bay (*Umbellularia californica*) | Severe |
| | California nutmeg (*Torreya californica*) | Severe |

Table 5 - Continued

| Power Plant | Vegetation Damaged | Degree of Damage |
|---|---|---|
| PG&E 7,8 | Canyon live oak (Quercus chrysolepis) | Severe |
| | Chamise (Adenostoma fasciculatum) | Moderate |
| | Interior live oak (Quercus wislizenii var. frutescens | Severe |
| | Yellow pine (Pinus ponderosa) | Moderate |
| | Scrub oak (Quercus dumosa) | Severe |
| PG&E 9,10 | California bay (Umbellularia californica) | Severe |
| | Hoary manzanita (Arctostaphylos canescens) | Moderate |
| | Interior live oak (Quercus wislizenii var. frutescens | Moderate |
| | Knobcone-Monterey pine hybrid (Pinus attenuata x radiata) | Moderate |
| | Poison oak (Rhus diversiloba) | Moderate |
| | Scrub oak (Quercus dumosa) | Moderate |
| PG&E 11 | Canyon live oak (Quercus chrysolepis) | Moderate |
| | Interior live oak (Quercus wislizenii var. frutescens | Moderate |
| | Scrub oak (Quercus dumosa) | Moderate |
| PG&E 17 | Sugar pine (Pinus lambertiana) | Moderate |

SOURCE: Malloch et al., 1979.

(Table 6). Diagrams based on aerial photographs clearly show the incremental nature of vegetation stress (Figure 8, 9). All units except 1 and 2 and 9 and 10 have shown increases in area of stressed vegetation over the six year survey period. Vegetation stress at Units 1 - 6 has been detected at a maximum distance of 2,000 feet from cooling towers. Ninety percent of all damage occurs less than 1,640 feet from the towers.

Units 3 - 6, which have the largest stressed areas (210 acres), also have higher cooling tower drift rates and among the highest boron concentrations in the circulating cooling water. As Figure 10 shows, there is a trend toward increasing boron concentrations in circulating water over time. If this trend continues, the area of stressed vegetation and the severity of stress within this area is likely to increase. However, because the variability of boron levels in the steam reservoir cannot be predicted, it is impossible to predict whether boron concentrations will increase or decrease in the future.

Although boron-induced vegetation stress appears to be restricted to the immediate vicinity of operating power plants, transport of boron considerable distances from development areas has been documented by J. Koranda (1980). During preliminary studies, small but easily detectable levels of boron were recorded at three monitoring stations on Cobb Mountain: Cobb Mountain near Geysers Rock, 27 ppm; Sawmill Flats Road (0.4 miles from Bottle Rock Road), 14 ppm; and Sawmill Flats Road (1.4 miles from Bottle Rock Road), 15 ppm. The two measurements on Sawmill Flats Road on the north side of Cobb Mountain suggest that some drift or well-site effluents are moving over Cobb Mountain into the adjacent airshed to the east. These Boron concentrations observed by Koranda are one and two orders of magnitude smaller than those found in damaged vegetation near power plants (cf. Malloch et al., 1979, Table 12, 13, 14).

Table 6

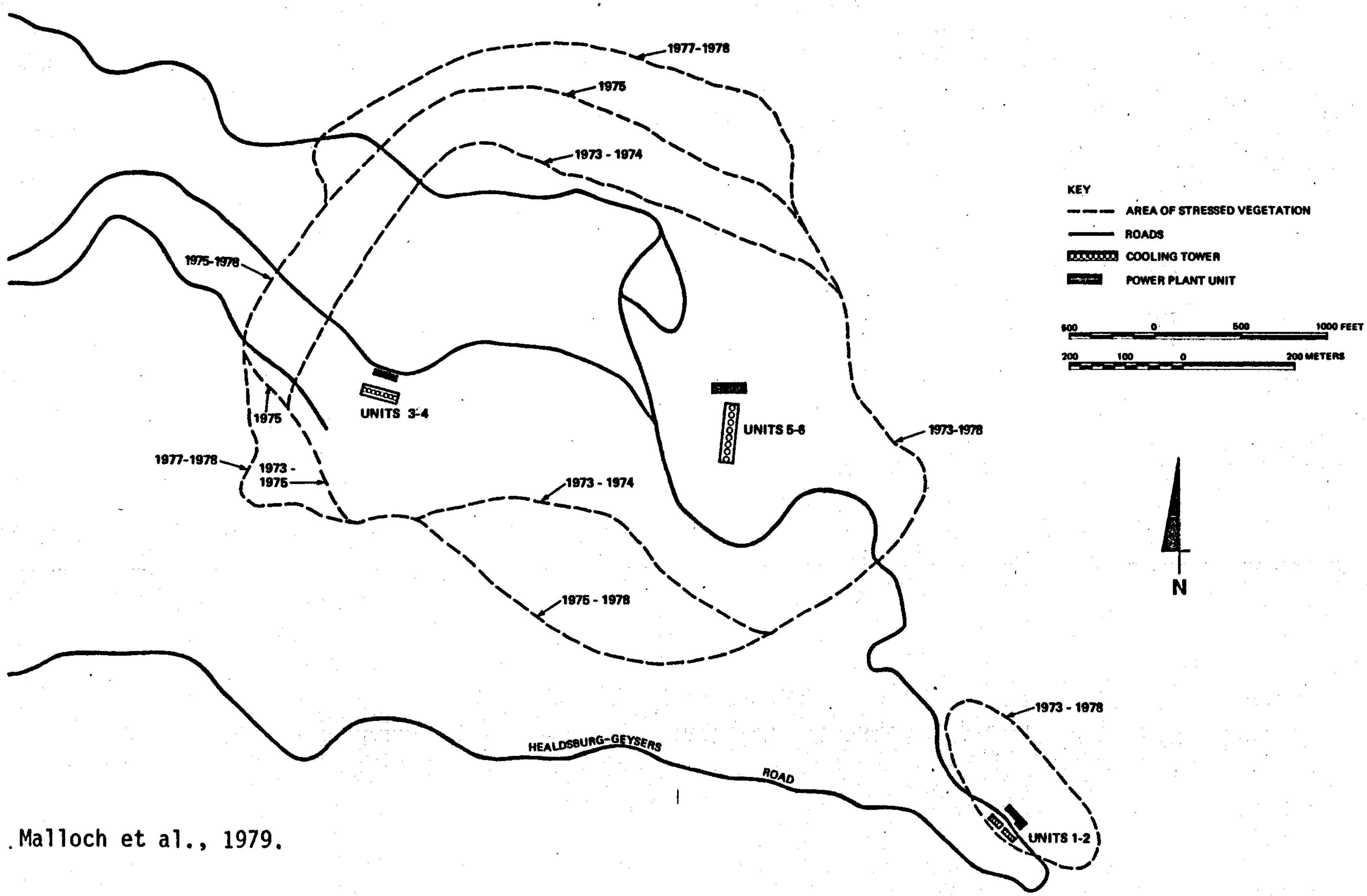
ANNUAL EXTENT OF STRESSED VEGETATION AROUND PG&E UNITS 1-11
DURING 1973-1978 (ACRES)

| Year | Unit 1 and 2 | 3 and 4; 5 and 6 | 7 and 8 | 9 and 10 | 11 | Total | Annual Change (%) |
|---|---|---|---|---|---|---|---|
| 1973 | 10 | 133 | 7 | * | * | 150 | |
| 1974 | 10 | 133 | 7 | 5 | * | 155 | 3 |
| 1975 | 10 | 185 | 7 | 5 | 5** | 212 | 27 |
| 1976 | | No Photo Coverage | | | | | |
| 1977 | 10 | 210 | 10 | 5 | 10 | 245 | 7.5 |
| 1978 | 10 | 210 | 12 | 5 | 10 | 247 | .8 |

*Units Not Operational

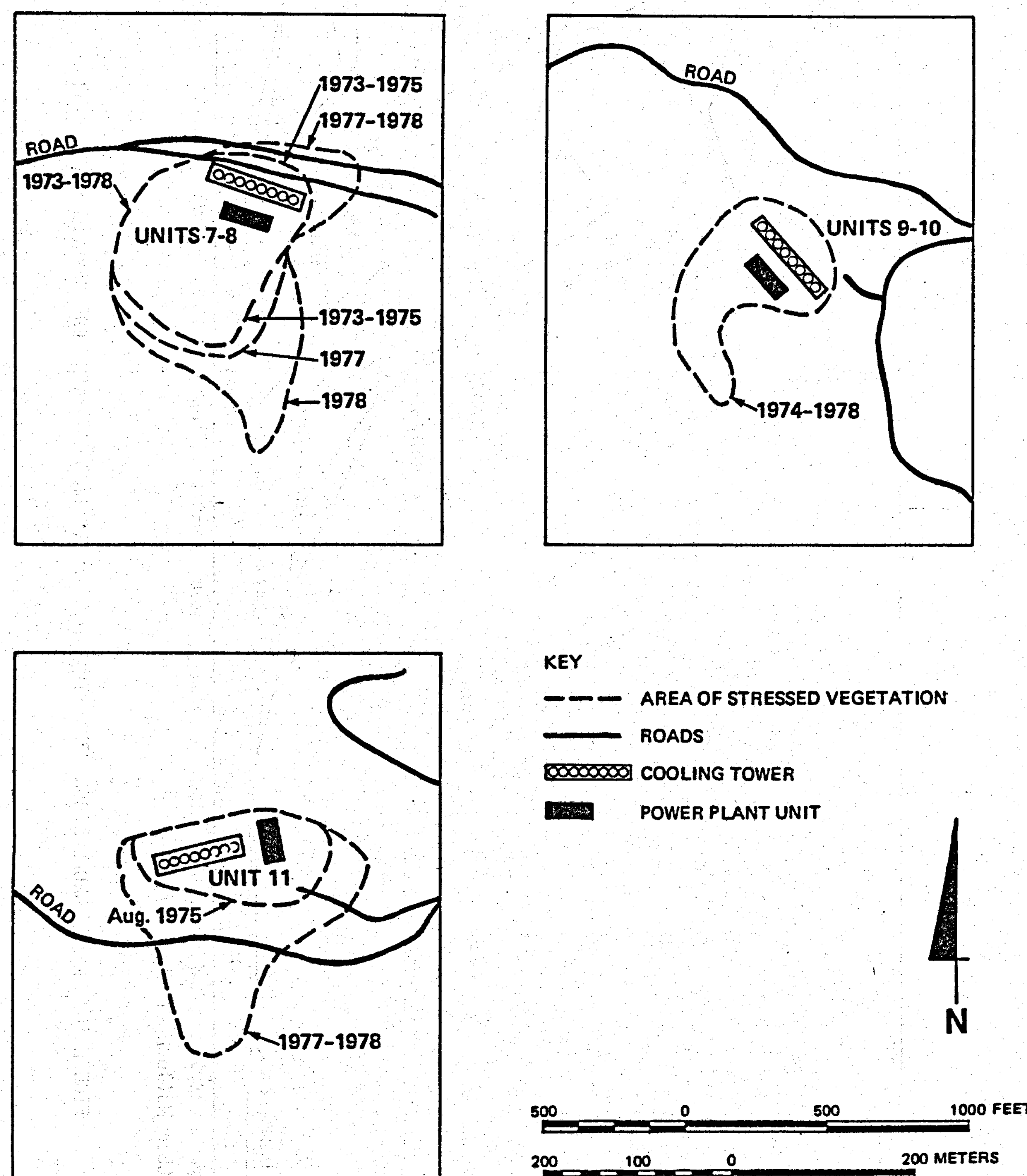
**Unit began operation in May 1975, film survey flown in August 1975.

SOURCE: Malloch et al., 1979.



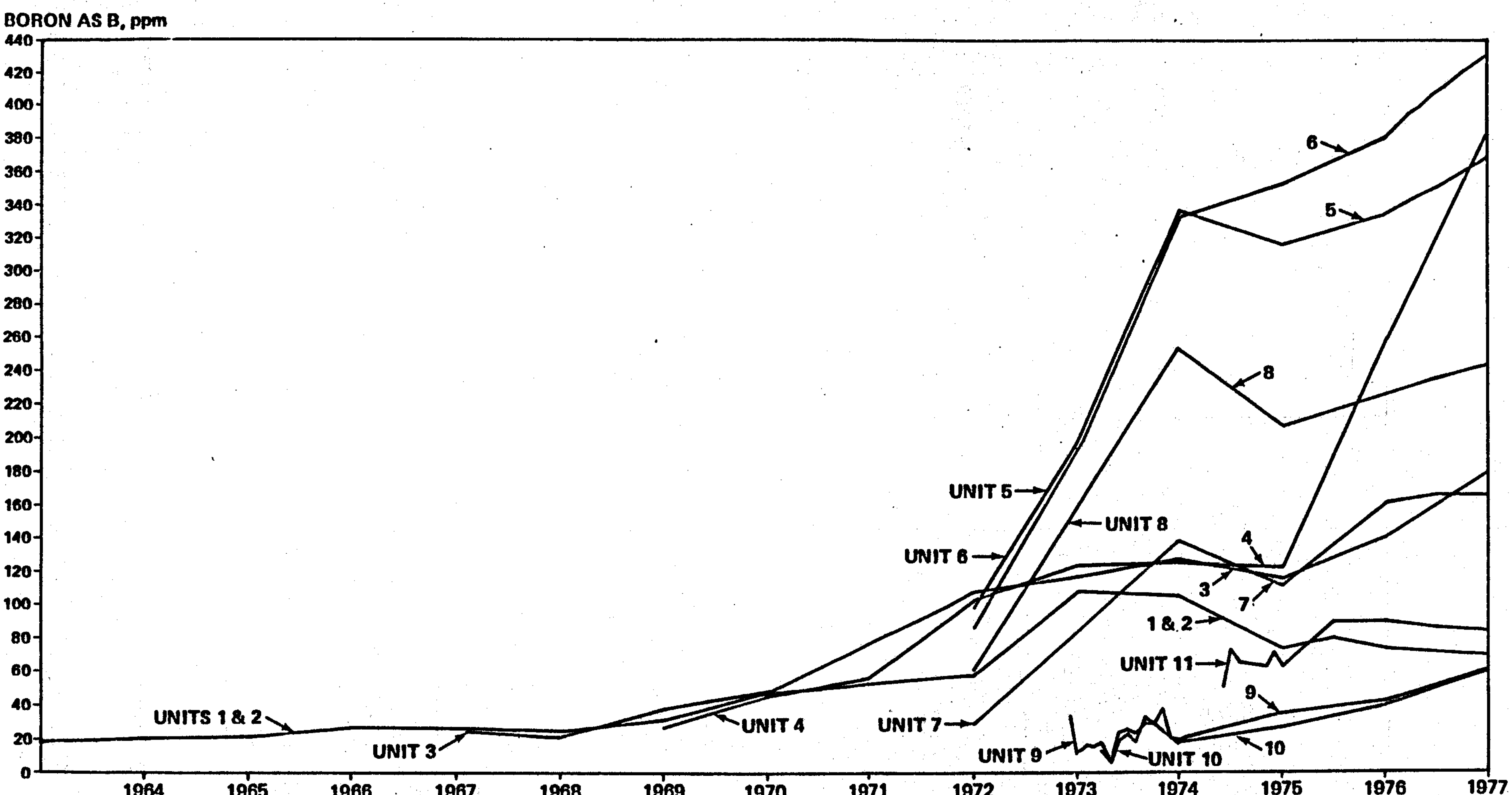

Source: Malloch et al., 1979.

FIGURE 8: THE AREA OF STRESSED VEGETATION AROUND GEYSERS UNITS 1-6 IN 1973-1978




Source: Malloch et al., 1979.

FIGURE 9: THE AREA OF STRESSED VEGETATION AROUND GEYSERS UNITS 7-11 IN 1973-1978




SOURCE: Malloch et al., 1979

FIGURE 10. MEAN ANNUAL BORON CONCENTRATIONS IN CIRCULATING WATER FOR GEYSERS UNITS 1-11

Hydrogen Sulfide Emissions--In light of the present data, and relative to other biological resource concerns at The Geysers, the effects of $H_2S$ on vegetation cannot be considered important. Thompson (1978) states that it is unclear "whether the present atmospheric level of $H_2S$ or its reaction products is causing environmental injury to local vegetation."* He does state that the rate at which $H_2S$ is oxidized to sulfur dioxide ($SO_2$), a much more phytotoxic gas than $H_2S$, is 67 percent faster than previously believed (half-life $H_2S$ = 12 hrs). This allows less opportunity for atmospheric dilution and dispersion, thereby increasing the risk of vegetation damage.

Long-term exposure (8 - 10 weeks) of native vegetation to $H_2S$ at concentrations in the 0.1 - 3.0 ppm range has been reported by Thompson and Kats (1978) to have damaged yellow pine (*Pinus ponderosa*), California buckeye (*Aesculus californica*), and Douglas fir (*Pseudotsuga menziesii*). The same range of $H_2S$ concentrations has been observed at The Geysers, but for only very brief intervals. Measured concentrations of $H_2S$ at the fence line of a Geysers power plant without abatement were 1.0 ppm maximum and averaged 0.2 ppm over an 8-hour period. Ambient levels during nocturnal inversions in the Big Sulphur Creek watershed under nonabatement conditions, with 11 units operating, average 0.1 - 0.2 ppm (Malloch et al., 1979).

The phytotoxic effects of chronic, very low level exposure of native vegetation to $H_2S$ or $SO_2$ are unknown. Low levels of $H_2S$, such as those observed at The Geysers, have been shown to stimulate growth in studies on cultivated plants, such as grapes (e.g., Thompson and Kats, 1978). Bennett, et al., (1974) argued that plants that are adapted to low pollutant concentrations may

*$H_2S$ may be responsible for the reduction in diversity and abundance of lichens within .62 miles of PGandE Units 1 - 6 (Malloch et al., 1979).

be at a disadvantage when grown in the absence of pollutants (as in the control in the Thompson and Kats study). Thus, the growth stimulation noted by Thompson and Kats (1978) may indeed be related to a fertilizing effect (as they suggest) or due to adapted tolerance (as suggested by Bennett, et al.). This disparity demonstrates a current lack of understanding about the effect of air pollutants on vegetation. Even where growth stimulations are known to occur as a result of pollutant exposures, there are differing opinions as to the "benefit" of such a phenomenon. Some plant ecologists (e.g., Winner, 1981) view the potential stimulatory affect from air pollution to be a type of "terrestrial eutrophication", which may substantially alter the composition of native ecosystems.

Acid Rain Formation--Hydrogen sulfide emissions in The Geysers area have prompted speculation concerning the formation of acid rain (e.g., Axtmann, 1975; ECOVIEW, 1976a; EPA, 1977; U.S. Fish and Wildlife Service, 1978). The effects of acid rain on ecosystems are not completely understood, but can include acidification of lakes and rivers and modification of soil nutrient leaching rates. If acid rain formation is to occur in The Geysers area, hydrogen sulfide released into the atmosphere must be converted to sulfur oxides. These undergo further reactions to produce sulfuric acid, which eventually returns to Earth in rain (Ehrlich et al., 1977).

Only one acid rain survey has been conducted in The Geysers area (Ebbeson, 1978). Samples collected from three stations after eight different rain events did not show any statistically significant differences in acidity. Transport of hydrogen sulfide and sulfur oxides in sufficient quantities to cause acid rain formation in agricultural areas adjacent to The Geysers appears highly unlikely, considering the effects of dilution and the reduction in hydrogen sulfide emissions due to abatement efforts.

Climate Modification--Evidence for localized atmospheric changes due to steam emissions is anecdotal. Increased fog formation in cold weather is said to occur within one mile of geothermal power plants (SRI, 1977). This is believed to be a consequence of the large increases in atmospheric water vapor and chemical and particulate nuclei that accompany steam emissions (ECOVIEW, 1976b). ECOVIEW (1975b) suggests that increased humidity may result in increased disease incidence in vegetation. At present, a quantitative basis for determining a relationship between power plant emissions and fog incidence does not exist. In the absence of this data, it is not possible to draw conclusions concerning disease incidence in vegetation.

Mechanical Damage--Minor sources of vegetation damage have been associated with steam well operations. Vegetation adjacent to several well pads at various sites has been damaged by scalding and coating of leaf surfaces with condensate (Atlantis, 1976). Fine sand blown out of a Shell Oil Company well temporarily damaged some vegetation within a half mile radius of the well (ECOVIEW, 1976b, 1978).

Staff Position--From the data above, it appears that the most significant source of indirect vegetation impacts is exposure of vegetation to boron from the cooling tower drift. Impacts of boron drift around individual power plant sites include both damage and some actual vegetation loss. Of additional concern is the potential for cumulative impacts from full geothermal development which could lead to chronic low level exposure of vegetation to drift containing boron over large areas.

The site-specific issue of the effects of boron on vegetation from cooling tower drift has been raised by staff in all geothermal regulatory cases. The potential for cumulative regional effects has been raised by staff in The Geysers 16 and 17 cases.

Monitoring has been required by the Commission on a site-specific basis for drift effects, particularly those caused by boron. PGandE is conducting a study of the extent of drift effects as a permit condition for Unit 17. This study includes effects at four different power plants. Sufficient information is not currently available for a determination of low level chronic cumulative effects, if any, to be made. However, as more information is gathered in PGandE's ongoing study and other power plant monitoring programs, staff will attempt to develop a position on the potential cumulative impacts due to cooling tower drift from the combined power plants in The Geysers.

While not considered as a primary concern at this time, other indirect vegetation impacts, including acid rain, local climate modification, and low level chronic exposure to hydrogen sulfide emissions, may cause adverse vegetation effects and/or possible changes in species composition as the geothermal power plant density and size of the development increases.

Proposed Solutions--Site-specific monitoring should be used by staff to determine the severity and acceptability of local boron drift effects and to predict the potential for significant cumulative effects resulting from full field geothermal development. Spot monitoring should be initiated to detect cumulative chronic low level boron impacts and the other potential impacts if they appear as full geothermal development occurs. These monitoring efforts will require a continuing cooperative effort between the CEC staff and applicant utilities.

