THE HAWAII SCIENTIFIC OBSERVATION HOLE (SOH) PROGRAM

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ABSTRACT

The Hawaii Natural Energy Institute of the University of Hawaii is directing a Scientific Observation Hole (SOH) program. The SOHs are for scientific observation and monitoring purposes only. The holes will not be flow-tested or produced. The information to be gained from the SOHs will provide an assessment of subsurface geological conditions, ground water level and composition, temperature, drilling conditions, an inventory of possible mineral and geothermal resources, and an eruptive history of the island to the depth drilled. The SOHs, in combination with existing geothermal wells or future geothermal wells to be drilled by producers, can be instrumented to provide data relating to reservoir productivity, and to monitor changes in ground water conditions and volcanic activity.

BACKGROUND

General details of the SOH program were presented at the GRC Annual Meeting in San Diego (Olson 1988). At the time of the writing of this paper, the first hole, SOH 4, has not been completed, and little of technical interest can be reported. This paper provides details of the drilling plan and permitting requirements. Drilling results, costs, and operating experiences will be reported at the GRC 1990 International Meeting in Kona, Hawaii.

The Hawaiian Islands lie above a geological "hot spot" in the earth's mantle that has been volcanically active for the past 70 million years. The Big Island has an obvious, large potential for geothermal energy resources, both for electrical generation and direct utilization. Since the 1976 drilling of the HGP-A well and the discovery of the Kapoho Geothermal Reservoir in the lower Kilauea East Rift Zone, geothermal power potential on the Big Island has been estimated at between 500 and 700 megawatts (Thomas 1987).

The $500 million Hawaii Deep Water Cable Program to transmit geothermally-generated electricity from the Big Island to the load center on Oahu is based on the assumption that the estimated reservoir size is correct. Reservoir size, however, has not been proven by further exploration, and the definition of the Kapoho or other potential reservoirs is still essentially unknown. To date, only a reservoir with a "known" production capability of 3 megawatts has been proven.

The Scientific Observation Hole (SOH) program plans to drill: (1) four scientific observation holes to a nominal depth of 1,200 meters (4,000 feet) to test the geological conditions and the geothermal potential within Geothermal Resource Subzones along the Kilauea East Rift Zone, and (2) two holes in the Haleakala Southwest Rift Zone. These holes will be drilled to provide regional knowledge regarding rock types, alteration, and structures within the rift zones; the depth to potential geothermal reservoirs; the depths and compositions of the ground water tables; and the temperatures of rock and fluids at depth.

The project specifically meets the University of Hawaii's stated mission of providing scientific and technology transfer to the private sector for utilization and commercialization, and has provided a stimulus for private development of Hawaii's geothermal resources. If the holes are successful in locating or indicating the presence of geothermal reservoirs, the project will expand Hawaii's geothermal resource base not only for electrical generation potential, but also for direct utilization in such fields as food and materials processing, animal husbandry, agriculture, aquaculture, fisheries, geothermal spas, and other uses.

SCIENTIFIC OBSERVATION HOLE PROGRAM

Location and Description

The locations of the SOHs, which are shown in Figure 1, have been sited on the basis of surface geological, geophysical, and geochemical observations, environmental considerations, residential locations, and existing access to minimize impacts of the program.

Four of the proposed SOH locations are within the Kilauea East Rift Zone in the Puna District of the Big Island of Hawaii. SOH 1 and SOH 2 are located within the lower or eastern portion of the Kilauea East Rift Zone in the Geothermal Resources Subzone on property controlled by Puna Geothermal Ventures, Ltd. SOH 1 is approximately 3,000 feet northwest of the HGP-A geothermal well at the Noi'i O Puna facility in a fallow papaya field. SOH 2 is located approximately 2,200 feet north-northeast of the Halekamahina crater, and about 4,800 feet west-northwest of the Kapoho BM (166), beside a farm road in an area largely devoted to papaya orchards.

SOH 3 and SOH 4 are located on Campbell Estate property in the middle or central portion of the East Rift Zone to the southwest of Pahoa. SOH 3 is to be located between True/Mid-Pacific (TMP) Geothermal Venture's drill pads 1 and 2. SOH 4 is located a few hundred feet inside the TMP access road gate.

Since SOH 1 and SOH 2 are located on abandoned sugarcane and fallow papaya fields, respectively, a network of unpaved roads exist. However, SOHs 3 and 4 are located in undeveloped areas; thus, drill roads constructed by private geothermal developers will be used.

