A STUDY OF THE HEALTH STATUS OF A POPULATION EXPOSED TO LOW LEVELS OF HYDROGEN SULFIDE (AND OTHER GEOTHERMAL EFFLUENTS) IN PUNA, HAWAII

A PRELIMINARY REPORT

A Collaborative Study by Agencies of the

STATE OF HAWAII

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Advisory Panel and Review Committee

The Director of Health appointed a committee (to act as as advisory panel and review committee) to conduct a long-term study of the effects of hydrogen sulfide and certain other air pollutants on human health, pursuant to House Resolution 253 (H.R. 253, H.D. 2), passed during the regular session of the 1983 Legislature. This study has been conducted, in part, to fulfill this legislative request.

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SUMMARY AND CONCLUSIONS

The Kilauea East Rift Zone on the Island of Hawaii is one of the most promising areas for geothermal energy development in Hawaii. Since the drilling of the first successful geothermal wells in 1976, residents in the area have raised concerns that hydrogen sulfide (H_2S) released into the atmosphere from geothermal wells may be adversely affecting their health. The emission of H_2S gas is currently considered to be the most important public health problem related to the utilization of geothermal energy. Although H_2S is unquestionably a toxic gas at high concentrations, experts disagree on the lowest levels at which adverse health effects may occur; very little is known about health effects that may be related to long-term, low-level exposure.

In February 1984, the State Department of Health (DOH) conducted a door-to-door health interview survey of a residential community, Leilani Estates, located near a two megawatt geothermal power plant in the Puna District. The primary purposes of this survey were to establish the health status of this community and to compare the health status of this community to another community in Puna, Hawaiian Beaches Estates, and to other areas of Hawaii. Ambient H_2S air monitoring data from three monitoring stations in Leilani Estates and a station recently established in Hawaiian Beaches Estates was supplied by the Hawaii Geothermal Project.

The health survey utilized a form adapted from the National Health Survey, National Center for Health Statistics, and consists of both demographic and health-oriented questions. This form is used by the Hawaii Health Survellance Program (HSP), DOH, for the on-going, state-wide Hawaii Health Survey. This allowed for the comparison of the prevalence of reported health conditions in Leilani Estates to the State as a whole and Hawaii County. A supplemental questionnaire form was also administered to gather more detailed information on chronic respiratory conditions and to determine the perception of nuissances (i.e., noise and odor) perceived by residents in Leilani Estates to be associated with geothermal development.

Interviews were administered by HSP to 135 (88.8%) of the 152 eligible households in Leilani Estates, representing a total of 350 individuals who live in the area. The rates of all acute and chronic health conditions reported in Leilani Estates were found to be similar to Hawaiian Beaches Estates with the exception of the "common cold," which was substantially higher in Leilani Estates in January 1984. There were no statistically significant differences in other measures of disability in terms of "bed days" due to chronic conditions and "activity limitation days over the past month" between these two communities.

Perhaps most noteworthy, the rates of chronic respiratory conditions including "bronchitis/emphysema," "asthma," "hayfever," "sinusitis" and "other respiratory system disease" were found to be similar in Leilani Estates and Hawaiian Beaches Estates from January 1983 - January 1984. These conditions have been most often associated with long-term exposure to air pollutants.

However, the prevalence rates of a number of acute and chronic health conditions in these study areas were higher than Hawaii County and Hawaii statewide rates reported for 1983, including all chronic respiratory conditions. These differences may be due in part to expected seasonal fluctuation in disease prevalence, differing demographic features that may affect disease prevalence and reporting, and/or other environmental factors (e.g., exposure to pollens or fungi) may be involved and are discussed.

Results of air monitoring from three monitoring stations in Leilani Estates during the period extending from January 1983 - January 1984 indicated hydrogen sulfide (H_2S) levels ranged from below the reliable detection limit (5 ppb) to 11 ppb, based on one-hour averages. Average one-hour levels of H_2S in Hawaiian Beaches never exceeded the detection limit. Subsequent air monitoring results have indicated that ambient H_2S levels in Leilani Estates may be higher during open, unabated venting of effluent from nearby geothermal wells. Due to venting from natural volcanic fumaroles in the area, the contribution of H_2S from geothermal wells was difficult to assess accurately.

It could not be determined that H_2S produced as a result of geothermal development in the area was responsible for any of the health conditions reported in Leilani Estates. Further studies are required to determine what factors account for the relatively high rates of chronic respiratory conditions reported in the areas surveyed in Puna when compared to average State-wide and County-wide rates. Recommendations are included in this report with regard to the utility of conducting further surveys to address community concerns of adverse health effects associated with geothermal development in Hawaii.

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INTRODUCTION

Background

The Kilauea East Rift Zone on the Island of Hawaii is one of the most promising areas for geothermal energy production in Hawaii (Figure 1). Drilling of the first successful geothermal well in this area was completed in April 1976. This well was named the Hawaii Geothermal Well-A (HGP-A) and is located near the town of Pahoa in the Puna District. In July 1981, the first electrical power was generated from an experimental power plant at the HGP-A wellhead. Since then, several privately financed geothermal exploration projects have begun in the area.

The emission of hydrogen sulfide (H_2S) gas is currently considered to be the most important public health problem related to the utilization of geothermal energy. H_2S is very toxic at high levels and has been the cause of severe disability and death. It is heavier than air; therefore, it may accumulate to toxic levels in low-lying areas under adverse meteorologic conditions (e.g., in basin areas with inversions or when prevailing trade winds are calm). Serious occupational and community exposures to H_2S may occur under these conditions (Milby and Spear, 1979). H_2S has a distinctive "rotten egg" smell that can be readily detected at extremely low levels. The median level for odor detection is 0.005 ppm. Therefore, its presence at levels far below those which eye irritation can be readily detected.

Residents in Puna have expressed considerable concern that hydrogen sulfide (H_2S) and other effluents released by the HGP-A well and other geothermal development projects may adversely affect their health and quality of life. Little concern was publicly voiced about H_2S and other potentially toxic gases naturally vented in the area prior to the drilling of these wells. Indeed, possible health effects of emissions from Hawaiian volcanoes have not been adequately studied.

The Kilauea East Rift Zone is a volcanically active area where natural emissions of hydrogen sulfide, steam, sulfur dioxide, and other gases vary but occur continually. All proposed utilization schemes for geothermal energy result in releases to the atmosphere of gases that do not condense during the extraction process. These non-condensed gases may include, in addition to hydrogen sulfide, large amounts of carbon dioxide, ammonia, and trace amounts of substances such as Radon 222 and mercury (Anspaugh and Hahn, 1980).

Mercury emissions in geothermal areas have been implicated as a potential environmental health hazard (Seigel and Seigel, 1975). Mercury has been shown to be present in a wide variety of natural thermal fluids, from geothermal well effluents in California (Crecelius et al., 1976; Robertson et al., 1977) and from volcanic emissions in Hawaii (Seigel and Seigel, 1980). However, mercury has not been detected at the wellhead of the HGP-A power plant (Thomas, 1984). In California, mercury emissions from geothermal power plants have been found to be roughly comparable to those from coal-fired power plants, on a per megawatt basis (Robertson et al., 1977). Thus, the relative risk posed by the contibution of mercury to the atmosphere from geothermal development activities in Hawaii in volcanically active areas may have been overstated.

Unfortunately, there is no practical means of controlling volcanic emissions from natural vents in the area. Volcanic venting during eruptions of the Kilauea Rift Zone (Figure 1) have occurred frequently since January 1983. Vast amounts of sulfur dioxide and particulates are emitted into the ambient air in the area during eruption periods. Depending on prevailing wind conditions, these may accumulate to cause health problems for those with chronic respiratory conditions (e.g., asthma or emphysema). The State of Hawaii Department of Health (DOH) is currently investigating possible health effects that may be associated with volcanic emissions and promulgating regulations to control emissions from the development of geothermal resources.

Although H_2S is unquestionably a very toxic gas at high concentrations which can cause rapid death, experts disagree on levels that may begin to be associated with adverse health effects. The "problem" exists primarily because little is known about health effects related to long-term, low-level exposure. There are no Federal ambient air quality standards for H_2S and the State of Hawaii has not officially adopted a standard to date. Consequently, health officials find community concerns difficult to address at present.

Review of Health Effects Associated with Long-term Exposure To Low Levels of Hydrogen Sulfide

The health effects of H_2S are dependent upon the intensity and duration of exposure, and upon individual susceptibility. H_2S is readily absorbed through the lung but rapidly detoxified; thus, it is considered an acute-acting substance. Exposure to concentrations above 500 ppm results in respiratory distress and, above this level, respiratory paralysis may ensue. However, for those who survive a single high-level exposure, recovery is usually rapid and complete.

The acute effects of H_2S on populations exposed to levels above 50.0 ppm are delineated in Table 1. The levels and corresponding effects reported by various investigators agree surprisingly well in this range. In concentrations between 50 ppm and 500 ppm, H_2S acts primarily as an irritant to the membranes of the eyes and respiratory tract (Yant, 1939). Olfactory paralysis occurs at concentrations of 150 to 200 ppm and, consequently, its characteristic odor becomes unrecognizable at life-threatening levels (Yant, 1930).

The threshold level for serious eye damage is generally accepted to be between 90-100 ppm (Layton et al., 1981), although this depends on an investigator's definition of the word "serious." A condition called "gas eye," characterized by tearing, distorted vision and the illusion of rainbow colors around lights, is often associated with exposures ranging from 50-100 ppm (Yant, 1930). Eye irritation and decreased corneal pupillary reflex are associated with exposure at levels as low as 10.5 ppm (Elkins, 1939; Nesswetha, 1969; NIOSH, 1979; WHO, 1981). These effects have been reported to be associated with exposure to levels of H_2S as low as 1.0 ppm (Lewey, 1938; Rubin and Arieff, 1945) but then other toxic agents were present in addition to H_2S.

Eye irritation is the first and most commonly reported effect of H_2S exposure (WHO, 1981), but its effect as a pulmonary tract irritant is potentially more serious. At levels above 300 ppm, H_2S is known to cause pulmonary edema or pneumonitis (Haggard, 1925). The pulmonary edema and pneumonitis is thought to be due to a mechanism similar to acute respiratory distress syndrome (Gelb, et al., 1973; Staub, 1974) whereby H_2S damages the alveolar capillary membrane and causes leakage of protein-rich fluid into the alveolar space. The sequelae of this reaction may be fibrosis and permanent destruction of functioning alveoli. A devastating reaction is easy to detect, but subtle changes may occur.

Increased humidity may exaserbate the irritative effects of H_2S (Rubin and Arieff, 1945; IIEQ, 1974; USNRC, 1979). The degree of lung damage induced by high levels of H_2S is also reported to increase when humidity is high (Nyman, 1954; Suzman, 1936).

While it is relatively easy to detect catastrophic lung damage due to acute high-level exposure, it is much more difficult to assess subtle degrees of lung damage resulting from long-term or repeated low-level exposures. Researchers measure the effect of lung damage by assessing the ability of the lung to maintain diffusion of gases across the alveolar membranes. One commonly used diffusion test is "the single breath

method." Unfortunately, more than 30% of the lung must be damaged before diffusion loss is detectable using this test. A more sensitive test is needed to detect less severe lung damage.

Animal studies have revealed nervous system changes resulting from H_2S exposure (Duan, 1961). Recent research has indicated that rats exposed to levels of 45 ppm H_2S for 4-6 hours exhibited a significant ($P<.01$) reduction in the ability to inactivate viable staphylococci (pathogenic bacteria) in their lungs (Rogers and Ferin, 1981). It was hypothesized that this was due to an impairment of the alveolar macrophages which normally phagocytize these bacteria. This finding may help explain the development of secondary pneumonias in humans subsequent to acute high-level exposures. Of more importance, however, is the possibility that long-term exposure to lower levels may affect the intra-pulmonary antibacterial defense system in man, thereby favoring the establishment of pulmonary infections.

There is no good evidence in the published literature that H_2S in air is carcinogenic, mutagenic or teratogenic in man or animals (Yant, 1930; NIOSH, 1977; Andrew et al., 1980)). On the other hand, there have been no long-term controlled chronic epidemiologic studies of either community or occupational exposure (See Discussion).

Certain individuals or groups of individuals may be especially sensitive to H_2S (Ahlborg, 1951; Milby, 1962) although there is no good evidence of increased susceptibility in the literature. Those who may be at an increased risk of adverse health effects of H_2S include the aged, infants, and individuals with predisposing chronic respiratory disease. Poda (1966) found individuals who had recently consumed alcohol were especially sensitive. He also noted that individuals with neuro-psychiatric problems were at a greater risk with some evidence of worsening psychiatric or bizarre symptoms following exposure.

In keeping with the World Health Organization's definition of health, that is "a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity," it is appropriate to consider odor nuisance to be a possible health effect. Odor nuisance is the most well documented effect to be associated with community exposure to low levels of H_2S.

H_2S has a characteristic "rotten egg" odor detectable at levels far below those at which the first physiological health effects (i.e., conjunctivitis) have been reported (Table 1). The median threshold for odor perception is 0.005 parts per million (ppm) (Anspaugh and Hahn, 1980), although odor detection thresholds reportedly vary from 0.0005 to 0.03 ppm (and higher) in the literature (Yant, 1930; Ryazaonov, 1962; WHO, 1969). Ambient levels of hydrogen sulfide in Puna have been found to exceed 0.005 ppm on occasion without the contributions of man-made geothermal sources (NEA, 1984).

Although odor annoyance due to H_2S is the best documented adverse result of geothermal energy development, noise is another nuisance that has been associated with the development of geothermal resources. The normal procedures of drilling a well and of plant operations are

inherently noisy. In California, "venting" (discharge of steam to clear mud and debris from the wellbore) at wells at the Geysers Power Plant has produced noise levels as high as 120 dBA and caused complaints from nearby residents (Anspaugh and Hahn, 1980).

Since December 1975, the HGP-A well and other projects have received a total of approximately 40 complaints from residents in the Puna district concerning geothermal activities (DOH records). Most of these complaints, approximately 34 (87.5%), concern odor and/or noise only; recently, more have involved illnesses purported to be associated with the discharge of gaseous effluents. Symptoms noted in the complaints include headaches, sinus congestion, sore throats, and others including symptoms of mental disturbances and stress (DOH records).

Residents downwind of geothermal wells situated in "The Geysers" area (in Northern California) have also complained of headaches, nausea, sinus congestion, abrupt awakening, and other symptoms they associated with H_2S exposure (U.S. Dept. of Energy, 1980). It is difficult, at best, to evaluate quantitatively subjective symptoms of illness residents have associated with geothermal effluents. Obviously, a number of residents in the Puna area are concerned.

Purpose and Objectives

This study was designed to obtain data which may be helpful in addressing concerns of possible adverse health effects associated with geothermal development in Puna by assessing the health status of a population exposed to low levels of H^2S (and other effluents) from geothermal wells and natural sources.

More specifically, the purposes of this study were:

- To establish the health status of a community in Puna intermittently exposed to low levels of H_2S (and other geothermal effluents) by using a health interview survey.
- To compare the health status of this community to another community in Puna exposed to lower levels of H_2S and to other communities in Hawaii.
- To identify in that community those persons who may be at a high risk of illness due to exposure to H_2S (e.g., asthmatics and others with chronic respiratory impairments).

The study involved a door-to-door health interview survey of residents in two residential communities in Puna and ambient air monitoring for H_2S. A cross-sectional approach was determined to be most expedient in studying any possible long-term effects of living in an area subject to low levels of H_2S. Cross-sectional studies, however, do not lend themselves to showing direct cause-and-effect relationships because it is difficult to control for exposure to other potential environmental hazards that may affect disease rates.

The objective of the study was not to show a direct cause-and-effect relationship between exposure to H_2S and reported illness but rather to generate data that will be useful in determining whether or not a community exposed to low levels of H_2S (and other geothermal effluents) is experiencing an unusual amount of illness. However, the data collected may also be useful as baseline information if it is determined in the future that a long-term (prospective cohort) study is desirable to answer some of the questions which remain concerning possible health effects of long-term, low-level exposure to H_2S.

Two residential communities were selected for study: (1) "Leilani Estates," a community that is directly downwind of existing geothermal wells (on prevailing tradewind days); and (2) a portion of "Hawaiian Beaches Estates" as a control. Leilani Estates was selected because of its close proximity to the HGP-A well and history of complaints associated with geothermal development activities. Hawaiian Beaches Estates was selected as a control for comparison because of its location (normally, during prevailing tradewind days, upwind from existing geothermal wells) and, presumably, similar demographic characteristics.

Description of the Study Areas

Leilani Estates

Leilani Estates is located east of the town of Pahoa (Figure 2). The area was subdivided approximately 10 years ago into large residential lots ranging from 2 to 5 acres in size. With the exception of access roads, much of the area exists in a natural state, although it is not pristine (Figure 3A). Flora consists largely of native ohia lehua (Metrisiderous polymorpha) and false staghorn fern ("uluhe," in Hawaiian) (Dicranopteris emarginata) as the principle ground cover. The area is heavily infiltrated with guava, grasses, and other exotics.

Leilani Estates is sparsely populated. Houses or structures exist on only a small proportion of the available lots, although it may be anticipated that the population there will be growing rapidly as more people move to the area. A telephone survey conducted by SMS Research (1982) in 1982 to obtain basic demographic information in the Puna District indicated that the Puna population contains a large proportion of newcomers. In the survey sample, 32 percent had lived in the "Kapoho-Kalapana" area (which includes Leilani Estates) for two years or less; a cumulative 59 percent had lived there no more than five years; and only 3 percent had been in this area for twenty years or more (SMS, 1982).

Previous air monitoring data from Leilani Estates obtained by Environmental Analysis Laboratory, Inc. (provided by the Hawaii Geothermal Project) indicated H_2S levels ranged from below the reliable detection limit (0.001 ppm) to 0.048 ppm (averaged over one-hour); the mean level of H_2S in Leilani Estates for the period extending from January 1981 through December 1982 was less than 0.005 ppm (based on one-hour averages).

Hawaiian Beaches Estates

Hawaiian Beaches Estates is northeast of the town of Pahoa and approximately four miles northeast or normally upwind (on prevailing trade wind days) of the HGP-A well. Flora is similar to that found in Leilani Estates.

Hawaiian Beaches was subdivided before Leilani Estates and is, in that sense, a more established community. The lots are generally smaller and it is more densely populated. Otherwise, the results of the SMS (1982) survey indicated the area is similar demographically to Leilani Estates.

METHODS AND PROCEDURES

Health Interview Survey

A door-to-door health interview survey of residents of Leilani Estates and Hawaiian Beaches Estates was conducted by the Health Surveillance Program of the State of Hawaii Department of Health from February 6-17, 1984. The standardized Hawaii Health Interview Survey (HIS) form and a supplemental questionnaire form was administered to all residents who could be contacted in Leilani Estates and a selected area of Hawaiian Beaches Estates. A letter was delivered to all households in these areas prior to the door-to-door interview to inform residents of the the study and the impending interview (see Appendix A).

The Health Surveillance Program has been conducting interviews of randomly selected households throughout the State since 1969 using the same HIS form (with slight modifications). This makes it possible to compare the health status of a population in one place to another and from one year to another. It is an established survey instrument in Hawaii which is readily adaptable for investigative purposes.

The HIS form is adapted from the National Health Survey of the National Center for Health Statistics and consists of both demographic and health-oriented questions. The survey is conducted as a means of providing the DOH (and other agencies) with statistics for planning and evaluation of health services, and to investigate special problems.

The households interviewed in the ongoing statewide survey are selected systematically from a target population limited to non-institutional population. The interviews were administered by trained interviewers regularly employed by the Health Surveillance Program. Persons excluded from the sample are those living in military barracks, nursing homes or rest homes, prisons, dormitories, hospitals, and other institutions. Because of the exclusion of this group, the health characteristics of the non-institutionalized target population may not be exactly representative of the population of the State as a whole.

The survey was designed to ascertain incidence and prevalence of acute and chronic health conditions based on reports by the individuals surveyed. Information on the extent of disability associated with illness was also measured in terms of work loss days, school days lost, bed disability days, and other indices of disability.

A supplemental questionnaire form was developed specifically for this survey and was used to gather information on exposure and other factors that may, retrospectively, be important in evaluating individual illnesses reported. Included in this form were questions relating to the length of residence in the study area, more specific information on chronic respiratory conditions, family health history, occupational history, smoking history, and noise and odor associated with geothermal energy development (see Appendix A). This form was administered after the standard health interview survey so as not to bias the response to the standard survey. The questionnaire was pretested using State Department of Health personnel as subjects.

No attempt was made to confirm reports of illness by physical examination nor were individuals' medical records reviewed to verify statements. However, if individuals were uncertain about the nature of a condition, these conditions were defined by the interviewers. Data on "acute" conditions were collected for the month prior to the interview (January, 1984); data on "chronic" conditions were collected for the one-year period prior to the interview (February, 1983 to February, 1984).

Data collected on the health survey form was coded and transferred onto coding sheets. Thereafter, it was keypunched and edited for errors of range and logic. Analysis was facilitated by use of the IBM 370 computer at the State of Hawaii Computer Center.

Ambient Air Monitoring

Ambient air monitoring for H_2S in Leilani Estates has been conducted since 1981 and continued through the study period (January 1983 - January 1984). Data was obtained by Environmental Analysis Laboratory, Inc. (EAL), under contract to collect baseline monitoring data for the Hawaii Geothermal Project since 1981. The instruments used by EAL to monitor H_2S at various sites throughout this period are Houston-Atlas (lead acetate tape type) monitors which allow for continuous monitoring in the 0.001 to 0.100 ppm range. The accuracy of the instruments is conservatively estimated to be plus or minus approximately 0.002 ppm (Burkhart, 1984).

Three monitoring sites have been established in the Leilani Estates area, located near residences in the area. These monitors are designated "Schroeder," "Gilman," and "Hess" and named after residents in the area (Figure 2). A fourth monitor (the "Wood" station) has been located in a position so as to obtain background levels. The directions and distances of the monitoring stations from the HGP-A well site are: Schroeder, South-Southwest, 1.1 miles; Gilman, West-Southwest, 0.7 miles; Hess, Southwest, 1.3 miles; and Wood, North-Northeast, 1.6 miles. In January 1984, the "Hess" monitor was moved and installed at the "Bellow" residence in Hawaiian Beaches Estates for the purpose of monitoring H_2S in this area.

Meteorologic data, including temperature, wind direction and speed, relative humidity, precipitation, sigma theta and solar radiation were collected concurrently at Wood station. H_2S and meteorologic data was analyzed at the American Lung Association of Hawaii.

RESULTS

Health Interview Survey

Interviews were administered in 135 (88.8%) of the 152 eligible households in Leilani Estates, representing a total of 350 individuals in this area. Those not surveyed either refused or were away on extended trips and could not be contacted within the survey period. In Hawaiian Beaches Estates, interviews were administered in 179 (93.2%) of the 192 eligible households, representing a total of 604 persons in the area selected for study. Altogether, a total of 314 households were interviewed, representing a total of 954 individuals in these areas.

The prevalence rates of selected acute conditions reported in Leilani Estates in January 1983 (over a one-month period) are compared to those reported in Hawaiian Beaches Estates over the same period in Table 1. Although the rates of acute conditions differ in these communities, only the rates for the "common cold" were substantially higher in Leilani Estates during this period.