## CUMULATIVE WILDLIFE IMPACTS

### WILDLIFE INTRODUCTION

The increased demand for geothermal energy has changed the originally perceived Geysers geothermal development level of few megawatts and a few power plants to a large geothermal energy park. The expanded geothermal development changes the impacts on wildlife resources from an area which previously had limited logging and cattle grazing as potential conflicts with wildlife to an area now being subject to an industrial type of development. These potential impacts affect the area's abundant and diverse wildlife, as well as a few legally protected species (rare, endangered, fully protected) and species of special concern. This section identifies the known information about these species, the potential cumulative impacts from full geothermal development, and the CEC staff recommendations to effectively quantify and resolve potential development conflicts.

### WILDLIFE SPECIES

Approximately 13 amphibian species, 21 reptile species, 51 mammal species, and 132 bird species have reportedly been found or are expected to be found in the KGRA (Meneghin et al., 1978). This diversity is a reflection of the numerous types of plant communities present, each providing habitat for different numbers and species of animals. A brief listing of the fauna of each habitat type is available in Appendix C.

A small number of wildlife species in the KGRA are listed as endangered, rare, or fully protected (Table 7). The endangered southern bald eagle (Haliaeetus leucocephalus leucocephalus) is known to occur or have occurred recently in the KGRA (SRI, 1977). From July 1974 to March 1978, 11 sightings of the endangered American peregrine falcon (Falco peregrinus anatum) have been made

Table 7

PRELIMINARY LIST OF RARE, ENDANGERED, AND PROTECTED
WILDLIFE SPECIES OF THE KGRA

Endangered Species

Southern bald eagle (Haliaeetus leucocephalus leucocephalus)

Peregrine Falcon (Falco peregrinus anatum)

Rare Species

Yellow-billed cuckoo (Coccyzus americanus occidentalis)

Fully Protected

Ring-tail (Bassariscus astutus)

Golden eagle (Aquila chrysaetos)

Species of Special Concern*

Long-eared owl (Asio otus)

River otter (Lutra canadensis)

California red-legged frog (Rana aurora)

Federal Status Undetermined*

Burrowing owl (Speotyto cunicularia hypugaea)

Osprey (Pandion haliaetus carolinensis)

Red-shouldered hawk (Buteo lineatus)

*Lack legal status and protection as rare and endangered

SOURCE: C.D.F.G., 1977
Meneghin et al., 1978
PG&E, 1977b
S.R.I., 1977

within the KGRA (Meneghin et al., 1978). Peregrines nesting near Mt. St. Helena have successfully fledged young and are reported to be doing well (GRIPS, 1980). The rare yellow-billed cuckoo (Coccyzus americanus occidentalis), the fully protected ringtail (Bassariscus astutus), and the golden eagle (Aquila chrysaetos) also occur in the KGRA.

Other species of special concern that are being considered for protection include the California red-legged frog (Rana aurora draytoni), the river otter (Lutra canadensis), long-eared owl (Asio otus), burrowing owl (Speotyto cunicularia hypugea), osprey (Pandion haliatus carolinensis), and red-shoulder hawk (Buteo lineatus).

The fully protected ringtail is known to utilize the steam-dominated portion of the geothermal area, and it appears there is a viable breeding population present (Kock and Brody, 1981). The endangered peregrine falcon forages in the steam-dominated portion and nests in the vicinity, although until the steam-dominated resource boundary is better defined, it cannot be stated with certainty that a breeding population exists within the steam-dominated area.

Peregrine Falcon--The peregrine falcon population's precipitous decline in North America over the last 30 years has resulted in the elimination of this species from most of its former range. In California, almost all of approximately 100 historical nesting sites are currently unoccupied, with only a remnant population existing in the northern part of the state. The KGRA is one of the few areas in California in which the peregrine is successfully reproducing. The potential threat to the continued survival of the peregrine due to encroaching geothermal energy development is therefore an issue of concern (Kirven, 1980).

Of the 11 peregrine sightings reported between 1974 and 1978, at least four may be of questionable validity. Surveys of Cobb Mountain, reported to have been the site of a nesting eyrie, have yielded no evidence of peregrine activity or presence (Stager, 1976). The eyries in the KGRA known to be active nesting sites are located in the Mt. St. Helena and Palisades - Table Rock areas, officially designated Critical Habitat Zones (Figure 11).

Located 6 km from a geothermal development site in the Briggs Creek drainage, the Mt. St. Helena eyrie is closest to geothermal development and has been occupied from 1970 - 1973 and 1977 to the present (Enderson and Kirven, 1980). During a 5-year period, 14 young have fledged. This is an average of 2.8 young per year. The fledging success at this site is considered to be exceptionally high in light of the widespread reproductive failure of the species elsewhere in North America (Kirven, 1980). A 1979 foraging behavior study of the Mt. St. Helena peregrines concluded that the falcons were relatively nonselective in their choice of foraging flight direction and returned with prey from the direction of the geothermal area on 17 percent of all such flights.

Because of the generally high abundance of prey around the eyrie, the loss of foraging resource due to the development of a small geothermal site is not believed to be significant (Enderson and Kirven, 1980). However, widespread industrial, residential, or agricultural development of the area will likely threaten the long-term survival of the species in this location. Extensive foraging habitat loss plus increased human access and disturbance are significant threats to peregrine reproductive success (Kirven, 1980).

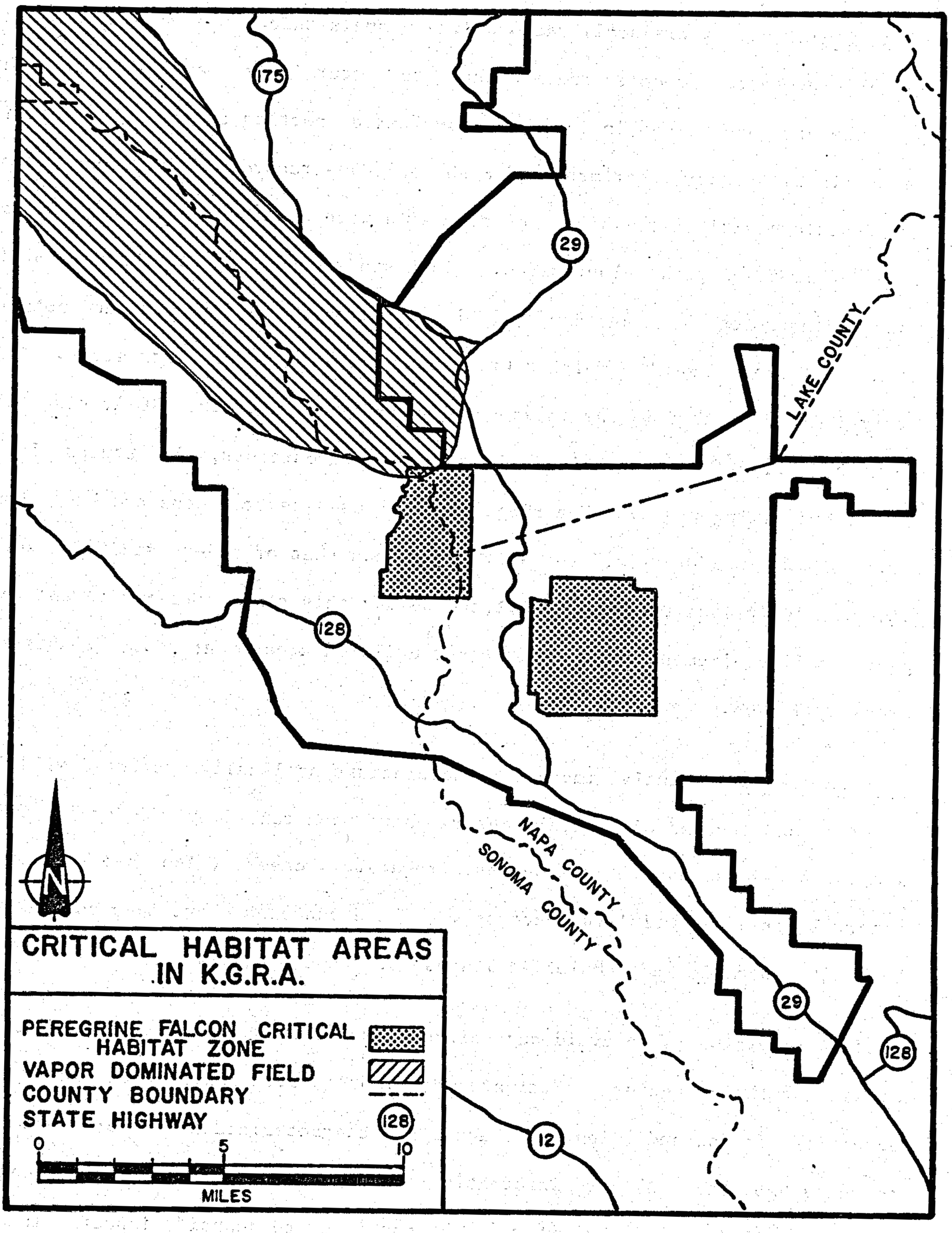



FIGURE 11: PEREGRINE FALCON CRITICAL HABITAT ZONE

Ringtail--Ringtails are small raccoon-like mammals which have been designated as fully protected species and are known to cccur in The Geysers KGRA. The presence of populations in the steam dominated portion of the reservoir is noted in California Department of Fish and Game records. In recent power plant sitings activities, signs of ringtails were observed near both Geysers 18 and SMUDGEO #1 power plant sites. In a study conducted for the California Energy Commission (Koch and Brody, 1981), ringtails were collected and populations monitored along Big Sulphur Creek near existing power plant sites. This study indicates that in the steam-dominated portion of the KGRA, ringtails occur near riparian zones, often denning in rock outcrops, old stumps, large snags, and living trees. The ringtails each used several dens and had a home range of 400 to 500 acres, a density lower than that of other studied populations. Individual ringtails monitored during this study appeared to tolerate geothermal development and in some cases utilized areas near power plants and steam well pads.

Staff Position--Potential impacts to populations of legally protected wildlife species and species of special concern have been raised by CEC staff, CDFG, and USFWS as issues in all Geysers regulatory cases (also see following material for other wildlife concerns). These concerns have been voiced over both site-specific and cumulative losses for these species.

Staff's position is to avoid any direct loss of breeding or other critical areas for these species. Estimates of impacts for all species except the peregrine falcon and ringtail have been characterized as minor losses of foraging habitats. As more information on the peregrine falcon, golden eagle, and ringtail is developed, it will be possible to quantify impacts in more definite terms, hopefully resulting in satisfactory protection for these species.

Present geothermal development has not been considered a significant threat to peregrine falcon foraging areas because of the distance from known active eyries in the Mt. St. Helena and Palisades - Table Rock Critical Habitat Zones. Any geothermal development expansion into the southeast portion of the vapor-dominated geothermal field must be carefully evaluated and monitored for potential effects on peregrine foraging areas. Development of the Pacific Coast Recovery Plan for the American peregrine falcon is nearing completion. The Geysers-Calistoga KGRA lies within a proposed high peregrine falcon density management area in the recovery plan: Compatibility between geothermal resource development and the peregrine falcon recovery plan will require careful analysis and coordination. Collisions with transmission lines is considered a common mortality factor for this species, and as a result the CEC staff is concerned about the location of future transmission line corridors with respect to known peregrine falcon eyries and foraging areas. At present, the significance of these collisions for the local peregrine falcon population has not been assessed, but plans are now under way to evaluate this impact.

Because of concern for potential impacts to the ringtail, the Commission sponsored a study to determine the occurrence, distribution, and habitat preference of this species in the dry steam resouce area. This study confirmed the presence of the ringtail and has identified riparian and mixed evergreen forest habitat types as important habitat for this species. Based on these results and other demonstrated wildlife values of riparian habitats, it is staff's position that geothermal development should avoid disturbance to riparian habitats. If potential impacts on riparian areas are likely from a geothermal project, site-specific studies should be conducted to determine the presence of ringtails and their usage of the specific area so that appropriate mitigation plans can be developed.

Proposed Solutions--The CEC staff will take an active role in coordinating with the state and federal Pacific Coast American Peregrine Falcon Recovery Team. Maximum coordination, including possible participation in interagency contract studies, will assure early and adequate planning for geothermal energy development. Studies will consider potential eyrie and critical foraging locations and allow cooperative development of mitigation measures which can be incorporated into geothermal development plans. Similar efforts will be undertaken to address concerns for the golden eagle.

To avoid significant impacts to ringtail populations, geothermal development should be avoided in riparian zones and other physical features used by ringtails for denning, such as rockpiles, snags, and large mature trees, unless the applicant can adequately demonstrate that the area is not being used. The Commission should support additional studies to determine ringtail activities, behavior, and habitat preference during other seasons and in other areas of the KGRA.

## WILDLIFE HABITAT LOSS

The primary wildlife impact is loss of habitat, which results in an absolute reduction in species abundance, and an overall reduction in an area's ability to support wildlife. Because development occurs in a variety of habitats (Table 8), and wildlife have different habitat requirements (Table 9), differential mortality and displacement of wildlife species occur. Although habitat destruction adversely affects some species, those preferring "edge" created by clearing activities are thought to benefit. Clearings in dense stands of brush will aid deer and other species by increasing browse edge,

Table 8

PREDOMINANT VEGETATION HABITAT TYPES ADJACENT TO POWER PLANTS IN THE GEYSERS KGRA

Vegetation Habitat Type

| Power Plant | Mixed Evergreen Forest | Northern Oak Woodland | Mixed Chaparral | Chamise Chaparral | Meadow |
|---|---|---|---|---|---|
| <u>Operating</u>: | | | | | |
| PG&E 1 & 2 | | X | | | |
| PG&E 3 & 4 | | X | | | |
| PG&E 5 & 6 | | X | | | |
| PG&E 7 & 8 | | X | X | | |
| PG&E 9 & 10 | | | X | X | |
| PG&E 11 | | | X | X | |
| PG&E 12 | | | X | | |
| PG&E 13 | X | | | | |
| PG&E 14 | X | | | | |
| PG&E 15 | | X | | | |
| <u>Under Construction</u>: | | | | | |
| PG&E 17 | | | X | X | |
| PG&E 18 | X | | | | X |
| NCPA 2 | | | X | X | |
| DWR Bottle Rock | X | X | | X | |
| SMUDGEO 1 | | | X | X | |
| <u>Proposed</u>: | | | | | |
| PG&E 16 | X | | X | | |
| DWR So. Geysers | X | X | | | |
| NCPA 1 | | X | | X | |

SOURCE: CDWR, 1978, 1979; Malloch et al., 1979; NCPA, 1978, 1979; PG&E, 1979b; SMUD, 1980.

Table 9

FOOD AND HABITAT REQUIREMENTS OF GAME SPECIES
FOUND IN THE GEYSERS KGRA

| Species | Description of Habitat | Food |
|---|---|---|
| Gamebirds: | | |
| Mountain Quail (Oreortyx picta) | Higher elevations; most abundant in serpentine chaparral | Seeds (e.g. lupine); ants, beetles, grasshoppers |
| California Quail (Lophortyx californica) | Cover edges; don't reach high population levels in large areas of thick brush | Feed primarily on forbs and grass seeds |
| Mourning Dove (Zenaidura macroura) | Uses most habitat except deep forest, marshes or great expanses of open territory. Often have large range that includes forage, water and roost areas at widely separated locations | Feed almost exclusively on grass and forb seeds |
| Band-tailed pigeon (Columba fasciata) | Douglas fir, ponderosa pine forests | Seed eaters; prefer acorns, pine seeds, fruit of dogwood or madrone |
| Game Mammals: | | |
| Gray squirrel (Sciurus griseus) | Open pine, oak woodland | Acorns, seeds of ponderosa pine; other seeds, fungus |
| Black-tailed Jack Rabbit (Lepus californicus) | Feeds in grassland. Takes cover during day in chaparral, woodland, forest habitats | Filaree, other herbs |
| Brush Rabbit (Sylvilagus bachmani) | Restricted entirely to mixed chaparral. Most abundant along chaparral-grass edge | Herbs |
| Hoofed Browsers: | | |
| Columbian Black-tailed Deer (Odocoileus hemionus columbianus) | Carrying capacities fluctuate over a broad range. Encouraged by establishment of herbs and sprouting shrubs as are present along ecotones | Ceonothus, oak, deervetch, pine, manzanita, grasses |

SOURCE: CDWR, 1978; Martin et al, 1951; VTN Consolidated Inc., 1976 improving access, and producing larger quantities of palatable vegetative growth. Many animals, including brush rabbits, quail, and deer, will utilize openings in the brush for feeding areas adjacent to a cover habitat (Atlantis, 1975). The amount and benefit of edge depends on where the edge is created. For example, it is difficult to get an edge effect in the middle of a grassland or meadow, whereas in a chaparral community, edge benefits depend on the age of the surrounding chaparral species. The assumed benefits of increased edge have not been documented by field work in The Geysers.

Between April 1976 and July 1976, a preliminary investigation of geothermal development impacts in The Geysers KGRA on wildlife population distribution and abundance was made by individuals from both the public and private sectors. The product of this cooperative effort, The Geysers Wildlife Study (PGandE, 1977b), was the most comprehensive wildlife census conducted in the KGRA. The study evaluated census results from geothermally developed and undeveloped sites in six habitat types: oak savannah, oak woodland, mixed evergreen forest, chamise chaparral, mixed chaparral, and riparian. Preliminary results, which have yet to be statistically confirmed, indicated that some wildlife population densities (e.g., songbird, amphibian) were lower in geothermally developed areas as compared to geothermally undeveloped areas (Table 10).

Because this study was conducted over only a brief interval, it is uncertain if the observed differences will be borne out over a long period of time. The long-term impacts on species diversity and density due to continued habitat destruction and resultant division of habitat into discontiguous patches is unclear. Wildlife using habitat patches near developed areas are subjected to

Table 10

SUMMARY OF THE GEYSERS WILDLIFE STUDY:
PRELIMINARY RESULTS

| Species Data | Geothermal Area of Higher Wildlife Population Density |
|---|---|
| Amphibians: | |
| Red-bellied newt (Taricha rivularis) | Undeveloped |
| Rough-skinned newt (Taricha granulosa) | Undeveloped |
| Foothill yellow-legged frog (Rana boylei) | Undeveloped |
| Reptiles: | |
| Western aquatic garter snake (Thamnophis couchi) | Undeveloped |
| Western pond turtle (Clemmys marmorata) | Undeveloped |
| Western fence lizard (Sceloporus occidentalis) | |
| oak savannah; chamise chaparral | Developed |
| oak woodland; riparian | Undeveloped |
| Other lizards, snakes | N/A |
| Birds: | |
| Raptors | N/A |
| Owls | N/A |
| Songbirds | |
| Wrentit (Chamaea fasciata) | |
| Mixed chaparral | Undeveloped |
| Rufous-sided towhee (Pipilo erythrophthalmus) | |
| Mixed chaparral | Undeveloped |
| Black-headed grosbeak (Pheucticus melanocephalus) | |
| Riparian | Undeveloped |
| Not species specific | |
| Mixed chaparral | Undeveloped |
| Mixed evergreen forest | Undeveloped |
| Oak woodland | Undeveloped |
| Oak savannah | No Difference |
| Riparian | No Difference |
| Mammals: | |
| Bats | N/A |
| Small mammals | N/A |
| Western gray squirrel (Sciurus griseus) | |
| Mixed evergreen forest | Undeveloped |
| Oak woodland | Undeveloped |
| Carnivores | N/A |
| Deer, rabbit, cattle | N/A |

Symbols: NA: Data unavailable or insufficient for analysis

SOURCE: PG&E, 1977b

potentially detrimental disturbance from noise and increased human activity. As in the case of edge effects, the consequences of increased habitat patchiness are unknown.

Staff Position--The issue of wildlife loss associated with alteration and removal of habitat has been raised by CEC staff, CDFG, and other intervenors in all Geysers regulatory cases. Concerns have been raised regarding both site-specific and cumulative losses. Only the wildlife losses directly associated with power plant facilities for each geothermal development have been presented or mitigated. Losses from well field or road development have not been adequately dealt with.

Staff has indicated concern for habitat loss and the associated loss of wildlife in both past and current power plant proposals. The final decisions and the compliance monitoring programs for the power plants which have been certified by the Commission verify both the Commissioner's and the staff's commitment and concern for wildlife populations and their habitat. Staff concern is for all wildlife species, but primary emphasis has been placed on legally protected species, recreational species, and species of special concern. It is staff's position to continue emphasizing the importance of wildlife populations in planning for geothermal development in the Geysers KGRA.

Proposed Solutions--Staff will continue to require mitigation efforts which minimize the area of wildlife disturbance and enhance the habitat surrounding the disturbed areas. The enhancement techniques reduce the effects of habitat loss by improving the surrounding habitat for certain species, thereby increasing the habitat's capacity to support greater numbers of wildlife.

Staff believes that baseline and monitoring studies of mitigated and enhanced areas are important to provide valuable information identifying the effectiveness of the implemented measures. This provides staff with valuable feedback on methods used to date, provides accurate information for decision making, and leads to mitigation and enhancement programs which benefit a larger portion of the biological resource.

In the past staff has emphasized site-specific mitigation, but off-site mitigation and compensation offers another acceptable alternative on a site-specific basis. On a regional basis, on-site mitigation and enhancement does not adequately correct for the cumulative loss of habitat and wildlife populations from full geothermal development. Off-site mitigation, enhancement, and compensation can, to a degree, offset cumulative wildlife losses in The Geysers resulting from full geothermal development resource. Staff proposes to produce detailed vegetation maps of The Geysers KGRA so that the significance of vegetation and wildlife habitat losses can be evaluated on a cumulative basis. To adequately mitigate for losses, identification and preservation of representative and unique habitats may also be necessary.

In summary, offsetting significant adverse wildlife impacts resulting from full geothermal development will require the use of all available methods, including on-site mitigation to minimize disturbance, utilization of proven and promising enhancement techniques, careful monitoring to ensure maximum effectiveness, and off-site mitigation and compensation to preserve representative and unique habitats.

## OTHER WILDLIFE IMPACTS

Noise--Wildlife are exposed to noise during all phases of geothermal development; venting of steam is the loudest noise and can reach 100 - 125 dBA* at 20 to 100 feet. Most of the other noise sources fall below 100 dBA and are those usually associated with construction and industrial projects (Leitner, 1978a). Preliminary results of noise studies on various wildlife species indicate that moderately increased sound pressure levels characteristic of developed areas at The Geysers are not accompanied by drastic changes in wildlife communities. There is some evidence that certain species may be depleted in noisy areas, but there is no proof that noise is the causal factor (Leitner, 1978b).