SOHs 5M and 6M are located within the southwestern portion of the Haleakala Southwest Rift Zone on the island of Maui in the Geothermal Resources Subzone on property controlled by True-Mid Pacific. The SOHs are located northwest and south of the Puu Naio cinder cone on the Ulupalakua Ranch. Hole locations and access are shown on the map in Figure 2.

Organization

Dr. Harry J. Olson, Hawaii Natural Energy Institute (HNEI) researcher, is the principal investigator. Dr. Donald M. Thomas, Hawaii Institute of Geophysics geochemist, is responsible for geological investigations and decisions; Arthur Seki, HNEI associate researcher, is the project manager and John Deymonaz, HNEI consultant, is the drilling manager. GeoThermEx, Inc., is the major reservoir engineering consultant. Fred Page International Drillers, of Kailua-Kona, will drill and set the conductor casing to a depth of approximately 100 feet for three of the four SOHs on the Big Island. Tonto Drilling Services, Inc., of Salt Lake City, Utah, will core the SOHs to total depth.

Budget

The SOH program is a joint effort of the Hawaii state government, University of Hawaii, Hawaiian Electric Company (HECO), Electric Power Research Institute, Bonneville Power Authority, and private geothermal developers (Puna Geothermal Venture and True/Mid- Pacific Geothermal Ventures). The state government has appropriated $3 million for this effort with cost-sharing and in-kind funding from the private sector organizations mentioned above. The total funding packet is in excess of $7 million over a 1.5 to 2 year period.

Drilling Plan and Schedule

A combination of cable drilling by a water well rig and rotary and diamond core drilling by Tonto's Universal 5000 rig will supply the capability to meet the variety of anticipated drilling conditions. The size of the drill sites, the capability of the drill rigs, and the total environmental impact is approximately one-tenth that of the rotary oil rigs normally used to drill geothermal production wells.

Drilling is being conducted continuously, 24-hours a day, seven days a week, until completion of the hole, which is expected to take between 90 and 120 days to complete at each location. Figure 3 shows the tentative SOH drilling schedule. Drilling personnel includes three-man crews, plus a drilling foreman and drilling supervisor.

Casing and cementing programs and blow out prevention (BOP) equipment provide protection from any potential over-pressured zones and allow the hole to be shut in at any stage during the drilling after the upper 100 feet of conductor casing are in place. The drilling and casing program was largely dictated by regulatory stipulations and is more suitable for a production well than a research hole that will not be produced. Figure 4 shows the tentative drilling/casing plan for the SOHs as approved by the Hawaii Board of Land and Natural Resources (1989).

Assuming total loss circulation during core drilling and a drilling fluid pumping rate of five-gallons per minute, a maximum of less than 7,500 gallons of water per day is used to replace that which is lost down the hole. During rotary drilling, water storage and haulage limitations restrict pumping rates to 50 gallons or less per minute.

The primary water source for drilling and testing operations, drinking, sanitation, and work force safety (fire fighting) measures is transported on to the project site from an existing county water point. A 20,000 gallon storage tank is located on the drill site. In addition, a sump pit with a total capacity of 60,000 gallons is located adjacent to the drilling site. Drilling fluids and excess drilling mud, as well as rainfall runoff, is directed to the sump pit. Every attempt will be made to recycle all water used in drilling operations.

Reservoir Engineering

Initial testing of the well will involve taking geophysical logs and temperature gradients to determine the rate of increase of temperature with depth and the absolute bottom hole temperature. Measurements will be made before and after the hole has reached thermal equilibrium, and temperatures will be monitored thereafter to note any changes in temperature which can be related to natural or production processes.

If reservoir conditions are encountered during drilling, reservoir analysis will be attempted by injecting water into the hole and measuring the rate of fluid acceptance, the pressures required to inject the fluids, the time required to achieve pressure equilibrium after pumping, and the zone or zones that will accept the fluids.

Permit Status

The four SOHs on the Big Island have been permitted or approved to proceed. Drilling permits for all six SOHs have been received from the State Department of Land and Natural Resources (DLNR). A Geothermal Resource Permit from the County of Hawaii Planning Commission for the three SOHs on agriculture land has been issued. DLNR has also given approval to drill SOH 3 on State Conservation land under a Conservation District Use Permit (HA 12/20/85 - 1830) issued to the Estate of James Campbell.

Groundwork has been initiated for submitting a Geothermal Resource Permit application on Maui. The County of Maui, however, has yet to approve any rules and regulations governing geothermal development, and the filing of the GRP will probably be delayed until the regulations are in place.