Table 2 shows the prevalence of selected chronic conditions reported by residents of Leilani Estates compared to Hawaiian Beaches Estates over the previous one-year period (January 1983 - January 1984). Chronic conditions are defined as those with a date of onset over three months prior to the interview and, thus, may include infective and parasitic diseases. The rate of reported "blood disorders (including anemia)" was higher in Leilani Estates, but the numbers are so small that it is difficult to attribute any significance to this difference.

Tables 4 shows the prevalence of selected acute conditions reported by residents of Leilani Estates in January, 1984, compared to Hawaii County and Hawaii statewide prevalence rates for 1983. Acute conditions are defined as those with a date of onset within three months prior to the interview.

Leilani Estates reported slightly higher rates of a number of acute conditions during this one-month period than Hawaii County and statewide in 1983, including the "common cold" and "other upper respiratory infections," "digestive system disorders," "diseases of the eye and ear," "non-allergic skin diseases," "musculo-skeletal conditions," and "other acute conditions" (includes nervousness, depression, debility, undue fatigue, and other general symptoms not otherwise classified). A slightly lower rate of "various infective and parasitic diseases" (excludes dysentery and diarrheal disease) was reported in Leilani Estates compared to county and statewide rates. Differences reported may be partially due to seasonal fluctuations in disease prevalence rates.

Table 5 shows the prevalence of selected chronic conditions reported by residents of Leilani Estates over a one-year period, January 1983 - January 1984, compared to Hawaii County and Hawaii statewide prevalence rates for 1983. Although residents of Leilani Estates report a higher prevalence of a number of chronic conditions, chronic respiratory conditions may be most directly related to the presence of potentially toxic air pollutants. These include "bronchitis/emphysema," "asthma," "hayfever," "sinusitis," and "other respiratory system disease." Chronic

bronchitis is defined as chronic productive cough throughout the year. Asthma is defined as having more than one spell of wheezing during this time. Hay fever is the designation for sneezing (or nose-itching) plus nasal discharge most days of the year. Chronic sinusitis refers to recurring symptoms of sinus pain and discharge. Persons with these conditions were placed in only one of the above categories.

Leilani Estates residents reported higher rates of all major respiratory conditions than were reported in Hawaii County or statewide in 1983. However, these rates are lower than those reported from Hawaiian Beaches Estates during the one-year study period. These findings point to environmental factors other than H_2S exposure per se as possibly contributing to these relatively high respiratory disease prevalence rates. For example, the presence of pollens or molds have been shown to be associated with asthma and hayfever (see Discussion).

Table 6 shows there were no substantial differences in the rates of selected chronic conditions between those who lived in Leilani Estates less than one year compared to those who lived there one year or more. If one were exposed to an environmental hazard which may have insidious (chronic) effects, one might expect a higher prevalence rate of chronic conditions among long-term residents. Apparently, this is not the case as those who have been living in Leilani Estates one year or more report practically identical rates of chronic conditions as those who have lived there less than one year.

Other indices of health in Leilani Estates compared to Hawaiian Beaches Estates are shown in Table 7 in terms of disability days due to chronic conditions (chronic conditions are listed in Tables 3, 5, and 6). No statistically significant differences ($p > .05$ by Chi-square analysis) in the number of "days spent in bed over the past year (1984)" were reported per 100 population. Of course, a tally of total days spent in bed is a very crude way of determining disability as a few individuals with severe or prolonged chronic disease may account for a large proportion of the total number of days spent in bed. Therefore, the contribution of these individuals may result in a total number of days spent in bed which does not represent the community as a whole. Also, days spent in bed due to "acute" conditions are not included.

Disability was also determined on the basis of "activity limitation days over the past month." Table 7 shows no statistically significant differences ($p > .05$ by Chi-square analysis) in activity limitation days over the past month (January, 1984)" per 100 population reported by residents in the two communities. This question was asked only of persons who reported having at least one chronic health condition during the twelve-month period prior to the month of interview (February, 1984). These people were asked to rate themselves in terms of their health according to a scale of 1 to 4. The scale was as follows: (1) not able to work at all; (2) able to work (or partake in major activity) but limited in type or amount of work; (3) able to work (or partake in major activity) but limited in type or amount of other activity; and (4) not limited in any way.

There were no statistically significant differences in age or sex distribution between the sample population in Leilani Estates and Hawaiian Beaches Estates ($p > .05$ by Chi-square analysis). However, there were statistically significant differences in other demographic variable including ethnicity, population movement, length of stay in Hawaii, education and income levels.

Ambient Air Monitoring

The results of ambient air monitoring for hydrogen sulfide in Leilani Estates for 1983 are included in Appendix B. The highest one-hour average level in the Leilani Estates area was 0.011 ppm (11 ppb) at the Gilman station for this one-year period. Values at the Wood station were occasionally higher but never exceeded a one-hour average of 13 ppb. The mean one-hour average for all four monitoring stations was below 2 ppb.

In Leilani Estates, the months of September, October, November, and December, had the greatest number of hours with concentrations greater than 5 ppb. A value of 5 ppb (0.005 ppm) was chosen as a reference point because it is currently accepted as the median level for odor perception (Anspaugh and Hahn, 1980). Altogether, the total number of hours with concentrations greater than 5 ppb for the Schoeder, Gilman and Hess stations were 14, 19, and 1 respectively. The Wood station, upwind from HGP-A under normal daytime wind conditions, reported a total of 117 hours in which H_2S levels exceeded the 5 ppb level.

H_2S levels were highest in the early afternoon hours (between 3:00 pm and 6:00 pm). A distinct difference in wind direction has been observed between the daytime and nighttime hours. The day winds blow mainly from the north or northeast and night winds are mainly westerly. The wind directions having the greatest number of hours with concentrations greater than 5 ppb for Schroeder and Gilman stations were Northeast and East-Southeast. The Wood station reported the greatest number of hours with concentrations exceeding 5 ppb from the West-Southwest, West-Northwest, and Northwest.

Multiple regression analysis was performed on this data using the variables; time, temperature, wind direction, wind speed, relative humidity, precipitation, sigma theta, solar radiation, and hydrogen sulfide concentrations. There was no correlation between the hydrogen sulfide concentrations and any of the individual variables listed above.

It is difficult to determine the extent to which the HGP-A well is contributing to the ambient concentrations of H_2S in Leilani Estates. As previously mentioned, Leilani Estates is located on the Kilauea East Rift Zone where venting from natural volcanic fumaroles is contributing an indeterminant amount of H_2S to the ambient air in the area. The Wood monitoring station had the highest H_2S concentrations but is located north of the HGP-A well, in the opposite direction from the predominantly northerly wind dispersion pattern (See Figures III-V in Appendix B).

In Hawaiian Beaches Estates, maximum one-hour H_2S levels during the months of February 1984 never exceed 5 ppb. Sporadically, low levels of

H_2S were detected. Venting from natural volcanic fumaroles most likely accounts for all H_2S (less than 5 ppb) detected there during this period. By way of comparison, the H_2S levels at the Schroeder station in Leilani Estates ranged from 0 to 6 ppb and averaged 2.5 ppb during this one-month period.

An air quality baseline study of the Kilauea Rift Zone was recently completed by NEA, Inc., under contract to the State Department of Planning and Economic Development (Houck, 1983). This study included air sampling of total suspended particulates (TSP), H_2S, sulfur dioxide (SO_2), chlorine, carbon monoxide, mercury, and radon.

TSP concentrations ranged from 3.6 to 39.1 micrograms per cubic meter (ug/m^3), based on a 24 hour average. By way of comparison, these levels are lower than most urban and non-urban areas on the Mainland U.S.. The federal primary ambient air quality standard is 75 ug/m^3, based on 24 hour averages.

SO_2, H_2S, and chlorine samples were based on one to two week integrated samples; thus, since 24-hour averages were not reported, comparison to ongoing H_2S monitoring by EAL, Inc. is difficult. SO_2 levels ranged from less than 0.1 to 43 ug/m^3; H_2S ranged from less than 0.06 to 1.8 ug/m^3; and chlorine ranged from less than 0.02 to 0.37 ug/m^3. These levels are are below those which have been associated with adverse health effects.

Only during periods of volcanic eruptions did SO_2 concentrations in the Volcano National Park area reach levels at which adverse health effects may be expected. In this area, State Department of Health monitoring results indicated 24-hour ambient air concentrations as high as 982 ug/m^3 during an eruption in January, 1983. In Hilo, levels of SO_2 were as high as 654 ug/m^3 during this period. The federal primary ambient air quality standard for SO_2 is 365 ug/m^3. No continuous SO_2 monitoring was conducted in Leilani Estates during this period.

Forty-eight hour elemental mercury concentrations were several orders of magnitude less than H_2S or SO_2 levels and ranged from 4 - 45 nanograms per cubic meter (ng/m^3). Houck (1983) reported particulate mercury concentrations as high as 4 ng/m^3 and noted that scientists at the Mauna Loa Observatory (on the Island of Hawaii) observed fifty-fold increases in particulate mercury during volcanic eruptions. Total airborne mercury was not determined since other gaseous forms (e.g., mercury halides and mercury organo-metallic compounds) were not sampled.

Radon samples were collected as three-month averages and ranged from 130 to 1,960 picocuries per cubic meter. The maximum value was recorded in close proximity to an active vent. These values are not unusual for outdoor exposures and are well below indoor exposure levels reported in mainland U.S. houses.

DISCUSSION

The results of this investigation indicate no direct association between the levels of hydrogen sulfide in the ambient air in various locations in Puna and reported acute or chronic respiratory conditions. However, higher rates rates of all chronic respiratory condition were found both in Leilani Estates and Hawaiian Beaches Estates during the study period, January 1983 - January 1984, than Hawaii County or Hawaii statewide rates in 1983 (Table 5). These include "bronchitis/emphysema," "asthma," "hayfever," "sinusitis" and "other respiratory system disease."

Cigarette smoking is the most important factor to consider when evaluating the incidence of bronchitis and emphysema in a population and has been shown to be clearly related to cases of bronchitis and emphysema. Although a detailed smoking history was obtained from individuals in the populations surveyed in Puna, it is difficult to relate the differences in prevalence rates of bronchitis/emphysema reported in the study areas to statewide or countywide rates because information on smoking is not available for these populations.

Hawaii statewide rates for chronic respiratory conditions have been shown to vary from year to year and place to place. For example, the rate of hayfever (with or without asthma) reported from the Hawaii County Health Surveillance Program sample for 1982 and 1983 are 29.6 and 46.9 per 1,000 population, respectively, after adjusting for age. Asthma and/or hay fever have been by far the most frequently reported chronic conditions on the island of Oahu (Anderson et al., 1984). Rates of asthma, hay fever and bronchitis reported in the study areas in Puna may be compared to rates found in other health surveys on Oahu.

The first reported survey of chronic respiratory conditions on Oahu, conducted from October 1958 through September 1959, estimated that the rate of asthma and/or hay fever was 77.5 per 1,000 population, the rate of chronic bronchitis was 10.4 per 1,000 population, and chronic sinusitis was 31.9 per 1,000 population (U.S. Public Health Service, 1960). A survey that followed, conducted from May 1964 through April 1967 (Bruyere et al., 1965; Viele, 1968) reported that the rate of asthma and/or hay fever was 99.4 per 1,000 population, indicating a 28 percent increase from the 1959 rate. Asthma (with or without hay fever) was estimated at 40.5 per 1,000 population. The highest rates of asthma and/or hay fever (139.1-140.3 per 1,000 pop.) were found in East Honolulu (the area extending Diamond Head to Hawaii Kai), on the leeward side of Oahu, and in the Kailua-Lanikai area on the windward side. The lowest rates were found in the area in the northern and southwest sides of the island, perhaps due to ambient weather conditions or other factors.

There are no clear answers as to what factors may be responsible for the high rates of asthma and hay fever in various areas of Hawaii, although there has been considerable speculation on this matter. Asthma and hay fever are both considered allergic conditions. Roth and Shira (1966) concluded that a high incidence of allergy in a group of 500 atopic children was likely due to perennial exposure to pollen, fungi, and dust without the benefit of quiescent periods as occur during the winter on the mainland U.S.. Others attribute the high rates of asthma and hay fever in

Hawaii to increased air pollution (Holland, 1972; Waldbott, 1973). Another possibility is that crystalline particles formed by adiabatic drying of salt air mist in passing over sharply rising land may serve as irritants. Not much is known of the exact mechanism under which allergens act on the respiratory system.

There are also those who contend that high rates of asthma and hay fever in Hawaii result largely from the influx of people already afflicted with these conditions coming to Hawaii to seek relief. This theory has yet to be substantiated but, if valid, may explain in part the high prevalence of chronic respiratory conditions in the study area. Previous surveys have shown that the Puna study areas have a large proportion of newcomers (SMS, 1981). A recent study by Vu (1977) in the Waianae Coast of Oahu showed that Caucasians in the study area had the highest rate of asthma and/or hay fever (140.3 per 1,000 pop.). However, he could find no significant difference in levels of aeroallergens (e.g., fungal spores, pollen, and dust) between homes of asthmatics and non-asthmatics.

Other Investigations of Community Exposure To Hydrogen Sulfide

Two situations are often cited as being relevant when one is considering the effects of low-level community exposures to H_2S; one is a pollution episode in Terre Haute, Indiana (USPHS, 1964), the other is a report of health effects associated with natural long-term, low-level exposure in Roturua, New Zealand (Thom and Douglas, 1976).

In Terre Haute, Indiana, ambient H_2S levels reaching a one-hour mean concentration of 0.3 ppm resulted from the biodegradation of industrial wastes in a waste disposal lagoon (USPHS, 1964). The highest concentrations of H_2S measured were between 2 and 8 ppm at the fence line near this lagoon. Altogether, over a one month period, 81 complaints were registered; of these, 41 (50.6%) involved signs and symptoms of illness associated with an unpleasant odor. These complaints commonly included nausea, interruption of sleep, burning eyes, shortness of breath, and other respiratory problems. Less common symptoms were cough, headache, and anorexia. Besides a general association between ambient air levels and complaints, little data on health effects were obtained. It was simply concluded in this report that the incident exceeded that of a "mere nuisance." Terre Haute is located in a heavily industrialized area where mercaptans (other malodorous substances) were present in addition to H_2S, and these may have contributed to the problems in the area.

Rotorua, New Zealand, is a geothermal area in which a large proportion of the population is exposed to natural ambient H_2S concentrations of 0.1 to 0.3 ppm for eight hours or more on most days (Milby, 1979). Thom and Douglas (1976) concluded that, since there were no unsolicited reports that the population suffers from H_2S related illness as a result of long-term exposure to these levels, then there is "no direct evidence that exposure to the levels (of H_2S) experienced in Rotorua is producing sub-clinical health effects apart from the nuisance of odors." No sound epidemiologic data has been reported to date from Rotorua to substantiate this observation.

The risks to the public from industrial accidents resulting in exposure to high-levels of H_2S are all too evident. The most livid example was an incident in Poca, Mexico, which caused 22 deaths and resulted in 320 other persons exposed to be hospitalized (McCabe and Clayton, 1952). Other incidents have also been cited which may exemplify the pervasive threat inherent with the production of large quantities of H_2S gas (Milby, 1962). Accidents involving occupational exposure to hydrogen sulfide have been reported from the Geysers area in California and, recently, in Puna, Hawaii.

Reports of chronic health effects of H_2S have also been reported in industry studies where exposure to low-levels is common (Ahlborg, 1952; Lewey, 1938; Rubin and Arieff, 1945). Unfortunately, however, the presence of other toxic substances in these complicates interpretation of this data.

Ahlborg (1952) reported an increase in neurasthenic symptoms (primarily fatigue) in workers in the shale oil industry exposed to concentrations exceeding approximately 20 ppm H_2S when compared to, presumably, less exposed individuals, but little difference in objective signs and symptoms of irritation. Confounding variables, such as age, length of employment, and the presence of other gases, and other possibly important factors were not adequately considered in this study.

Similarly, Rubin and Arieff (1945) studied the effects of long-term exposure to carbon disulfide (CS_2) and H_2S in a viscose rayon plant where exposures to CS_2 and H_2S ranged from 1.9 to 26.4 ppm and 1.0 to 5.5 ppm, respectively. The presence of both toxic gases in this study too makes it difficult to attribute any effect to either or both toxic substances. They reported that 16 percent of an exposed group had diminished or absent corneal reflexes, compared to 12 percent in a less-exposed group, but the difference between the groups is not statistically significant by chi-square analysis ($P<.05$). They concluded that the chronic effects of such exposure, if present, appear to be minimal.

An older study by Lewey (1938), also of workers in the rayon industry, reported that 50 percent of the exposed workers had decreased corneal reflexes when exposed to CS_2 and H_2S in ranges similar to those found by Rubin and Arieff (1945).

Russian scientists have reported health effects they associated with low-level occupational exposure which have been reviewed by other investigators (IIEQ, 1974; NIOSH, 1977; Walton and Simmons, 1978; CEC, 1982). Reportedly, infants exposed to maximum concentrations of 0.03 ppm H_2S and 0.05 ppm CS_2 showed less weight gain, were listless, regurgitated more, were more susceptible to infectious disease, and generally exhibited retarded development (Glebova, 1950). Again, it is difficult to assess the extent of CS_2 involvement and actual H_2S exposure levels. In studies of villagers residing near petroleum centers releasing H_2S, it was reported that persons exposed to H_2S levels of 0.036 ppm or greater complained of headaches and a variety of other neurological symptoms (Loginova, 1957).

Air Quality Standards for Hydrogen Sulfide

Occupational Standards

Occupational illnesses have been observed at the Geysers, California, and at geothermal well sites in Puna that are directly attributable to H_2S exposure in geothermal effluents or to abatement products. In fact, the rates of illness and accidents at geothermal energy facilities have been increasing when compared to private utilities (DOE, 1980), indicating that more attention must be paid to occupational exposure and illness in geothermal energy production.

The U.S. National Institute for Occupational Safety and Health (NIOSH, 1979) maintains an allowable ceiling concentration of 10.0 ppm for 10-minutes is safe for the work place, based on a 10-hour work shift in a 40-hour week. Evacuation is required if the concentration of H_2S at any time exceeds 47 ppm.

The American Conference of Governmental Industrial Hygienists (1981) recommends for H_2S a "Threshold Limit Value" (TLV) of 10 ppm and a short-term exposure limit of 15 ppm. The TLV of 10 ppm refers to the airborne concentration of H_2S to which it is believed that nearly all humans may be repeatedly exposed in the working environment day after day (over an 8-hour exposure period) without adverse health effects. These occupational guidelines are not intended to assure that there will not be an occasional hypersensitive person who may respond unfavorably to the recommended TVL, nor do they pertain to those who may be exposed for 24-hours every day.

Ambient Air Quality Standards

The U.S. Federal Government has not set an ambient air quality standard for H_2S and is unlikely to do so in the near future. To date, the State of Hawaii has not officially adopted a standard, although a standard of 0.100 ppm (averaged over one hour) has recently been proposed to protect residents from adverse physiologic health effects (e.g, conjunctivitis). Public hearings are presently underway in an effort to promulgate the regulation of H_2S in Hawaii.

Other individual states have adopted ambient standards when H_2S exposure becomes problematic. Montana established 0.05 ppm, but recently extended the averaging period from 30 minutes to one-hour (MAQB, 1979). California and five other states chose a level of or near 0.03 ppm over a one-hour averaging period, originally based on odor detection (i.e., nuisance) levels.

Studies have subsequently shown the median threshold for odor detection is considerably below that on which the California standard was based. In fact, the currently accepted median threshold value for odor detection is 0.005 ppm (Anspaugh and Hahn, 1980). However, after considering recent data, reviewers determined that a more restrictive standard would not be likely to effect any perceptible improvement in the public health (CDMS, 1981). Many foreign countries have standards lower than those adopted in the U.S., providing a greater margin for safety.

Comments

Regulations are currently being promulgated by the State Department of Health to control emissions from geothermal facilities. As a result, normal operations should not result in substantial deterioration of air quality. However, "flashing" (open, unabated venting of effluent from a geothermal well) clearly contributes to natural ambient H_2S levels as indicated by monitoring data in March, 1984.

H_2S levels were measured during flashing of the HGP-A well over a two-day period (March 20-21, 1984) at various locations in Leilani Estates and in the vicinity of the well by DOH investigators. Levels of H_2S during this period ranged from 0.021 ppm to 0.520 ppm (adjacent to and immediately downwind of the HGP-A well - see Figure 3B) (DOH records). These readings were taken with a portable monitor during a five-minute period and averaged so they are difficult to compare directly to ongoing ambient air monitoring results but they are clearly higher than average ambient levels reported in this study. Routine H_2S monitoring in Leilani Estates (Schroeder station) over this same period revealed one-hour concentrations as high as 0.012 ppm during the day (11:00 a.m. - 4:00 p.m.) when NE winds prevailed.

It is perhaps noteworthy that the 1983 ambient H_2S concentrations were greatly reduced over those reported for 1982 (Carter, 1984). This may be attributed to improved abatement facilities and improved operating efficiency of the HGP-A plant. A standby "scrubber" was installed at HGP-A during 1983 which can be used a backup system to the "incinerator scrubber" when necessary (Thomas, 1984). The extent to which changes in air quality may affect disease reporting during periods of venting cannot be determined from existing data.

This health survey provided the opportunity to collect baseline data which may be useful in determining a change in health status of Leilani Estates in the event that geothermal resources continue to be developed in the vicinity of the HGP-A experimental well. In the development of any resource, there are social, economic, and political issues which also must be resolved. One of the more serious is expected to be conflicts over land-use. Unfortunately, conflicts over land-use priorities and adverse reactions to changes in life-style which may accompany the development of a new industry have already surfaced in Puna. Bias may have been introducted into the survey as a result.

It is likely that residents were acutely sensitive and concerned about even modest changes in their health when this survey was conducted, at least partially due to outspoken opponents of geothermal resource development who suspected that geothermal emissions were responsible for their illnesses. This understandable concern may have prompted some over-reporting, which it is impossible to measure or adjust for retrospectively. Under these conditions, the reporting of certain conditions may be highly susceptible to differences in interpretation. This makes an objective study of health effects, especially those effects for which symptoms studied are largely subjective, very difficult.

The study was not intented to demonstrate a direct cause-and-effect relationship between H_2S exposure and health effects. Indeed, it is impossible to control for the wide variety of environmental factors that

may affect disease rates in a cross-sectional study. At best, only indirect (or secondary) associations between a potential health hazard (e.g., H_2S) and disease rates may be expected. Even those situations which allow for the planning of a thorough prospective study do not yield an implicit causal relationship between a particular hazard and health effects; invariably this becomes a subjective judgment based on the evidence. The following recommendations are made with these caveats in mind.

RECOMMENDATIONS

This study was completed pursuant to H.R. 253, H.D. 2, of the Twelfth Legislature, Regular Session of 1983, requesting the formation of a medical advisory panel to conduct a study of the effects of hydrogen sulfide and certain other air pollutants on human health. The Advisory Panel and Review Committee (hereinafter referred to as the Committee) has found that the cross-sectional survey approach utilized in this study was an effective way of establishing the health status of a community in Puna intermittently exposed to low levels of H_2S. The data collected in this survey will be very useful as baseline health information in the event that follow-up surveys are conducted in Leilani Estates.

The Department of Health has requested the Committee to make recommendations with regard to conducting baseline health surveys in other communities in the Puna area, pursuant to H.R. 218, H.D. 1, of the Thirteenth Legislature, Regular Session of 1984. This resolution urges the Department of Health and the Department of Planning and Economic Development to conduct a baseline survey of the Volcano community as soon as practicable. Geothermal development has been proposed for Kahauale'a, also on the Kilauea East Rift Zone, near "Fern Forest" subdivision and Volcano Village.