Cooling Tower Drift--The damage to 247 acres of vegetation caused by cooling tower drift has reduced the quality of the forage and habitat for wildlife. Oak species, chamise, buckeye, and poison oak have been moderately to severely damaged at Units 1 - 11 (Table 5). All of these plants are significant browse species for deer (PGandE, 1978).

Trace Metals--Geothermal steam contains very small concentrations of arsenic (0.019 ppm) and mercury (0.0050 ppm). Arsenic is released from cooling towers in the form of suspended droplets entrained in drift. Although some of the small amount of mercury which is released is in the form of insoluble mercuric sulphide, 50 to 67 percent of the mercury released from power plants is in gaseous elemental form. Annual arsenic deposition at the fence line at PGandE

*Sound pressure level weighted in accordance with the "A" scale. A-weighted scale expresses the relative intensity of sounds, similar to the response of the human ear. One dBA represents the faintest audible sound; 50 to 60 dBA represents normal conversation at three to five feet (Keezer, 1976).

Units 5 and 6 is estimated to be 0.27 pounds/acre, a concentration four orders of magnitude less than that used for herbicidal purposes. Mercury concentrations in cooling tower exhaust air have ranged from 0.02 to 0.2 ppb (Malloch, et al., 1979).

Because arsenic and mercury can have detrimental effects on vegetation and wildlife, the possible accumulation of these metals in terrestrial and aquatic food chains must be evaluated. Information on accumulation rates, concentrations in vegetation and wildlife, and the rates at which these metals are transported to streams is unavailable. Without further research it is impossible to assess the present or future significance of this issue.

Staff Position--The other wildlife impacts, including noise, drift, and trace elements, have not been raised before the Commission as issues in Geysers regulatory cases. On a site-specific and cumulative impact basis, these concerns have not been considered significant when compared to other causes of wildlife loss.

Noise impacts are closely associated with power plant and steam field construction activities. Both of these activities are considered temporary even though they may occur during several years of construction. Noise levels at operating power plants and well pads (when steam releases are muffled) do not seem to significantly reduce wildlife use of adjacent habitats.

As discussed previously, wildlife habitat loss is a general concern of staff. Present levels of vegetation loss and damage from cooling tower drift contribute to this general concern. However, the wildlife habitat loss resulting from drift is hard to quantify and has not been isolated as a separate concern from general habitat loss. PGandE is studying the extent of observed annual increases in vegetation damage. The results of this study will be used by staff to further evaluate the the potential significance of wildlife habitat loss from cooling tower drift.

At present levels, toxic trace metals do not appear to be contributing to the loss of wildlife or their habitat. Potential impacts caused by toxic trace metal accumulations in the food chain need to be examined further and monitored as geothermal development proceeds.

Proposed Solutions--The following recommendations are made by staff:

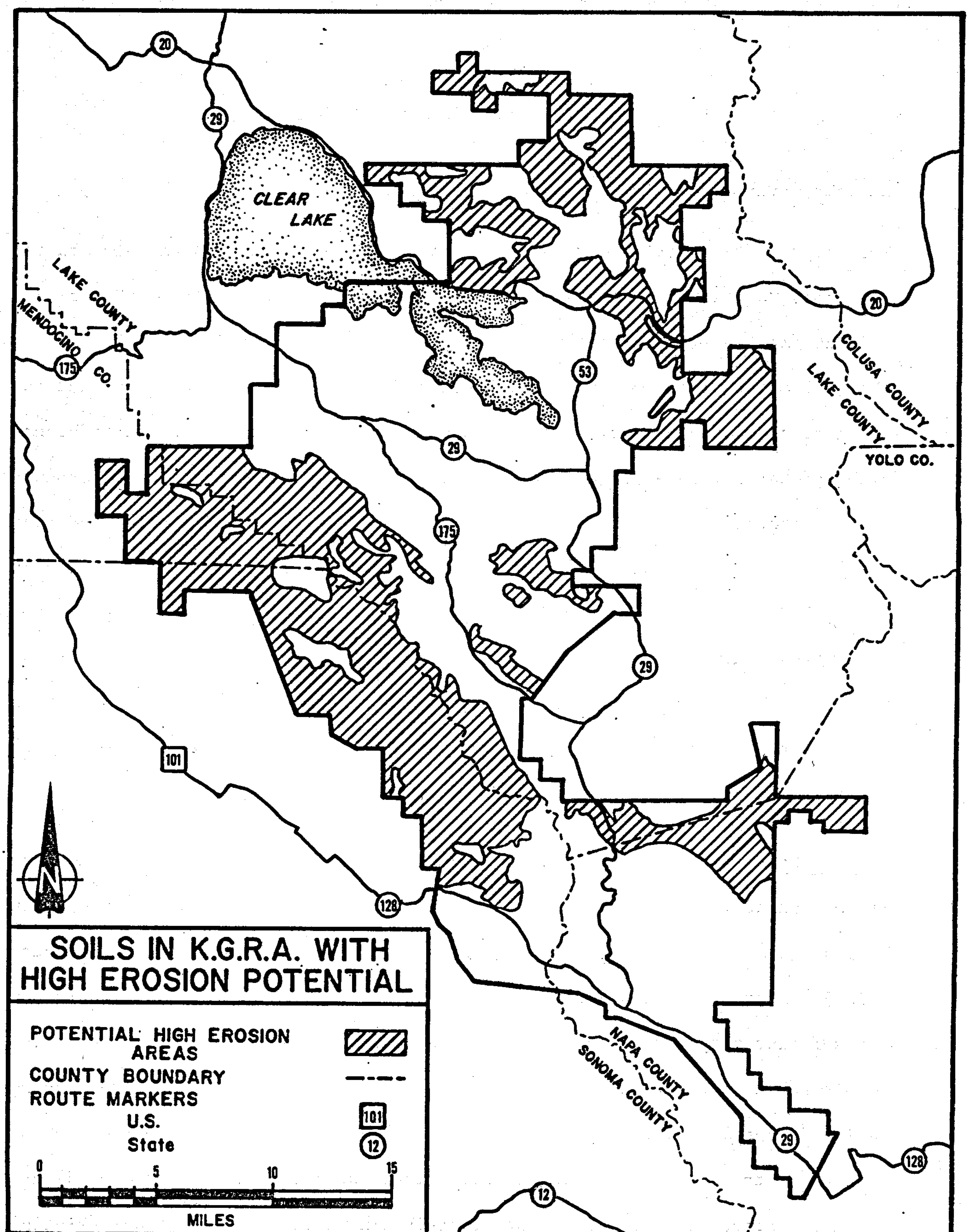
- o Noise from muffled steam venting and current levels do not require additional attention to reduce impacts on wildlife.
- o Staff will review the results of ongoing cooling tower drift studies to determine if potential wildlife habitat losses are significant and to determine appropriate mitigation measures.
- o Staff recommends that the Commission support the development of a program to monitor toxic trace elements in wildlife food chains. Development of this program will require a baseline study to establish existing levels of toxic materials.

## CUMULATIVE AQUATIC BIOTA IMPACTS

### EROSION AND SEDIMENTATION

The rock units underlying major portions of The Geysers KGRA (mainly in the Mayacamas Mountains) are assigned to the Franciscan assemblage (Figure 5). This assemblage is generally unstable under natural conditions because of chemical alteration, innumerable faults and shear zones in the rock and the presence of complex matrices of metamorphic rocks (melange). Interference with the natural balance between such factors as natural slope angle, groundwater, vegetation, and surface loading can result in downhill soil and rock creep, slope failure on rock of the Franciscan formation, and particularly on the melange matrix (Figure 12), and in undercutting roads and other facilities. Removal of vegetation in The Geysers area destroys the network of roots which bind the unstable soil materials together and, more importantly, destroys the vegetative canopy which retards runoff and reduces erosion (Bacon et al., 1976).

Consequences of Vegetation Removal--In this region characterized by a heavy winter rainfall, highly erodible soils and steep topography, vegetation removal and construction activity are of particular importance (Leitner, 1978b). For example, at the Unit 17 site, soil losses are 1.0 ton/acre on north-facing slopes and 1.3 tons/acre on south-facing slopes and are expected to increase to 20 tons/acre (north-facing slopes) and 25 tons/acre (south-facing slopes) during construction (PGandE, 1979a). It is estimated that 30 percent of the soil lost during construction, or 6 to 8 tons/acre, finds its way into streams. This is approximately six times greater than existing




Source: Modified From SRI, 1977b.

FIGURE 12: MAP SHOWING SOILS WITH HIGH EROSION POTENTIAL

erosion and sedimentation rates. These figures are consistent with observations in the California North Coast Ranges, where rural construction increased sedimentation rates six times the normal rate (California Division of Forestry, 1972). Although a three-month winter moratorium on construction in The Geysers undoubtedly reduces soil losses, losses from soil surfaces exposed during premoratorium construction continue during heavy rainfall periods.

With proper revegetation and engineering practices, soil erosion and sedimentation due to power plant site construction are short term; however, road development creates long-term disturbances. Road construction in other small, steep watershed areas increased sedimentaton by an estimated 30 times over rates from comparable undisturbed forested areas (California Division of Forestry, 1972). Erosion increases exponentially as road density (miles of road per square mile) increases. For example, estimates of erosion caused by road development show a sixfold increase as road density doubles (CEC, 1979a). Furthermore, the larger the cuts and fills, and the steeper the terrain traversed, the greater the erosion and sedimentation resulting from road construction. Steep crossroads result in higher cuts, longer fill slopes, and greater areas exposed to erosion for a given road width (California Department of Conservation, 1971).

Vegetation removal, especially due to road construction, in a region already erosion prone, exacerbates the existing condition. Without mitigation, construction activities could increase soil erosion twentyfold over background rates (CEC, 1979d). Because field measurement of natural erosion rates for the KGRA exist only for a few sites, it is not possible to accurately estimate cumulative soil losses. However, if background losses are assumed to be 1 ton of soil per acre per year,* then losses due to construction could be 20 tons per acre per year. Based on the cumulative vegetation loss estimates (Table 4), development-induced soil losses for the KGRA could range from 22,000 tons/year to 70,400 tons/year under the Low Scenario, and from 44,000 tons/ year to 140,800 tons/year under the High Scenario. These estimates are not exact, but they illustrate the potentially enormous increases in erosion that are possible if mitigation measures are not uniformly implemented.**

In addition to the removal of protective vegetation, geothermal development operations can alter runoff rates and activate landslides (Leitner, 1978b). Tables 11 and 12 document the number of geothermal facilities (power plants and steam wells) built on unstable terrain. Ninety-one of 168 wells listed in the table (54 percent) are located on landslides. Units 1 and 2 and 3 and 4 are located on slides, while Units 5 and 6, 12, and 14 are located close to slides.

## IMPACTS ON AQUATIC BIOTA

The KGRA encompasses six major areas of significant value to fisheries (Figure 13): (1) the watersheds west of the Mayacamas Mountains, whose streams are tributary to the Russian River by way of Big Sulphur Creek and smaller drainage ways; (2) the Putah Creek Watershed; (3) the Kelsey Creek Watershed; (4) the Cache Creek Watershed; (5) Thurston Lake and its watershed; and (6) Clear

*Losses at Unit 17 are 1 ton soil/acre/year (PGandE, 1978) and 3 tons/acre/year at Unit 18 (CEC, 1979d). Vegetation, soil types, and topography of these sites are similar to those found at some of the other power plant locations.

**Discrepancies exist between mitigation measures required by local authorities and those required by the state, e.g., the CEC.

Table 11

TERRAIN ANALYSIS OF GEOTHERMAL WELLS

| Location Of Well | Total Wells In Section | Wells On Landslide |
|---|---|---|
| Sec. 6, T11N, R8W | 7 | 3 |
| Sec. 7 | 14 | 9 |
| Sec. 17 | 4 | 2 |
| Sec. 18 | 14 | 4 |
| Sec. 19 | 1 | 0 |
| Sec. 20 | 14 | 1 |
| Sec. 26 | 6 | 1 |
| Sec. 27 | 3 | 1 |
| Sec. 28 | 3 | 3 |
| Sec. 29 | 1 | 0 |
| Sec. 30 | 1 | 0 |
| Sec. 33 | 2 | 2 |
| Sec. 34 | 2 | 1 |
| Sec. 35 | 1 | 0 |
| Sec. 1, T11N, R9W | 6 | 4 |
| Sec. 10 | 1 | 1 |
| Sec. 11 | 9 | 7 |
| Sec. 12 | 28 | 17 |
| Sec. 13 | 30 | 26 |
| Sec. 14 | 20 | 8 |
| Sec. 35, T12N, R9W | 1 | 1 |
| Totals | 168 | 91 |

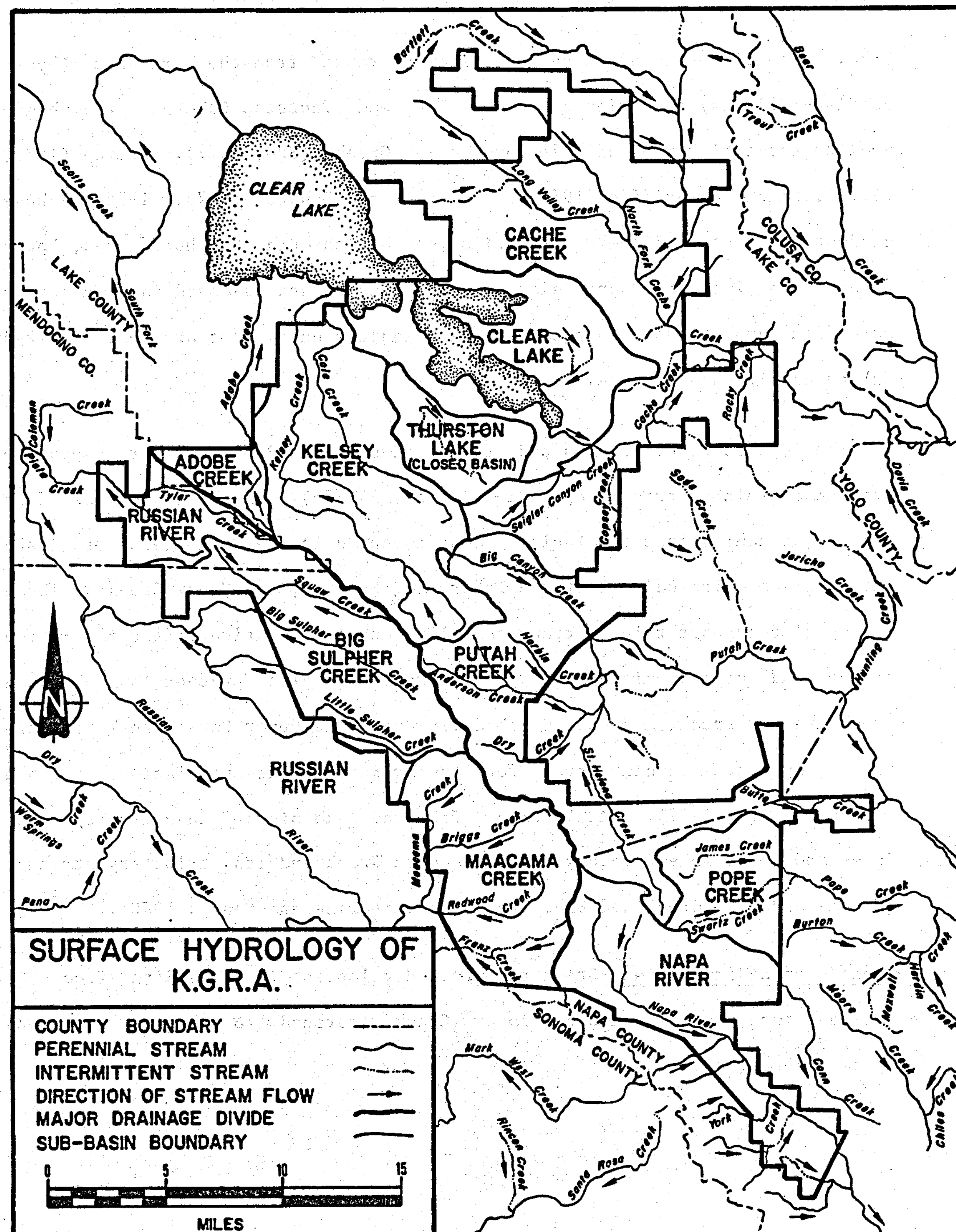
SOURCE: Bacon et al., 1976.

Table 12

TERRAIN ANALYSIS OF GEOTHERMAL POWER PLANTS

| Power Plant | Location | Type of Terrain |
|---|---|---|
| PG&E 1,2* | SW$\frac{1}{4}$, Sec. 19, T11N, R8W | Partly on a slide |
| PG&E 3,4 | NW$\frac{1}{4}$, Sec. 13, T11N, R9W | Entirely on a slide |
| PG&E 5,6 | NE$\frac{1}{4}$, Sec. 13, T11N, R9W | On greenstone and altered melange with a slide encroaching |
| PG&E 7,8** | SW$\frac{1}{4}$, Sec. 7, T11N, R8W | Stable terrain |
| PG&E 9,10 | N$\frac{1}{2}$, Sec. 13, T11N, R8W | On Franciscan graywacke with minor shale and conglomerate |
| PG&E 11 | NW$\frac{1}{4}$, Sec. 7, T11N, R8W | On melange and greenstone |
| PG&E 12 | SE$\frac{1}{4}$, Sec. 18, T11N, R8W | On sedimentary breccia very close to a slide |
| PG&E 13 | SE$\frac{1}{4}$, Sec. 27, T11N, R8W | Stable terrain |
| PG&E 14 | SE$\frac{1}{4}$, Sec. 19, T11N, R8W | 1 slide below cooling tower; 2 slides above site |
| PG&E 15 | SE$\frac{1}{4}$, Sec. 14, T11N, R9W | Stable terrain |
| PG&E 16 | SW$\frac{1}{4}$, Sec. 35, T11N, R8W | Built on two different rock types; possibility of differential compaction |
| PG&E 17 | NE$\frac{1}{4}$, Sec. 7, T11N, R8W | Stable terrain |
| PG&E 18 | NE$\frac{1}{4}$, Sec. 33, T11N, R8W | Stable terrain |
| DWR Bottlerock | SW$\frac{1}{4}$, Sec. 5, T11N, R8W | Stable terrain |
| DWR So. Geysers | SW$\frac{1}{4}$, Sec. 13, T11N, R9W | Stable terrain |
| NCPA 1 | SW$\frac{1}{4}$, Sec. 29, T12N, R8W | Stable terrain |
| NCPA 2 | SW$\frac{1}{4}$, Sec. 2, T10N, R8W | Stable terrain; local landslides existing near the site should not effect the power plant |
| SMUDGEO 1 | SW$\frac{1}{4}$, Sec. 21, T11N, R8W | Stable terrain |

SOURCES: *PG&E Units 1-6, 9-12 from Bacon, 1976
**PG&E Units 7,8, 13-18 from Stockton, 1979
CDWR 1978,1979
NCPA 1978, 1979
SMUD 1980




Source: Modified From SRI, 1977b.

FIGURE 13: SURFACE HYDROLOGY MAP

Lake. The fisheries of these water regions range from the warm water (bass-catfish-bullhead) fisheries of Clear Lake and Thurston Lake to the high-quality trout fisheries of Cole and Kelsey Creeks (SRI, 1977). Price (1975, 1977a), Price and Griffin (1975), and Price and Kubicek (1975, 1976a,b) have conducted extensive fishery investigations of the Big Sulphur Creek, Upper Putah Creek, Cole Creek and Kelsey Creek drainages and assessed game and non-game fish populations. In general, these aquatic ecosystems are characterized as "productive and diverse."

In The Geysers KGRA, streams and tributaries to the Russian River support a steelhead rainbow trout population (Price, 1977b). These anadromous fish migrate as adults from the Pacific Ocean to spawn in the headwaters of fresh-water streams, including Little Sulphur, Big Sulphur, and Squaw Creeks. These creeks also support rainbow trout that live out their entire life cycle in the streams and do not migrate. Rainbow trout are also present in the Putah Creek, Kelsey Creek, and Cole Creek drainages. The Upper Putah Creek Drainage is an important spawning area for the rainbow trout population in Lake Berryessa (SRI, 1977). Adult trout from the lake migrate annually up Putah Creek and spawn in suitable gravels in Putah Creek and its tributary streams, such as Anderson Creek and Bear Canyon Creek (Price and Geary, 1980).

Impacts of Sedimentation--Steam resource development is expanding from the original locations within Big Sulphur Creek watershed to those in Putah and Kelsey Creek (Table 13).

Table 13

GEOTHERMAL DEVELOPMENT IN KGRA WATERSHEDS

| | Big Sulphur Creek | Putah Creek | Kelsey Creek |
|---|---|---|---|
| Power Plant | PGandE 1-12, 14,15,17,18 NCPA 2, SMUDGEO 1, DWR South Geysers | PGandE 13, 16, OXY 1 | NCPA 1, DWR Bottle Rock |
| Steam Field | PGandE 1-12, 14,15,17,18 NCPA 2, SMUDGEO 1, DWR South Geysers | PGandE 13, 16, OXY 1, NCPA 2 | NCPA 1, DWR Bottle Rock, PGandE 17 |

As the development process expands, the attendant surface disturbances are increasing erosion and sedimentation into KGRA streams (Figure 1). Increased sedimentation is of concern because of the well documented effects this process has on aquatic life. Streambed sedimentation can damage trout spawning areas, decrease dissolved oxygen concentrations, block the emergence of fry, and destroy cover needed by trout (Price, 1977b). Sedimentation can also destroy favorable breeding sites for amphibians or prevent successful transformation of gilled aquatic larvae to terrestrial adults. Reduction in insect prey populations may in turn contribute to reduced survivorship of salmonid fry and amphibian larvae.

Results of several studies link geothermal development to increased erosion and sedimentation in KGRA streams receiving runoff from disturbed areas. Fishery studies in the Big Sulphur Creek and Alder Creek drainages found significantly higher sediment levels in areas adjacent to geothermal operations, as compared to undeveloped areas (Steele, 1977a,b). Sediment levels were not yet high enough to inhibit salmonid spawning in Big Sulphur Creek, but the levels did adversely affect trout populations in Alder Creek. This trout population was both smaller and in poorer condition than populations in undeveloped areas of Alder Creek.