It is the opinion of the Committee that further health surveys of this type in the Volcano area at this time would be premature. More specifically, with regard to this request, the Committee recommends:

1. Further health surveys in the Puna area not be undertaken until plans are finalized for developing geothermal resources in the Kahauale'a area. Before proceeding with a baseline health survey, it would be important to determine which communities (if any) would be most impacted by a change in air quality due to the development of geothermal resources in the area; then, it would be necessary to select a control community to be surveyed for comparison.

2. Baseline air monitoring data for H_2S, sulfur dioxide and particulates should be collected before geothermal exploratory activities commence in any proposed development areas.

A health survey approach is a proven method of assessing the health status of a community and, potentially, of demonstrating a change in health status of that community; however, they do require considerable funding. With regard to follow-up surveys in Leilani Estates, the Committee recommends:

3. Air monitoring for H_2S be continued in the Leilani Estates. Follow-up surveys should be undertaken only if it can be shown that air quality has changed appreciably in the area.

The Committee further recommends that the State Department of Health promulgate and formally establish an ambient air standard (and appropriate action levels) for H_2S as soon as practicable. It is the position of the Committee that at present any uncertainties regarding long-term health effects of H_2S should be resolved in favor of protecting the public health.

Respectfully submitted,

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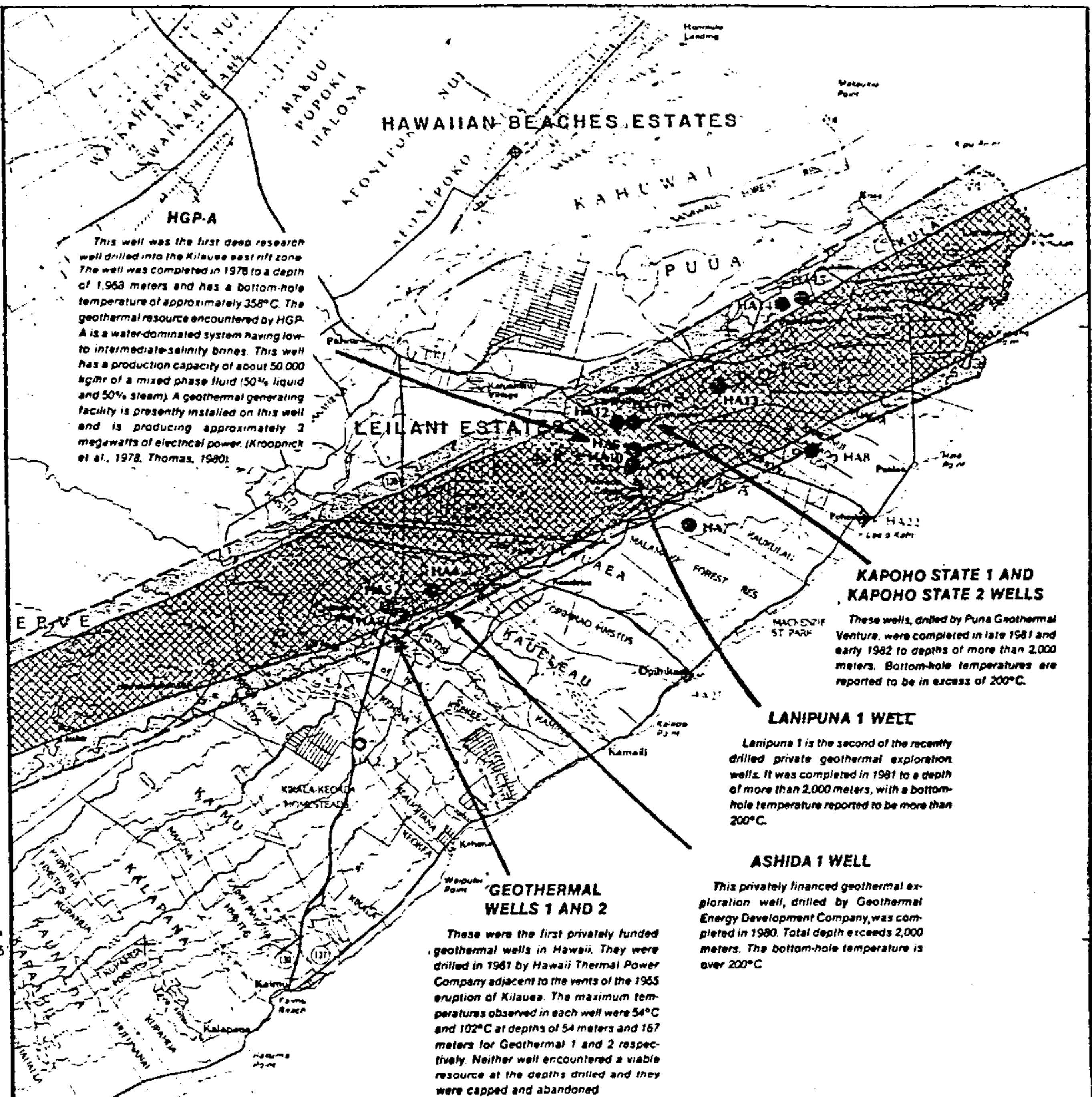
LIST OF FIGURES


155° 0.0
154° 52.5
HAWAIIAN BEACHES ESTATES
KAHUWAI
PUUA
LEILANI ESTATES
KAUAEA
KAUELEAU
KAMU
KALAPANA
HAUNALOA
HGP-A
This well was the first deep research well drilled into the Kilauea east rift zone. The well was completed in 1976 to a depth of 1,968 meters and has a bottom-hole temperature of approximately 358°C. The geothermal resource encountered by HGP-A is a water-dominated system having low-to intermediate-salinity brines. This well has a production capacity of about 50,000 kg/hr of a mixed phase fluid (50% liquid and 50% steam). A geothermal generating facility is presently installed on this well and is producing approximately 3 megawatts of electrical power. (Kroopnick et al., 1978, Thomas, 1980).
KAPOHO STATE 1 AND KAPOHO STATE 2 WELLS
These wells, drilled by Puna Geothermal Venture, were completed in late 1981 and early 1982 to depths of more than 2,000 meters. Bottom-hole temperatures are reported to be in excess of 200°C.
LANIPUNA 1 WELL
Lanipuna 1 is the second of the recently drilled private geothermal exploration wells. It was completed in 1981 to a depth of more than 2,000 meters, with a bottom-hole temperature reported to be more than 200°C.
ASHIDA 1 WELL
This privately financed geothermal exploration well, drilled by Geothermal Energy Development Company, was completed in 1980. Total depth exceeds 2,000 meters. The bottom-hole temperature is over 200°C.
GEOTHERMAL WELLS 1 AND 2
These were the first privately funded geothermal wells in Hawaii. They were drilled in 1961 by Hawaii Thermal Power Company adjacent to the vents of the 1955 eruption of Kilauea. The maximum temperatures observed in each well were 54°C and 102°C at depths of 54 meters and 167 meters for Geothermal 1 and 2 respectively. Neither well encountered a viable resource at the depths drilled and they were capped and abandoned.
HA1
HA4
HA8
HA12
HA13
HA22
19° 30.0
19° 22.5
19° 15.0

KILAUEA EAST RIFT ZONE

The east rift zone of Kilauea Volcano has been the site of frequent eruptive volcanic activity. During the last 2,000 years, the frequency of these surface outbreaks is estimated to be approximately once every 20 years. Geophysical evidence suggests that, in addition to effusive activity, substantial volumes of magma never reach the surface but are intruded into the rift zone.

In spite of the very extensive volcanic activity in this area, surface geothermal manifestations are limited, being restricted to isolated areas of steaming ground, several low-temperature (<50°C) coastal springs, and numerous cracks and fissures along the trace of the rift emitting low-temperature vapor. Nonetheless, extensive geophysical and geochemical work during the last decade suggests that the entire subsurface along the rift zone may be at a substantially elevated temperature.

Four deep (>2,000 m) exploratory wells drilled into the lower east rift have encountered temperatures as high as 358°C. The first of these wells is producing approximately 3 megawatts of electrical power at a geothermal generator facility built as a "proof-of-feasibility" project under the joint sponsorship of the U.S. Department of Energy, the State of Hawaii, the County of Hawaii, and the Hawaiian Electric Company. The other wells are privately financed exploration wells. Further field exploratory and developmental drilling is expected to continue through 1990. On the basis of geological and geophysical evidence alone, the Kilauea east rift zone has been estimated to have sufficient geothermal fluids to provide 50 to 3,000 megawatts of electricity for approximately one century.

Episodic intrusion of magma injects thermal energy into the Kilauea east rift zone that is estimated to be equivalent to about 100 megawatts electrical (MWE) on a continuous basis. Therefore, the geothermal resource within the Kilauea east rift zone will probably be depleted somewhat more slowly than would the residual heat in a geothermal system associated with a dormant or extinct volcanic area.

FIGURE 1

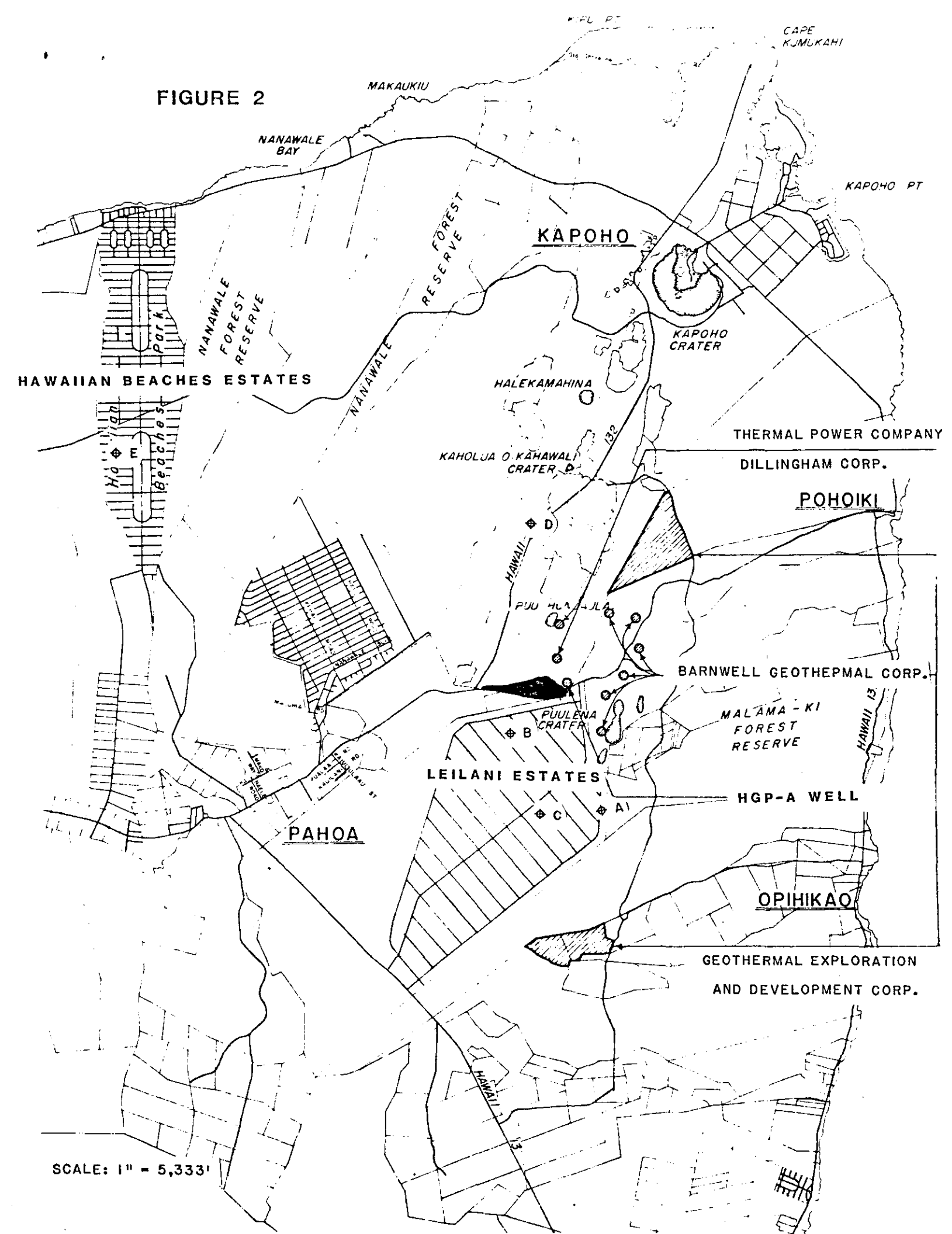
Hawaii
Kilauea East Rift Zone
Scale 1:125,000

KILOMETERS 1 0 1 2 3 4 5 6 7 8 9 10
MILES 1 0 1 2 3 4 5
FEET 5000 0 5000 10000 15000 20000 25000

CONTOUR INTERVAL 40 METERS
SUPPLEMENTARY CONTOUR INTERVAL 20 METERS
NATIONAL GEODETIC VERTICAL DATUM OF 1929

155° 0.0'
154° 52.5'

FIGURE 2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HAWAIIAN BEACHES ESTATES
HALEKAMAHINA
NANAWALE
THERMAL POWER COMPANY
DILLINGHAM CORP.
KAHOLUA O KAHAWALI CRATER
132
POHOIKI
HAWAII
PUU HOKUALA
BARNWELL GEOTHEPMAL CORP.
PUULENA CRATER
MALAMA - KI FOREST RESERVE
HAWAII 13
LEILANI ESTATES
HGP-A WELL
PAHOA
OPIHIKAO
GEOTHERMAL EXPLORATION AND DEVELOPMENT CORP.
HAWAII 13
SCALE: 1" = 5,333'

A

B

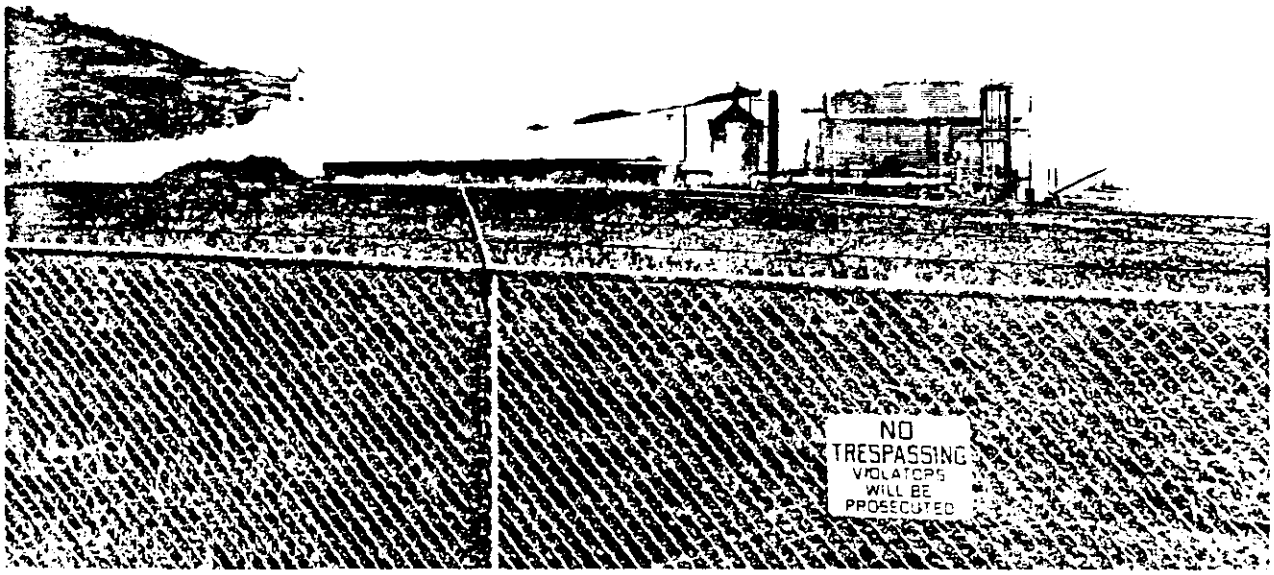

FIGURE 3

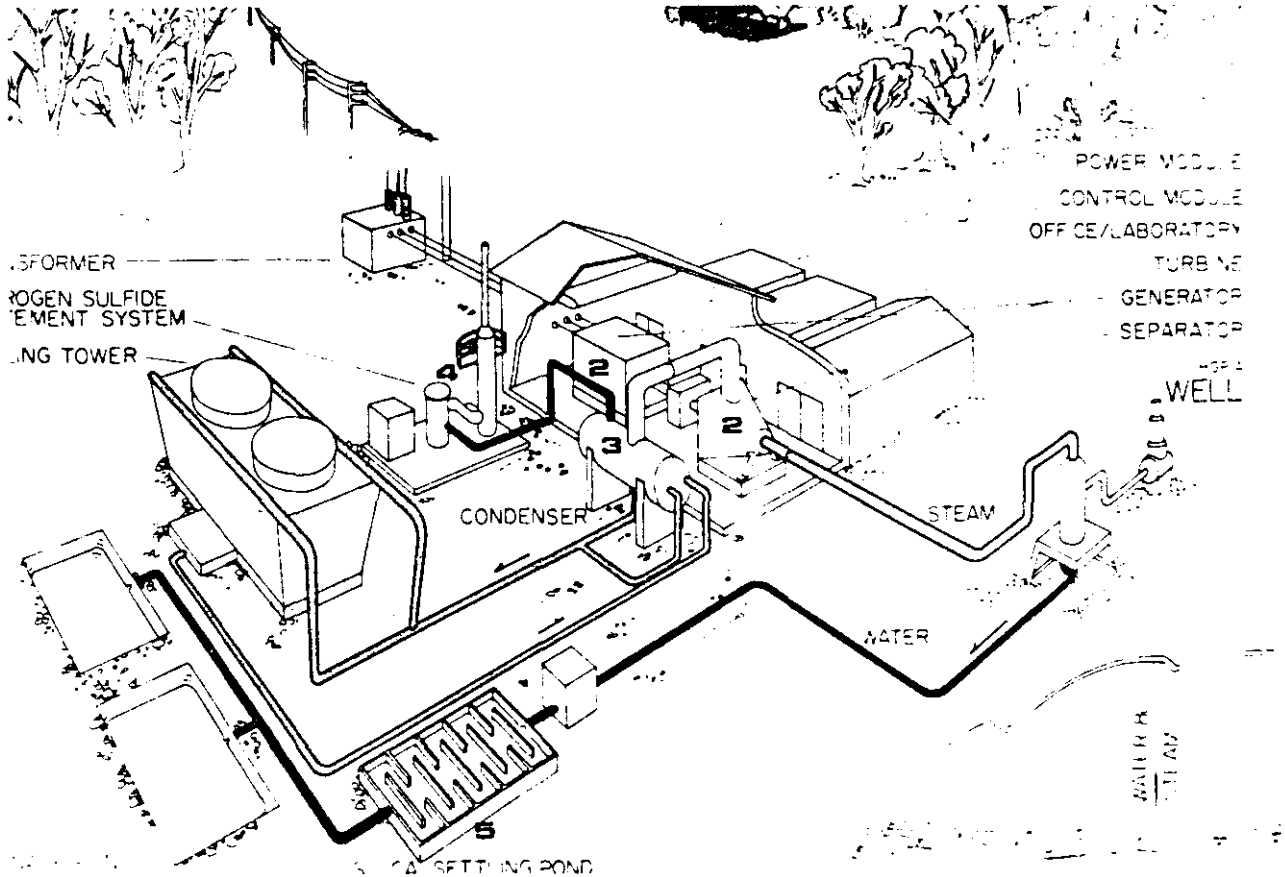
POWER MODULE
CONTROL MODULE
OFFICE/LABORATORY
TURBINE
GENERATOR
SEPARATOR
WELL
TRANSFORMER
HYDROGEN SULFIDE
ABATEMENT SYSTEM
COOLING TOWER
CONDENSER
STEAM
WATER
1
2
2
3
4
5
EVAPORATION SETTLING POND

FIGURE 4

Table 1

Effects of Hydrogen Sulfide at various concentrations in air.

Health Effect(s)	Concentration (ppm)	Duration of Exposure	References
Approximate threshold range for odor perception	0.0005-0.13	< 1 minute	Yant (1930) Ryazanov (1962) WHO (1969)
Median threshold of odor perception	0.005	--	Anspaugh and Hahn (1980)
Occupation standard	10.0	8 hours	NIOSH (1979)
Threshold of eye irritation	10.5-21.0	6-7 hours	Elkins (1939) Nesswetha (1969)
Reduced ability to inactivate bacteria in the lungs[a]	45.0	4-6 hours	Rogers and Ferin (1981)
Acute conjunctivitis "Gas Eye"	50-100	> 1 hour	Yant (1930)
Olfactory paralysis	150-200	2-15 minutes	Sayer et al. (1925)
Local irritation and slight systemic symptoms (possibly death after several hours)[a]	500-700	< 1 hour	Haggard (1925)
Systemic symptoms (death in less than 1 hour)	900	< 30 minutes	Haggard (1925)
Death	1,500	15-30 minutes	Haggard (1925)

[a] Although these data pertain to experimental animals, there is no better quantitative data available concerning man.

Table 2

Prevalence of selected acute conditions[a] reported by residents of Leilani Estates over a one-month period, January 1984, compared to Hawaiian Beaches Estates

Acute Conditions	LEILANI ESTATES Number Observed	LEILANI ESTATES Age-Adjusted Rate (per 1,000 pop.) [A]	HAWAIIAN BEACHES ESTATES Number Observed	HAWAIIAN BEACHES ESTATES Age-Adjusted Rate (per 1,000 pop.) [B]	Morbidity Ratio [A/B]
Various infective and parasitic diseases	1	3.1	8	10.5	0.3
Common cold	54	143.4	37	56.9	2.5
Other upper respiratory infections	29	75.9	58	91.4	0.8
Digestive system disorders	6	16.3	4	7.3	2.2
Diseases of the eye and ear	6	11.8	7	9.4	1.2
Non-allergic skin diseases	5	12.0	5	7.0	1.7
Musculo-skeletal conditions	1	3.1	3	5.5	0.6
Other acute conditions[b]	1	3.1	3	5.5	0.6
TOTAL EXAMINED	350		603		

[a] Acute conditions are defined as those with a date of onset within 3 months prior to the interview.

[b] "Other acute conditions" includes nervousness, depression, debility, undue fatigue, and other general symptoms not classified above.

Note: In Tables 2 - 5, rates were adjusted for age using the direct method (Colton, 1974). The population distribution of the State of Hawaii was used as a standard population (U.S. Census, 1980).

Table 3

Prevalence of selected chronic conditions[a] reported by residents of Leilani Estates over a one-year period, January 1983 - January 1984, compared to Hawaiian Beaches Estates

Chronic Conditions	LEILANI ESTATES Number Observed	LEILANI ESTATES Age-adjusted Rate (per 1,000 pop.) [A]	HAWAIIAN BEACHES ESTATES Number Observed	HAWAIIAN BEACHES ESTATES Age-adjusted Rate (per 1,000 pop.) [B]	Morbidity Ratio [A/B]
Infective and parasitic diseases	5	13.1	5	8.4	1.6
Malignant neoplasms	5	13.5	10	18.3	0.7
Benign neoplasms	2	6.3	3	5.5	1.1
Blood disorders (including anemia)	3	8.6	1	1.8	4.7
Nervousness, depression and other specified mental disorders	8	23.3	8	13.9	1.7
Hypertensive disease	24	66.9	48	86.0	0.8
Bronchitis/emphysema	16	40.1	21	35.6	1.1
Asthma (with or without hay fever)	14	39.8	36	58.3	0.7
Hayfever (with or without asthma)	25	73.8	49	78.7	0.9
Sinusitis	17	49.0	30	52.1	0.9
Other respiratory system disease	4	10.5	10	16.9	0.6
Digestive system disorders	5	14.3	12	19.9	0.7
Allergic skin disease	13	39.7	28	47.8	0.8
TOTAL EXAMINED	350		603		

[a]Chronic conditions are defined as those with a date of onset over 3 months prior to the interview.