Price and Griffin (1975) conclude that flow, color, turbidity and settleable solids in Big Sulphur Creek and Squaw Creek increased over an 85-month period and that increases in these sedimentation indicators are linked to erosion due to expanding geothermal development. In a subsequent analysis using an additional year of data to that used by Price and Griffin (1975), Price (1977a) concludes that no link exists between geothermal development (as measured in MW) and stream condition parameters. However, an analysis by Pimentel (Pimentel, 1978; letter from Pimentel to L.A. Enriquez at PGandE, November 17, 1978) of water quality data in the two reports (Price and Griffin, 1975; Price 1977a) has led to the same conclusions originally reached in the 1975 report: that there is convincing evidence supporting a link between geothermal development and increased sedimentation.

When highly erosive soils, such as those in The Geysers region, are disturbed due to development of geothermal facilities, harmful effects can result from the subsequent soil erosion. Obvious signs of erosion are silt deposits and turbidity. Siltation and/or turbidity can alter stream bed characteristics, which will increase water velocities and force directional flow changes, leading to additional erosion and flooding. Changes in water quality constituents, increased temperatures, and algae/bacteria growth can result in less desirable biological productivity. Large amounts of sediment transported in streams can injure fish by physically damaging gill tissue and interfering with respiration. If eroded soil sediment settles in the stream beds, incubating fish and amphibian eggs as well as bottom dwelling aquatic insects can be smothered.

Impacts of Chemical Discharges--Additional threats to stream quality and aquatic fauna result from condensate spills and the discharge of drilling muds, waste materials, and detergent to streams (Appendix D). The 71 reported pollution incidents between 1965 and 1980 are as follows: 33 condensate spills, 13 landslides and sedimentation incidents, 11 drilling-mud sump failures, 4 spills of fuel oil or other petroleum products, and 10 cases involving well blowouts, spills of abatement chemicals, and other miscellaneous pollutants. Of these reported incidents, only four fish kills have been documented since 1965. In addition, Department of Fish and Game reports that the elimination of the young of the year, detected in their 1978 trout population survey in affected creeks, was due to the 250,000 gallon condensate spill on June 2, 1977 (Pimentel, 1978).

Toxic materials can enter streams as a consequence of delivery truck accidents, such as the one which occurred on January 21, 1978 (Appendix D). Transport of sludge from cooling tower wastes and the delivery of hydrogen peroxide to abatement systems is expected to require 3,340 trips per year (9.1 trips/day) for Units 1 - 18 (CEC, 1979d). Although it is not possible to predict how many accidents will occur, it is sufficient to note that accidents become more likely as truck traffic increases.

Release of toxic substances through spills which reach streams can cause either immediate death or chronic physiological stress to aquatic organisms. Water quality conditions in an affected stream can often take weeks, months, or even years to return to normal. Toxicants can adhere to stream bed deposits or can remain suspended within the water column. Absorbed spills flushed from the soil during spring runoff periods can also add toxicants to streams over a long period.

Staff Position--The issue of adverse impacts on aquatic biological resources, particularly on steelhead and other trout spawning areas, has been raised by

CEC staff, CDFG, USFWS, and other intervenors in all Geysers regulatory cases. Mitigation to reduce erosion and the containment of spills to protect the fishery resources has been evaluated for both the power plant sites and the supporting geothermal development.

It is the CEC staff position that there should be full implementation of mitigation measures on a site-specific basis to control erosion and spills and that there be monitoring of these measures to assure their effectiveness. Power plant applicants have developed revegetation and erosion control plans, as well as plans and mitigation measures to reduce the potential for toxic spills. Within the CEC regulatory siting process, the CEC has required containment of chemical substances and wastes at power plant sites. In addition, CEC staff recommends that a long-term regional aquatic monitoring program be established to evaluate cumulative impacts on the affected watersheds.

Proposed Solutions--The staff should do the following:

1. Maintain present function of working with the utilities to more effectively control site-specific erosion and to contain spills of toxic substances.

2. Identify most sensitive areas so that development can avoid highly erodible soils.

3. Continue preleasehold development environmental review, comment on measures to reduce unnecessary ground disturbance, and encourage implementation of erosion control measures.

4. Continue working with developers and agencies concerning toxic substance transport, storage, and disposal to minimize potential hazards.

5. The CEC should continue to require regional aquatic resource monitoring (presently known as The Geysers KGRA-ARM Program) as a condition of geothermal power plant certification. These monitoring requirements should be coordinated with local and federal regulatory agencies so that regional cumulative impacts and the success of proposed mitigation measures can be determined in the most cost-effective manner.

INJECTION

Artificial recharge of the steam reservoir in the form of condensate injection has been practiced since 1969, with no observable decrease in the capacity of the reservoir to receive condensate.* Injected condensate is believed to move slowly through the fractured reservoir rock, increasing in temperature, eventually vaporizing and ultimately reextracted. If injection continues at present rates, an additional 5 to 8 percent of the rock heat content may be extracted for power generation (GeothermEx, 1980).

Alternate methods of increasing the amount of water available for injection include the use of dry cooling towers and diversion of surface water from KGRA streams. If a method were developed to substitute dry cooling towers for the present evaporative type, it might be possible to reinject the entire condensate produced from the steam wells. The dual considerations of extra cost for dry cooling towers and uncertainty as to the optimum rate for injection have forestalled this development (GeothermEx, 1980).

*Approximately 20 percent of the steam supplied to power plants is condensed and reinjected via injection wells. One injection well is capable of handling condensate from five to eight production wells (GeothermEx, 1980).

Diversion of surface stream water for purposes of injection has been started by the Union Oil Company of California, one of the principal steam suppliers in The Geysers. Union has constructed a water collection system in the bed of Big Sulphur Creek upstream from PGandE Units 1 and 2. The system has a pumping capacity of 2,000 gpm and will operate about 6 months of the year, or the period during which stream flow exceeds 15 cfs. Annual water removal is approximately 1,600 acre-feet, or 518 million gallons (California Department of Fish and Game, 1978). Continued efforts by steam suppliers to expand their injection capacity by diverting or impounding stream water can be expected in the future.

Staff Position--The issue of the use of surface waters for injection into the steam reservoir, if it becomes a common practice, will cause potential problems when combined with existing water diversions in maintenance of in-stream flows for aquatic biological resources, particularly flows adequate to maintain trout spawning areas.

This issue has not been raised in any geothermal power plant regulatory cases to date, since it is not a part of power plant operation but is confined to steam production. However, use of surface water for injection is being considered by steam developers in the KGRA along with the current practice of the reinjection of excess condensate to prolong the life of The Geysers KGRA steam resource. The water resources in the developed Geysers area are adequate to allow a reasonable level of development for this type of water use. However, restrictions on stream flow withdrawals and water storage are essential to protect aquatic biological resources and other beneficial uses.

Proposed Solutions--Staff should initiate a study to determine (1) how widespread the need to inject will be in the future and (2) the potential of the streams in The Geysers KGRA to provide water and water storage sites for injection purposes. Information on the existing and proposed placement, size, and use restrictions of such facilities should be made available to USGS, the Commission, U.S. Geological Survey, State Water Resources Control Board, Regional Water Quality Control Board, California Department of Fish and Game, and county representatives for review and comment. This information should be used to develop an acceptable regional plan for the long-term use of surface waters from streams within the developing portion of the geothermal resource area.

# SUMMARY AND CONCLUSIONS

## SUMMARY

Geothermal generating capacity is projected to expand at the rate of 200 MW per year for at least another 10 years. If utility forecasts are accurate, capacity will reach 2,994 MW by 1990. The vapor-dominated resource at The Geysers will cover at least 25 square miles and may involve as much as 100 square miles. The most likely generating capacity from this field is assumed to be about 3,000 MW.

The temporal and spatial scale of geothermal energy development dictates the magnitude of cumulative biological impacts. Therefore, adequate information as to the spatial extent, operational lifetime, and megawatt potential of the steam resource is of central importance. Without accurate estimates of these factors or policy concerning management of short- or long-term energy production, it is difficult to predict the magnitude of cumulative impacts except within very wide bounds. Therefore, three development scenarios of 2,000 MW, 3,000 MW, and 4,000 MW have been selected to demonstrate the range of impacts which may occur.

Vegetation--The focal point of present and future biological disruption in The Geysers is the loss of and damage to native vegetation. The major impacts on vegetation are (1) direct loss due to clearing for construction and (2) indirect loss and damage due to release of chemicals in the steam, including the deposition of boron.

Direct vegetation losses range from 6.3 percent (0.55 acres/MW) to 20 percent (1.77 acres/MW) of the leasehold. The best documented estimate is 11.5

percent (0.93 acres/MW) which amounts to an estimation of 1,137 acres for PGandE Units 1 - 18. Using the 0.93 acres/MW as a conservative estimate, there would be a loss of 2,790 acres associated with the development of 3,000 MW, or a potential loss of 5,280 acres if the 1.77 acres/MW loss occurred. The CEC staff position is to avoid development on areas of rare or unique vegetation and to keep vegetation disturbance and loss to a minimum. If cumulative impacts from direct vegetation loss of full geothermal development are not mitigated, the potential impacts could be significant.

Indirect vegetation impacts include toxic elements from the steam emissions, acid rain, local climate modifications, and mechanical damage. Steam emissions contain elements which are toxic to vegetation in high concentrations. Stress and damage to vegetation from boron in cooling tower drift has been observed over 247 acres (6 percent) of the total leasehold area of PGandE Units 1 - 11. PGandE is currently conducting studies to quantify effects of airborne boron deposition. Changes in the design of new cooling towers may reduce this impact, although some effects from deposition near power plants are expected to continue. There is also concern about cumulative effects on vegetation from chronic low-level boron and hydrogen sulfide exposure. Concerns about impacts associated with acid rain formation and localized climate modification have been expressed but are not well documented and are hard to quantify in The Geysers area. Mechanical damage, from steam scalding and from coating of leaf surfaces with condensate, has been restricted to very small areas and are considered minor sources of vegetation damage.

Of these indirect impacts CEC staff considers the boron damage to be an important site-specific effect and have required monitoring of new power plant designs to determine if impacts are being reduced. While not considered by staff as a primary concern at this time the other potential indirect impacts should be monitored for adverse vegetation effects and/or possible changes in species composition as geothermal development increases.

The CEC staff recommends the following measures to reduce potentially significant direct impacts and to aid in determining the significance of indirect impacts:

1. Development of Geysers resource maps showing detailed plant associations and the location and distribution of unique vegetation resources for use by permitting agencies.

2. Appropriate surveys of potential rare plant habitat proposed for disturbance in order to avoid disturbance to rare plants or other unique vegetation.

3. Revegetation of all disturbed areas with native plant species of benefit to wildlife.

4. Site-specific monitoring at each power plant for the effects of boron on vegetation.

5. Occasional spot monitoring to detect potential cumulative vegetation effects from chronic low-level boron exposure and to determine if acid rain impacts are occurring.

<u>Wildlife</u>--There is a potential for significant cumulative impacts to wildlife in The KGRA. Habitat loss of 2,790 acres or greater is expected and the remaining habitat will be scattered through the developed area. Wildlife in these areas will be subjected to the surrounding secondary disturbances. All

habitat losses reduce the wildlife carrying capacity of an area, but the point at which such declines can be called "significant" is arbitrary, especially considering the lack of existing baseline data.

Basic information such as population densities and species diversities are unknown for most of the potential 100 square mile vapor-dominated field. Without the field data needed to evaluate the effects of such factors as increased access, patchiness, and edge, it is not possible to decide how detrimental expanded geothermal development will be. Long-term effects are likely to include increases in disturbance-tolerant wildlife populations, decreases in disturbance-intolerant wildlife populations, and shifts in overall species diversity and distribution. Development which destroys critical habitat, such as meadows, springs, seeps, and riparian areas, will undoubtedly have adverse impacts on wildlife. Losses of breeding and foraging areas for protected wildlife species will pose a threat to the continued success of those species in the geothermal area.

The accumulation of mercury and arsenic in terrestrial and aquatic food chains has not been assessed to date because of insufficient baseline data. Because background levels of arsenic and mercury in The Geysers are likely to be elevated due to natural geo-hydrothermal activity, it may be difficult to meaningfully assess the significance of very low levels of trace metal emissions.

The CEC staff recommends the following to reduce adverse impacts to wildlife:

1. Coordinate with various agencies and the Federal Pacific Coast American Peregrine Falcon Recovery Team to identify and monitor potential eyries and critical foraging locations and to identify mitigation measures and

support their efforts to determine transmission line impacts on peregrine mortality.

2. Participate in interagency studies to identify eyries and foraging habitat critical to the golden eagle population in The Geysers areas and to identify mitigation measures adequate to reduce geothermal development impacts on this species to acceptable levels.

3. Baseline studies and monitoring be conducted to determine habitats used by the fully protected ringtail. Avoid development in riparian zones, particularly riparian areas known to support ringtail populations.

4. Minimize the area of wildlife disturbance and enhance habitat surrounding disturbed areas to help offset wildlife losses.

5. Monitor the effectiveness of implemented wildlife mitigation programs in order to determine those which benefit the greatest number of wildlife species.

6. Utilize off-site mitigation, enhancement, and compensation as necessary to preserve unique and representative habitats.

7. Develop monitoring programs to assess the potential accumulation of toxic trace elements in wildlife food chains.

<u>Aquatic Biota</u>--A direct consequence of vegetation destruction in the KGRA is accelerated soil erosion and subsequent sediment loading of some streams located in watersheds undergoing geothermal development. This is a potentially significant problem, which will rapidly escalate as road density increases and power plant construction continues. Given the topographic,

hydrologic, and geologic features of the KGRA, any further development will incrementally increase naturally high erosion rates. Existing construction has triggered landslides and slumping in many areas which further disrupts vegetation and accelerates erosion.

Detrimental impacts to game fish populations caused by increased sedimentaton have been documented only in the case of Alder Creek. However, sediment loading of streams in Putah, Kelsey, and Big Sulphur Creek drainages will increase as geothermal development intensifies. If full geothermal development is unmitigated, it is highly likely that game fish populations in these drainages will be adversely impacted.

Other impacts of uncertain long-term significance include accidental dumping or spilling of toxic chemicals and increased water diversion for purposes of injection into the steam reservoir. Spills are more likely to be short term in nature; however, they are unpredictable, will continue to occur in the future, and can have significant effects. The significance of biological impacts caused by water diversion projects or creation of small impoundments can have potentially significant effects on game fish populations, but quantitative impacts cannot be determined at this time.

In order to reduce potential significant adverse impacts on aquatic resources, staff recommends:

1. Development of effective controls for site-specific erosion and the design of facilities to contain spills of toxic substances.

2. Avoidance of development on the most sensitive areas of highly erodable soils.

3. Early review of all geothermal-related development to reduce unnecessary ground disturbance and to encourage implementation of erosion control measures.

4. Continue working with developers to minimize potential hazards from transport, storage, and disposal of toxic substances.

5. Development of and CEC participation in a regional aquatic resources monitoring program.

## CONCLUSIONS

Development and use of the geothermal steam resource in The Geysers KGRA is characterized by the incremental division and conversion of a rural area with considerable biological resource values into a regional industrial development. Constrained by the nature of the steam resource, power plants average only 97 MW in capacity and must be located within approximately 1 mile of their supply wells. Development of the resource thus takes on a land-intensive nature, with power plants and support facilities covering hundreds and potentially thousands of acres, leaving none of the remaining area far from development.

Vegetation loss, destruction of wildlife habitat, and accelerated stream sedimentation are the most significant existing and long-term impacts associated with geothermal development. Discussion of these impacts has been limited to a 20-year period and to an area which potentially covers 100 square miles. Geothermal development and its associated impacts could conceivably last much longer than the 30-year economic lifetime of power plants. However, the lifetime of the steam resource under different exploitation scenarios is unknown, effectively precluding long-range resource planning and impact forecasting. And yet, the long-term consequences of geothermal development for biological resources must be considered now, rather than after the resource has been exhausted and power plants decommissioned. Accurate steam reservoir assessment (e.g., using computer models*) coupled with regional biological resource planning and assessment can provide a useful framework by which future geothermal development can be expanded in an economically and biologically sound manner.

This report has identified the potential cumulative biological resource impacts which may result from full development of the steam-dominated portion of The Geysers-Calistoga KGRA. It also has described actions proposed by staff to avoid or mitigate such impacts. Staff recognizes the need to develop biological resource protection policies and mitigation measures which can be used cooperatively by all planning and regulatory bodies (utilities, developers, counties, state, and federal) involved in The Geysers geothermal resource development. As a precursor to establishing such policies and mitigation measures, CEC staff will hold technical workshops to review the biological resource mitigation programs. The California Energy Commission will be holding hearings during 1981-82 to receive public comments on these staff-proposed policies and programs. The goal of the hearings is to adopt resource protection policies and mitigation programs that will adequately protect biological resources and facilitate geothermal energy development in The Geysers.

*A computer model of the vapor dominated Larderello, Italy, geothermal system is considered feasible and is now being developed in Pisa, Larderello, and Berkeley (Weres, 1978).

## REFERENCES


American Association of Petroleum Geologists, 1978. Field Trip Guidebook Castle Steam Field, Great Valley Sequence. 53rd Annual Meeting, Pacific Sections AAPG, SEPM, SEG.

Angwin, M., and W. Toy. 1979. Assessment of $H_2S$ Control Technologies for Geothermal Power Plants. Acurex Final Report 79-345.

Atlantis Scientific. 1975. Environmental Impact Report, Castle Rock Springs Geothermal Steam Area: Burmah Oil and Gas Company. Lake County, CA.

Atlantis Scientific. 1976. Environmental Impact Report, Geothermal Steam Area, Lake County, California. Lake County, CA. July 15, 1976

Axtmann, R.C. 1975. Environmental impact of a geothermal power plant. Science 187:795.

Bacon, C.F., Amimoto, P.Y., Sherburne, R.W., Slosson, J.E. 1976. Engineering Geology of The Geysers Geothermal Resources Area, Lake, Mendocino and Sonoma Counties, California. California Division of Mines and Geology Special Report 122.

Bennett, J.P., Resh, H.M., and Runeckels, V.C. 1974. Apparent stimulations of plant growth by air pollutants. Can.J. Bot. 52:35-41.

California Department of Conservation. 1971. Environmental Impact of Urbanization on Foothill and Mountainous Lands of California. State of California, the Resources Agency, Department of Conservation, Division of Soil Conservation, Sacramento, CA. 70 pages.

California Department of Fish and Game. 1977. Status Designations of California Animals. Nongame Wildlife Investigations, Sacramento, CA.

California Department of Fish and Game. 1978. Notification of Removal of Materials and/or Alteration of Lake, River, or Streambed Bottom or Margin. No. III-1222-78. September 26, 1978.

California Department of Water Resources. 1978. Department of Water Resources Notice of Intention. Bottlerock Power Plant.

California Department of Water Resources. 1979. Department of Water Resources Notice of Intention, South Geysers Power Plant. Sacramento, CA.

California Division of Forestry. 1972. Wildland Soils, Vegetation and Activities Affecting Water Quality. Report for State Water Resources Control Board, Sacramento, CA.

California Energy Commission. 1979a. Final Report on the DWR Notice of Intention to File an Application for Certification for Bottlerock Power Plant. California Energy Commission, Sacramento, CA. May 1979.

California Energy Commission. 1979b. Final Report on the Pacific Gas and Electric Company's Notice of Intention to Seek Certification for Geysers Unit 16. California Energy Commission, Sacramento, CA. July 1979.

California Energy Commission. 1979c. Pacific Gas and Electric Company. Geysers 17 Geothermal Power Plant, Sonoma County, CA. Environmental Impact Report. California Energy Commission, Sacramento, CA.

California Energy Commission. 1979d. Pacific Gas and Electric Company, Geysers Unit 18 Geothermal Power Plant, Sonoma Co., CA. Draft Environmental Impact Report. California Energy Commission, Sacramento, CA. December 1979.

California Energy Commission. 1981. Status of Geothermal Electricity Projects. Staff report P700-81-013. Sacramento, CA.

California Office of Planning and Research. 1981. CEQA: The California Environmental Quality Act, Laws and Guidelines. State of California, Sacramento.

COMARC Design Systems. 1975. The Geysers KGRA: A Vegetation and Wildlife Habitat Mapping, prepared by Comarc Design Systems and Envicom Corp. under contract to Pacific Gas and Electric Company and Union Oil Company of California and in cooperation with the California Department of Fish and Game and U.S. Fish and Wildlife Service, San Francisco, CA.

Crow, N.B. 1978. An Environmental Overview of Geothermal Development: The Geysers-Calistoga KGRA. Volume 4. Environmental Geology. Lawrence Livermore Laboratory, Livermore, CA.

Dykstra, H. 1981. Reservior Assessment of The Geysers Field-Reservoir Engineering. Unpublished report to the California Division of Oil and Gas, Sacramento, CA.

Eaton, M. K. 1981. Wildlife Habitat Loss Due to Geothermal Development in The Geysers-Calistoga Known Geothermal Resources Area. Report No. 420-80.2. Pacific Gas and Electric Company Department of Engineering Research, San Ramon, CA.

Ebbeson, H. 1978. Acid rain study. In: Geothermal Environmental Seminar-'78. May 9 - 11, 1978. Sacramento, CA. F.L. Tucker and L.R. Tanner, eds. Lake County Printing, Clear Lake Oaks, CA.

ECOVIEW. 1975a. The Geothermal Leasehold of Union Oil Company at The Geysers, Sonoma County, CA. February 1975.

ECOVIEW. 1975b. A Draft EIR for Burmah Oil and Gas Company, Wildhorse Leasehold (Part I) on the Squaw Creek Drainage in N.E. Sonoma and Small Parts of Mendocino and Lake Counties, CA.

ECOVIEW. 1976a. A Draft Environmental Impact Report for Shell Oil Company United States Geothermal Leasehold Drill Site E, Lake County, CA.

ECOVIEW. 1976b. A Draft EIR for Shell Oil Company, USGR Lease Two (CA-950) Drill Site G, Sonoma County, CA, Napa County, CA.

ECOVIEW. 1978. Draft EIR. Thermogenics, Inc. Klau Mine Leasehold Expansion Project, Lake County, CA.

Ehrlich, P.R., Ehrlich, A.H., Holdren, J.P. 1977. Ecoscience. W.H. Freeman and Company. 1,052 pp.