Table 4

Prevalence of selected acute conditions[a] reported by residents of Leilani Estates over a one-month period, January 1984, compared to Hawaii County and Hawaii statewide prevalence rates for 1983.

Acute Conditions	AGE-ADJUSTED RATES (per 1,000 pop.) Leilani Estates (January 1984)	Hawaii County (1983)	State of Hawaii (1983)
Various infective and parasitic diseases	3.1	8.2	7.3
Common cold	143.4	63.9	74.4
Other upper respiratory infections	75.9	36.6	40.5
Digestive system disorders	16.3	3.9	2.6
Diseases of the eye and ear	11.8	2.8	4.5
Non-allergic skin diseases	12.2	4.2	4.5
Musculo-skeletal conditions	3.1	2.0	2.1
Other acute conditions[b]	3.1	1.8	2.7
TOTAL EXAMINED	350	2,530	15,184

[a] Acute conditions are defined as those with a date of onset within 3 months prior to the interview.

[b] "Other acute conditions" includes nervousness, depression, debility, undue fatigue, and other general symptoms not classified above.

Table 5

Prevalence of selected chronic conditions[a] reported by residents of Leilani Estates over a one-year period, January 1983 - January 1984, compared to Hawaii County and Hawaii statewide prevalence rates for 1983.

Chronic Conditions	AGE-ADJUSTED RATES (per 1,000 pop.) Leilani Estates (1983-1984)	Hawaii County (1983)	State of Hawaii (1983)
Infective and parasitic diseases	13.1	5.7	8.2
Malignant neoplasms	13.5	4.7	6.3
Benign neoplasms	6.3	2.9	4.7
Blood disorders (including anemia)	8.6	1.2	1.7
Nervousness, depression and other specified mental disorders	23.3	9.4	11.1
Hypertensive disease	66.9	85.1	75.0
Bronchitis/emphysema	40.1	12.7	12.9
Asthma (with or without hay fever)	39.8	38.0	36.7
Hayfever (with or without asthma)	73.8	46.9	51.3
Sinusitis	49.0	29.6	24.2
Other respiratory system disease	10.5	4.1	4.5
Digestive system disorders	14.3	11.7	10.5
Allergic skin disease	37.9	17.2	30.9
TOTAL EXAMINED	350	2,530	15,184

[a]Chronic conditions are defined as those with a date of onset over 3 months prior to the interview.

Table 6

Prevalence of selected chronic conditions[a] reported by residents of Leilani Estates by length of residence, 1984

Chronic Conditions	Total		LENGTH OF RESIDENCE IN LEILANI ESTATES			
			Less Than One Year[a]		One Year or More	
	Number Observed	Per 100 Pop.	Number Observed	Per 100 Pop.	Number Observed	Per 100 Pop.
Infective and parasitic diseases	5	1.4	2	2.2	3	1.1
Malignant neoplasms	5	1.4	0	0	5	1.9
Benign neoplasms	2	0.6	2	2.2	0	0
Blood disorders (including anemia)	3	0.9	1	1.1	2	0.8
Nervousness, depression and other specified mental disorders	8	2.3	3	3.4	5	1.9
Hypertensive disease	24	6.9	1	1.1	23	8.8
Bronchitis/emphysema	16	4.6	2	2.2	14	5.4
Asthma (with or without hay fever)	14	4.0	3	3.4	11	4.2
Hayfever (with or without asthma)	25	7.1	7	7.9	18	6.9
Sinusitis	17	4.9	3	3.4	14	5.4
Other respiratory system disease	4	1.1	0	0	4	1.5
Digestive system disorders	5	1.4	1	1.1	4	1.5
Allergic skin disease	13	3.7	1	1.1	12	4.6
TOTAL EXAMINED	350		89		261	

[a] Includes individuals less than one year of age.

Table 7

Other indices of health in Leilani Estates compared to Hawaiian Beaches Estates, January - February, 1984

Disability Days Due to Chronic Condition(s)[a]	LEILANI ESTATES Number Observed	LEILANI ESTATES Days per 100 Pop.	HAWAIIAN BEACHES ESTATES Number Observed	HAWAIIAN BEACHES ESTATES Days per 100 Pop.
Days spent in bed over the past year	350	100.0	572	94.7
Activity limitation days over the past month:				
Unable to partake in major activity (e.g., work, housekeeping, school)	6	1.7	9	1.5
Limited in ability to partake in major activity	22	6.3	26	4.3
Able to partake in major activity but limited in kind or amount of other activity	12	3.4	16	2.6
Not limited in any way due to chronic condition(s)	120	34.2	192	31.7
TOTAL EXAMINED	350		604	

[a] Chronic conditions are listed in Table 3.

Note: The limitation of activity question was asked only of persons who reported having at least one chronic health condition during the twelve month period prior to the month of interview. These people were asked to rate themselves in terms of their health according to a scale of 1 to 4. The scale was as follows: (1) not able to work at all; (2) able to work but limited in type or amount of work; (3) able to work but limited in type or amount of other activity; and (4) not limited in any way.

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APPENDIX A

Questionnaire Forms

GEORGE R. ARIYOSHI
GOVERNOR OF HAWAII

CHARLES G. CLARK
DIRECTOR OF HEALTH

STATE OF HAWAII
DEPARTMENT OF HEALTH
P. O. BOX 3378
HONOLULU, HAWAII 96801

In reply, please refer to:
File:

January 27, 1984

Dear Resident:

The Research and Statistics Office of the State Department of Health is conducting a special health survey in Puna. The purpose of this survey is to obtain information that will be helpful in assessing the health status of your community.

Within a week or so, a Health Survey Interviewer will call upon you to ask questions about the health of members of your household and other related questions. The interviewer will show you an official identification card. All information collected will be held in the strictest confidence and will be used for statistical purposes only.

Your cooperation in this survey is extremely important to ensure the completeness and accuracy of the results. Your participation will be much appreciated and will be a distinct service to your community.

Mahalo,

Charles G. Clark

CHARLES G. CLARK
Director of Health

CONFIDENTIAL: All information collected in the Hawaii Health Surveillance Program which identifies individuals or families will be held strictly confidential and will be used only for statistical purpose.

George Yuen
Director of Health

HAWAII STATE DEPARTMENT OF HEALTH
RESEARCH AND STATISTICS OFFICE

HEALTH SURVEILLANCE PROGRAM

(This form adapted from that used in the National Health Survey of the U. S. Public Health Service)

1. Address or description of location	4. Zone	5. Sample no.	6. Questionnaire ____ of ____ questionnaires	7. Total copies of Part III

8. Does anyone else living in this building use your entrance to get to his living quarters? [ ] Yes [ ] No
If "Yes" interview person(s)

9. Does anyone additional to your household live at this address? [ ] Yes [ ] No
If "Yes" interview additional person(s) or family.

2. What is the telephone here? [ ] No phone

3. When is the best time to call?

10. RECORD OF CALLS AT HOUSEHOLD

Item			1	Com.	2	Com.	3	Com.	4	Com.	5	Com.
Entire household		Date										
		Time										
Record of return calls for individual respondents	Col. No.	Date										
		Time										
	Col. No.	Date										
		Time										

11. REASON FOR NONINTERVIEW

[ ] Refusal
[ ] No one at home after ____ visits
[ ] Vacant
[ ] Demolished
[ ] Other (specify)
_____

Interview not obtained for:
Columns ____ ____ ____ ____ ____ ____
because:
_____

12. Type of Dwellings [ ] Single Family [ ] Duplex [ ] Apt. [ ] Rooming House [ ] Group Quarters [ ] Other (Specify)

13. Other Comments:

14. Signature of interviewer

15. Date

Part I

1. (a) What is the name of the head of this household? (Enter name in first column)
   (b) What are the names of all other persons who live here? (List all persons who live here)
   (c) I have listed (Read names). Is there anyone else staying here now such as friends, relatives, or roomers [ ] Yes (List) [ ] No
   (d) Have I missed anyone who usually lives here but is now ...Temporarily in a hospital? [ ] Yes (List) [ ] No
   Away on business? [ ] Yes (List) [ ] No
   On a visit or vacation? [ ] Yes (List) [ ] No
   (e) Do any of the people in this household have a home anywhere else?
   [ ] Yes (Apply household membership rules; if not a household member, delete) [ ] No (Leave on questionnaire)

Last name (1)

First name

2. How are you related to the head of the household? (Enter relationship to head, for example: wife, daughter, grandson, mother-in-law, partner, roomer, roomer's wife, etc.)

Relationship
Head

3. How old were you on your last birthday?

Age [ ] Under 1 year

4. Sex (Check one box for each person)

[ ] Male [ ] Female

5. Are you now married, widowed, divorced, separated or never married?
(Check one box for each person)

[ ] Common Law [ ] Never married
[ ] Married [ ] Divorced
[ ] Widowed [ ] Separated

6. (a) What were you doing most of the past 12 months —
(For males): working, going to school, or doing something else, or retired?
(For females): keeping house, going to school, working or doing something else, or retired?
If "Something else" checked, and person is 45 years old or over, ask:
(b) If "retired" ask: Did you retire because of your health?

a)
[ ] Going to school
[ ] Working [ ] Retired
[ ] Keeping house
[ ] Something else

b)
[ ] Yes [ ] No

7. (a) Did you work at any time last month?
If "No," ask BOTH 7(b) and 7(c):
(b) Even though you did not work last month, do you have a job or business?
(c) Were you looking for work or on layoff from a job?

a)
[ ] Yes [ ] No

b)
[ ] Yes [ ] No

c)
[ ] Yes [ ] No

If "yes" in 7(a) or 7(b) or 7(c) ask:
If "yes" in 7(c), 8(a) (c) applies to person's last full-time job.

8. (a) For whom did you work? What kind of business or industry was this?
(b) What kind of work were you doing?

Business or industry

Kind of work

9. (a) What is the highest grade you attended in school?

"Other" includes Business Schools, Trade Schools, Hospital Nursing Schools, etc.

(Circle highest grade attended or check "None")

(b) Did you finish the — grade (year)?

[ ] None [ ] Pre School [ ] Kndgtn.
Elem: 1 2 3 4 5 6 7 8
High: 1 2 3 4
College: 1 2 3 4 5 6
Other (Specify)

[ ] Yes [ ] No [ ] Now in this grade

10. Of what race or combination of races is: Your father? Your mother? (If a combination of races, enter only the 3 major ones)

Father

Mother

11. Which of these income groups represents your total combined family income for the past 12 months, that is, your's, your -'s, etc? (Show Card H) Includes income from all sources, such as wages, salaries, rents from property, social security or retirement benefits, help from relatives, etc. Combine income of all related persons. Ask separately for non related persons.

Group (1)

12. Where were you (your) born? (State or Country)

[ ] Hawaii [ ] Other State
[ ] U.S. Terr. or Poss.
[ ] Foreign Country

13. How long have you lived in Hawaii?

[ ] Life [ ] Other years

Part II	Indicate which person(s) were respondent(s). Beginning with Question 1 you are to interview for himself or herself, each adult person who is at home. Person(s) under 19 may respond for himself or herself.	[ ] Respondent [ ] Non-Respondent [ ] Other
1.	**Were you sick at any time LAST MONTH?** (That is, during the calendar period of)	[ ] Yes (1) [ ] No
	(a) What was the matter? (c) Were you sick from before the 15th of the month or later in the month?	
	(b) Anything else? (Before the 15th: 1 Later in month: 2 Before 15th and later: 3)	
2.	**Last month did you take any medicine or treatment for any condition (besides which you told me about)?**	[ ] Yes [ ] No
	(a) For what conditions? (c) Did you have before the 15th of the month or later in the month?	
	(b) Anything else? (Before the 15th: 1 Later in month: 2 Before 15th and later: 3)	
3.	**Last month did you have any accidents or injuries?**	[ ] Yes [ ] No
	(a) What were they? (c) Did happen before the 15th of the month or later in the month?	
	(b) Anything else? (Before the 15th: 1 Later in month: 2)	
4.	**Did you ever have an (any other) accident or injury that still bothers you or affects you in any way?**	[ ] Yes [ ] No
	(a) In what way does it bother you? (Record present effects)	
	(b) Anything else?	
5.	**Has anyone in the family — you, your—, etc. — had any of these conditions DURING THE PAST 12 MONTHS?** (Read Checklist A, condition by condition; record in his column any conditions mentioned for the person)	[ ] Yes [ ] No
6.	**Does anyone in the family have any of these conditions?** (Read Checklist B, condition by condition; record in his column any conditions mentioned for the person)	[ ] Yes [ ] No
7.	**Do you have any other ailments, conditions, or problems with your health?**	[ ] Yes [ ] No
	(a) What is the condition? (Record condition itself if still present; otherwise record present effects.)	
	(b) Any other problems with your health?	
8.	(a) Have you been in a hospital at any time since , a year ago?	[ ] Yes (1) [ ] No
	If "Yes," ask:	
	(b) How many times were you in the hospital during that period? Record details in Part IV.	_____ No. of times
9.	(a) Has anyone in the family been a patient in a nursing home, rest home, or any similar place since , a year ago?	[ ] Yes [ ] No
	If "Yes," ask:	
	(b) Who was this?	
	(c) How many times were you in a nursing home or rest home during that period? Record details in Part IV.	_____ No. of times

Part III—ILLNESSES, IMPAIRMENTS, AND INJURIES

Line Number	Col. No. of person (a)	For conditions which occurred last month, ask . . . **"Last month, did you see or talk to a doctor about . . .?"** For conditions which did not occur last month, ask . . . **"Other than this month, when did you last see or talk to a doctor about . . .?"** (c)	For all illnesses and present effects of "old" injuries (a) If doctor talked to, ask: **What did the doctor say it was? did he give it a medical name?** (b) If doctor not talked to, record original entry and ask (d-2) - (d-4) as required. For all injuries which happened **LAST MONTH**, ask: **What part of the body was hurt?** **What kind of injury was it?** **Anything else?** (Also, fill Part IIIA for all current injuries) (d-1)	**CAUSE** If the entry in Col. (d-1) is An IMPAIRMENT, or a SYMPTOM or came from Question 4 or 6 of Part II, ask: **What was the cause of . . .?** (d-2)	**KIND** For any entry in Col. (d-1) or Col. (d-2) that includes the words: Ailment, Asthma, Attack, Condition, Cyst, Defect, Disease, Disorder, Growth, Measles, Rupture, Trouble, Tumor, Ulcer Ask: **What kind of . . . is it?** For an allergy or stroke ask: **How does the allergy (stroke) affect you?** (d-3)	**PART OF BODY** Ask only for: IMPAIRMENTS, "CURRENT" INJURIES and PRESENT EFFECTS OF "OLD" INJURIES And for: Abscesses, Aches*, Bleeding, Blood Clot, Boils, Cancer, Cyst, Growth, Hemorrhage, Infection, Inflammation, Neuralgia, Neuritis, Pains, Palsy, Paralysis, Rupture, Sores, Soreness, Tumor, Ulcers, Varicose Veins, Weak, Weakness *(ex. Headaches) **What part of the body is affected?** Show detail for: **Ear or eye** (One or both) **Head** (Skull, scalp, face) **Back**—(Upper, middle, lower) **Arm** (Shoulder, upper, elbow, lower, wrist, hand; one or both) **Leg** (Hip, upper, knee, lower, ankle, foot; one or both) (d-4)
1.		☐ Last month ☐ Before last month How long ago . . . . 3+ yrs. . . . . ☐ None		x	x	x
2.		☐ Last month ☐ Before last month How long ago . . . . 3+ yrs. . . . . ☐ None		x	x	x
3.		☐ Last month ☐ Before last month How long ago . . . . 3+ yrs. . . . . ☐ None		x	x	x
4.		☐ Last month ☐ Before last month How long ago . . . . 3+ yrs. . . . . ☐ None		x	x	x
5.		☐ Last month ☐ Before last month How long ago . . . . 3+ yrs. . . . . ☐ None		x	x	x

Part III—ILLNESSES, IMPAIRMENTS, AND INJURIES

Line Number	Col. No. of person (a)	For conditions which occurred last month, ask . . . **"Last month, did you see or talk to a doctor about . . .?"** For conditions which did not occur last month, ask . . . **"Other than this month, when did you last see or talk to a doctor about . . .?"** (c)	For all illnesses and present effects of "old" injuries (a) If doctor talked to, ask: **What did the doctor say it was? did he give it a medical name?** (b) If doctor not talked to, record original entry and ask (d-2) - (d-4) as required. For all injuries which happened **LAST MONTH**, ask: **What part of the body was hurt? What kind of injury was it? Anything else?** (Also, fill Part IIIA for all current injuries) (d-1)	**CAUSE** If the entry in Col. (d-1) is An IMPAIRMENT, or a SYMPTOM or came from Question 4 or 6 of Part II, ask: **What was the cause of . . .?** (d-2)	**KIND** For any entry in Col. (d-1) or Col. (d-2) that includes the words: Ailment, Asthma, Attack, Condition, Cyst, Defect, Disease, Disorder, Growth, Measles, Rupture, Trouble, Tumor, Ulcer. Ask: **What kind of . . . is it?** For an allergy or stroke ask: **How does the allergy (stroke) affect you?** (d-3)	**PART OF BODY** Ask only for: IMPAIRMENTS, "CURRENT" INJURIES and PRESENT EFFECTS OF "OLD" INJURIES. And for: Abscesses, Aches*, Bleeding, Blood Clot, Boils, Cancer, Cyst, Growth, Hemorrhage, Infection, Inflammation, Neuralgia, Neuritis, Pains, Palsy, Paralysis, Rupture, Sores, Soreness, Tumor, Ulcers, Varicose Veins, Weak, Weakness. *(ex. Headaches) **What part of the body is affected?** Show detail for: **Ear or eye** (One or both) **Head** (Skull, scalp, face) **Back**—(Upper, middle, lower) **Arm**—(Shoulder, upper, elbow, lower, wrist, hand; one or both) **Leg** (Hip, upper, knee, lower, ankle, foot; one or both) (d-4)
6.		☐ Last month ☐ Before last month How long ago ... 3+ yrs. ... ☐ None		x	x	x
7.		☐ Last month ☐ Before last month How long ago ... 3+ yrs. ... ☐ None		x	x	x
8.		☐ Last month ☐ Before last month How long ago ... 3+ yrs. ... ☐ None		x	x	x
9.		☐ Last month ☐ Before last month How long ago ... 3+ yrs. ... ☐ None		x	x	x
10.		☐ Last month ☐ Before last month How long ago ... 3+ yrs. ... ☐ None		x	x	x
11.		☐ Last month ☐ Before last month How long ago ... 3+ yrs. ... ☐ None		x	x	x

Sample No. _____

Name of head of household _____ Date _____ of _____ Part III sheets

Part III—ILLNESSES, IMPAIRMENTS, AND INJURIES—Continued

LAST MONTH did . . . cause you to cut down on the things you usually do? Check one: No (Go to Col. (k)) (e)	Yes → (f)	How many days did you have to cut down during that one month period? (g)	During that one month period, how many days did . . . keep you in bed all or most of the day? (h)	LAST MONTH How many days did . . . keep you from school LAST MONTH? (i)	LAST MONTH how many days did . . . keep you from work? (For females add) not counting work around the house? (j)	When did you first notice your . . . Did it occur during the past 3 months or over that time? Check one: Over 3 mos. NEC (k-1)	During past 3 mos. (k-2)	During past 4-12 mos. (k-3)	Over 12 mos. (k-4)	Unknown (k-5)	To interviewer — CONTINUE if Col. (k-1) is checked, or the condition is on Card A or is an impairment; otherwise, STOP (aa)	ABOUT how many days during the past 12 months has . . . kept you in bed all or most of the day? (l)	Ask after completing last condition for each person. Please look at each statement on this card. Then tell me which statement fits you best, in terms of health. (Show Cards as appropriate) (m)	If "1", "2" or "3" in Col. (m) ask: Is this because of any of the conditions you have told me about? (n)	If "Yes" in Col. (n), ask: Which condition(s) is causing limitation? (Enter X on line for each condition named) If "No" in Col. (n) ask: "What is causing your limitation?" (Pick up cause as a condition.) (o)	If "1", "2" or "3" in Col. (m), ask: In what way are you limited? Record limitation not the condition. (p)	About how long have you been limited? (q)	Line Number
		___ Days	___ Days or [ ] None	___ Days or [ ] None	___ Days or [ ] None							___ Days or [ ] None		[ ] Yes [ ] No				1.
		___ Days	___ Days or [ ] None	___ Days or [ ] None	___ Days or [ ] None							___ Days or [ ] None		[ ] Yes [ ] No				2.
		___ Days	___ Days or [ ] None	___ Days or [ ] None	___ Days or [ ] None							___ Days or [ ] None		[ ] Yes [ ] No				3.
		___ Days	___ Days or [ ] None	___ Days or [ ] None	___ Days or [ ] None							___ Days or [ ] None		[ ] Yes [ ] No				4.
		___ Days	___ Days or [ ] None	___ Days or [ ] None	___ Days or [ ] None							___ Days or [ ] None		[ ] Yes [ ] No				5.

Part III—ILLNESSES, IMPAIRMENTS, AND INJURIES—Continued

LAST MONTH did . . . cause you to cut down on the things you usually do? Check one: No (Go to Col. (k))	Yes →	How many days did you have to cut down during that one month period?	During that one month period, how many days did . . . keep you in bed all or most of the day?	LAST MONTH How many days did . . . keep you from school LAST MONTH?	LAST MONTH how many days did . . . keep you from work? (For females add) not counting work around the house?	When did you first notice your . . . Did it occur during the past 3 months or over that time? Check one: Over 3 mos. NEC	During past 3 mos.	During past 4-12 mos.	Over 12 mos.	Unknown	To interviewer CONTINUE if Col. (k-1) is checked, or the condition is on Card A or is an impairment; otherwise, STOP	ABOUT how many days during the past 12 months has . . . kept you in bed all or most of the day?	Ask after completing last condition for each person. Please look at each statement on this card. Then tell me which statement fits you best, in terms of health. (Show Cards as appropriate)	If "1", "2" or "3" in Col. (m) ask: Is this because of any of the conditions you have told me about?	If "Yes" in Col. (n), ask: Which condition(s) is causing limitation? (Enter X on line for each condition named) If "No" in Col. (n) ask: "What is causing your limitation?" (Pick up cause as a condition.)	If "1", "2" or "3" in Col. (m), ask: In what way are you limited? Record limitation not the condition.	About how long have you been limited?	Line Number
(e)	(f)	(g)	(h)	(i)	(j)	(k-1)	(k-2)	(k-3)	(k-4)	(k-5)	(aa)	(l)	(m)	(n)	(o)	(p)	(q)	
		___ Days	___ Days or [ ] None	___ Days or [ ] None	___ Days or [ ] None							___ Days or [ ] None		[ ] Yes [ ] No				6.
		___ Days	___ Days or [ ] None	___ Days or [ ] None	___ Days or [ ] None							___ Days or [ ] None		[ ] Yes [ ] No				7.
		___ Days	___ Days or [ ] None	___ Days or [ ] None	___ Days or [ ] None							___ Days or [ ] None		[ ] Yes [ ] No				8.
		___ Days	___ Days or [ ] None	___ Days or [ ] None	___ Days or [ ] None							___ Days or [ ] None		[ ] Yes [ ] No				9.
		___ Days	___ Days or [ ] None	___ Days or [ ] None	___ Days or [ ] None							___ Days or [ ] None		[ ] Yes [ ] No				10.
		___ Days	___ Days or [ ] None	___ Days or [ ] None	___ Days or [ ] None							___ Days or [ ] None		[ ] Yes [ ] No				11.