Enderson, J.H., and Kirven, M.N. 1980. Final Report, Peregrine Falcon Foraging Study in The Geysers-Calistoga Known Geothermal Resource Area, Sonoma County, California, 1979. In: Final Report Peregrine Falcon Study. February 1, 1980. Geothermal Research Information and Planning Services Commission.

Fontes, R.A., L. Joyce. 1978. Air Quality as the Limiting Factor on Development of The Geysers Geothermal Resources. California Energy Commission, Sacramento, CA.

GeothermEx, Inc. 1980. Evaluation of the Potential for generation of electricity, Geothermal Lease CA-1862, Sonoma and Lake Counties, California. Prepared for Sacramento Municipal Utility District, Sacramento, California a by GeothermEx, Inc., Berkeley, CA.

GRIPS Commission. 1980. Final Report, Peregrine Falcon Study. Geothermal Research Information and Planning Services (GRIPS)--A California Joint Powers Agency, Napa, CA.

Isherwood, W. 1977. Geothermal reservoir interpretation from change in gravity. In: Proc.3rd Workshop Geoth. Res. Eng. P. Kruger, H.J. Ramey, Jr., eds. December 14-16, 1977. Stanford Geothermal Program, Stanford University, Stanford, CA.

Keezer, G.S. 1976. Testimony submitted before the California Energy Commission in the matter of Pacific Gas and Electric Company's Notice of Intention, Combined-Cycle Plant. Docket No. 76-NOI-3. California Energy Commission, Sacramento, CA.

Kirven, M.N. 1980. Phase I Field Study. Peregrine Falcons of Mount St. Helena in The Geysers-Calistoga Known Geothermal Resource Area. U.S. Dept. of Energy Grant No. ET-78-G-03-2068. Submitted to Geothermal Resource Impact Project Study Joint Powers Agency, Santa Rosa, CA.

Koch, D. and Brody A. 1981. Status of the Ringtail (Bassariscus astutus) in the Geysers-Calistoga known Geothermal Resource Area. Contract 700-80-030, California Energy Commission, Sacramento, CA.

Koranda, J. 1980. Interim Report: Studies of Boron Deposition Near Geothermal Power Plants. (Limited external distribution). Lawrence Livermore Laboratory, Livermore, CA.

Leitner, P. 1978a. An Environmental Overview of Geothermal Development: The Geysers-Calistoga KGRA. Volume 3: Noise. Lawrence Livermore Laboratory, Livermore, CA.

Leitner, P. 1978b. An Environmental Overview of Geothermal Development: The Geysers-Calistoga KGRA. Volume 5: Ecosystem Quality. Lawrence Livermore Laboratory, Livermore, CA.

Lipman, S.C., Strobel, C.J., Gulati, M.S. 1977. Reservoir performance of The Geysers Field. In: Proceedings of the Larderello Workshop in Geothermal Resource Assessment and Reservoir Engineering. September 12-16, 1977.

Lofgren, B.E. 1978. Monitoring Crustal Deformation in The Geysers-Clear Lake Geothermal Area. USGS Open-file Report 78-597, Sacramento, CA.

Malloch, B.S., Eaton, M.K., and Crane, N.L. 1979. Assessment of Vegetation Stress and Damage Near The Geysers Power Plant Units. Pacific Gas and Electric Company, Department of Engineering Research Report 420-79.3, San Ramon, CA.

Martin, A.C., Zim, H.S., Nelson, A.L. 1951. American Wildlife and Plants. Dover Publications, Inc., NY. ix + 500 pp.

McLaughlin, R.J. and Stanley, W.D. 1975. Pre-Tertiary Geology and Structural Control of Geothermal Resources, The Geysers Steam Field, California. Proc. from 2nd UN Symposium on the Development and Use of Geothermal Resources Vol. I. San Francisco, CA, May 1975.

Meneghin. G.R., Hall, D.J., Malloch, B.S., Choteau, N.C. 1978. The Geysers 18 Leasehold and Site Specific Studies Terrestrial Ecology. Pacific Gas and Electric Company, Department of Engineering Research Report 411-78.194. San Ramon, CA.

Northern California Power Agency. 1978. Notice of Intention for the NCPA Geothermal Project No. 2 (NCPA/Shell Project). NCPA, Santa Clara, CA.

Northern California Power Agency. 1979. Notice of Intention for the NCPA 66 MW Geothermal Power Plant. Santa Clara, CA.

Ornduff, R. 1976. Introduction to California Plant Life. University of California Press. Berkeley, CA.

Pacific Gas and Electric Company. 1977a. Environmental Data Statement, Geysers Unit 17. San Francisco, CA.

Pacific Gas and Electric Company. 1977b. The Geysers Known Geothermal Resource Area Wildlife Study. The Distribution and Abundance of Wildlife Populations in Relation to Geothermal Development: Interim Report. San Ramon, CA.

Pacific Gas and Electric Company. 1978. Notice of Intention, Geysers Unit 17. San Francisco, CA.

Pacific Gas and Electric Company. 1979a. Application for Certification, Geysers Unit 17. San Francisco, CA.

Pacific Gas and Electric Company. 1979b. Application for Certification, Geysers Unit 18. San Francisco, CA.

Pacific Gas and Electric Company. 1979c. San Francisco, CA. Letter to R. Therkelsen, California Energy Commission, Sacramento, CA.

Pimentel, K.D. 1978. An Environmental Overview of Geothermal Development: The Geysers-Calistoga KGRA. Volume 6: Water Quality. Lawrence Livermore Laboratories, Livermore, CA.

Pimentel, K.D. 1978. Lawrence Livermore Laboratory, Livermore, California, letter to L. A. Enriquez. Pacific Gas and Electric Company, San Ramon, CA. November 17, 1978.

Price, D.G. 1975. KGRA Fishery Investigations. PGandE Co. Department of Engineering Research Report. 7784-75. San Ramon, CA.

Price, D.G. 1976a. An Inventory of Fishery Resources in the Kelsey Creek Drainage. The Geysers KGRA Fishery Investigations. PGandE Co. Dept. of Engineering Research. Report 7784.6-76. San Ramon, CA.

Price, D.G. 1976b. An Inventory of Fishery Resources in the Cole Creek Drainage. The Geysers KGRA Fishery Investigations. PGandE Co. Dept. of Engineering Research. Report 7784.6-76. San Ramon, CA.

Price, D.G. 1977a. An Investigation of Unique Water Quality Conditions in The Big Sulphur Creek Watershed Related to Natural Geothermal Activity, Streamflow, and Geothermal Development. PGandE Co. Department of Engineering Research. Report 420-77.1. San Ramon, CA.

Price, D.G. 1977b. Protecting Fishery Resources During Geothermal Development. Ecosystem Quality Workshop, October 25-27, 1977. Pacific Gas and Electric Company, San Ramon, CA.

Price, D.G., Geary, R.E., and Longenecher, D.R. 1980. Upper Putah Creek Monitoring Studies: Fishery Resources, Stream Sedimentation and Water Temperature Characteristics. PGandE Co. Dept. of Engineering Research. Report 420-80.94. San Ramon, CA.

Price, D.G. and Griffin, D.P. 1975. An Evaluation of Stream Water Quality Monitoring Data Collected from May 1968 through May 1975 at the Geysers and its Implications to the Biological, Chemical, and Physical Environment. PGandE Co. Department of Engineering Research. Report 7784.2.-75. San Ramon, CA.

Price, D.G. and Kubicek, P.F. 1975. An Inventory of Fishery Resources on the Upper Putah Creek Drainage. The Geysers KGRA Fishery Investigation. PGandE Co. Department of Engineering Research. Report 7784.3-75. San Ramon, CA.

Ramey, H.J., Jr. Testimony before the California Energy Commission in relation to PGandE Geysers Unit 16 Notice of Intention. December 8, 1978. Sacramento, CA.

Reed, J.J., and Campbell, G.E. 1975. Environmental impact of development in The Geysers geothermal field, USA. In: Proc. 2nd U.N. Symposium on the Development and Use of Geothermal Resources. ed. Lawrence Berkeley Laboratory. pp. 1399-1410.

Rosen L.C., and Molenkamp, C.R. 1978. Air Quality, An Environmental Overview of Geothermal Development: The Geysers-Calistoga KGRA. Volume 2.

Stager, K.E. 1976. Report of Survey of the Status of the Peregrine Falcon in the Vicinity of Geysers Unit 13. Pacific Gas and Electric Company, San Ramon, CA.

Stanford Research Institute, International. 1977a. Consultant Report on Environmental Analysis for Geothermal Energy Development in The Geysers Region. Volume II. Master Environmental Assessment. Menlo Park, CA.

Stanford Research Institute, International. 1977b. Environmental Analysis for Geothermal Energy Development in The Geysers Region--Executive Summary. Prepared for the California Energy Commission. SRI, Menlo Park, CA.

Sacramento Municipal Utility District. 1980. Application for Certification. SMUDGEO 1. Sacramento, CA.

State of California. 1978. Guidelines for Implementation of the California Environmental Quality Act. California Administrative Code, title 14 division 6, chapter 3. Secretary of State, Sacramento, CA.

Steele, J.A. 1977a. Streambed Sedimentation in Drainages of the Clear Lake-Geysers KGRA. Department of Fish and Game, Environmental Services, Region 3, Yountville, CA.

Steele, J.A. 1977b. Effects of Geothermal Development on Blood Physiology of Salmonids. California Department of Fish and Game, Environmental Services, Region 3, Yountville, CA.

Stockton, D. June 1979. Personal communication. Division of Oil and Gas. Sacramento, CA.

Suter, G.W. 1978. Geothermal Development and Wildlife Behavior, Trans. Geo. Res. Council. pp. 627-629.

Temple, P.J., and Linzon, S.N. 1976. Boron as a phytotoxic air pollutant. J. Air Pollut. Control Assoc. 26(5):498-499.

Temple, P.J., and Smith, M.L. 1978. Fluoride and boron effects on vegetation in the vicinity of a fiberglass plant. Water, Air, and Soil Pollution. 10(2):163.

Thompson, C.R., and Kats, G. 1978. Effects of Continuous $H_2S$ Fumigation on Crop and Forest Plants. Env. Sce. Tech. 2(5):550-553.

Thompson, C.R. 1978. Behavior of $H_2S$ in the atmosphere and its effects on vegetation. Testimony for the State Geothermal Task Force, April 14 - 15, 1977.

United States Environmental Protection Agency. 1977. Western Energy Resources and the Environment: Geothermal Energy. Prepared by Resource Planning Assoc., Inc. For Office of Research and Development, Washington, DC.

United States Geological Survey. 1979. Assessment of Geothermal Resources of the United States-1978 (Geological Survey Circular 790).

United States Fish and Wildlife Service. 1978. Effects of Geothermal Energy Development on Fish and Wildlife. Biological Services Program, United States Department of the Interior.

VTN Consolidated, Inc. 1976. Draft EIR, Thurston Lake Exploratory Project, prepared for Lake County Planning Department. Lake County, CA.

Weinberg, C.J. 1978. Environmental Aspects of Geysers Geothermal Operations. Pacific Gas and Electric Company, San Francisco, CA.

Weres, O. 1978. The dynamics of steam producing geothermal reservoirs. In: Geothermal Environmental Seminar -'78. May 9-11, 1978, sponsored by Environmental Systems and Services, held in Kelseyville, CA and Lake County Air Pollution Control District, Lake County, CA. Sacramento, CA.

Winner, W.E. 1981. The effect of $SO_2$ on photosynthesis and stomatal behavior of Mediterranean-Climate shrubs. In: Components of Productivity of Mediterranean Regions--Basic and Applied Aspects. Margaris, N.S., and H. A. Monney (eds). W. Junk Publ., The Hague.

APPENDICES

CONTENTS

Appendix A

PLANT COMMUNITIES OF THE KGRA
AND THEIR CHARACTERISTIC SPECIES

PLANT COMMUNITIES OF THE KGRA

AND THEIR CHARACTERISTIC SPECIES

## GRASSLAND

### Introduced Species:

| | |
|---|---|
| Soft chess | *Bromus mollis* |
| Ripgut | *Bromus diandrus* |
| Red brome | *Bromus rubens* |
| Western cheatgrass | *Bromus tectorum* |
| Wild oats | *Avena fatua* |
| Slender wildoats | *Avena barbata* |
| Hairgrass | *Aira caryophyllea* |
| Foxtail fescue | *Festuca megalura* |
| Little quakinggrass | *Briza minor* |
| Dog-tail | *Cynosurus echinatus* |
| Golden top | *Lamarckia aurea* |
| Filaree | *Erodium botrys, E. cicutarium,* |
| Bur clover | *Medicago polymorpha* |
| Bull thistle | *Cirsium vulgare* |
| Napa thistle | *Centaurea melitensis* |
| Vernal Whitlow grass | *Draba verna* |

### Native Species:

| | |
|---|---|
| Popcorn flower | *Plagiobothrys nothofulvus* |
| Tricolored gilia | *Gilia tricolor* |
| Blue-field gilia | *Gilia capitata* |
| Valparaiso clover | *Trifolium microdon* |
| Indian clover | *Trifolium dichotomum* |
| Sour clover | *Trifolium fucatum* |
| Common linanthus | *Linanthus androsaceus* |
| Yellow owl's clover | *Orthocarpus attenuatus* |
| Napa cryptantha | *Cryptantha hispidula* |
| Fringe pod | *Thysanocarpus laciniatus* |
| Dwarf athysanus | *Athysanus pusillus* |
| Clarkia | *Clarkia gracilis* |

## OAK SAVANNAH

| | |
|---|---|
| Big leaf maple | *Acer macrophyllum* |
| Blue oak | *Quercus douglasii* |
| Oregon oak | *Quercus garryana* |
| California black oak | *Quercus kelloggii* |
| Valley oak | *Quercus lobata* |
| Digger pine | *Pinus sabiniana* |
| Elderberry | *Sambucus mexicana* |
| Hair grass | *Aira caryophyllea* |
| Whitlow grass | *Athysanus pusillus* |
| Wild oats | *Avena barbata, A. fatua* |
| Small quaking grass | *Briza minor* |
| Brome grasses | *Bromus diandrus, B. inermis, B. mollis* |
| Dogtail grass | *Cynosurus echinatus* |
| Foxtails<br>Fescue grasses | *Festuca dertonensis, F. erecta*<br>*F. idahoensis* |
| Tall stephanomeria | *Stephanomeria virgata* |

## OAK WOODLAND

| | |
|---|---|
| Valley oak | *Quercus lobata* |
| Interior live oak | *Quercus wislizenii* |
| Garry oak | *Quercus garryana* |
| Canyon oak | *Quercus chrysolepis* |
| Buckeye | *Aesculus californica* |
| Yellow pine | *Pinus ponderosa* |
| Digger pine | *Pinus sabiniana* |
| Douglas Fir | *Pseudotsuga menziesii* |
| Madrone | *Arbutus menziesii* |
| Big-leaf maple | *Acer macrophyllum* |
| California bay | *Umbellularia californica* |
| Yerba santa | *Eriodictyon californicum* |
| California coffeeberry | *Rhamnus californica* |
| Poison oak | *Rhus diversiloba* |
| Gum plant | *Grindelia hirsutula* |
| Bird's foot fern | *Pellaea mucronata* |

| | |
|---|---|
| Bracken fern | *Pteridium aquilinum* |

CHAPARRAL

| | |
|---|---|
| **Mixed Chaparral** | |
| Chamise | *Adenostoma fasciculatum* |
| Manzanitas | *Arctostaphylos*—*A. canescens*, *A. glandulosa*, *A. manzanita*, *A. stanfordiana*, *A. viscida* |
| Ceanothus | *Ceanothus cuneatus*, *C. foliosus* |
| Mountain mahogany | *Cercocarpus betuloides* |
| Yerba santa | *Eriodictyon californicum* |
| California fescue | *Festuca californica* |
| Silk tassel | *Garrya elliptica* |
| Small willow herb | *Gayophytum nuttalli* |
| Toyon | *Heteromeles arbutifolia* |
| Gold wire | *Hypericum concinnum* |
| Lomatium | *Lomatium marginatum* |
| Mountain monardella | *Monardella odoratissima* ssp. *pinetorum* |
| Chaparral pea | *Pickeringia montana* |
| Scrub oak | *Quercus dumosa* |
| Dwarf interior live oak | *Quercus wislizinii* var. *frustescens* |
| Coffeeberry | *Rhamnus californica* |
| Poison oak | *Rhus* (*Toxicodendron*) *diversilobum* |
| Squaw bush | *Rhus trilobata* |
| Canyon gooseberry | *Ribes menziesii* var. *leptosmum* |
| Gooseberry | *Ribes quercetorum* |
| California bay | *Umbellularia californica* |
| Star lily | *Zigadenus fremontii* |
| **Serpentine Chaparral** | |
| Chamise | *Adenostoma fasciculatum* |
| Whiteleaf manzanita | *Arctostaphylos viscida* |
| Jepsons ceanothus | *Ceanothus jepsonii* |

| | |
|---|---|
| Sargent cypress | *Cupressus sargentii* |
| Willow herb | *Epilobium minutum* |
| Cliffrake | *Onychium densum* |
| Bird's foot fern | *Pellaea mucronata* |
| Digger pine | *Pinus sabiniana* |
| Leather oak | *Quercus durata* |
| *Chamise Chaparral* | |
| Chamise | *Adenostoma fasciculatum* |
| Buckbrush | *Ceanothus cuneatus* |
| Wavyleaf ceanothus | *Ceanothus foliosus* |
| Mountain mahogany | *Cercocarpus betuloides* |
| Horehound | *Marrubium vulgare* |
| Green monaradella | *Monardella viridis* |
| Virgate phacelia | *Phacelia heterophylla* |
| Star lily | *Zigadenus fremontii* |

MIXED EVERGREEN FOREST

| | |
|---|---|
| Bigleaf maple | *Acer macrophyllum* |
| Buckeye | *Aesculus californica* |
| Madrone | *Arbutus menziesii* |
| Hoary manzanita | *Arctostaphylos canescens* |
| Deer bush | *Ceanothus integerrimus* |
| California fescue | *Festuca californica* |
| Bluegrass | *Poa* sp. |
| Douglas fir | *Pseudotsuga menziesii* |
| Bracken fern | *Pteridium aquilinum* var. *lanuginosum* |
| Canyon oak | *Quercus chrysolepis* |
| Scrub oak | *Quercus dumosa* |
| Oregon oak | *Quercus garryana* |
| California black oak | *Quercus kelloggii* |
| California coffeeberry | *Rhamnus californica* |

| | |
|---|---|
| Poison oak | *Rhus* (=*Toxicodendron*) *diversilobum* |
| California rose | *Rosa californica* |
| California nutmeg | *Torreya californica* |
| California bay | *Umbellularia californica* |

YELLOW PINE FOREST

| | |
|---|---|
| Chamise | *Adenostoma fasciculatum* |
| Manzanita | *Arctostaphylos* spp. |
| Deer brush | *Ceanothus integerrimus* |
| Mountain mahogany | *Cercocarpus betuloides* |
| Dogwood | *Cornus* sp. |
| Mountain ash | *Fraxinus dipetala* |
| Bedstraw | *Galium californicum* |
| Sugar pine | *Pinus lambertiana* |
| Ponderosa pine | *Pinus ponderosa* |
| Douglas fir | *Pseudotsuga menziesii* |
| Canyon oak | *Quercus chrysolepis* |
| Black oak | *Quercus kelloggii* |
| Canyon live oak | *Quercus wislizenii* |
| Coffeeberry | *Rhamnus californica* |

KNOBCONE PINE FOREST

| | |
|---|---|
| Chamise | *Adenostoma fasciculatum* |
| Manzanita | *Arctostaphylos* spp. |
| California lilac | *Ceanothus* spp. |
| Silk-tassel bush | *Garrya elliptica* |
| Knobcone pine | *Pinus attenuata* |
| Leather oak | *Quercus durata* (on serpentine soils) |
| Interior live oak | *Quercus wislizenii* |

DOUGLAS FIR FOREST

| | |
|---|---|
| Douglas fir | *Pseudotsuga menziesii* |
| Black oak | *Quercus kelloggii* |

| | |
|---|---|
| Canyon oak | *Quercus chrysolepis* |
| Madrone | *Arbutus menziesii* |
| Dogwood | *Cornus nuttallii* |
| Big leaf maple | *Acer macrophyllum* |
| California bay | *Umbellularia californica* |
| Giant chinquapin | *Castanopsis chrysophylla* |
| Snowberry | *Symphoricarpos albus* |
| Deer brush | *Ceanothus integerrimus* |
| Coffeeberry | *Rhamnus californica* |
| Shrub interior live oak | *Quercus wislizenii* var. *frutescens* |
| Gooseberry | *Ribes* spp. |
| Bracken fern | *Pteridium aquilinum* var *lanuginosum* |
| Lupines | *Lupinus latifolius*, *L. andersonii* |
| Leafless wintergreen | *Pyrola aphylla* |
| Sugarstick saprophyte | *Allotropa virgata* |
| Yellow-flowered groundsel | *Senecio aronicoides* |
| White-flowered hawkweed | *Hieracium albiflorum* |

CYPRESS FOREST

| | |
|---|---|
| Chamise | *Adenostoma fasciculatum* |
| Hoary manzanita | *Arctostaphylos canescens* |
| Parry manzanita | *Arctostaphylos manzanita* |
| Macnab cypress | *Cupressus macnabiana* |
| Yerba santa | *Eriodictyon californicum* |
| Bedstraw | *Galium andrewsii* |
| Interior live oak | *Quercus wislizenii* |
| Knobcone pine | *Pinus attenuata* |

RIPARIAN

| | |
|---|---|
| White alder | *Alnus rhombifolia* |
| Mugwort | *Artemisia vulgaris* |

| | |
|---|---|
| Sedge | Cyperus aristatus, C. eragrostis |
| Perennial rye grass | Elymus glaucus, E. triticoides |
| Horsetail | Equisetum arvense |
| Rush | Juncus tenuis, var. congestus |
| Wood rush | Lazula subsessilis |
| Pellitory | Parietaria pensylvanica |
| California polypody | Polypodium californicum |
| Rabbitsfoot grass | Polypogon monspeliensis |
| California fern | Polystichum californicum |
| Western sword fern | Polystichum munitum |
| Fremont cottonwood | Populus fremontii |
| Willows | Salix laevigata, S. lasiandra |
| Squirreltail | Sitanion hystrix |
| Western verbena | Verbena lasiostachys var. septentrionalis |
| Grape | Vitis californica |