PART IV HOSPITALIZATIONS (Hospital, Nursing Home and Care Home)

Line Number	Col. No. of person (a)	Question No. (b)	You said that you were in the hospital, nursing home or care home (once, twice, etc.) during the past year — When did you enter the hospital, nursing home or care home (the last time)? (Enter separately each hospitalization reported. Begin with last Hospitalization and work backwards; if exact date not known, obtain estimate.) (c)			How many nights were you in the hospital? (If exact number not known accept best estimate) (d)	For what condition did you enter the hospital -- do you know the medical name? (If medical name not known, enter respondent's description.) (Entry must show "Cause," "Kind," and "Part of body" in same detail as required in Part III.) "CAUSE", "KIND", "PART OF BODY" (e)	Were any operations performed on you during this stay at the hospital? If "Yes," ask: (a) What was the name of the operation? (b) Any other operations? If "yes", ask: Name of operation? (f)	Name of Hospital, Nursing Home or Care Home (g)	Line Number
1.			Month	Day	Year	Nights		[ ] Yes [ ] No		1.
2.			Month	Day	Year	Nights		[ ] Yes [ ] No		2.
3.			Month	Day	Year	Nights		[ ] Yes [ ] No		3.
4.			Month	Day	Year	Nights		[ ] Yes [ ] No		4.

INTERVIEWER: Inquire about children under 1 year in the household. Include hospitalization for delivery of mother.
For delivery ask: "Was this a normal delivery?"
For newborn ask: "Was baby normal at birth?"

Department of Planning and Economic Development
Survey of Population Movement

Island ____________

Sample No. ____________

Question	Column 1	Column 2	Column 3	Column 4
Where did each member of your household live exactly one year ago? (Ask for each person except children under 1 year of age. For children under 1 year, check item 6, "under 1 year.")	1.___ Same house 2.___ Different house on this island 3.___ Different island Name: ________ 4.___ Different state Name: ________ 5.___ Different country Name: ________ 6.___ Under 1 year 7.___ U.S. Terr/Poss Name: ________	1.___ Same house 2.___ Different house on this island 3.___ Different island Name: ________ 4.___ Different state Name: ________ 5.___ Different country Name: ________ 6.___ Under 1 year 7.___ U.S. Terr/Poss Name: ________	1.___ Same house 2.___ Different house on this island 3.___ Different island Name: ________ 4.___ Different state Name: ________ 5.___ Different country Name: ________ 6.___ Under 1 year 7.___ U.S. Terr/Poss Name: ________	1.___ Same house 2.___ Different house on this island 3.___ Different island Name: ________ 4.___ Different state Name: ________ 5.___ Different country Name: ________ 6.___ Under 1 year 7.___ U.S. Terr/Poss Name: ________

	Column 5	Column 6	Column 7	Column 8
	1.___ Same house 2.___ Different house on this island 3.___ Different island Name: ________ 4.___ Different state Name: ________ 5.___ Different country Name: ________ 6.___ Under 1 year 7.___ U.S. Terr/Poss Name: ________	1.___ Same house 2.___ Different house on this island 3.___ Different island Name: ________ 4.___ Different state Name: ________ 5.___ Different country Name: ________ 6.___ Under 1 year 7.___ U.S. Terr/Poss Name: ________	1.___ Same house 2.___ Different house on this island 3.___ Different island Name: ________ 4.___ Different state Name: ________ 5.___ Different country Name: ________ 6.___ Under 1 year 7.___ U.S. Terr/Poss Name: ________	1.___ Same house 2.___ Different house on this island 3.___ Different island Name: ________ 4.___ Different state Name: ________ 5.___ Different country Name: ________ 6.___ Under 1 year 7.___ U.S. Terr/Poss Name: ________

We are conducting this supplementary survey on population movement in cooperation with the State Dept. of Planning and Economic Development. The information is needed to plan government services more effectively. Planning for such services as education, medical care facilities, etc., requires current and up-to-date population data, especially in this rapidly changing community of ours. The information provided by you will be kept strictly confidential. Only the combined statistics of all persons will be published.

Department of Planning and Economic Development and
Commission on Population and the Hawaiian Future
Survey of Population Movement

Island ____________________

Sample NO. ________________

QUESTION	Column 1	Column 2	Column 3	Column 4
How likely is it that this person will be living some place other than Hawaii one year from today? Please treat military service or school attendance out of State as residence elsewhere.	( ) Almost certain to be living in Hawaii a year from now. ( ) Some possibility of living elsewhere. ( ) A good chance of living elsewhere. ( ) Almost certain to be living elsewhere.	( ) Almost certain to be living in Hawaii a year from now. ( ) Some possibility of living elsewhere. ( ) A good chance of living elsewhere. ( ) Almost certain to be living elsewhere.	( ) Almost certain to be living in Hawaii a year from now. ( ) Some possibility of living elsewhere. ( ) A good chance of living elsewhere. ( ) Almost certain to be living elsewhere.	( ) Almost certain to be living in Hawaii a year from now. ( ) Some possibility of living elsewhere. ( ) A good chance of living elsewhere. ( ) Almost certain to be living elsewhere.

	Column 5	Column 6	Column 7	Column 8
	( ) Almost certain to be living in Hawaii a year from now. ( ) Some possibility of living elsewhere. ( ) A good chance of living elsewhere. ( ) Almost certain to be living elsewhere.	( ) Almost certain to be living in Hawaii a year from now. ( ) Some possibility of living elsewhere. ( ) A good chance of living elsewhere. ( ) Almost certain to be living elsewhere	( ) Almost certain to be living in Hawaii a year from now. ( ) Some possibility of living elsewhere. ( ) A good chance of living elsewhere. ( ) Almost certain to be living elsewhere.	( ) Almost certain to be living in Hawaii a year from now. ( ) Some possibility of living elsewhere. ( ) A good chance of living elsewhere. ( ) Almost certain to be living elsewhere.

6/73 3/78
4/81 Revised

HAWAII HEALTH SURVEILLANCE PROGRAM

FLASH CARD SIDE A

A. HAVE YOU OR ANYONE ELSE IN THIS HOUSEHOLD EVER HAD ANY OF THE FOLLOWING ?

1. RHEUMATIC FEVER (childhood condition; inflammation of heart)
2. TUBERCULOSIS (lungs; bones or joints)

B. HAVE YOU OR ANYONE ELSE IN THIS HOUSEHOLD HAD ANY OF THE FOLLOWING ANYTIME DURING THE PAST TWELVE MONTHS (PAST YEAR) ?

1. ASTHMA (wheezing; strong coughing)
2. BRONCHITIS (strong coughing; sticky sputum)
3. SINUS (headaches with nasal/post nasal discharges)
4. HARDENING OF THE ARTERIES (arterio-sclerosis)
5. HIGH BLOOD PRESSURE (hypertension; pressure greater than 140/90)
6. HEART TROUBLE (pain in the chest; heart attack; congenital)
7. STROKE (cerebral/brain hemorrhage; apoplexy)
8. VARICOSE VEINS (veins are enlarged, bluish, prominent)
9. HEMORRHOIDS (piles; painful bowel movement)
10. HAY FEVER (allergy to matter in the air)
11. OTHER ALLERGIES (food; hives; chemicals; medicine; hot/cold; etc.
12. TUMOR, CYST, or GROWTH (breast; brain; ovaries; mouth; etc.)
13. GALLBLADDER or LIVER TROUBLE (gallstones; cirrhosis; hepatitis; etc.)
14. STOMACH ULCER (gastric ulcer; duodenal ulcer; etc.)
15. OTHER STOMACH TROUBLE (chronic gastritis; etc.)
16. KIDNEY TROUBLE (stones; failure; dialysis; etc.)
17. ARTHRITIS or RHEUMATISM (inflammation/deep pain in joints, tendons; etc.
18. GOUT (sharp pain usually in one joint)
19. DIABETES (sugar diabetes; pituitary diabetes)
20. THYROID TROUBLE (goiter; under-active; over-active)
21. EMPHYSEMA (hard-time breathing; shortness of breath; etc.)
22. EPILEPSY (seizures; grand mal; petit mal;)
23. NERVOUS TROUBLE (trouble sleeping; worry all the time; anxiety)
24. CANCER (unusual cell growth; affects any body part)
25. SKIN TROUBLE (red patches; boils; psoriasis; herpes; etc.)
26. HERNIA or RUPTURE (diaphragm or hiatus; etc.)
27. PROSTATE TROUBLE (frequent night urination; enlarged prostate)
28. Any Other Health Condition Not Mentioned Above ?

FLASH CARD SIDE B

C. DO YOU OR ANYONE ELSE IN THIS HOUSEHOLD HAVE ANY OF THE FOLLOWING ?

1. DEAFNESS or TROUBLE HEARING with one or both ears ?

2. BLINDNESS or SERIOUS TROUBLE SEEING with one or both eyes even when wearing glasses ?

3. CLEFT PALATE (a split or opening in the roof of the mouth) ?

4. Any SPEECH DEFECT (-lisp, stuttering, etc.-) ?

5. MISSING PHYSICAL EXTREMITIES (such as toes, fingers, foot, arm, hand) ?

6. MISSING INTERNAL ORGANS (such as kidney, lung, gallbladder, etc.)?

7. PARALYSIS of any kind (such as due to stroke, accidents, etc.) ?

8. Repeated trouble with BACK or SPINE ?

9. CLUB FOOT (a foot that is twisted out of position) ?

10. Permanent STIFFNESS or any DEFORMITY of the foot, leg, fingers, arm or back ?

11. MENTAL RETARDATION (such as in learning, maturation, social adjustment) ?

12. Any Condition Present Since Birth ?

(2/1/84)

PUNA HEALTH SURVEY
SUPPLEMENTAL QUESTIONAIRE FORM 1

1. Sample Number: __ __ __ __ 2. Census Tract Number: __ __ __ __ __

3. Telephone Number: _____

4. Interviewer Number: _____ Date: _____

INTRODUCTORY STATEMENT: (Read to Respondent/Family)

I WOULD LIKE TO ASK YOU SOME MORE SPECIFIC QUESTIONS. ALL INFORMATION OBTAINED HERE WILL BE KEPT CONFIDENTIAL AND WILL BE USED FOR STATISTICAL PURPOSES ONLY.

COMMENTS/NOTES:

Turn the page and abstract the names and person numbers for all persons living at this household, and begin asking the questions.

5. PERSON NUMBERS: --->	5.Person Number 1	5.Person Number 2
6. NAMES OF HOUSEHOLD MEMBERS: --->	6. Person's Name:	6. Person's Name:
7. HOW LONG HAVE YOU LIVED AT THIS ADDRESS?	7. How long here? Number years_____ Numbr months_____ [] Unknown	7. How long here? Number years_____ Numbr months_____ [] Unknown
8. (Check the Respondent:) ---> NOW I'D LIKE TO ASK A FEW QUESTIONS ABOUT PAST ILLNESSES.	8. [] Respondent [] Non-Resp. [] Other_____	8. [] Respondent [] Non-Resp. [] Other_____
9. DID YOU EVER HAVE ANY LUNG TROUBLE? --->	9. []Yes []No []DK	9. []Yes []No []DK
10A. HAVE YOU EVER HAD ANY OF THE FOLLOWING? ATTACKS OF BRONCHITIS OR CHRONIC BRONCHITIS? ----->	10A. [] No,Skip to 11A [] DK,Skip to 11A [] Yes,Go to 10B	10A. [] No,Skip to 11A [] DK,Skip to 11A [] Yes,Go to 10B
(If YES to 10A, Ask:) 10B. WAS IT CONFIRMED BY A DOCTOR? --->	10B. []Yes []No []DK	10B. []Yes []No []DK
10C. AT WHAT AGE WAS YOUR FIRST ATTACK? ----->	10C. Years old _____ [] DK	10C. Years old _____ [] DK
11A. PNEUMONIA? (INCLUDE BRONCHOPNEUMONIA) ----->	11A. [] No,Skip to 12A [] Dk,Skip to 12A [] Yes,Go to 11B	11A. [] No,Skip to 12A [] Dk,Skip to 12A [] Yes,Go to 11B
(If YES to 11A, Ask:) 11B. WAS IT CONFIRMED BY A DOCTOR? -->	11B. []Yes []No []Dk	11B. []Yes []No []Dk
11C. AT WHAT AGE DID YOU FIRST HAVE IT? ---->	11C. Years old _____ [] Dk	11C. Years old _____ [] Dk
12A. HAY FEVER? ---->	12A. [] No,Skip to 13A [] Dk,Skip to 13A [] Yes,Go to 12B	12A. [] No,Skip to 13A [] Dk,Skip to 13A [] Yes,Go to 12B
(If YES to 12A, Ask:) 12B. WAS IT CONFIRMED BY A DOCTOR? --->	12B. []Yes []No []Dk	12B. []Yes []No []Dk
12C. AT WHAT AGE DID IT START? ---->	12C. [] Dk Years old _____	12C. [] Dk Years old _____

5.Person Number 3	5.Person Number 4	5.Person Number 5	5.Person Number 6
6. Person's Name:	6. Person's Name:	6. Person's Name:	6. Person's Name:
7. How long here? Number years_____ Numbr months_____ [] Unknown	7. How long here? Number years_____ Numbr months_____ [] Unknown	7. How long here? Number years_____ Numbr months_____ [] Unknown	7. How long here? Number years_____ Numbr months_____ [] Unknown
8. [] Respondent [] Non-Resp. [] Other_____	8. [] Respondent [] Non-Resp. [] Other_____	8. [] Respondent [] Non-Resp. [] Other_____	8. [] Respondent [] Non-Resp. [] Other_____
9. []Yes []No []Dk	9. []Yes []No []Dk	9. []Yes []No []Dk	9. []Yes []No []Dk
10A. [] No,Skip to 11A [] Dk,Skip to 11A [] Yes,Go to 10B	10A. [] No,Skip to 11A [] Dk,Skip to 11A [] Yes,Go to 10B	10A. [] No,Skip to 11A [] Dk,Skip to 11A [] Yes,Go to 10B	10A. [] No,Skip to 11A [] Dk,Skip to 11A [] Yes,Go to 10B
10B. []Yes []No []Dk	10B. []Yes []No []Dk	10B. []Yes []No []Dk	10B. []Yes []No []Dk
10C. Years old _____ [] Dk	10C. Years old _____ [] Dk	10C. Years old _____ [] Dk	10C. Years old _____ [] Dk
11A. [] No,Skip to 12A [] Dk,Skip to 12A [] Yes,Go to 11B	11A. [] No,Skip to 12A [] Dk,Skip to 12A [] Yes,Go to 11B	11A. [] No,Skip to 12A [] Dk,Skip to 12A [] Yes,Go to 11B	11A. [] No,Skip to 12A [] Dk,Skip to 12A [] Yes,Go to 11B
11B. []Yes []No []Dk	11B. []Yes []No []Dk	11B. []Yes []No []Dk	11B. []Yes []No []Dk
11C. Years old _____ [] Dk	11C. Years old _____ [] Dk	11C. Years old _____ [] Dk	11C. Years old _____ [] Dk
12A. [] No,Skip to 13A [] Dk,Skip to 13A [] Yes,Go to 12B	12A. [] No,Skip to 13A [] Dk,Skip to 13A [] Yes,Go to 12B	12A. [] No,Skip to 13A [] Dk,Skip to 13A [] Yes,Go to 12B	12A. [] No,Skip to 13A [] Dk,Skip to 13A [] Yes,Go to 12B
12B. []Yes []No []Dk	12B. []Yes []No []Dk	12B. []Yes []No []Dk	12B. []Yes []No []Dk
12C. [] Dk Years old _____	12C. [] Dk Years old _____	12C. [] Dk Years old _____	12C. [] Dk Years old _____

5. PERSON NUMBERS: --->	5.Person Number 1	5.Person Number 2
6. NAMES OF HOUSEHOLD MEMBERS: --->	6. Person's Name:	6. Person's Name:
13A.SINUS TROUBLE? ----->	13A. [] No,Skip to 14A [] Dk,Skip to 14A [] Yes,Go to 13B	13A. [] No,Skip to 14A [] Dk,Skip to 14A [] Yes,Go to 13B
(If YES to 13A, Ask:) 13B.WAS IT CONFIRMED BY A DOCTOR?--->	13B. []Yes []No []Dk	13B. []Yes []No []Dk
13C.AT WHAT AGE DID IT START? ---->	13C. [] Dk Years old _____	13C. []Dk Years old _____
14A.HAVE YOU EVER HAD EMPHYSEMA? --->	14A. [] No,Skip to 15A [] Dk,Skip to 15A [] Yes,Go to 14B)	14A. [] No,Skip to 15A [] Dk,Skip to 15A [] Yes,Go to 14B)
(If YES to 14A, Ask:) 14B.DO YOU STILL HAVE IT? --->	14B. []Yes []No []DK	14B. []Yes []No []DK
14C.WAS IT CONFIRMED BY A DOCTOR?--->	14C. []Yes []No []Dk	14C. []Yes []No []DK
14D.AT WHAT AGE DID IT START? --->	14D. [] Dk Years old _____	14D. [] Dk Years old _____
15A.HAVE YOU EVER HAD ASTHMA? --->	15A. [] No,Skip to 16A [] Dk,Skip to 16A [] Yes,Go to 15B	15A. [] No,Skip to 16A [] Dk,Skip to 16A [] Yes,Go to 15B
(If YES to 15A, Ask:) 15B.DO YOU STILL HAVE IT? --->	15B. []Yes []No []DK	15B. []Yes []No []Dk
15C.WAS IT CONFIRMED BY A DOCTOR?--->	15C. [] No,Skip to 16A [] Dk,Skip to 16A [] Yes,Go to 15D	15C. [] No,Skip to 16A [] Dk,Skip to 16A [] Yes,Go to 15D
15D.AT WHAT AGE DID IT START? ---->	15D. [] Dk Years old _____	15D. [] Dk Years old _____
15E.IF YOU NO LONGER HAVE IT, AT WHAT AGE DID IT STOP? ---->	15E. [] Dk Years old _____	15E. [] Dk Years old _____
HAVE YOU EVER HAD: 16A.ANY OTHER CHEST ILLNESS? --->**(If YES, Ask:)** PLEASE SPECIFY. --->	16A. []Yes []No []Dk Kinds:	16A. []Yes []No []Dk Kinds:

5.Person Number 3	5.Person Number 4	5.Person Number 5	5.Person Number 6
6. Person's Name:	6. Person's Name:	6. Person's Name:	6. Person's Name:
13A. [] No,Skip to 14A [] Dk,Skip to 14A [] Yes,Go to 13B	13A. [] No,Skip to 14A [] Dk,Skip to 14A [] Yes,Go to 13B	13A. [] No,Skip to 14A [] Dk,Skip to 14A [] Yes,Go to 13B	13A. [] No,Skip to 14A [] Dk,Skip to 14A [] Yes,Go to 13B
13B. []Yes []No []Dk	13B. []Yes []No []Dk	13B. []Yes []No []Dk	13B. []Yes []No []Dk
13C. [] Dk Years old _____	13C. [] Dk Years old _____	13C. [] Dk Years old _____	13C. [] Dk Years old _____
14A. [] No,Skip to 15A [] Dk,Skip to 15A [] Yes,Go to 14B	14A. [] No,Skip to 15A [] Dk,Skip to 15A [] Yes,Go to 14B	14A. [] No,Skip to 15A [] Dk,Skip to 15A [] Yes,Go to 14B	14A. [] No,Skip to 15A [] Dk,Skip to 15A [] Yes,Go to 14B
14B. []Yes []No []Dk	14B. []Yes []No []Dk	14B. []Yes []No []Dk	14B. []Yes []No []Dk
14C. []Yes []No []Dk	14C. []Yes []No []Dk	14C. []Yes []No []Dk	14C. []Yes []No []Dk
14D. [] Dk Years old _____	14D. [] Dk Years old _____	14D. [] Dk Years old _____	14D. [] Dk Years old _____
15A. [] No,Skip to 16A [] Dk,Skip to 16A [] Yes,Go to 15B	15A. [] No,Skip to 16A [] Dk,Skip to 16A [] Yes,Go to 15B	15A. [] No,Skip to 16A [] Dk,Skip to 16A [] Yes,Go to 15B	15A. [] No,Skip to 16A [] Dk,Skip to 16A [] Yes,Go to 15B
15B. []Yes []No []Dk	15B. []Yes []No []Dk	15B. []Yes []No []Dk	15B. []Yes []No []Dk
15C. [] No,Skip to 16A [] Dk,Skip to 16A [] Yes,Go to 15D	15C. [] No,Skip to 16A [] Dk,Skip to 16A [] Yes,Go to 15D	15C. [] No,Skip to 16A [] Dk,Skip to 16A [] Yes,Go to 15D	15C. [] No,Skip to 16A [] Dk,Skip to 16A [] Yes,Go to 15D
15D. [] Dk Years old _____	15D. [] Dk Years old _____	15D. [] Dk Years old _____	15D. [] Dk Years old _____
15E. [] Dk Years old _____	15E. [] Dk Years old _____	15E. [] Dk Years old _____	15E. [] Dk Years old _____
16A. []Yes []No []Dk Kinds:	16A. []Yes []No []Dk Kinds:	16A. []Yes []No []Dk Kinds:	16A. []Yes []No []Dk Kinds:

5. PERSON NUMBERS: --->	5.Person Number 1	5.Person Number 2
6. NAMES OF HOUSEHOLD MEMBERS: --->	6. Person's Name:	6. Person's Name:
PAST ILLNESS(Continued) HAVE YOU EVER HAD:	16B. []Yes []No []Dk	16B. []Yes []No []Dk
16B.ANY CHEST OPERATIONS? ---->	Kinds:	Kinds:
(If YES, Ask:) PLEASE SPECIFY. ---->		
16C.ANY CHEST INJURIES? ---->	16C. []Yes []No []DK	16C. []Yes []No []DK
(If YES, Ask:) PLEASE SPECIFY. ---->	Kinds:	Kinds:
17A.HAS A DOCTOR EVER TOLD YOU THAT YOU HAD HEART TROUBLE? ---->	17A. []Yes []No []DK	17A. []Yes []No []Dk
(If YES, Ask:) 17B.HAVE YOU EVER HAD TREATMENT FOR FOR HEART TROUBLE IN THE PAST TEN YEARS? -->	17B. []Yes []No []Dk	17B. []Yes []No []Dk
18A.HAS A DOCTOR EVER TOLD YOU THAT YOU HAD HIGH BLOOD PRESSURE? --->	18A. []Yes []No []Dk	18A. []Yes []No []DK
(If YES, Ask:) 18B.HAVE YOU HAD ANY TREATMENT FOR HIGH BLOOD PRESSURE(HYPERTENSION) IN THE PAST TEN YEARS? ---->	18B. []Yes []No []Dk	18B. []Yes []No []Dk
FAMILY HISTORY 19. WERE EITHER OF YOUR NATURAL PARENTS EVER TOLD BY A DOCTOR THAT THEY HAD A CHRONIC LUNG CONDITION, SUCH AS:		
19A.CHRONIC BRONCHITIS? ---->	19A. []Yes []No []Dk	19A. []Yes []No []Dk
19B.EMPHYSEMA? ---->	19B. []Yes []No []Dk	19B. []Yes []No []Dk
19C.ASTHMA? ---->	19C. []Yes []No []Dk	19C. []Yes []No []Dk
19D.TUBERCULOSIS? ---->	19D. []Yes []No []Dk	19D. []Yes []No []Dk