AQUATIC VEGETATION

| | |
|---|---|
| Ponds | |
| Cattails | Typha latifolia |
| Common smartweed | Polygonum hydropiper |
| Duckweed | Lemna minima |
| Marsh pennywort | Hydrocotyle ranunculoides |
| Curly dock | Rumex crispus |
| Wood rush | Luzula parviflora |
| Blue eyed grass | Sisyrinchium bellum |
| Slender rush | Juncus tenius |
| Sedge | Carex dudleyi |

| | |
|---|---|
| Springs | |
| Yellow willow | |
| Horsetails | Equisetum arvense |
| Pinnate-leaved hosakia | Lotus pinnatus |
| Yellow monkey-flower | Mimulus guttatus |
| Panicled willow herb | Epilobium paniculatum |
| Redtops | Agrostis ampla |
| Junegrass | Koeleria cristata |
| Sweet vernal grass | Anthoxanthum odoratum |
| Bracken fern | Pteridium aquilinum var. lanuginosum |
| Hot Springs | |
| Yellow sedge bluestem | Andropogon virginicus |
| Centaury | Centarium umbellatum |
| Panicum grass | Panicum thermale |
| WEEDY VEGETATION | |
| Athysanus | Athysanus pusillus |
| Foxtail chess | Bromus rubens |
| Centaury | Centaurium muehlenbergii |
| Hairgrass | Deschampsia caespitosa |
| Rye grass | Elymus caput-medusae |
| Rye grass | Elymus glaucus |
| Turkey mullein | Eremocarpus setigerus |
| Filaree | Erodium spp. |
| Cranesbill | Geranium spp. |
| Dwarf flax | Hesperolinon sp. |
| Bird's foot trefoil | Lotus spp. |
| Tall stephanomeria | Stephanomeria virgata |
| Turpentine weed | Trichostema laxum |
| Vetch | Vicia spp. |

SOURCE: S.R.I. 1977, Meneghin, et al. 1978, P.G&E. 1978

Appendix B

RARE AND ENDANGERED VASCULAR PLANTS
OF THE GEYSERS KGRA, STATUS, AND BLOOMING TIMES

CONTENTS FOR APPENDIX B

TABLE 1

KNOWN OCCURRENCE OF VERY RARE,
RARE AND ENDANGERED PLANT SPECIES

| Habitat/Species | County Lake | Napa | Sonoma | Mendocino | Known Occurrence Within the KGRA |
|---|---|---|---|---|---|
| SPECIES ON WET SITES | | | | | |
| Blennosperma bakeri Heiser | | | X | | No |
| Carex albida Bailey | | | X | | No |
| *Dicanthelium acuminatum (SW) Gould & Clark var. acuminatum | X | | X | | Yes |
| Gratiola heterosepala Mason and Bacig. | X | | | | Yes |
| Lasthenia burkei (Greene) Greene | X | | X | X | Yes |
| Lasthenia conjugens Greene | | X | | X | Yes |
| Legenere limosa (Greene) McVaugh | X | X | X | | Yes |
| Navarretia pauciflora Mason | X | | | | Yes |
| Navarretia plieantha Mason | X | | | | Yes |
| Orcuttia tenuis Hitchc. | X | | X | | Yes |
| Parvisedum leiocarpum (H.K. Sharsm.) Clausen | X | | | | Yes |
| Perideridia gairdneri (H.&A.) Math. ssp. gairdneri | | X | | | Yes |

*=Panicum thermale Bolander sp. emend. Schmoll. Taxonomic changes are acknowledged; species remains listed pending confirmation of its rarity status.

| Habitat/Species | Lake | Napa | County<br>Sonoma | Mendocino | Known Occurrence Within the KGRA |
|---|---|---|---|---|---|
| *Plagiobothrys strictus* (Greene) Jtn. | | X | X | | Yes |
| *Poa napensis* Beetle | | X | | | Yes |
| *Pogogyne douglasii* Benth ssp. *parviflora* (Benth.) J.T. Howell | X | | X | X | Yes |
| *Sidalcea oregana* (Nutt.) Gray ssp. *hydrophila* (Heller) Hitchc. | X | X | X | | Yes |
| *SPECIES ON DRY OR MOIST SITES* (nonserpentine) | | | | | |
| *Astragalus clarianus* Jeps. | X | X | X | | Yes |
| *Brodiaea coronaria* (Salisb.) Engler ssp. *rosea* (Greene) Niehaus | X | | | | No |
| *Ceanothus confusus* Howell | X | X | X | | Yes |
| *Ceanothus divergens* Parry | X | X | X | | Yes |
| *Eriastrum brandegeae* Mason | X | | | | Yes |
| *Eryngium constancei* Sheikh, ined. | X | | | | Yes |
| *Hesperolinon drymarioides* (Curran) Small | X | | | | No |
| *Parvisedum leiocarpum* (H.K. Sharsm.) Clausen | X | | | | Yes |
| *Tracyina rostrata* Blake | X | | | | No |
| *SPECIES ON SERPENTINE SITES* | | | | | |
| *Antirrhinum subcordatum* Gray | X | | X | | Yes |

| Habitat/Species | Lake | Napa | Sonoma | Mendocino | Known Occurrence Within the KGRA |
|---|---|---|---|---|---|
| Cordylanthus tenuis Gray ssp. capillaris (Pennell) Chuang and Heckard | | | X | | Yes |
| Eriogonum nervulosum (Stokes) Reveal | X | | X | | Yes |
| Helianthus exilis Gray | X | X | | | Yes |
| Hesperolinon adenophyllum (Gray) Small | X | | | | Yes |
| Hesperolinon breweri (Gray) Small | | X | | | Yes |
| Hesperolinon didymocarpum H.K. Sharsm. | X | | | | Yes |
| Streptanthus brachiatus Hoffm. | | | X | | Yes |
| Streptanthus morrisonii complex Hoffm. | X | X | X | | Yes |

TABLE 2

KNOWN OCCURRENCE OF
RARE BUT NOT ENDANGERED PLANTS*

| Habitat/Species | County: Lake | Napa | Sonoma | Mendocino | Known Occurrence Within the KGRA |
|---|---|---|---|---|---|
| SPECIES ON WET SITES | | | | | |
| Cuscuta howelliana Rubtzoff | X | | | | Yes |
| Delphinium uliginosum Curran | X | X | | | Yes |
| Lepidium latipes Hook | | X | | | Yes |
| Ranunculus lobbii (Hiern.) Gray | X | X | X | | Yes |
| SPECIES ON DRY OR MOIST SITES (nonserpentine) | | | | | |
| Amsinckia lunaris Macbr. | X | | X | | |
| Antirrhinum virga Eastw. | X | | X | X | Yes |
| Arabis modesta Roll. | | X | X | | No |
| Astragalus breweri Gray | X | X | X | | Yes |
| Astragalus clevelandii Gray | X | X | | | Yes |
| Calochortus pulchellus Dougl ex. Benth | X | X | X | X | Yes |
| Calyptridium quadripetalum Wats | | X | X | | |
| Ceanothus purpureus Jeps. | | X | | | Yes |
| Collinsia greenei Gray | X | X | X | | Yes |
| Erigeron petrophilus (Greene) | X | X | X | X | Yes |
| Eriogonum caninum (Greene) Munz | X | X | X | | Yes |

| Habitat/Species | County: Lake | Napa | Sonoma | Mendocino | Known Occurrence Within the KGRA |
|---|---|---|---|---|---|
| *Euphorbia ocellata* Dur. & Hilg. var. *rattanii* (Wats.) Wheeler | X | | | | Yes |
| *Fritillaria pluriflora* Torrey ex Bentham | X | X | | | No |
| *Lilium rubescens* Wats. | | X | X | X | Yes |
| *Lomatium ciliolatum* Jeps. var. *hooveri* Math & Const. | X | X | | | |
| *Lomatium repostum* (Jeps.) Math. | X | X | X | | Yes |
| *Lupinus sericatus* Kel. | X | X | X | | Yes |
| *Mimulus nudatus* Curran ex. Greene | X | X | | | Yes |
| *Monardella viridis* Jeps. ssp. *viridis* | X | X | | | Yes |
| *Pityopus californicus* (Eastw.) Copel. | X | X | | X | |
| *Ribes victoris* Greene | | X | X | | Yes |
| **SPECIES ON SERPENTINE SITES** | | | | | |
| *Asclepias solanoana* Woodson | X | X | X | | Yes |
| *Calamagrostis ophitidis* (Howell) Nygren | X | | X | | Yes |
| *Collomia diversifolia* Greene | X | X | | | Yes |
| *Cryptantha hispidula* Greene ex. Brand | X | X | | | Yes |
| *Fritillaria purdyi* Eastw. | X | X | | | Yes |
| *Hesperolinon adenophyllum* (Gray) Small | X | | | X | Yes |

| Habitat/Species | County Lake | Napa | Sonoma | Mendocino | Known Occurrence Within the KGRA |
|---|---|---|---|---|---|
| *Hesperolinon bicarpellatum* (H.K. Sharsm.) H.K. Sharms. | X | X | X | | Yes |
| *Navarettia jepsonii* Bailey ex. Jeps. | X | X | | | Yes |
| *Nemacladus montanus* Greene | X | X | X | | Yes |
| *Senecio clevelandii* Greene | X | X | | | Yes |

TABLE 3

KNOWN OCCURRENCE OF PLANTS RARE
IN CALIFORNIA BUT COMMON ELSEWHERE

| Habitat/Species | County: Lake | Napa | Sonoma | Mendocino | Known Occurrence Within the KGRA |
|---|---|---|---|---|---|
| SPECIES ON WET SITES | | | | | |
| Calochortus uniflorus | | X | X | | |

TABLE 4

OFFICIAL STATUS OF VERY RARE, RARE AND ENDANGERED PLANT SPECIES (CNPS LIST 2)

| Habitat/Species | Rare Plant Status: CNPS[1] R-E-V-D | USFWS[2] | State[3] |
|---|---|---|---|
| SPECIES ON WET SITES | | | |
| Blennosperma bakeri Heiser | 3-2-2-3 | 1 | |
| Carex albida Bailey | 3-3-2-2 | 1 | |
| *Dicanthelium acuminatum (SW) Gould & Clark var. acuminatum | 3-2-1-3 | 1 | E |
| Gratiola heterosepala Mason and Bacig. | 3-3-2-3 | 1 | E |
| Lasthenia burkei (Greene) Greene | 3-3-2-3 | 1 | E |
| Lasthenia conjugens Greene | 3-2-2-3 | 1 | |
| Legenere limosa (Greene) McVaugh | 3-3-3-3 | 1 | |
| Navarretia pauciflora Mason | 2-2-1-3 | 1 | |
| Navarretia plieantha Mason | 3-2-1-3 | 1 | E |
| Orcuttia tenuis Hitchc. | 3-3-2-3 | 1 | E |
| Parvisedum leiocarpum (H.K. Sharsm.) Clausen | 2-2-2-3 | 1 | |
| Perideridia gairdneri (H.&A.) Math. ssp. gairdneri | 2-2-2-3 | 1 | |

*=Panicum thermale Bolander sp. emend. Schmoll. Taxonomic changes are acknowledged; species remains listed pending confirmation of its rarity status.

| Habitat/Species | Rare Plant Status CNPS[1] R-E-V-D | USFWS[2] | State[3] |
|---|---|---|---|
| Plagiobothrys strictus (Greene) Jtn. | 3-2-2-3 | 1 | |
| Poa napensis Beetle | 3-3-2-3 | 1 | |
| Pogogyne douglasii Benth ssp. parviflora (Benth.) J.T. Howell | 2-1-1-3 | 2 | |
| Sidalcea oregana (Nutt.) Gray ssp. hydrophila (Heller) Hitchc. | 2-1-1-3 | 2 | |
| SPECIES ON DRY OR MOIST SITES (nonserpentine) | | | |
| Astragalus Clarianus Jeps. | 3-2-3-3 | 1 | |
| Brodiaea coronaria (Salisb.) Engler ssp. rosea (Greene) Niehaus | 3-3-2-3 | 1 | |
| Ceanothus confusus Howell | 3-2-1-3 | 1 | |
| Ceanothus divergens Parry | 2-1-1-3 | 1 | |
| Eriastrum brandegeae Mason | 3-2-2-3 | 1 | |
| Eryngium constancei Sheikh, ined. | 3-1-1-3 | 1 | |
| Hesperolinon drymarioides (Curran) Small | 2-1-1-3 | 2 | |
| Parvisedum leiocarpum (H.K. Sharsm.) Clausen | 2-2-2-3 | 1 | |
| Tracyina rostrata Blake | 3-1-1-3 | 1 | T |

| Habitat/Species | CNPS[1] R-E-V-D | USFWS[2] | State[3] |
|---|---|---|---|
| | *Rare Plant Status* | | |
| **SPECIES ON SERPENTINE SITES** | | | |
| *Antirrhinum subcordatum* Gray | 2-2-2-3 | 1 | |
| *Cordylanthus tenuis* Gray ssp. *capillaris* (Pennell) Chuang and Heckard, comb. nov. ined. | 2-2-1-3 | 1 | R |
| *Eriogonum nervulosum* (Stokes) Reveal | 2-1-1-3 | 2 | |
| *Helianthus exilis* Gray | 2-2-2-3 | 2 | |
| *Hesperolinon breweri* (Gray) Small | 2-1-2-3 | 1 | |
| *Hesperolinon didymocarpum* H.K. Sharsm. | 3-2-2-3 | 1 | E |
| *Streptanthus brachiatus* Hoffm. | 3-2-1-3 | 1 | |
| *Streptanthus morrisonii* complex. Hoffm. | 2-2-1-3 | 1 | |

TABLE 5

OFFICIAL STATUS OF RARE BUT NOT ENDANGERED PLANTS (CNPS LIST 3)

| Habitat/Species | CNPS[1] R-E-V-D | USFWS[2] | State[3] |
|---|---|---|---|
| | Rare Plant Status | | |
| SPECIES ON WET SITES | | | |
| Cuscuta Howelliana Rubtzoff | 1-1-1-3 | - | |
| Delphinium uliginosum Curran | 1-1-1-3 | - | |
| Lepidium latipes Hook | 1-1-1-2 | - | |
| Ranunculus lobbii (Hiern.) Gray | 1-1-1-2 | - | |
| SPECIES ON DRY OR MOIST SITES (nonserpentine) | | | |
| Amsinckia lunaris Macbr. | 1-1-1-3 | - | |
| Antirrhinum virga Eastw. | 1-1-1-3 | - | |
| Arabis modesta Roll. | 2-1-1-2 | | |
| Astragalus breweri Gray | 1-1-1-3 | - | |
| Astragalus clevelandii Gray | 1-1-1-3 | - | |
| Calyptridium quadripetalum Wats. | 1-1-1-3 | - | |
| Calochortus pulchellus Dougl ex Benth | 1-1-1-3 | - | |
| Ceanothus purpureus Jeps. | 1-1-1-3 | - | |
| Collinsia greenei Gray | 1-1-1-3 | - | |
| Eriogonum caninum (Greene) Munz | 1-2-1-3 | - | |
| Erigeron petrophilus (Greene) | 1-1-1-2 | - | |
| Euphorbia ocellata Dur. & Hilg. var. Rattanii (Wats.) Wheeler | 1-1-1-3 | - | |
| Fritillaria pluriflora Torrey ex Bentham | 1-2-1-3 | 2 | |

| Habitat/Species | Rare Plant Status CNPS[1] R-E-V-D | USFWS[2] | State[3] |
|---|---|---|---|
| Lilium rubescens Wats. | 1-1-1-2 | - | |
| Lomatium ciliolatum Jeps. var. hooveri Math & Const. | 1-1-1-3 | - | |
| Lomatium repostum (Jeps.) Math. | 1-1-1-3 | - | |
| Lupinus sericatus Kel. | 1-1-1-3 | - | |
| Mimulus nudatus Curran ex. Greene | 1-1-1-3 | - | |
| Monardella viridis Jeps. ssp. viridis | 1-1-1-3 | - | |
| Pityopus californicus (Eastw.) Copel. | 1-2-1-2 | - | |
| Ribes victoris Greene | | - | |
| SPECIES ON SERPENTINE SITES | | | |
| Asclepias solanoana Woodson | 1-1-1-3 | - | |
| Calamagrostis ophitidis (Howell) Nygren | 1-1-1-3 | - | |
| Collomia diversifolia (Greene) | 1-1-1-3 | - | |
| Cryptantha hispidula Greene ex. Brand | 1-1-1-3 | - | |
| Fritillaria purdyi Eastw. | 1-1-1-3 | - | |
| Hesperolinon adenophyllum (Gray) Small | 1-1-1-3 | 2 | |
| Hesperolinon bicarpellatum (H.K. Sharsm.) H.K. Sharsms. | 1-1-1-3 | 2 | |
| Navarettia jepsonii Bailey ex. Jeps. | 1-1-1-3 | - | |
| Nemacladus montanus Greene | 1-1-1-3 | - | |
| Senecio clevelandii Greene | 1-1-1-3 | - | |

TABLE 6

OFFICIAL STATUS OF PLANTS RARE
IN CALIFORNIA BUT COMMON ELSEWHERE

| Habitat/Species | Rare Plant Status CNPS[1] R-E-V-D | USFWS[2] | State[3] |
| --- | --- | --- | --- |
| SPECIES ON WET SITES | | | |
| Calochortus uniflorus | 1-1-1-1 | | |

SYMBOLS FOR TABLES 4,5, AND 6.

[1] California Native Plant Society, Rarity--Endangerment--Vigor--Distribution Code

R (Rarity)

1 - rare, but danger of extinction low

2 - several populations or one large population

3 - one or a few highly restricted populations

E (Endangerment)

1 - not endangered

2 - endangered in a portion of its range

3 - endangered throughout its range

V (Vigor)

1 - increasing or stable

2 - declining

3 - approaching extinction

D (Distribution)

1 - widespread outside California

2 - rare outside California

3 - California endemic

[2] United States Fish and Wildlife Service--Federal Register. The species noted are currently under review as Endangered or Threatened.

1 - Taxa for which the service has sufficient information to support listing as Endangered or Threatened Species.

2 - Taxa for which information indicates probable appropriateness of listing as Endangered or Threatened Species.

[3]State of California - Native Plant Protection Act

E - Endangered

R - Rare, but not endangered

T - Threatened

## TABLE 7. BLOOMING TIMES OF RARE PLANTS IN THE KGRA*

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct | Nov |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ceanothus divergens | | X | X | | | | | | | | |
| Ceanothus confusus | | X | X | X | | | | | | | |
| *Ceanothus purpureus | | X | X | X | | | | | | | |
| *Fritillaria pluriflora | | X | X | X | | | | | | | |
| *Ranunculus lobbii | | X | X | X | | | | | | | |
| *Ribes victoris | | | X | X | | | | | | | |
| *Lepidium latipes | | | X | X | X | | | | | | |
| Plagiobothrys strictus | | | X | X | X | X | | | | | |
| Blennosperma bakeri | | | X | X | X | X | | | | | |
| *Fritillaria purdyi | | | X | X | X | X | | | | | |
| Lasthenia burkei | | | X | X | X | | | | | | |
| *Astragalus breweri | | | X | X | X | | | | | | |
| *Lomatium repostum | | | X | X | X | | | | | | |
| *Arabis modesta | | | X | X | X | | | | | | |
| Parvisedum leiocarpum | | | X | X | X | | | | | | |
| Astragalus clarianus | | | X | X | X | X | | | | | |
| Gratiola heterosepala | | | X | X | X | X | | | | | |
| *Lupinus sericatus | | | X | X | X | X | | | | | |
| *Cryptantha hispidula | | | X | X | X | X | | | | | |
| *Amsinckia lunaris | | | X | X | X | X | | | | | |
| *Calochortus pulchellus | | | X | X | X | X | | | | | |
| Legenere limosa | | | | X | X | X | | | | | |
| Navarretia plieantha | | | | X | X | X | | | | | |
| Orcuttia tenuis | | | | X | X | X | | | | | |
| Poa napensis | | | | X | | | | | | | |



EE-23 RPS

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct | Nov |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Lomatium ciliolatum var. hooveri | | | | — | — | | | | | | |
| Pogogyne douglasii ssp. parviflora | | | | — | — | | | | | | |
| Lasthenia conjugens | | | | — | — | — | | | | | |
| Tracyina rostrata | | | | — | — | — | | | | | |
| *Hesperolinon bicarpellatum | | | | — | — | — | | | | | |
| *Calyptridium quadripetalum | | | | — | — | — | | | | | |
| Hesperolinon didymocarpon | | | | — | — | — | | | | | |
| *Delphinium uliginosum | | | | — | — | — | | | | | |
| *Collomia diversifolia | | | | — | — | — | | | | | |
| *Mimulus nudatus | | | | — | — | — | | | | | |
| *Navarretia jepsonii | | | | — | — | — | | | | | |
| Carex albida | | | | — | — | — | | | | | |
| Brodiaea coronaria ssp. rosea | | | | — | — | — | | | | | |
| *Calamagrostis ophiditis | | | | — | — | — | — | | | | |
| Hesperolinon breweri | | | | — | — | — | — | | | | |
| *Collinsia greenei | | | | — | — | — | — | | | | |
| *Nemacladus montanus | | | | — | — | — | — | | | | |
| *Pityopus californicus | | | | — | — | — | — | | | | |
| Eriastrum brandegeae | | | | — | — | — | — | — | — | | |
| Hesperolinon drymarioides | | | | — | — | — | — | — | — | | |
| *Asclepias soloanoa | | | | | — | — | | | | | |
| Streptanthus brachiatus | | | | | | — | | | | | |
| Streptanthus morrisonii complex | | | | | | — | | | | | |
| Navarretia pauciflora | | | | | | — | | | | | |
| Perideridia gairdneri ssp. gairdneri | | | | | | — | | | | | |
| Antirrhinum subcordatum | | | | | | — | — | | | | |

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct | Nov |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Antirrhinom virga | | | | | — | — | — | | | | |
| Cordylanthus tenuis ssp. capillaris | | | | | — | — | — | | | | |
| *Lilium rubescens | | | | | — | — | — | | | | |
| *Senecio clevelandii | | | | | — | — | — | — | | | |
| [1]Dicanthelium acuminatum var. acuminatum | | | | | — | — | — | — | | | |
| *Hesperolinon adenophyllum | | | | | — | — | — | — | — | | |
| Eriogonum nervulosum | | | | | — | — | — | — | — | | |
| *Cuscuta Howelliana | | | | | — | — | — | — | — | | |
| *Astragalus clevelandii | | | | | — | — | — | — | — | | |
| Sidalcea oregana ssp. hydrophila | | | | | | | | | | | |
| *Eriogeron peterophilus | | | | | | — | — | — | — | | |
| *Monardella viridis ssp. virdis | | | | | | — | — | — | — | | |
| Helianthus exilis | | | | | | — | — | — | — | — | — |

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All plants are CNPS List 2 (Rare and Endangered) unless noted with (*). These plants are CNPS List 3 (Rare, but not Endangered).

1. Panicum thermale--Taxonomic changes acknowledged, species remains listed pending determination of its rarity status.

## REFERENCES


California Native Plant Society. Maps of rare and endangered vascular plants of California.

California Native Plant Society. Rare plant status reports.

California Natural Diversity Data Base. Map file. Callizo, J. 1979. Rare and endangered plants of Napa County.

Lacey, J. 1981. Department of Water Resources, Report of Communication.

Munz, P.A. 1959. A California Flora. In collaboration with D.D. Keck. University of California Press. Berkeley. 1681 pp.

Munz, P.A. 1968. Supplement to a California Flora. University of California Press. Berkeley. 224 pp.

Smith, Jr., J.P., et al. 1980 Inventory of Rare and Endangered Plants of California. California Native Plant Society. Berkeley. 116 pp.

Smith, J.P. Jr, et al. 1980 Inventory of Rare and Endangered Vascular Plants of California, First Supplement. Berkeley. 28 pp.

State of California. 1980. Inventory of the threatened flora of California.

United States Fish and Wildlife Service. 1980. Federal Register.

Appendix C

# VERTEBRATE ANIMALS OF THE GEYSERS KGRA

| | | Mixed Ever-green | Oak Wood-land | Oak Savan-nah | Chamise Chap-arral | Mixed Chap-arral | Montane Chap-arral | Serpen-tine Chap-arral | Knob-cone Pine | Cypress Forest | Yellow Pine | Mixed Coni-ferous | Ripar-ian | Meadow |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MAMMALS: | | | | | | | | | | | | | | |
| Opossum | Didelphis marsupialis | PO | PO | | | | | | | | | PO | PO | PO |
| Vagrant shrew | Sorex vagrans | PO | | | | | | | PO | PO | PO | PO | | PO |
| Ornate shrew | Sorex ornatus | PO | PO | PO | PO | PO | PO | PO | X | PO | PO | PO | X | PO |
| Water shrew | Sorex palustris | | | | | | | | | | | | PO | |
| Trowbridge shrew | Sorex trowbridgii | PO | X | | X | | | | PO | PO | PO | PO | X | PO |
| Western mole | Scapanus latimanus | PO | PO | PO | PO | PO | PO | PO | PO | PO | PO | PO | X | PO |
| Shrew mole | Neurotrichus gibbsii | | | | | | | | | | PO | PO | PO | PO |
| Little brown myotis | Myotis lucifugus | PO | PO | | | | | | | | PO | PO | PO | PO |
| Fringed myotis | Myotis thysanodes | PO | PO | | | | | | | | PO | PO | PO | PO |
| California myotis | Myotis californicus | PO | PO | PO | PO | PO | PO | PO | PO | PO | PO | PO | PO | PO |
| Hairy-winged myotis | Myotis volans | PO | PO | | | | | | | | PO | PO | PO | PO |
| Long-eared myotis | Myotis evotis | PO | PO | | | | | | | | PO | PO | PO | PO |
| Yuma myotis | Myotis yumanensis | PO | PO | | | | | | | | PO | PO | PO | PO |
| Silvery-haired bat | Lasionycteris noctivagans | PO | PO | | | | | | | | PO | PO | PO | PO |
| Hoary bat | Lasiurus cinereus | PO | PO | | | | | | | | PO | PO | PO | PO |
| Red bat | Lasiurus borealis | PO | PO | | | | | | | | PO | PO | PO | PO |
| Big brown bat | Eptesicus fuscus | PO | PO | | | | | | | | PO | PO | PO | PO |
| Pallid bat | Antrozous pallidus | | | PO | PO | PO | PO | PO | | | | | PO | |
| Townsend's big-eared bat | Plecotus townsendii | PO | | | PO | PO | PO | PO | | | | | | |
| Braziliam free-tailed bat | Tadarida brasiliensis | | PO | PO | PO | PO | PO | PO | | | | | PO | |
| Black-tailed hare | Lepus californicus | | X | X | PO | X | —PO | X | X | X | X | X | X | X |
| Audubon cottontail | Sylvilagus audubonii | | X | PO | | | | | | | | | | |
| Brush rabbit | Sylvilagus bachmani | PO | X | X | X | X | PO | X | PO | PO | PO | PO | PO | |
| Beechey ground squirrel | Otospermophilus beecheyi | | PO | X | | | | X | X | | X | | X | PO |
| Sonoma chipmunk | Eutamias sonomae | X | | | X | X | X | X | PO | X | X | X | X | |
| Western gray squirrel | Sciurus griseus | X | X | X | | | | | X | | X | X | X | |
| Botta pocket gopher | Thomomys bottae | PO | PO | PO | PO | PO | PO | PO | PO | PO | X | | PO | X |
| Heermann kangaroo rat | Dipodomys heermanni | | PO | PO | X | X | PO | PO | | | | | | |
| Western harvest mouse | Reithrodontomys megalotis | X | PO | X | X | X | PO | PO | PO | PO | PO | | X | PO |
| Brush mouse | Peromyscus boylii | X | X | X | X | X | PO | PO | X | PO | PO | X | X | |
| Pinyon mouse | Peromyscus truei | X | PO | PO | X | X | PO | PO | X | PO | PO | X | X | PO |
| Deer mouse | Peromyscus maniculatus | X | X | X | X | X | PO | PO | X | PO | PO | X | X | X |
| Dusky-footed woodrat | Neotoma fuscipes | X | X | | X | X | PO | PO | X | PO | X | X | PO | |
| California meadow mouse | Microtus californicus | X | X | X | X | X | PO | PO | | | | X | X | X |
| Porcupine | Erithizon dorsatum | | | | | | | | PO | | PO | PO | PO | |

| | | Mixed Ever-green | Oak Wood-land | Oak Savan-nah | Chamise Chap-arral | Mixed Chap-arral | Montane Chap-arral | Serpen-tine Chap-arral | Knob-cone Pine | Cypress Forest | Yellow Pine | Mixed Coni-ferous | Ripar-ian | Meadow |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MAMMALS: - contd. | | | | | | | | | | | | | | |
| Gray fox | Urocyon cinereoargenteus | PO | PO | PO | PO | PO | PO | PO | PO | | PO | PO | PO | PO |
| Black bear | Ursus americanus | | | | | | | | X | | | | X | PO |
| Coyote | Canis latrans | PO | PO | PO | PO | X | PO | PO | PO | PO | X | PO | PO | PO |
| Raccoon | Procyonlotor | PO | PO | | | | | | PO | | PO | X | X | |
| Ringtail cat | Bassariscus astutus | PO | | | PO | PO | PO | PO | | | | | PO | X |
| Mink | Mustela vison | | | | | | | | | | PO | | PO | |
| Long-tailed weasel | Mustela frenata | PO | PO | PO | PO | PO | PO | PO | PO | PO | PO | PO | PO | PO |
| Badger | Taxidea taxus | PO | PO | PO | PO | PO | PO | PO | PO | PO | PO | PO | PO | PO |
| Striped skunk | Mephitis mephitis | PO | X | X | | | | | PO | | PO | X | PO | |
| Spotted skunk | Spilogale putorius | | | PO | PO | PO | PO | PO | | | | | PO | |
| River otter | Lutra canadensis | | | | | | | | | | | | X | |
| Mountain lion | Felis concolor | | PO | | PO | PO | PO | PO | PO | | PO | PO | PO | |
| Feral domestic cat | Felis domestica | X | PO | X | PO | X | PO | PO | PO | PO | X | PO | PO | |
| Bobcat | Lynx rufus | PO | PO | PO | PO | X | PO | X | X | | PO | PO | X | |
| Wild boar | Sus scrofa | | X | X | X | X | PO | | PO | | | PO | PO | |
| Black-tailed deer | Odocoileus hemionus | X | X | X | X | X | X | X | X | X | X | X | X | X |
| BIRDS: | | | | | | | | | | | | | | |
| Pied-billed grebe | Podilymbus podiceps | | | | | | | | | | | | PO | |
| Great blue heron | Ardea herodias | | | | | | | | | | | | PO | |
| Mallard | Anas platyrhynchos | | | | | | | | | | | | X | |
| Turkey vulture | Cathartes aura | X | X | X | X | X | X | X | X | PO | X | X | X | X |
| White-tailed kite | Elanus leucurus | | PO | PO | | PO | | PO | | | | | | |
| Sharp-shinned hawk | Accipiter striatus | PO | PO | PO | | X | PO | PO | X | | X | X | X | PO |
| Cooper's hawk | Accipiter cooperii | X | PO | X | PO | X | PO | PO | PO | | PO | X | PO | X |
| Red-tailed hawk | Buteo jamaicensis | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Red-shouldered hawk (red bellied) | Buteo lineatus | PO | X | X | X | PO | | | X | | | | X | PO |
| Rough-legged hawk | Buteo lagopus | | | PO | PO | PO | | | | | | | PO | PO |
| Golden eagle | Aquila chrysaetos | X | X | X | X | X | PO | PO | PO | | PO | PO | PO | X |
| Peregrine falcon | Falco peregrinus | | | | | | X | | | | X | | X | PO |
| Prairie falcon | Falco mexicanus | X | | | | X | | | | | X | | | X |
| American kestrel | Falco sparverius | | X | X | | | X | | PO | | X | X | X | X |
| California quail | Lophortyx californicus | X | X | X | X | X | X | X | X | PO | X | X | X | X |
| Mountain quail | Oreortyx pictus | X | PO | PO | PO | X | X | X | X | PO | X | X | X | PO |
| American coot | Fulica americana | | | | | | | | | | | | X | |
| Killdeer | Charadrius vociferus | | | X | | X | | | | | | | X | X |

BIRDS: - contd.

| | | Mixed Ever-green | Oak Wood-land | Oak Savan-nah | Chamise Chap-arral | Mixed Chap-arral | Montane Chap-arral | Serpen-tine Chap-arral | Knob-cone Pine | Cypress Forest | Yellow Pine | Mixed Coni-ferous | Ripar-ian | Meadow |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Band-tailed pigeon | Columba fasciata | X | PO | X | PO | X | X | PO | X | | PO | PO | PO | |
| Mourning dove | Zenaida macroura | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Barn owl | Tyto alba | | PO | PO | | | | | | | | | | |
| Screech owl | Otus asio | X | X | | | | | | X | | X | X | X | PO |
| Great-horned owl | Bubo virginianus | X | X | X | X | X | PO | X | X | | X | X | X | X |
| Pygmy owl | Glaucidium gnoma | PO | PO | | X | | | | X | | X | X | | |
| Long-eared owl | Asio otus | | PO | X | | | | | | | PO | PO | X | |
| Saw-whet owl | Aegolius acadicus | X | | | | | | | PO | | PO | | X | |
| Poor-will | Phalaenoptilus nuttallii | | | | PO | PO | X | X | | | | | | PO |
| Black swift | Cypseloides niger | | | X | | | | | | | | | PO | PO |
| Vaux's swift | Chaetura vauxi | PO | PO | PO | | | | | PO | | PO | PO | PO | |
| Anna's hummingbird | Calypte anna | PO | PO | PO | PO | PO | X | X | X | X | X | X | PO | X |
| Rufous hummingbird | Selasphorus rufus | PO | | | | | X | | PO | PO | PO | X | PO | PO |
| Allen's hummingbird | Selasphorus sasin | X | | | PO | X | X | PO | X | | | | PO | X |
| Calliope hummingbird | Stellula calliope | | | | | | | | PO | | PO | PO | | |
| Belted kingfisher | Megaceryle alcyon | | | | | | | | | | | | X | |
| Common flicker | Colaptes auratus | X | X | X | PO | X | X | X | X | X | X | X | X | X |
| Pileated woodpecker | Dryocopus pileatus | X | | | | | | | X | | X | X | X | |
| Acorn woodpecker | Melanerpes formicivorus | X | X | X | | | | | X | | X | X | X | |
| Lewis' woodpecker | Melanerpes lewis | PO | PO | PO | | | | | | | | | | |
| Yellow-bellied sapsucker | Sphyrapicus varius | X | PO | | | | | | | | X | X | X | |
| Hairy woodpecker | Picpides villosus | X | X | | | | X | | X | | X | X | X | X |
| Downy woodpecker | Picpides pubescens | | PO | | | | X | | X | | X | X | X | |
| Nuttall's woodpecker | Picpides nutallii | | PO | X | PO | PO | PO | PO | | | X | X | PO | |
| Western kingbird | Tyrannus verticalis | | | X | PO | X | PO | PO | | | | | | X |
| Ash-throated flycatcher | Myiarchus cinerascens | X | PO | PO | PO | X | X | X | X | X | X | X | X | X |
| Black phoebe | Sayornis nigricans | X | | X | | | | X | X | | X | | X | X |
| Dusky flycatcher | Empidonax oberholseri | X | | | | | | | | | | | | |
| Willow flycatcher | Empidonax traillii | | | | | | | | | | PO | | PO | |
| Western flycatcher | Empidonax difficilis | X | PO | | | | | | X | | X | X | PO | X |
| Western wood pewee | Contopus sordidulus | X | PO | | | | | | X | | X | X | X | |
| Olive-sided flycatcher | Nuttallornis borealis | X | | | | | X | X | X | | X | X | PO | X |
| Horned lark | Eremophila alpestris | | | PO | | | | | | | | | | PO |
| Purple martin | Progne subis | PO | PO | PO | PO | PO | X | PO | | | X | PO | PO | PO |
| Violet-green swallow | Tachycineta thalassina | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Tree swallow | Iridoprocne bicolor | | PO | X | | | | X | PO | | PO | | PO | PO |
| Rough-winged swallow | Stelgidopteryx ruficollis | | | X | | | | | | | | | X | X |
| Barn swallow | Hirundo rustica | | X | X | PO | X | PO | PO | X | | X | | X | X |

BIRDS: - contd.

| | | Mixed Ever-green | Oak Wood-land | Oak Savan-nah | Chamise Chap-arral | Mixed Chap-arral | Montane Chap-arral | Serpen-tine Chap-arral | Knob-cone Pine | Cypress Forest | Yellow Pine | Mixed Coni-ferous | Ripar-ian | Meadow |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cliff swallow | Petrochelidon pyrrhonota | | | PO | | | | | | | | | X | X |
| Stellar's jay | Cyanocitta stelleri | X | X | X | | | X | | X | X | X | X | X | X |
| Scrub jay | Aphelocoma coerulescens | X | X | X | X | X | X | X | X | X | X | X | X | |
| Common raven | Corvus corax | PO | PO | X | | X | X | X | X | PO | X | X | X | X |
| Common crow | Corvus brachyrhynchos | | PO | X | | X | | | PO | | X | X | PO | PO |
| Chesnut-backed chickadee | Parus rufescens | X | X | PO | | | | | X | X | X | X | X | PO |
| Plain titmouse | Parus inornatus | X | X | X | | | X | X | X | X | PO | X | X | X |
| Bushtit | Psaltriparus minimus | X | X | X | PO | X | X | X | X | | X | X | X | X |
| White-breasted nuthatch | Sitta carolinensis | X | PO | X | | | PO | PO | X | | X | X | PO | X |
| Red-breasted nuthatch | Sitta canadensis | PO | | | | | X | | PO | | X | X | PO | |
| Pygmy nuthatch | Sitta pygmaea | X | PO | | | | X | | X | | X | X | PO | |
| Brown creeper | Certhia familiaris | PO | | | | | | | X | | X | X | X | |
| Wrentit | Chamaea fasciata | X | | | X | X | X | X | X | PO | X | | PO | X |
| Dipper (water ouzel) | Cinclus mexicanus | | | | | | | | | | | X | | X |
| House wren | Troglodytes aedon | X | PO | | PO | PO | PO | PO | PO | | X | PO | X | X |
| Winter wren | Troglodytes troglodytes | PO | PO | | | | | | X | | PO | PO | PO | |
| Bewick's wren | Thryomanes bewickii | PO | | | PO | X | X | X | X | X | X | PO | X | |
| Rock wren | Salpinctes obsoletus | | | | | | | | | | | | PO | |
| Mockingbird | Mimus polyglottos | | PO | PO | PO | PO | PO | PO | | | | | PO | |
| California thrasher | Toxostoma redivivum | | | | PO | X | X | X | X | | PO | | PO | |
| American robin | Turdus migratorius | X | X | X | | X | X | X | X | | X | X | X | X |
| Varied thrush | Ixoreus naevius | PO | | | | | X | | | PO | PO | X | PO | |
| Hermit thrush | Catharus guttatus | | | | PO | X | X | X | X | | X | X | X | |
| Swainson's thrush | Catharus ustulatus | | | | | X | | | PO | | PO | PO | PO | |
| Western bluebird | Sialia mexicana | X | X | X | | X | X | X | | X | X | X | PO | X |
| Blue-gray gnatcatcher | Polioptila caerulea | X | PO | | PO | PO | X | X | X | | PO | | | X |
| Golden-crowned kinglet | Regulus satrapa | PO | PO | | | | X | | PO | | X | X | PO | |
| Ruby-crowned kinglet | Regulus calendula | X | PO | | | X | X | | X | PO | X | X | PO | |
| Water pipit | Anthus spinoletta | | | PO | | X | | | | | | | PO | PO |
| Cedar waxwing | Bombycilla cedrorum | PO | X | | | | PO | | X | | X | PO | PO | |
| Loggerhead shrike | Lanius ludovicianus | | | PO | | PO | | | | | | | | PO |
| Starling | Sturnus vulgaris | | X | X | | | | | | | | | X | X |
| Hutton's vireo | Vireo huttoni | X | PO | | | | PO | | X | | X | X | X | |
| Solitary vireo | Vireo solitarius | X | PO | | | | | | X | | X | X | X | X |
| Warbling vireo | Vireo gilvus | X | X | | | | | | | | X | X | X | |
| Orange-crowned warbler | Vermivora celata | X | X | | PO | PO | X | PO | X | | X | X | PO | X |
| Nashville warbler | Vermivora ruficapilla | X | PO | | | | | | X | | X | X | PO | |
| Yellow warbler | Dendroica petechia | PO | | | | | | | | | X | | X | |

| | | Mixed Ever-green | Oak Wood-land | Oak Savan-nah | Chamise Chap-arral | Mixed Chap-arral | Montane Chap-arral | Serpen-tine Chap-arral | Knob-cone Pine | Cypress Forest | Yellow Pine | Mixed Coni-ferous | Ripar-ian | Meadow |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BIRDS: - contd. | | | | | | | | | | | | | | |
| Yellow-rumped warbler | Dendroica coronata | X | PO | | | | X | | X | PO | X | X | X | X |
| Black-throated gray warbler | Dendroica nigrescens | X | PO | PO | PO | PO | X | X | X | X | X | X | X | X |
| Hermit warbler | Dendroica occidentalis | | | | | | | X | X | | X | X | | |
| Townsend's warbler | Dendroica townsendi | PO | PO | | | | | | X | | X | X | PO | |
| MacGillivray's warbler | Oporonis tolmiei | PO | PO | | PO | PO | PO | PO | | | X | | X | |
| Common yellow throat | Geothylpis trichas | | | | | | | | | | X | X | X | |
| Yellow-breasted chat | Icteria virens | PO | | | | | | | | | | | X | |
| Wilson's warbler | Wilsonia pusilla | | | | | | X | | X | | X | X | X | |
| House sparrow | Passer domesticus | | | | | | | | | | X | | | |
| Western meadowlark | Sturnella neglecta | | | X | | X | | X | | | | | | X |
| Red-winged blackbird | Agelaius phoeniceus | | X | X | | | | | | | | | PO | X |
| Tri-colored blackbird | Agelaius tricolor | | | PO | | | | | | | | | PO | |
| Northern oriole | Icterus galbula | X | PO | X | | | | | X | | X | | X | |
| Brewer's blackbird | Euphagus cyanocephalus | X | X | X | | | | | X | | X | X | X | X |
| Brown-headed cowbird | Molothrus ater | X | | PO | | | | | X | | X | | X | X |
| Western tanager | Piranga ludoviciana | X | | X | | | X | | X | | X | X | PO | X |
| Black-headed grosbeak | Pheucticus melanocephalus | | X | X | | X | X | | X | | X | X | X | |
| Lazuli bunting | Passerina amoena | | | PO | PO | X | PO | PO | | | | | X | X |
| Purple finch | Carpodacus purpureus | X | PO | | | X | X | X | X | | X | X | X | X |
| House finch | Carpodacus mexicanus | | PO | X | PO | PO | PO | X | | | | | X | |
| Pine siskin | Cardyelis pinus | PO | | PO | | | X | | X | | X | X | PO | |
| American goldfinch | Cardyelis tristis | | | PO | | | X | X | | | | | PO | X |
| Lesser goldfinch | Cardyelis psaltria | | PO | X | PO | X | PO | X | X | X | X | X | X | X |
| Red crossbill | Loxia curvirostra | PO | | | | | | | PO | | PO | | | |
| Rufous-sided towhee | Pipilo erythrophthalmus | X | | | PO | X | X | X | X | X | X | X | X | X |
| Brown towhee | Pipilo fuscus | X | PO | X | X | X | PO | X | | | X | | X | X |
| Savannah sparrow | Passerculus sandwichensis | | | | PO | | | | | | | | | PO |
| Lark sparrow | Chondestes grammacus | | | X | PO | X | PO | PO | | | | | | X |
| Rufous-crowned sparrow | Aimophila ruficeps | | | | PO | X | PO | PO | | | | | | |
| Sage sparrow | Amphispiza belli | | | | PO | X | PO | X | | | | | | |
| Dark-eyed junco | Junco hyemalis | X | X | X | PO | X | X | X | X | X | X | X | X | X |
| Chipping sparrow | Spizella passerina | X | PO | PO | | | | | PO | | X | X | | X |
| White-crowned sparrow | Zonotrichia leucophrys | X | PO | PO | PO | X | PO | PO | PO | | X | X | PO | PO |
| Golden-crowned sparrow | Zonotrichia atricapilla | X | PO | PO | PO | X | PO | PO | PO | | X | X | PO | PO |
| White-throated sparrow | Zonotrichia albicollis | | | | PO | PO | PO | PO | | | | | | |
| Fox sparrow | Passerella iliaca | PO | | | PO | PO | X | PO | PO | | | | PO | |
| Lincoln's sparrow | Melospiza lincolnii | PO | | | | | | | | | PO | | PO | |
| Song sparrow | Melospiza melodia | X | | X | | | | | X | | | PO | X | |