5.Person Number 3	5.Person Number 4	5.Person Number 5	5.Person Number 6
6. Person's Name:	6. Person's Name:	6. Person's Name:	6.. Person's Name:
16B. []Yes []No []Dk Kinds:	16B. []Yes []No []Dk Kinds:	16B. []Yes []No []Dk Kinds:	16B. []Yes []No []Dk Kinds:
16C. []Yes []No []Dk Kinds:	16C. []Yes []No []Dk Kinds:	16C. []Yes []No []Dk Kinds:	16C. []Yes []No []Dk Kinds:
17A. []Yes []No []Dk	17A. []Yes []No []Dk	17A. []Yes []No []Dk	17A. []Yes []No []Dk
17B. []Yes []No []Dk	17B. []Yes []No []Dk	17B. []Yes []No []Dk	17B. []Yes []No []Dk
18A. []Yes []No []Dk	18A. []Yes []No []Dk	18A. []Yes []No []Dk	18A. []Yes []No []Dk
18B. []Yes []No []Dk	18B. []Yes []No []Dk	18B. []Yes []No []Dk	18B. []Yes []No []Dk
19A. []Yes []No []Dk	19A. []Yes []No []Dk	19A. []Yes []No []Dk	19A. []Yes []No []Dk
19B. []Yes []No []Dk	19B. []Yes []No []Dk	19B. []Yes []No []Dk	19B. []Yes []No []Dk
19C. []Yes []No []Dk	19C. []Yes []No []Dk	19C. []Yes []No []Dk	19C. []Yes []No []Dk
19D. []Yes []No []Dk	19D. []Yes []No []Dk	19D. []Yes []No []Dk	19D. []Yes []No []Dk

5. PERSON NUMBERS: --->	5.Person Number 1	5.Person Number 2
6. NAMES OF HOUSEHOLD MEMBERS: --->	6. Person's Name:	6. Person's Name:
	- - - - - - - - -	- - - - - - - - -
The Remaining Questions are ONLY for persons age 13 and over.		
PREAMBLE: A FEW MORE SPECIFIC QUESTIONS:		
OCCUPATIONAL HISTORY 20A. HAVE YOU EVER WORKED FULL TIME (30 HOURS PER WEEK OR MORE) FOR 6 MONTHS OR MORE? ---->	20A. [] No,Skip to 21A [] Dk,Skip to 21A [] Yes,Go to 20B	20A. [] No,Skip to 21A [] Dk,Skip to 21A [] Yes,Go to 20B
20B. HAVE YOU EVER WORKED FOR A YEAR OR MORE IN ANY DUSTY INDUSTRY?--> **(If YES, Ask:)** WHAT JOB OR INDUSTRY WAS IT? --->	20B. []Yes []No []Dk Job/Industry:	20B. []Yes []No []Dk Job/Industry:
HOW LONG DID YOU WORK AT IT? --->	Years worked_____	Years worked_____
WAS DUST EXPOSURE: --->	[] Mild [] Moderate [] Severe	[] Mild [] Moderate [] Severe
20C. HAVE YOU EVER BEEN EXPOSED TO GAS OR CHEMICAL FUMES IN YOUR WORK?-> (If YES, Ask:) WHAT JOB OR INDUSTRY WAS IT? --->	20C. []Yes []No []Dk Job/Industry:	20C. []Yes []No []Dk Job/Industry:
HOW LONG DID YOU WORK AT IT? --->	Years worked_____	Years worked_____
WAS EXPOSURE: --->	[] Mild [] Moderate [] Severe	[] Mild [] Moderate [] Severe
20D. WHAT HAS BEEN YOUR USUAL JOB OR OCCUPATION - THE ONE YOU HAVE WORKED AT THE LONGEST? ---->	20D. Job/Occupation:	20D. Job/Occupation:
HOW MANY YEARS HAVE YOU BEEN EMPLOYED IN THIS OCCUPATION? --->	Years worked_____	Years worked_____

5.Person Number 3	5.Person Number 4	5.Person Number 5	5.Person Number 6
6. Person's Name:	6. Person's Name:	6. Person's Name:	6.. Person's Name:
20A. [] No,Skip to 21A [] Dk,Skip to 21A [] Yes,Go to 20B	20A. [] No,Skip to 21A [] Dk,Skip to 21A [] Yes,Go to 20B	20A. [] No,Skip to 21A [] Dk,Skip to 21A [] Yes,Go to 20B	20A. [] No,Skip to 21A [] Dk,Skip to 21A [] Yes,Go to 20B
20B. []Yes []No []Dk Job/Industry:	20B. []Yes []No []Dk Job/Industry:	20B. []Yes []No []Dk Job/Industry:	20B. []Yes []No []Dk Job/Industry:
Years worked_____	Years worked_____	Years worked_____	Years worked_____
[] Mild [] Moderate [] Severe	[] Mild [] Moderate [] Severe	[] Mild [] Moderate [] Severe	[] Mild [] Moderate [] Severe
20C. []Yes []No []Dk Job/Industry:	20C. []Yes []No []Dk Job/Industry:	20C. []Yes []No []Dk Job/Industry:	20C. []Yes []No []Dk Job/Industry:
Years worked_____	Years worked_____	Years worked_____	Years worked_____
[] Mild [] Moderate [] Severe	[] Mild [] Moderate [] Severe	[] Mild [] Moderate [] Severe	[] Mild [] Moderate [] Severe
20D. Job/Occupation:	20D. Job/Occupation:	20D. Job/Occupation:	20D. Job/Occupation:
Years worked_____	Years worked_____	Years worked_____	Years worked_____

5. PERSON NUMBERS: --->	5.Person Number 1	5.Person Number 2
6. NAMES OF HOUSEHOLD MEMBERS: --->	6. Person's Name:	6. Person's Name:
TOBACCO SMOKING		
21A. HAVE YOU EVER SMOKED CIGARETTES? (Mark, NO if person smoked less than 20 packs of cigarettes or 12 oz. of tobacco in a lifetime, or less than 1 cigarette a day for one year.)	21A. [ ] No,Skip to 22A [ ] Dk,Skip to 22A [ ] Yes,Go to 21B	21A. [ ] No,Skip to 22A [ ] Dk,Skip to 22A [ ] Yes,Go to 21B
21B. DO YOU NOW SMOKE CIGARETTES? (As of one month ago)	21B. [ ] No,Skip to 21D [ ] Dk,Skip to 21D [ ] Yes,Go to 21C	21B. [ ] No,Skip to 21D [ ] Dk,Skip to 21D [ ] Yes,Go to 21C
(If YES to 21B, Ask:) 21C. HOW MANY CIGARETTES DO YOU SMOKE PER DAY NOW? SMOKING?	21C. Cgts /Day_____ [ ] Dk	21C. Cgts /Day____ [ ] Dk
21D. IF YOU HAVE STOPPED SMOKING CIGARETTES COMPLETELY, HOW OLD WERE YOU WHEN YOU STOPPED?	21D. Years old _____ [ ] Dk	21D. Years old _____ [ ] Dk
21E. HOW OLD WERE YOU WHEN YOU FIRST STARTED REGULAR CIGARETTE SMOKING?	21E. Years Old _____ [ ] Dk	21E. Years Old _____ [ ] Dk
21F. DURING THE ENTIRE TIME YOU SMOKED, ON THE AVERAGE, HOW MANY CIGARETTES DID YOU SMOKE PER DAY?	21F. Cgts /Day_____ [ ] Dk	21F. Cgts /Day_____ [ ] Dk
21G. DO OR DID YOU INHALE THE CIGARETTE SMOKE?	21G. [ ] Not at all [ ] Slightly [ ] Moderately [ ] Deeply [ ] Dk	21G. [ ] Not at all [ ] Slightly [ ] Moderately [ ] Deeply [ ] Dk
22A. HAVE YOU EVER SMOKED A PIPE REGULARLY? (YES means more than 12 oz. of tobacco in a lifetime.)	22A. [ ] No,Skip to 23A [ ] Dk,Skip to 23A [ ] Yes,Go to 22B	22A. [ ] No,Skip to 23A [ ] Dk,Skip to 23A [ ] Yes,Go to 22B
22B. DO YOU NOW SMOKE A PIPE?	22B. [ ] No,Skip to 22D [ ] Dk,Skip to 22D [ ] Yes,Go to 22C	22B. [ ] No,Skip to 22D [ ] Dk,Skip to 22D [ ] Yes,Go to 22C
(If YES to 22B, Ask:) 22C. HOW MUCH PIPE TOBACCO ARE YOU SMOKING NOW? (A standard pouch contains 1.5 Oz.)	22C. Oz./Week _____ [ ] Dk	22C. Oz./Week _____ [ ] Dk

5.Person Number 3	5.Person Number 4	5.Person Number 5	5.Person Number 6
6. Person's Name:	6. Person's Name:	6. Person's Name:	6. Person's Name:
21A. [] No,Skip to 22A [] Dk,Skip to 22A [] Yes,Go to 21B	21A. [] No,Skip to 22A [] Dk,Skip to 22A [] Yes,Go to 21B	21A. [] No,Skip to 22A [] Dk,Skip to 22A [] Yes,Go to 21B	21A. [] No,Skip to 22A [] Dk,Skip to 22A [] Yes,Go to 21B
21B. [] No,Skip to 21D [] Dk,Skip to 21D [] Yes,Go to 21C	21B. [] No,Skip to 21D [] Dk,Skip to 21D [] Yes,Go to 21C	21B. [] No,Skip to 21D [] Dk,Skip to 21D [] Yes,Go to 21C	21B. [] No,Skip to 21D [] Dk,Skip to 21D [] Yes,Go to 21C
21C. Cgts /Day_____ [] Dk	21C. Cgts /Day_____ [] Dk	21C. Cgts /Day_____ [] Dk	21C. Cgts /Day_____ [] Dk
21D. Years old _____ [] Dk	21D. Years old _____ [] Dk	21D. Years old _____ [] Dk	21D. Years old _____ [] Dk
21E. Years Old _____ [] Dk	21E. Years Old _____ [] Dk	21E. Years Old _____ [] Dk	21E. Years Old _____ [] Dk
21F. Cgts /Day_____ [] Dk	21F. Cgts /Day_____ [] Dk	21F. Cgts /Day_____ [] Dk	21F. Cgts /Day_____ [] Dk
21G. [] Not at all [] Slightly [] Moderately [] Deeply [] Dk	21G. [] Not at all [] Slightly [] Moderately [] Deeply [] Dk	21G. [] Not at all [] Slightly [] Moderately [] Deeply [] Dk	21G. [] Not at all [] Slightly [] Moderately [] Deeply [] Dk
22A. [] No,Skip to 23A [] Dk,Skip to 23A [] Yes,Go to 22B	22A. [] No,Skip to 23A [] Dk,Skip to 23A [] Yes,Go to 22B	22A. [] No,Skip to 23A [] Dk,Skip to 23A [] Yes,Go to 22B	22A. [] No,Skip to 23A [] Dk,Skip to 23A [] Yes,Go to 22B
22B. [] No,Skip to 23A [] Dk,Skip to 23A [] Yes,Go to 22C	22B. [] No,Skip to 23A [] Dk,Skip to 23A [] Yes,Go to 22C	22B. [] No,Skip to 23A [] Dk,Skip to 23A [] Yes,Go to 22C	22B. [] No,Skip to 23A [] Dk,Skip to 23A [] Yes,Go to 22C
22C. Oz./Week _____ [] Dk	22C. Oz./Week _____ [] Dk	22C. Oz./Week _____ [] Dk	22C. Oz./Week _____ [] Dk

5. PERSON NUMBERS: --->	5.Person Number 1	5.Person Number 2
6. NAMES OF HOUSEHOLD MEMBERS: --->	6. Person's Name:	6. Person's Name:
22D. IF YOU HAVE STOPPED SMOKING A PIPE COMPLETELY, HOW OLD WERE YOU WHEN YOU STOPPED? --->	22D. [] Dk Age Stopped _____	22D. [] Dk Age Stopped _____
22E. HOW OLD WERE YOU WHEN YOU STARTED TO SMOKE A PIPE REGULARLY? --->	22E. [] Dk Years old _____	22E. [] Dk Years old _____
22F. OVER THE ENTIRE TIME YOU SMOKED A PIPE, ON THE AVERAGE, HOW MUCH PIPE TOBACCO DID YOU SMOKE PER WEEK? ---->	22F. [] Dk Oz./Week _____	22F. [] Dk Oz./Week _____
22G. DO YOU OR DID YOU INHALE THE PIPE SMOKE? (Read Categories)-->	22G. [] Not at all [] Slightly [] Moderately [] Deeply [] Dk	22G. [] Not at all [] Slightly [] Moderately [] Deeply [] Dk
23A. HAVE YOU EVER SMOKED CIGARS REGULARLY? (YES means more than one cigar a week for a year) ---->	23A. [] No,Skip to 24 [] Dk,Skip to 24 [] Yes,Go to 23B	23A. [] No,Skip to 24 [] Dk,Skip to 24 [] Yes,Go to 23B
23B. DO YOU NOW SMOKE CIGARS? ---->	23B. [] No,Skip to 23D [] Dk,Skip to 23D [] Yes,Go to 23C	23B. [] No,Skip to 23D [] Dk,Skip to 23D [] Yes,Go to 23C
(If YES to 23B, Ask:) 23C. HOW MANY CIGARS ARE YOU SMOKING PER WEEK NOW? ---->	23C. [] Dk Cigars/Week_____	23C. [] Dk Cigars/Week_____
23D. IF YOU HAVE STOPPED SMOKING CIGARS COMPLETELY, HOW OLD WERE YOU WHEN YOU STOPPED? ---->	23D. Age Stopped _____ [] Dk	23D. Age Stopped _____ [] Dk
23E. HOW OLD WERE YOU WHEN YOU STARTED SMOKING CIGARS REGULARLY? ---->	23E. [] Dk Years old _____	23E. [] Dk Years Old _____
23F. OVER THE ENTIRE TIME YOU SMOKED CIGARS, ON THE AVERAGE, HOW MANY CIGARS DID YOU SMOKE PER WEEK? ---->	23F. Cigars/Week _____ [] Dk	23F. Cigars/Week _____ [] Dk
23G. DO OR DID YOU INHALE THE CIGAR SMOKE? ---->	23G. [] Not at all [] Slightly [] Moderately [] Deeply [] Dk	23G. [] Not at all [] Slightly [] Moderately [] Deeply [] Dk
24. HAVE YOU EVER SMOKED NON-TOBACCO PRODUCTS (FOR EXAMPLE, MARIJUANA REGULARLY? ---->	24. []Yes []No []Dk	24. []Yes []No []Dk

5.Person Number 3	5.Person Number 4	5.Person Number 5	5.Person Number 6
6. Person's Name:	6. Person's Name:	6. Person's Name:	6. Person's Name:
22D. [] Dk Age Stopped_____	22D. [] Dk Age Stopped_____	22D. [] Dk Age Stopped_____	22D. [] Dk Age Stopped_____
22E. [] Dk Years old _____	22E. [] Dk Years old _____	22E. [] Dk Years old _____	22E. [] Dk Years old _____
22F. [] Dk Oz./Week _____	22F. [] Dk Oz./Week _____	22F. [] Dk Oz./Week _____	22F. [] Dk Oz./Week _____
22G. [] Not at all [] Slightly [] Moderately [] Deeply [] Dk	22G. [] Not at all [] Slightly [] Moderately [] Deeply [] Dk	22G. [] Not at all [] Slightly [] Moderately [] Deeply [] Dk	22G. [] Not at all [] Slightly [] Moderately [] Deeply [] Dk
23A. [] No,Skip to 24 [] Dk,Skip to 24 [] Yes,Go to 23B	23A. [] No,Skip to 24 [] Dk,Skip to 24 [] Yes,Go to 23B	23A. [] No,Skip to 24 [] Dk,Skip to 24 [] Yes,Go to 23B	23A. [] No,Skip to 24 [] Dk,Skip to 24 [] Yes,Go to 23B
23B. [] No,Skip to 23D [] Dk,Skip to 23D [] Yes,Go to 23C	23B. [] No,Skip to 23D [] Dk,Skip to 23D [] Yes,Go to 23C	23B. [] No,Skip to 23D [] Dk,Skip to 23D [] Yes,Go to 23C	23B. [] No,Skip to 23D [] Dk,Skip to 23D [] Yes,Go to 23C
23C. [] Dk Cigars/Week _____	23C. [] Dk Cigars/Week_____	23C. [] Dk Cigars/Week_____	23C. [] Dk Cigars/Week_____
23D. Age Stopped _____ [] Dk	23D. Age Stopped _____ [] Dk	23D. Age Stopped _____ [] Dk	23D. Age Stopped _____ [] Dk
23E. [] Dk Years old _____	23E. [] Dk Years old _____	23E. [] Dk Years old _____	23E. [] Dk Years old _____
23F. Cigars/Week_____ [] Dk	23F. Cigars/Week_____ [] Dk	23F. Cigars/Week_____ [] Dk	23F. Cigars/Week------ [] Dk
23G. [] Not at all [] Slightly [] Moderately [] Deeply [] Dk	23G. [] Not at all [] Slightly [] Moderately [] Deeply [] Dk	23G. [] Not at all [] Slightly [] Moderately [] Deeply [] Dk	23G. [] Not at all [] Slightly [] Moderately [] Deeply [] Dk
24. []Yes []No []Dk	24. []Yes []No []Dk	24. []Yes []No []Dk	24. []Yes []No []Dk

5. PERSON NUMBERS: --->	5.Person Number 1	5.Person Number 2
6. NAMES OF HOUSEHOLD MEMBERS: --->	6. Person's Name:	6. Person's Name:

PREAMBLE:
THIS STUDY IS, IN PART, BEING DONE IN RESPONSE TO CONCERNS BY RESIDENTS IN PUNA OF POSSIBLE HEALTH EFFECTS OF GEOTHERMAL EFFLUENTS. ODOR AND NOISE HAVE ALSO BEEN ASSOCIATED WITH GEOTHERMAL DEVELOPMENT IN VARIOUS AREAS.

25A. DO YOU FIND THE ODOR OF HYDROGEN SULFIDE* TO BE ANNOYING HERE (AT THIS RESIDENCE)? ---> *(Hydrogen sulfide has a "rotten-egg" smell.)	25A. [] No,Skip to 26A [] Dk,Skip to 26A [] Yes,Go to 25B	25A. [] No,Skip to 26A [] Dk,Skip to 26A [] Yes,Go to 25B
(If YES to 25A, Ask:) 25B. USUALLY, HOW OFTEN TO YOU NOTICE THIS ODOR? ---->	25B. [] Every Day [] 1-6 Days/Week [] 1-3 Days/Month [] Under 1 Day/Mo [] None past Year [] Dk	25B. [] Every Day [] 1-6 Days/Week [] 1-3 Days/Month [] Under 1 Day/Mo [] None past Year [] Dk
25C. WHERE DO YOU THINK THIS ODOR COMES FROM? ----> (Read Categories:)	25C. []Natural Venting []Geothermal Wells []Comb. of above []Other sources []Dk	25C. []Natural Venting []Geothermal Wells []Comb. of above []Other sources []DK
26A. DO YOU FIND NOISES FROM GEOTHERMAL DEVELOPMENT ACTIVITIES TO BE ANNOYING HERE (AT THIS RESIDENCE)? --->	26A. [] No,Skip to 27 [] Dk,Skip to 27 [] Yes,Go to 26B	26A. [] No,Skip to 27 [] Dk,Skip to 27 [] Yes,Go to 26B
(If YES to 26A, Ask:) 26B. HOW OFTEN DOES THIS NOISE BOTHER YOU? ---->	26B. [] Every Day [] 1-6 Days/Week [] 1-3 Days/Month []When Drilling or Venting Wells Only [] Dk	26B. [] Every Day [] 1-6 Days/Week [] 1-3 Days/Month []When Drilling or Venting Wells Only [] Dk
27. HOW WOULD YOU CLASSIFY YOUR GENERAL FEELING TOWARD GEOTHERMAL DEVELOPMENT IN THE STATE OF HAWAII?... IN FAVOR OF GEOTHERMAL DEVELOPMENT IN PUNA? IN FAVOR OF GEOTHERMAL DEVELOPMENT, BUT NOT IN PUNA? OPPOSED TO GEOTHERMAL DEVELOPMENT IN THE STATE? (Select one)	27. [] In Favor of in Puna [] In Favor, but Not in Puna [] Opposed to in the State [] Dk	27. [] In Favor of in Puna [] In Favor, but Not in Puna [] Opposed to in the State [] DK

THANK YOU FOR PARTICIPATING IN THIS SURVEY!

5.Person Number 3	5.Person Number 4	5.Person Number 5	5.Person Number 6
6. Person's Name:	6. Person's Name:	6. Person's Name:	6. Person's Name:
25A. [] No,Skip to 26A [] Dk,Skip to 26A [] Yes,Go to 25B	25A. [] No,Skip to 26A [] Dk,Skip to 26A [] Yes,Go to 25B	25A. [] No,Skip to 26A [] Dk,Skip to 26A [] Yes,Go to 25B	25A. [] No,Skip to 26A [] Dk,Skip to 26A [] Yes,Go to 25B
25B. [] Every Day [] 1-6 Days/Week [] 1-3 Days/Month [] Under 1 Day/Mo [] None past Year [] Dk	25B. [] Every Day [] 1-6 Days/Week [] 1-3 Days/Month [] Under 1 Day/Mo [] None past Year [] Dk	25B. [] Every Day [] 1-6 Days/Week [] 1-3 Days/Month [] Under 1 Day/Mo [] None past Year [] Dk	25B. [] Every Day [] 1-6 Days/Week [] 1-3 Days/Month [] Under 1 Day/Mo [] None past Year [] Dk
25C. []Natural Venting []Geothermal Wells []Comb. of above []Other sources []Dk	25C. []Natural Venting []Geothermal Wells []Comb. of above []Other sources []Dk	25C. []Natural Venting []Geothermal Wells []Comb. of above []Other sources []Dk	25C. []Natural Venting []Geothermal Wells []Comb. of above []Other sources []Dk
26A. [] No,Skip to 27 [] Dk,Skip to 27 [] Yes,Go to 26B	26A. [] No,Skip to 27 [] Dk,Skip to 27 [] Yes,Go to 26B	26A. [] No,Skip to 27 [] Dk,Skip to 27 [] Yes,Go to 26B	26A. [] No,Skip to 27 [] Dk,Skip to 27 [] Yes,Go to 26B
26B. [] Every Day [] 1-6 Days/Week [] 1-3 Days/Month []When Drilling or Venting Wells Only [] Dk	26B. [] Every Day [] 1-6 Days/Week [] 1-3 Days/Month []When Drilling or Venting Wells Only [] Dk	26B. [] Every Day [] 1-6 Days/Week [] 1-3 Days/Month []When Drilling or Venting Wells Only [] Dk	26B. [] Every Day [] 1-6 Days/Week [] 1-3 Days/Month []When Drilling or Venting Wells Only [] Dk
27. [] In Favor of in Puna [] In Favor, but Not in Puna [] Opposed to in the State [] Dk	27. [] In Favor of in Puna [] In Favor, but Not in Puna [] Opposed to in the State [] Dk	27. [] In Favor of in Puna [] In Favor, but Not in Puna [] Opposed to in the State [] Dk	27. [] In Favor of in Puna [] In Favor, but Not in Puna [] Opposed to in the State [] Dk

THANK YOU FOR PARTICIPATING IN THIS SURVEY!