| | | Mixed Ever-green | Oak Wood-land | Oak Savan-nah | Chamise Chap-arral | Mixed Chap-arral | Montane Chap-arral | Serpen-tine Chap-arral | Knob-cone Pine | Cypress Forest | Yellow Pine | Mixed Coni-ferous | Ripar-ian | Meadow |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **REPTILES:** | | | | | | | | | | | | | | |
| Sagebrush lizard | Sceloporus graciosus | X | PO | X | X | X | PO | PO | X | X | X | X | X | X |
| Western fence lizard | Sceloporus occidentalis | X | X | X | X | PO | PO | PO | PO | X | | X | X | |
| Western skink | Eumeces skiltonianus | PO | PO | PO | | | | | | | X | PO | PO | |
| Western whiptail | Cnemidophorus tigris | | | | X | PO | PO | PO | PO | | PO | PO | | |
| Northern alligator lizard | Gerrhonotus coeruleus | PO | PO | | | | | | PO | | PO | PO | | |
| Southern alligator lizard | Gerrhonotus multicarinatus | X | X | X | X | PO | PO | PO | X | | X | X | | |
| Rubber boa | Charina bottae | PO | X | | | | | | | | | | X | PO |
| Racer | Coluber constrictor | X | X | X | PO | PO | PO | PO | | | X | X | X | X |
| Sharp-tailed snake | Contia tenuis | PO | PO | PO | | | | | | | | | PO | |
| Ringneck snake | Diadophis punctatus | X | X | PO | PO | PO | PO | PO | | | | | | PO |
| Coachwhip | Masticophis flagellum | | | | PO | PO | PO | PO | | | | | PO | |
| Common kingsnake | Lampropeltis getulus | | X | X | X | PO | PO | PO | PO | PO | PO | PO | X | PO |
| Long-nosed snake | Rhinocheilus lecontei | | | | PO | PO | PO | PO | | | | | | |
| California mountain kingsnake | Lampropeltis zonata | PO | PO | | | | | | | | PO | PO | X | |
| Striped racer | Masticophis lateralis | | PO | | PO | PO | PO | PO | | | | | | |
| Gopher snake | Pituophis melanoleucus | | X | X | X | X | PO | PO | X | PO | X | PO | PO | X |
| Common gopher snake | Thamnophis sirtalis | | | | | | | | | | | | X | PO |
| Western terrestrial garter snake | Thamnophis elegans | | X | X | PO | PO | PO | X | | | X | X | PO | X |
| Western aquatic garter snake | Thamnophis couchi | | X | X | | | | | | | | | X | |
| Western rattlesnake | Crotalus viridis | X | X | X | X | X | PO | X | PO | PO | PO | X | X | X |
| Western pond turtle | Clemmys marmorata | | | | | | | | | | | | X | |
| **AMPHIBIANS:** | | | | | | | | | | | | | | |
| Pacific giant salamander | Dicamptodon ensatus | X | X | | | | | | | | X | | X | |
| Rouht-skinned newt | Taricha granulosa | X | X | | | | | | | | | | X | |
| California newt | Taricha torosa | X | X | | | | | | | | | | X | |
| Red-bellied newt | Taricha rivularis | X | X | | | | | | | | | | X | |
| Ensatina | Ensatina eschscholtzi | PO | PO | | | | | | | | | | PO | |
| California slender salamander | Batrachoseps attenuatus | PO | X | X | | | | | PO | | PO | | PO | |

| | | Mixed Ever-green | Oak Wood-land | Oak Savan-nah | Chamise Chap-arral | Mixed Chap-arral | Montane Chap-arral | Serpen-tine Chap-arral | Knob-cone Pine | Cypress Forest | Yellow Pine | Mixed Coni-ferous | Ripar-ian | Meadow |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AMPHIBIANS: | | | | | | | | | | | | | | |
| Arboreal salamander | Aneides lugubris | PO | PO | | | | | | | | | | | |
| Black salamander | Aneides flavipunctatus | PO | PO | | | | | | PO | | PO | | | |
| Western toad | Bufo boreas | | | PO | | | | | | | | X | PO | |
| Pacific tree frog | Hyla regilla | PO | PO | PO | | | | | PO | | PO | X | X | |
| Bullfrog | Rana catesbeiana | | | | | | | | | | | | X | |
| Red-legged frog | Rana aurora | | | | | | | | | | | | X | |
| Foothill yellow-legged frog | Rana boylei | | | | | | | | | | | | X | |

X - Known Occurrence (Sightings)
PO - Probable Occurrence (From Other Reports)

Source: Meneghin, et al., 1978.

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Appendix D

# LISTING OF POLLUTION INCIDENTS AT THE GEYSERS GEOTHERMAL FIELD

# LISTING OF POLLUTION INCIDENTS
# AT THE
# GEYSERS GEOTHERMAL FIELD

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| 11/3/65 | Discharge of power generation wastewater into Big Sulphur Creek. |
| 11/28/67 | Siltation into Big Sulphur Creek from road building activities. |
| 1/4/68 | Unusual milky/soapy substance causing turbidity in Big Sulphur Creek from confluence with Squaw Creek to within ¼ mile of Russian River. |
| 1/5-6/68 | Drilling muds from Geothermal Resources Rorabaugh #2 found spilling into Big Sulphur Creek. Samples of "Magcogel" and "Magcobar Foam #44" obtained. Bioassays indicated Magcobar 44 toxic to trout at concentration of 10 ppm. |
| 1/11/68 | Sumps for GRI wells Rorabaugh #2 and #3 filled, earthen dams soft. Investigators felt they presented a threat to Big Sulphur if rains continued. |
| 10/2/68 | Reduction of fish food organisms and spawning gravels in area of Union Oil road construction (PG&E Units 3 & 4) (possible violation of Fish and Game Code Section 5650). |
| 10/31/68 | Silt and rock introducted to Big Sulphur as a result of road building. |
| 11/13/68 | Steelhead trout population downstream from Union Oil Company road reduced to ¼ that of July 16, 1968 levels. |
| 9/10/71 | 20,000 gallons of cooling tower wastewater and debris discharged to Big Sulphur Creek after pipeline faulure in Union Oil wastewater disposal system. Low-flow condition present in Big Sulphur Creek. |
| 7/6/72 | Drilling muds and waste materials discharged to Big Sulphur Creek when an earthen sump at a Union Oil drill site (Hoover Rig E2) broke. Test conducted with drilling mud samples (bantonite clay, tannithin and lignite) indicated these materials can be toxic to fishlife. |
| 4/19/73 | Drilling muds and waste materials discharged to Squaw Creek as a result of a leaking sump at Union Oil drill site (ottoboni #10). Seeps of drilling waste materials continued until 23 of April. |
| 7/17/73 | Discharge of cooling tower condensate reported and verified by DFG wildlife protection personnel. |

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| 10/73 | RWQCB cleanup on Abatement Order No. 73-101 for Geothermal Kinetics, Inc. Rorabaugh #1 Well. Discharge of sump wastes in tributary to Big Sulphur Creek. |
| 10/73 | RWQCB and Abatement Order No. 73-102 for Pacific Energy Corp. Well No. 47. Discharge of drilling wastes to surface of dirt roads will probably result in discharge to Big Sulphur Creek. |
| 12/11/73 | Letter from RWQCB informing PG&E power plant supervisor of (1) sandblasting materials being discharged at power plants #1 and #2. These materials could pass into the waters of Big Sulphur Creek. (2) Trash and garbage dump located at power plants 9 and 10 which had not been approved by the RWQCB. (ref: 12,11,1973 letter to W. Pearce, PG&E plant superintendent from D. Snetsinger RWQCB. RWQCB files). |
| 12/21/73 | Recommendations from State WRCB regarding soil erosion and waste disposal at The Geysers state that: "The commonly expedient methods used in pit or sump construction disallows for proper design considerations against potential slope failure and/or the prevention of fluid infiltration into subsurface materials. Percolation of fluids through bedrock fractures could affect the quality of local waters and promote instability of natural or man-made slopes." (ref: 12,21, 1973 Memorandum to Bob Tancreto, California Regional WQCB, Santa Rosa from State WRCB Geologist Gil Torres. RWQCB files). |
| 2/5/74 | Division of Oil and Gas notice of violation regarding unstable and overflowing sump for Union Oil Co. Well No. GDC 20-29. |
| 2/5/74 | Division of Oil and Gas notice of violation regarding unstable, washed out and eroded sump, natural springs draining at base for Union Oil Co. Well No. LF State 4597. |
| 5/74 | Approximately 2,000 gallons of water from the cooling tower basin and 50,000 to 70,000 gallons from the sediment basin emergency overflow drainage system of power plant Unit 5 & 6 discharged to the ground. Inspection of the plants also found oily discharges from stand pipes as a result of numerous spills from a waste oil and oil storage area. (ref: memorandum 5/28/74 to Tancreto, PG&E from D. Salisbury; 6/3/74 letter to BenKor CRWQCB, Santa Rosa from W. Pearce, PG&E. RWQCB files). |
| 5/15/74 | Condensate line from Unit 7 & 8 pond to Unit 11 broke at the drill rig water tie-in point. The tie-in weld broke, releasing condensate at the rate of 465 gpm. The total discharge was estimated at 28,000 gallons. There was a noticeable increase in turbidity in Squaw Creek noted. Parametrix personnel reported electroshocking data show fish to be healthy and active (?) (ref: Union 76 letter 5/22/74 to CRWQCB, Santa Rosa, attn: John Hannum). |

6/3/74 50,000 to 75,000 gallons of steam condensate spilled from a ruptured pipe at PG&E plant #7. Water from this spill reached Squaw Creek. The spill was reported approximately two months after it happened. (ref: Letter 6/3/74 to CRWQCB from W. Pearce. CRWQCB files).

7/8/74 Spill of detergents into Squaw Creek from Union Oil Co. drilling rig wash water. Tests indicated that the material was toxic to fish.

8/20/74 A discharge of condensate water occurred at cooling tower #2. The water contained approximately 14 mg/1 of iron in addition to the normal constituents found in the condensate. The high iron concentration was the result of an experiment by PG&E. The discharge reached Big Sulphur Creek and resulted in a red discoloration that persisted for approximately one hour ( 10 ppm). (ref: memo (interoffice) to Bob Tancreto and Ben Kor from D. Snetsinger 8/21/74. (CRWQCB files).

9/9/74 Mechanical failure of the fiberglass disposal line from Unit 5 & 6 settling pond discharged 4,500 gallons of condensate into Big Sulphur Creek. A fish kill and excessive siltation was noted. (ref: Union 76 letter 9/19/74 to CRWQCB. CRWQCB files).

9/16/74 A unit 5 & 6 settling pond overflow on 9/15/74 discharged 45,000 gallons of condensate to Big Sulphur Creek. Improper procedures in water transfer blamed. No fish kill noted, however, parametrix noted a higher than average ammonia and sulfate level present in Big Sulphur Creek. (ref: same as above).

1/6/75 Approximately 50 gallons of No. 2 diesel oil was spilled during routine fueling operations at the Ottoboni state well no. 20. The diesel was contained within a berm built for that purpose. Heavy rains overflowed the berm and released the diesel to Squaw Creek. (ref: Union 76 letter explaining the delay in reporting the spill to CRWQCB 1/15/75. CRWQCB files).

2/25/75 A water spill @ Horner state well #1 in Lake Co. released approximately 8,000 gallons condensed steam which had been used for drilling water was pumped onto the ground by accident. The water percolated into the ground and there was no visable signs of contamination noted immediately after the accident. Mr. Pardini noted suds in High Valley Creek. (ref: Union 76 letter 3/17/75 to CRWQCB, attn: J. Robertson, RWQCB files).

3/31/75 Blow-out of Union Oil Co. Well No. GDC 65-28. Hillsides near well covered with greenish dust which washed into stream tributary to Big Sulphur Creek.

4/9/75 Construction efforts to control blow-out of Union Oil Co. Well No. GDC 65-28 result in high turbidity and sedimentation of Big Sulphur Creek and tributary (reportedly a continuing problem).

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| 5/9/75 | Discharge of cooling tower water from PG&E Unit #11 into Squaw Creek. |
| 6/4/75 | A flange broke at Unit 11 spilling an estimated 20,000 gallons of condensate to the ground. Of the amount spilled, most was contained in a basin but 10% was reported to have reached Squaw Creek. The flange is of the same type as installed at other units. (ref: PG&E letter 6/4/75 to CRWQCB, attn: Mr. Snetsinger; Inter-office memo 6/5/75 to B. Tancreto, B. Kor, and D. Snetsinger from D. Salisbury. CRWQCB files). |
| 6/6/75 | A spill of 10,000 gallons from Unit 3 consisted of steam condensate and water from a tributary of Big Sulphur Creek. A vitrified clay pipe broke, and drained the water ½ mile down the hill carrying mud into the creek. Duration of the spill was approximately 4 hours. The clay pipe is being replaced with glass lined carbon steel pipe. (ref: PG&E letter 6/10/75 to CRWQCB, attn. Mr. Snetsinger. CRWQCB files). |
| 8/6/75 | Discharge of material from Shell Oil Company Well U.S. Geothermal One-1 on Federal lease, Lake County, Sec. 1, T10N, R8W, MDB&M. Grey material discharged from well covered approximately 3-4 acres, coating ground surface; shrubs, and trees. Portion entered intermittent tributary to Dry Creek. |
| 9/5/75 | Water was discharged from a Unit 10 cooling tower header pipe flange to the ground. The flange broke during a Unit 10 shutdown releasing 148,500 gallons of steam condensate in 4 minutes. The spill ran down ¼ mile of hillside to Cobb Creek and eventually to Big Sulphur Creek. There was no visible damage to fishlife or excess siltation in Big Sulphur Creek noted. (ref. PG&E letter 9/10/75 to CRWQCB, attn: Mr. Snetsinger. CRWQCB files). |
| 12/75 | Spill of drilling mud from PEC well near Eagle Rock Mine. Mud return line broke and discharged to tributary to Big Sulphur Creek. |
| 3/16/76 | Condensate pipeline failure at Unit 2 power plant, resulting in discharge of 4,260 gallons. The pipeline was of rebar reinforced concrete and had been badly corroded by the condensate. No extensive fish kill was observed in the stream below the discharge site. |
| 5/26/76 | Spill of 4,000 gallons of steam condensate at Unit 11, with a discharge to Squaw Creek. Spill caused by failure of a check valve in the condensate return line to an injection well. A total of 54 dead steelhead trout were found in a stream section of 200 yards below the discharge. |
| 3/28/77 | Single vehicle accident involving Shell Oil Company truck delivering fuel oil to McCulloch Oil Company Geothermal rig near Glenbrook, Lake County. About 2,000 gallons of fuel oil was discharged with approximately 50 gallons entering Alder Creek. Four dead fish observed in lower Alder Creek. |

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| 4/6/77 | Spill of 2,500 gallons of steam condensate at PG&E Geysers Unit 8. Excessive pumping of sediment pond caused low water levels, activated automatic valve which prevented usual discharge. The high water level alarm of the cooling tower basin was inoperative, which resulted in an overflow of the basin of about 250 gal/min for 10 minutes. The condensate discharged into Upper Geyser Canyon Creek, but apparently did not reach Big Sulphur Creek. The condensate soaked into ground which was dry as a result of drought conditions. |
| 4/18/77 | Failure of cut slope during Union Oil 1Co. road construction resulted in slide of soil, rocks, and debris entering Big Sulphur Creek above Unit 1 & 2. Road was being improved for access to Unit 14. Substation pool area filled, and siltation of stream. Stream was highly turbid when inspected on May 2, due to runoff from recent storm. |
| 4/19/77 | Spill of 25,500 gallons of condensate at Geysers Power Plant Unit 11. Water was discharged from the cooling tower into Squaw Creek. The cooling tower basin was being filled unattended during the night and the overflow alarm did not provide sufficient warning. Duration of the spill was approximately 45 minutes. |
| 5/6/77 | Large landslide at site of construction of Geysers Power Plant Unit 14. Slide occurred in cut slope for cooling tower basin. Site was not as stable as had been believed. A portion of the slide entered an adjacent tributary to Big Sulphur Creek, depositing soil, rocks, debris, and trees and shrubs filled by the slide. |
| 5/16/77 | Spill of 3,750 gallons of condensate from Geysers Unit 1 & 2 into Big Sulphur Creek. Discharge resulted from a blockage in the condensate line between the cooling tower basin and the sedimentation basin. The spill was probably related to recently-installed fine mesh screen strainers. |
| 6/2/77 | Discharge of 250,000 gallons of condensate from Unit 8 to Big Sulphur and Squaw Creeks, streams turbid and heavily sedimented below discharge sites. No fish kill observed, however, population sampling revealed a lack of young-of-the-year resident rainbow trout in Squaw Creek below discharge site. Young fish were found here in the previous year's survey and in the area above the discharge point. |
| 6/28/77 | Spill of 850 gallons condensate at Unit 9. Rupture in fire water system, did not reach Cobb Creek below the site. |
| 1/78 | Landslide at Unit 14 site into tributary of Big Sulphur Creek. Landslide at Geyser Canyon, tributary of Big Sulphur Creek. Landslide at Unit 14 supply well, entered Big Sulphur Creek. Sedimentation and turbidity. |

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| 1/18/78 | Improvement of road from Unit 14 site, through Little Geysers Area, to Unit 9 and 10. Replacement of culvert crossing at Little Geysers Creek. Repair of numerous failures of cut slopes along roadways. Big Sulphur Creek highly turbid below Little Geyser Creek, clear above. |
| 1/21/78 | Spill of 500 gallons acid ferrous sulfate into Lee Creek, Lake County. Result of tanker vehicle accident. Substance is used in $H_2S$ abatement process. Salamanders killed in Lee Creek. |
| 2/28/78 | Spill of 50,000 gallons condensate at Unit 8. Tekite pipe containing condensate from cooling tower basin ruptured. Discharged to Geyser Canyon, thence Big Sulphur Creek. Turbidities increased, no fish kill observed. |
| 3/10/78 | Overflow pipe observed discharging petroleum/water mixture to tributary, Lake County. Aminoil Co. drilling site near PG&E's Unit 13. Reported by J. Henno, Central Valley Regional Water Quality Control Board, Sacramento. Foreman on site requested to discontinue discharge. |
| 4/11/78 | Spill of 100,000 gallon condensate at Unit 8. Same cause as spill of 2/28. No fish kill reported. |
| 5/1/78 | Discharge 2,000 gallon condensate at Unit 1 for 5 minute period. 1,000 gallons entered Big Sulphur Creek. |
| 5/28/78 | Spill of 200 gallon condensate to Big Sulphur Creek from Unit 1 over a 6 minute period, no assessment of stream. |
| 6/1/78 | At 0640 spray jets at Unit 5 and 6 cooling tower plugged, and the condensate discharged into the area around the tower in a heavy rain. The discharge continued for one hour and an estimated 10 gal/min (600 gal) collected as runoff and entered Big Sulphur Creek. Stream inspected on 6/2 by Steve Miller, PG&E; no fish kill noted. |
| 6/25/78 | At 0700 discharge 3,000 gallon condensate to Big Sulphur Creek. No dead fish. Water samples taken by PG&E. |
| 7/11/78 | Spill of 14,000 gallon condensate from pipe rupture at Unit 7 and 8. Spill contained on site or soaked into ground near site. |
| 1/3/79 | Spill of 130,000 gallon condensate from Unit 7 into Squaw Creek, little rain to date, stream at low flow conditions. High turbidity and heavy siltation occurred; just prior to steelhead spawning period. |
| 2/1/79 | Spill of 15 gallon caustic soda to Big Sulphur Creek. Raised pH from 7.7 to 8.2. No damage to aquatic life noted by PG&E personnel. |

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| 5/8/79 | Spill at PG&E Unit 12. Steam condensate discharged into Cobb Creek at 0800 for 20 min. Union Oil closed off too many valves on sediment pond system causing backup and overflow. Alarms at plant site and Unit 5, 6 failed to sound, but will be corrected. Water samples were being taken in Cobb Creek and a report will be sent to NCRWQCB. Phone call from Glen Horton, PG&E. |
| 6/19/79 | Discharge of 400 gallons condensate at Unit 4. Stream examined 2 hours after spill; no evidence of loss of aquatic life. |
| 7/16/79 | Unit 3 discharged 60,000 gallons condensate to Big Sulphur Creek at 1:55 a.m. |
| 7/16/79 | Spill of condensate from pipeline from Units 5, 6, to Thermal 8 at 7:00 a.m. |
| 7/16/79 | Overflow of 1,000 gallons non-sulfide sludge from sump below Unit 11 at 9:30 p.m. No sludge reached stream. |
| 10/79 | Extensive fish kill in Big Sulphur Creek. Cause undetermined. |
| 11/28/79 | Discharge from sump by Aminoil, Anderson Creek, Lake County. Memorandum of 12/11/79 by J.L. Pearson, CVRWQCB. |
| 1/9/80 | Discharge by sump Neashon No. 1, Republic Geothermal, Lake County. Memo of 1/23/80 by E.E. Crawford, CVRWQCB. |
| 6/80 | Tributary from PGandE Unit 13 found to be contributing silt and turbidity to Anderson Creek, Lake County. Revegetation and restoration of sedimentation basin planned by PGandE and Aminoil. Memo of 7/18/80 by E.E. Crawford, CVRWQCB. |
| 12/11/80 | Discharge of drilling mud from Thermogenics, Inc. sump RA-13 in Sonoma County to roads and drill pads in violation of waste discharge requirements. Memo dated 12-12-80 by B.D. Kor, NCRWQCB. |

SOURCE: California Department of Fish and Game, Region III, Yountville, CA.