GEORGE R. ARIYOSHI
GOVERNOR OF HAWAII

CHARLES G. CLARK
DIRECTOR OF HEALTH

STATE OF HAWAII
DEPARTMENT OF HEALTH
P. O. BOX 3378
HONOLULU, HAWAII 96801

In reply, please refer to:
File:

March 16, 1984

Dear Resident:

I would like to take this opportunity to thank you for participating in the health survey recently conducted in the Puna area. The overall response rate in the areas surveyed was 90%! Your participation was appreciated and the data collected should be very valuable in assessing the health status of your community. The survey results should be available in June 1984 by contacting the Department of Health (961-7210).

Carl P. Hallenborg, M.D., President of the Hawaii Thoracic Society and Chief of Thoracic Medicine at the University of Hawaii School of Medicine, is planning to conduct a study of pulmonary (lung) function on a selected group of residents in the area. His staff will be contacting randomly selected households in the area on Saturday and Sunday, March 24-25, 1984.

Your participation in this pulmonary function study is, of course, strictly voluntary. Although this study is being conducted separately from the Department of Health survey, the information is intended to supplement that obtained in the survey. Together, the survey and this study may be helpful in addressing concerns of possible adverse health effects associated with natural volcanic and geothermal effluents in Puna.

If you have any questions about Dr. Hallenborg's study, please call Amy at the American Lung Association of Hawaii in Hilo (935-1206 or 935-7474). Thank you again for your cooperation in our survey.

Sincerely,

CHARLES G. CLARK
Director of Health

APPENDIX B

Results of Ambient Air Monitoring for Hydrogen Sulfide
in Leilani Estates, 1983

Prepared by

Linnie Sue Carter[a]

The results of ambient air monitoring for hydrogen sulfide (H_2S) in Leilani Estates for 1983 are presented in the following tables and graphs. The 5 ppb H_2S level was arbitrarily chosen as a reference point because it is currently accepted as the median level for odor detection (Anspaugh and Hahn, 1980).

The first four tables show information pertaining to the individual monitoring stations (See Figure 2). Tables VI and VII, and Figures I and II deal with the months and hours of the day which had concentrations greater than 5 ppb. Table VIII presents the wind data from which the wind roses in Figures III, IV, and V were constructed. In Table IX the hours having concentrations greater than 5 ppb are broken down by wind direction. Figures VI, VII, and VIII show the hours per wind direction for Schroeder, Gilman, and Wood monitoring stations. Table X shows the proportion of hours with winds blowing from the direction of the HGP-A well site.

[a] Prepared in partial fulfillment of Master's Degree Requirements at the University of Hawaii School of Public Health, 1983.

TABLE II

SCHROEDER RESIDENCE H2S DATA (1983)

PERIOD OF RECORD: 1 / 1 / 83 - 12 / 31 / 83

NUMBER OF DAYS IN PERIOD: 365

NUMBER OF HOURS IN PERIOD: 8760

NUMBER OF HOURS OF DATA: 7837

NUMBER OF MISSING HOURS: 923

PERCENTAGE DATA RECOVERY: 89.46%

HIGHEST VALUE (PPB): 8

LOWEST VALUE (PPB): 0

MEAN VALUE (PPB): 1.43

NUMBER OF VALUES > 10 PPB: 0

FRACTIONAL DISTRIBUTION OF VALUES

CONCENTRATION RANGE (PPB)	FRACTION	CUMULATIVE
0 - 2	0.778	0.778
3 - 5	0.220	0.998
6 - 8	0.002	1.000
9 - 11	0.000	1.000
12 - 14	0.000	1.000
15 - 17	0.000	1.000
18 - 20	0.000	1.000
21 - 23	0.000	1.000
24 - 26	0.000	1.000
27 - 29	0.000	1.000
> 30.	0.000	1.000

TABLE III

GILMAN RESIDENCE H2S DATA (1983)

PERIOD OF RECORD: 1 / 1 / 83 - 12/ 31 / 83

NUMBER OF DAYS IN PERIOD: 365

NUMBER OF HOURS IN PERIOD: 8760

NUMBER OF HOURS OF DATA: 8211

NUMBER OF MISSING HOURS: 549

PERCENTAGE DATA RECOVERY: 93.73%

HIGHEST VALUE (PPB): 11

LOWEST VALUE (PPB): 0

MEAN VALUE (PPB): 1.32

NUMBER OF VALUES > 10 PPB: 1

FRACTIONAL DISTRIBUTION OF VALUES

CONCENTRATION RANGE (PPB)	FRACTION	CUMULATIVE
0 - 2	0.887	0.887
3 - 5	0.111	0.998
6 - 8	0.002	1.000
9 - 11	0.000	1.000
12 - 14	0.000	1.000
15 - 17	0.000	1.000
18 - 20	0.000	1.000
21 - 23	0.000	1.000
24 - 26	0.000	1.000
27 - 29	0.000	1.000
> 30	0.000	1.000

TABLE IV

HESS RESIDENCE H2S DATA (1983)

PERIOD OF RECORD: 1 / 1 / 83 - 12 / 31 / 83

NUMBER OF DAYS IN PERIOD: 365

NUMBER OF HOURS IN PERIOD: 8760

NUMBER OF HOURS OF DATA: 8244

NUMBER OF MISSING HOURS: 516

PERCENTAGE DATA RECOVERY: 94.11%

HIGHEST VALUE (PPB): 8

LOWEST VALUE (PPB): 0

MEAN VALUE (PPB): 1.18

NUMBER OF VALUES > 10 PPB: 0

FRACTIONAL DISTRIBUTION OF VALUES

CONCENTRATION RANGE (PPB)	FRACTION	CUMULATIVE
0 - 2	0.946	0.946
3 - 5	0.053	1.000
6 - 8	0.000	1.000
9 - 11	0.000	1.000
12 - 14	0.000	1.000
15 - 17	0.000	1.000
18 - 20	0.000	1.000
21 - 23	0.000	1.000
24 - 26	0.000	1.000
27 - 29	0.000	1.000
> 30	0.000	1.000

TABLE V

WOOD RESIDENCE H2S DATA (1983)

PERIOD OF RECORD: 1 / 1 / 83 - 12 / 31 / 83

NUMBER OF DAYS IN PERIOD: 365

NUMBER OF HOURS IN PERIOD: 8760

NUMBER OF HOURS OF DATA: 8050

NUMBER OF MISSING HOURS: 710

PERCENTAGE DATA RECOVERY: 91.89%

HIGHEST VALUE (PPB): 13

LOWEST VALUE (PPB): 0

MEAN VALUE (PPB): 1.17

NUMBER OF VALUES > 10 PPB: 5

FRACTIONAL DISTRIBUTION OF VALUES

CONCENTRATION RANGE (PPB)	FRACTION	CUMULATIVE
0 - 2	0.893	0.893
3 - 5	0.092	0.985
6 - 8	0.012	0.998
9 - 11	0.002	1.000
12 - 14	0.000	1.000
15 - 17	0.000	1.000
18 - 20	0.000	1.000
21 - 23	0.000	1.000
24 - 26	0.000	1.000
27 - 29	0.000	1.000
> 30	0.000	1.000

LISTING OF VALUES > 10 PPB

DATE	HOUR	CONCENTRATION
17 DEC	11	11
18 DEC	9	11
18 DEC	10	12
18 DEC	11	13
18 DEC	12	11

TABLE VI

Months and Number of Hours with Concentrations Greater Than 5 ppb for Monitoring Sites at Schroeder, Gilman, Hess, and Wood Residences, 1983.

Months	Schroeder	Gilman	Hess	Wood	Total
Jan	0	0	0	0	0
Feb	0	0	0	0	0
Mar	0	0	0	0	0
Apr	0	1	0	0	1
May	7	0	0	0	7
June	1	0	0	0	1
July	0	0	0	0	0
Aug	4	3	0	0	7
Sep	1	13	0	0	14
Oct	0	2	1	16	19
Nov	0	0	0	29	29
Dec	1	0	0	72	73
Total	14	19	1	117	151

TABLE VII

The Hours of the Day Having Concentrations Greater Than 5 ppb for Monitoring Sites at Schroeder, Gilman, Hess, and Wood Residences, 1983.

Time	Schroeder	Gilman	Hess	Wood	Total
0100	0	0	0	3	3
0200	0	1	0	5	6
0300	0	0	0	6	6
0400	0	0	0	4	4
0500	0	0	0	5	5
0600	0	0	0	5	5
0700	0	0	0	5	5
0800	2	0	0	7	9
0900	0	1	0	8	9
1000	0	0	0	11	11
1100	0	1	0	16	17
1200	1	0	0	13	14
1300	0	2	0	11	13
1400	0	0	0	4	4
1500	0	3	0	1	4
1600	1	4	0	2	7
1700	1	4	0	2	7
1800	1	2	0	3	6
1900	2	0	0	0	2
2000	2	0	1	0	3
2100	1	0	0	0	1
2200	1	1	0	2	4
2300	1	0	0	1	2
2400	1	0	0	3	4
Total	14	19	1	117	151

FIGURE I

The Hours of the Day Having Concentrations Greater Than 5 ppb for the Wood Monitoring Station, 1983.

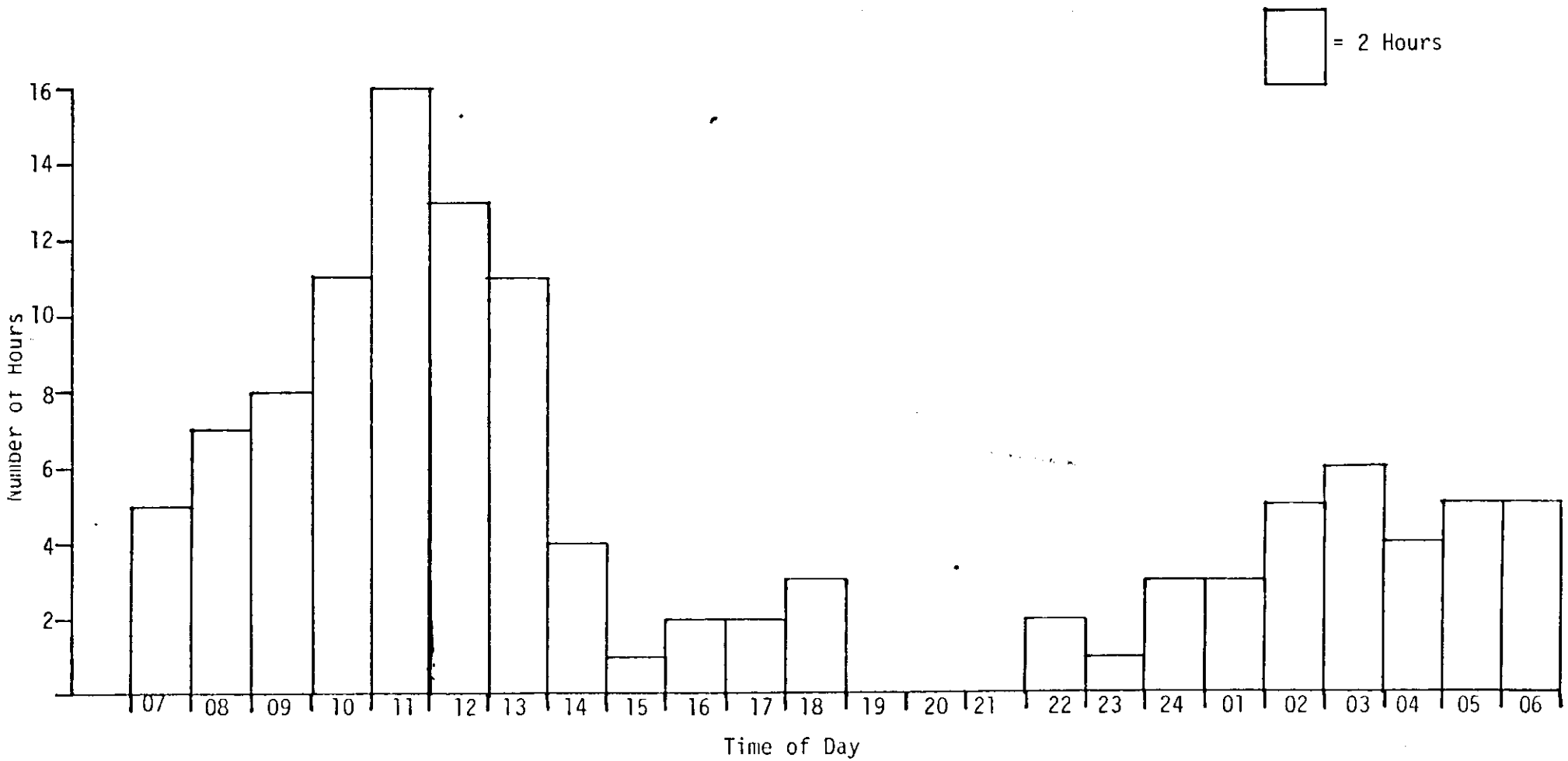

FIGURE II

The Hours of the Day Having Concentrations Greater Than
5 ppb for the Schroeder, Gilman, and Hess Monitoring Stations, 1983.

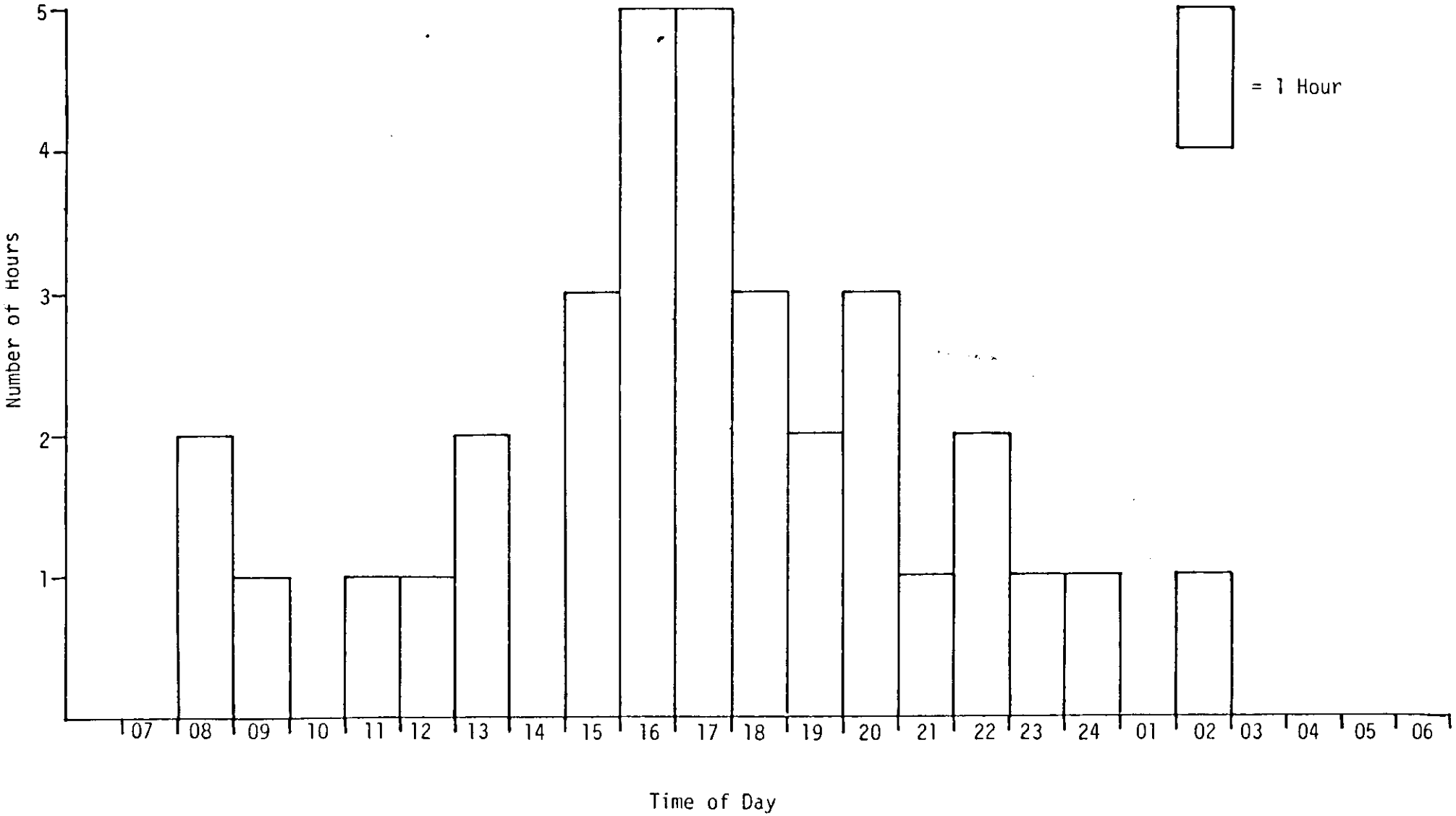

TABLE VIII

WIND ROSE FOR WOOD STATION (1983)- ALL HRS

SPEED (MPH)

DIRECTION	1-3	4-6	7-10	11-16	17-21	>21	TOTAL
N	.01379	.03706	.05004	.00643	.00000	.00047	.10779
NNE	.00807	.04010	.08043	.01181	.00000	.00035	.14075
NE	.00362	.02467	.05401	.00713	.00000	.00023	.08967
ENE	.00234	.00666	.03343	.00421	.00000	.00000	.04664
E	.00047	.00316	.01192	.00152	.00000	.00000	.01707
ESE	.00129	.00549	.01578	.00409	.00000	.00012	.02677
SE	.00152	.00433	.00947	.00585	.00000	.00000	.02116
SSE	.00245	.00631	.00924	.00760	.00000	.00000	.02560
S	.00433	.01052	.01204	.00444	.00000	.00012	.03145
SSW	.00409	.00818	.00409	.00047	.00000	.00000	.01683
SW	.00631	.01005	.00070	.00000	.00000	.00035	.01742
WSW	.02093	.04325	.00678	.00000	.00000	.00000	.07096
W	.01835	.06570	.03718	.00000	.00000	.00000	.12123
WNW	.01730	.05682	.04735	.00023	.00000	.00000	.12170
NW	.01567	.02864	.02209	.00257	.00000	.00023	.06921
NNW	.01707	.03028	.02256	.00479	.00000	.00012	.07482
TOTAL	.13760	.38123	.41711	.06114	.00000	.00199	0.99906

FRACTION OF CALMS DISTRIBUTED ABOVE = .00094

TOTAL 1-HOUR PERIODS = 8760

NO. OF MISSING 1-HR PERIODS = 206

PERCENTAGE WIND DATA RECOVERY = 97.6%

FIGURE III

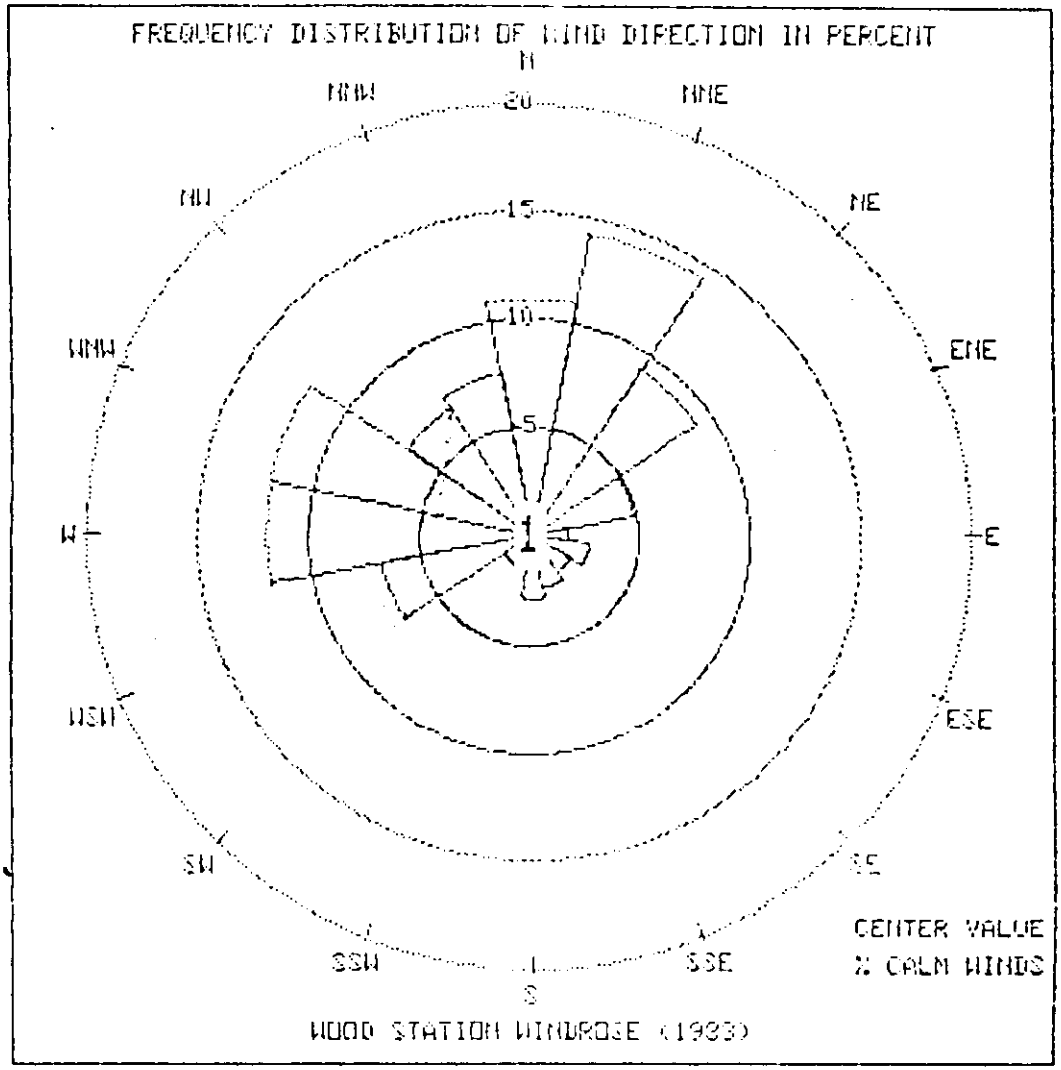
FREQUENCY DISTRIBUTION OF WIND DIRECTION IN PERCENT
N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW
20
15
10
5
1
CENTER VALUE
% CALM WINDS
WOOD STATION WINDROSE (1983)

FIGURE IV

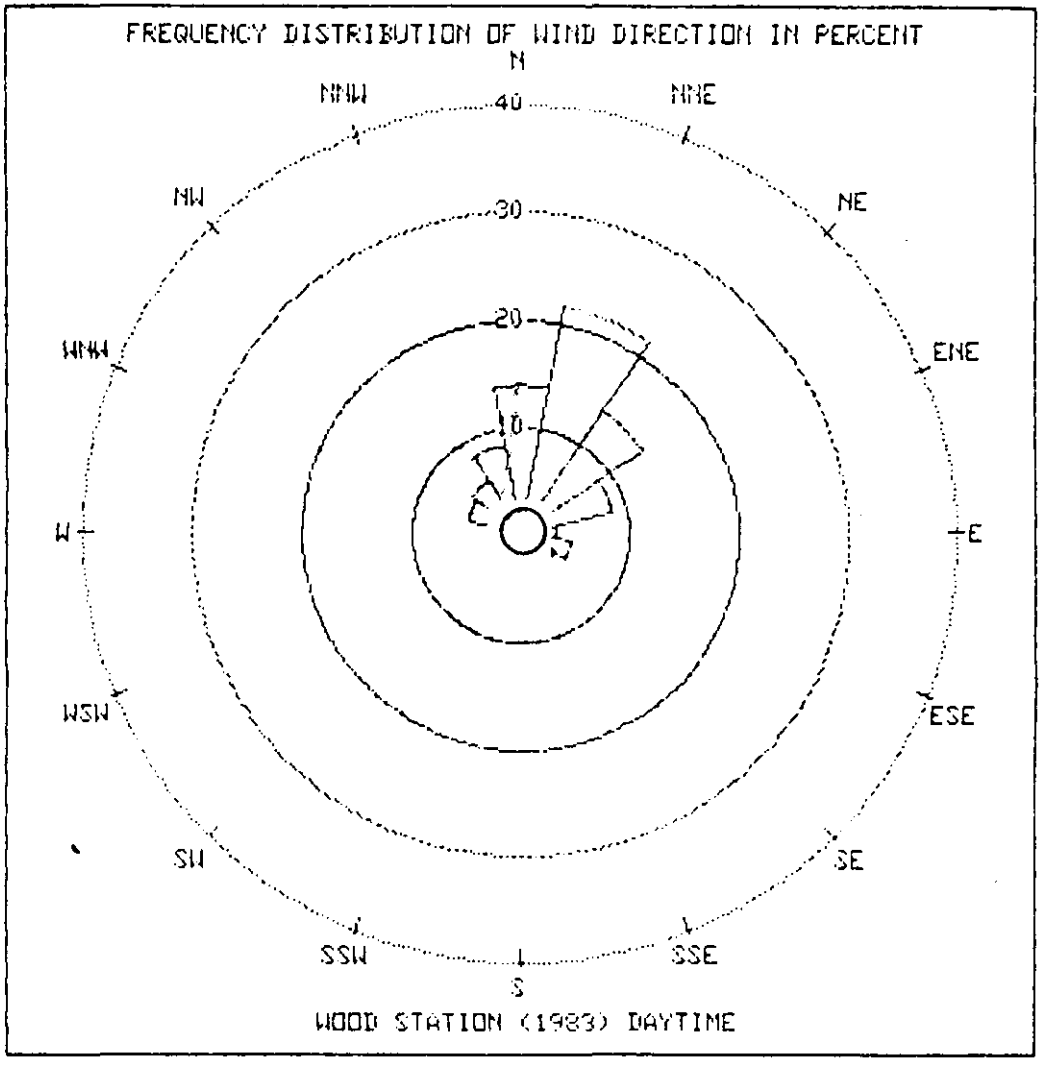
FREQUENCY DISTRIBUTION OF WIND DIRECTION IN PERCENT
N
NNW
NNE
NW
NE
WNW
ENE
W
E
WSW
ESE
SW
SE
SSW
SSE
S
40
30
20
10
WOOD STATION (1983) DAYTIME

FIGURE V

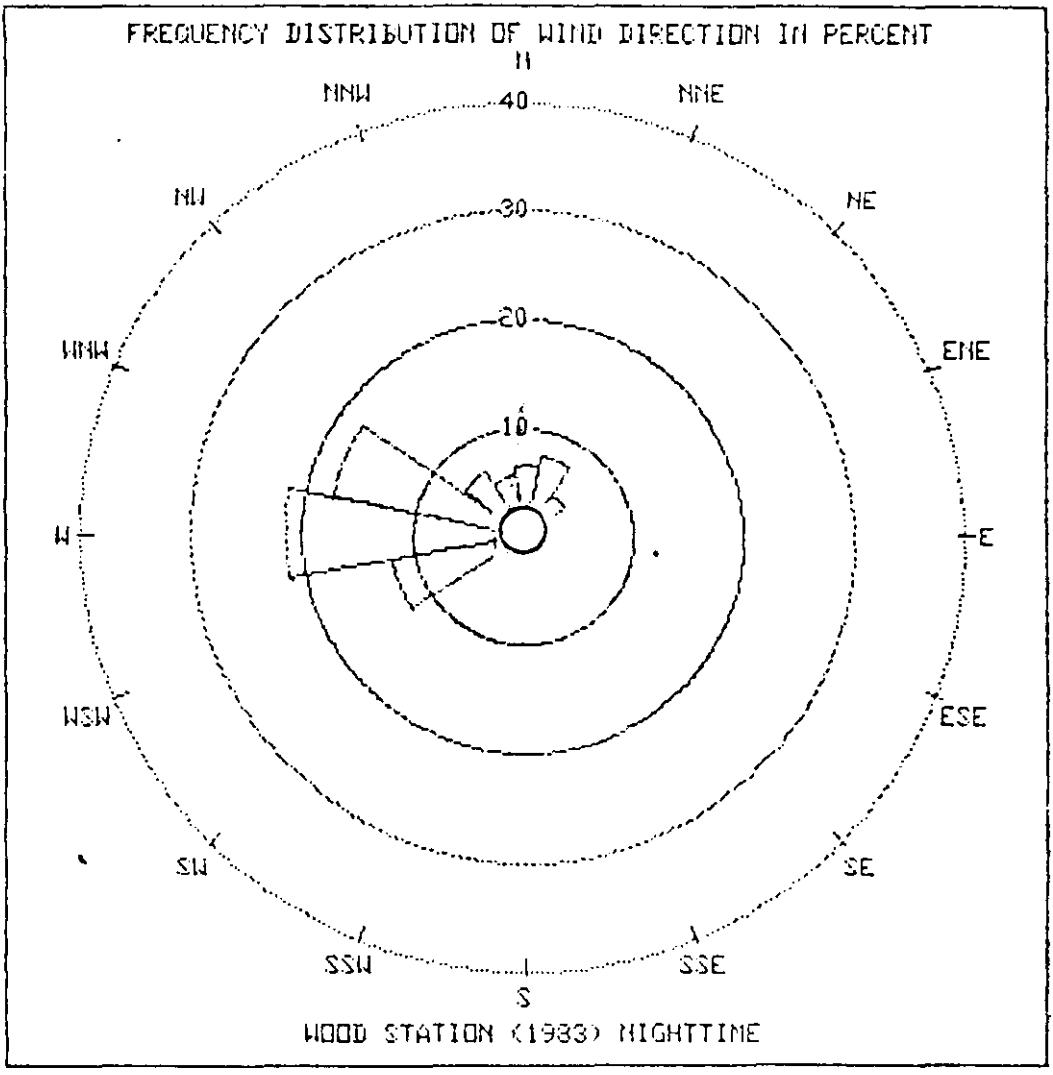
FREQUENCY DISTRIBUTION OF WIND DIRECTION IN PERCENT
N
NNW
NNE
NW
NE
WNW
ENE
W
E
WSW
ESE
SW
SE
SSW
SSE
S
40
30
20
10
WOOD STATION (1983) NIGHTTIME

TABLE IX

Wind directions and Number of Hours with Concentrations Greater Than 5ppb for Schroeder, Gilman, Hess, and Wood Monitoring Sites, 1983.

Direction	Azimuth	Schroeder	Gilman	Hess	Wood*	Total
N	360	1	0	0	0	1
NNE	0-30	1	2	0	16	19
NE	31-60	7	7	0	9	23
ENE	61-89	0	0	0	2	2
E	90	0	0	0	0	0
ESE	91-120	1	7	0	1	9
SE	121-150	0	1	0	0	1
SSE	151-179	0	0	0	1	1
S	180	0	0	0	1	1
SSW	181-210	0	0	0	2	2
SW	211-240	0	0	0	5	5
WSW	241-269	0	0	0	19	19
W	270	0	1	0	6	7
WNW	271-300	1	0	0	21	22
NW	301-330	2	1	0	19	22
NNW	331-359	1	0	1	13	15
Total		14	19	1	115	149

*Wind directions were not available for two hours at the Wood monitoring site.

FIGURE VI

Wind Directions and Numbers of Hours with Concentrations Greater Than 5 ppb, Schroeder Monitoring Station, 1983.

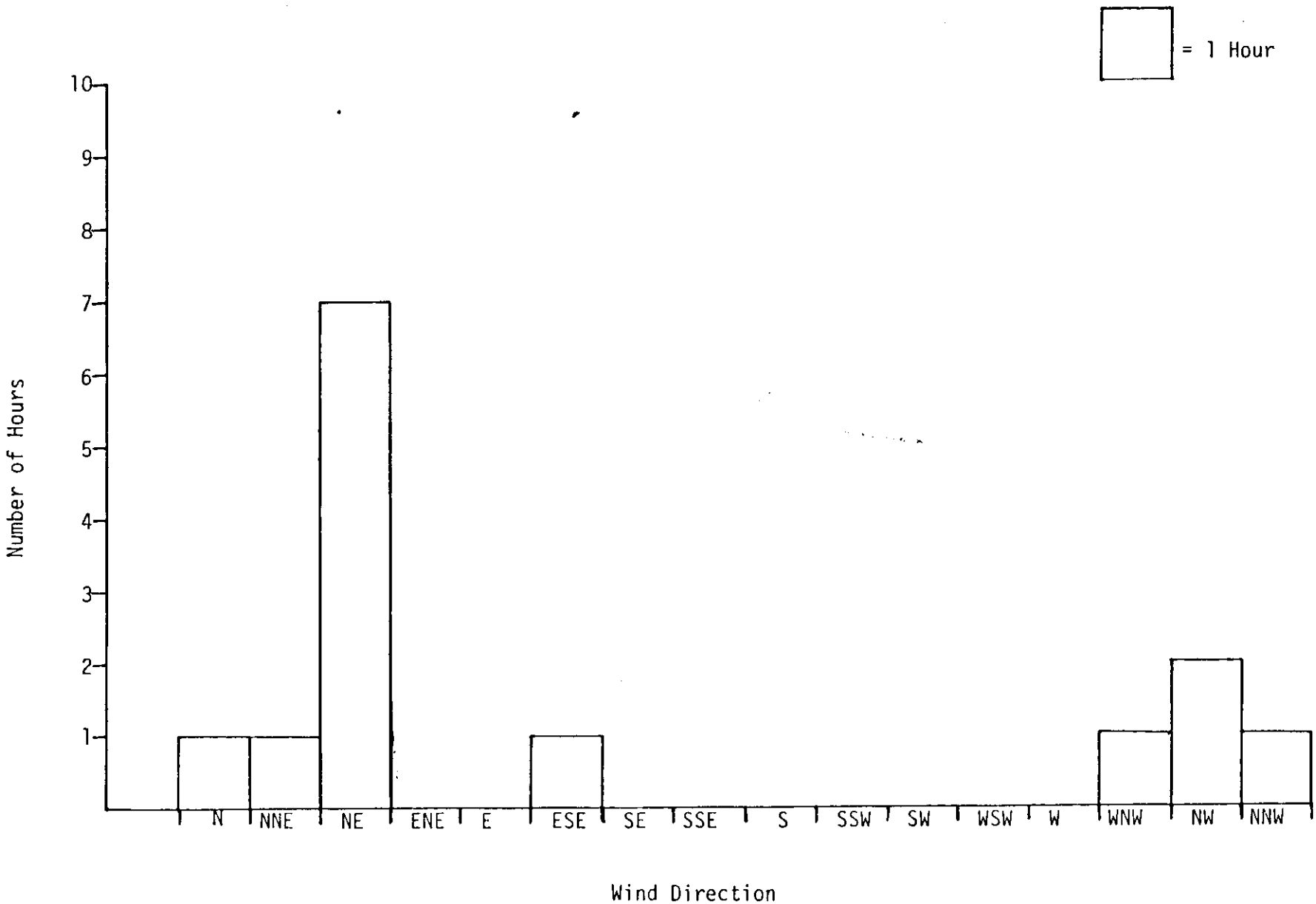

FIGURE VII

Wind Directions and Numbers of Hours with Concentrations Greater Than 5 ppb, Gilman Monitoring Station, 1983.

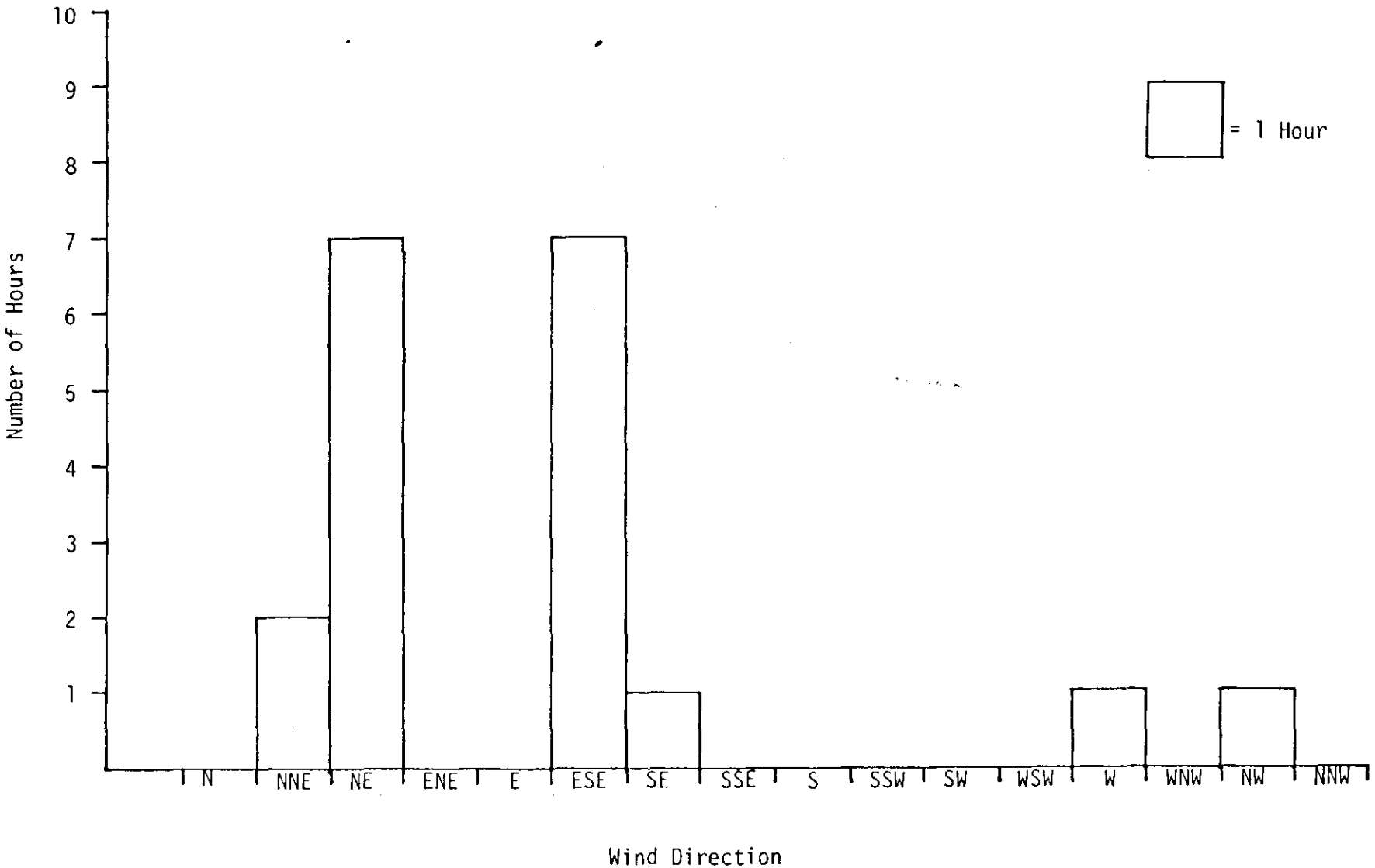

FIGURE VIII

Wind Direction and Number of Hours with Concentrations Greater Than 5 ppb, Wood Monitoring Station, 1983.

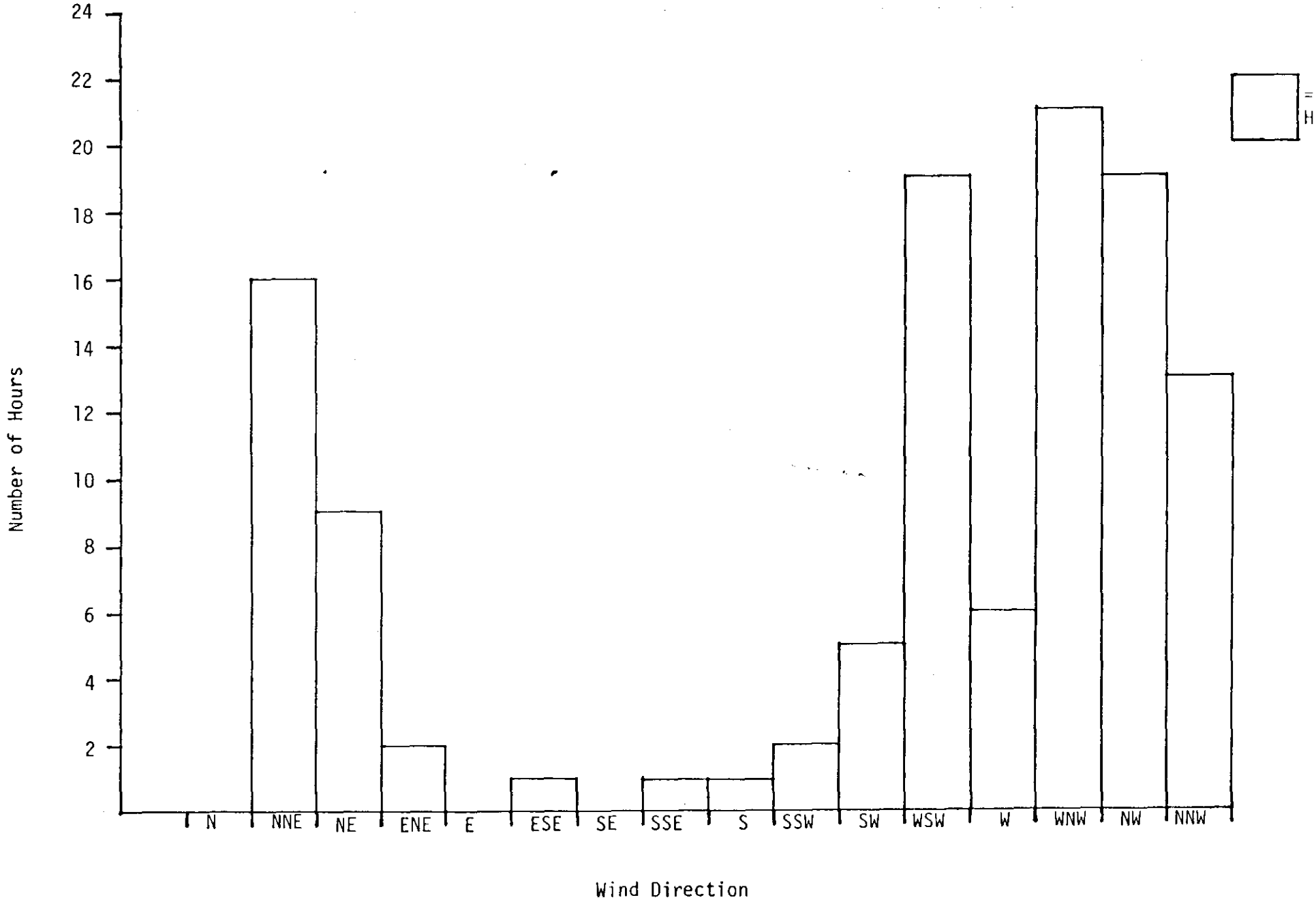

TABLE X

The Compass Headings from the Geothermal Plant for Schroeder, Gilman, Hess, and Wood Monitoring Stations and the Proportion of Hours with Concentrations Greater Than 5ppb Which Fit in a 60 Degree Directional Cone Extending from the Plant, 1983.

Residence	Azimuth	Direction From Plant	Wind Direction From Plant	Proportion
Schroeder	196	SSW	346-046 NNW-NE	8/14=57.1%
Gilman	268	WSW	058-118 NE-ESE	4/19=21.1%
Hess	230	SW	020-080 NNE-ENE	0/1 = 0%
Wood	026	NNE	176-236 SSE-SW	7/115=6.1%

JANUARY 1983

Pollutant	STANDARDS			EPISODE LEVELS		
				State and Federal		
	Hawaii State Standard	Federal Primary Standard	Federal Secondary Standard	Alert Level	Warning Level	Emergency Level
		(Health)	(Welfare)			
Carbon Monoxide						
1 hr.	10 mg/m^3 (9 ppm)	40 mg/m^3 (35 ppm)	40 mg/m^3 (35 ppm)			
8 hr.	5 mg/m^3 (4.4 ppm)	10 mg/m^3 (9 ppm)	10 mg/m^3 (9 ppm)	17 mg/m^3 (15 ppm)	34 mg/m^3 (30 ppm)	46 mg/m^3 (40 ppm)
Nitrogen dioxide						
1 hr.				1130 ug/m^3 (0.6 ppm)	2260 ug/m^3 (1.2 ppm)	3000 ug/m3 (1.6 ppm)
24 hr.	--	--	--	282 ug/m^3 (0.15 ppm)	565 ug/m^3 (0.3 ppm)	750 ug/m^3 (0.4 ppm)
Annnual	70 ug/m^3 (0.04 ppm)	100 ug/m^3 (0.05 ppm)	100 ug/m^3 (0.05 ppm)			
Particulate Matter						
24 hr.	100 ug/m^3	260 ug/m^3	150 ug/m^3	375 ug/m^3	625 ug/m^3	875 ug/m3
Annual	55 ug/m^3 (airth)	75 ug/m^3 (Geom)	60 ug/m^3 (Geom)			
Ozone						
1 hr.	100 ug/m^3 (0.05 ppm)	235 ug/m^3 (0.12 ppm)	235 ug/m^3 (0.12 ppm)	200 ug/m^3 (0.1 ppm)	800 ug/m^3 (0.4 ppm)	1,200 ug/m^3 (State) 1,000 ug/m^3 (Federal) (0.6 ppm)
Sulfur dioxide						
3 hr.	400 ug/m^3 (0.15 ppm)		1300 ug/m^3 (0.5 ppm)			
24 hr.	80 ug/m^3 (0.03 ppm)	365 ug/m^3 (0.14 ppm)	--	800 ug/m3 (0.3 ppm)	1600 ug/m^3 (0.6 ppm)	2100 ug/m^3 (0.8 ppm)
Annual	20 ug/m^3 (0.008 ppm)	80 ug/m^3 (0.03 ppm)				
Lead						
3 mo.	1.5 ug/m^3 (0.00017 ppm)	1.5 ug/m^3 (0.00017 ppm)				

Conversions: @ 25°C

CO	1 ppm	=	1,145 ug/m^3
NO_2	1 ppm	=	1,880 ug/m^3
Ozone	1 ppm	=	1,962 ug/m^3
SO_2	1 ppm	=	2,620 ug/m^3
Pb	1 ppm	=	8,457 ug/m^3

3/83 - EPB