CONDITIONS ON PERMITS AND APPROVALS

During the permitting process with the County of Hawaii Planning Commission, the local community requested mediation. Through a series of long and often painful meetings, the basis of the conditions was discussed and revised. In addition, DLNR imposed conditions under the existing Conservation District Use Permit for SOH 3. The following are the major conditions imposed on the SOH project, as approved by the County of Hawaii Planning Commission and state Department of Land and Natural Resource (HNEI 1989).

Land Use

The drill site covers approximately a quarter of an acre and include a drill pad, water storage, mud pit, storage area, sump pit, and parking for drill site personnel and visitors. The sump pit, with a maximum capacity of 60,000 gallons is located adjacent to the drilling site. Drilling fluids and excess drilling mud as well as rainfall runoff is directed to the sump pit. Figure 5 shows a typical layout of the drill site area. The site will be re-vegetated after completion of the drilling.

Field Surveys

Flora, fauna, and archaeological surveys were conducted on potential drill sites and right-of-way access areas before any clearing or grubbing. Survey reports were submitted to state and/or county officials for clearance to proceed.

General Plans

Management, operations, noise, air quality, environmental monitoring, and emergency plans were submitted for approval. The Best Available Control Technology (BACT) will be used wherever possible.

Air Quality, Environmental, and Emergency Plans

Although the possible emission of hydrogen sulfide from core drilling with mud is extremely remote and the core holes will not be flow-tested or produced, two hydrogen sulfide (H_2S) monitors with two-stage alarms and Scott air packs will be located on the drill rig. These monitors have two-stage visual and sound alarm systems which are triggered if H_2S is emitted from the hole. The detectors are set at levels (warning at 5 ppm and alarm at 20 ppm) sufficient to protect rig personnel.

In addition, as part of the air quality monitoring plan, H_2S measurements (in parts per billion) are being made with Houston-Atlas analyzers, along with wind speed and direction, on a continuous 24-hour basis for the duration of the core drilling.

All drill site personnel are updated on first-aid and CPR procedures, the hydrogen sulfide (H_2S) alarm system, and Scott air pack use.

The core rig has a mobile telephone located on site in the event of an emergency. Telephone numbers for police, fire department, hospital, and other emergency services are posted at the telephone. In addition, the telephone numbers of the drill manager, principal investigator, project manager, and appropriate state and county regulators are readily available.

Flow testing and open venting are not allowed.

Noise Monitoring Plan

Noise level limitations are 55 dbA during the day and 45 dbA at night.

The cable rig will operate only during the daylight hours. While, the Universal 5000 drill rig that will be used during the project are especially quiet, modifications were made to reduce noise levels further. Large hospital mufflers are installed on the diesel engine exhaust and baffles positioned under the diesel unit and drill rig substructure. All necessary motors on the rig and the mud pumping system have been converted to hydraulics. Noise measurements recorded at the SOH 4 operation are about 64 dbA at 70 feet.

The SOHs will not be flow tested or produced. As no geothermal fluids will be vented, there will be no associated noise.

Large vehicle deliveries, including water haulage, are limited to the daylight hours between 7:00 a.m. and 7:00 p.m.

Waste Disposal

Drilling mud additives and components are typically inert and consist of non-toxic components. Geothermal drilling fluids are not considered hazardous by the Environmental Protection Agency (EPA). These fluids and the rock cuttings will be pumped down the hole or distributed on the site and will percolate downward through the porous soil at the conclusion of the drilling program.

Ground water and geothermal resource characteristics at sites in the central portion of the Kilauea East Rift Zone are unknown and are being tested, whenever possible, during the drilling program.

These holes will not be flow tested or produced, and geothermal brines, other than those which may mix with the drilling fluids, will not be carried to the surface and discharged.

Project wastes, such as drill cuttings, drilling mud, and fluids, will be discharged into the sump pit at the drill site. Solids will be settled out and fluids recycled. After drilling, any existing material and/or fluid in the sump pit will be disposed in a manner acceptable to the County of Hawaii and Department of Health.

SOH Hazard Monitoring

The SOH sites are located in the volcanically active Kilauea East Rift Zone which is currently venting at the Puu O'o cinder cone and erupting as surface flows into the ocean at Kalapana, approximately 10 miles to the west and southwest of the Noi'i O Puna facility. If the rift zone were to become volcanically active at the SOH sites and flows were to threaten the rig and the sites, the drill rig would be removed and the wellhead protected by burying beneath volcanic cinders. The holes are protected from blowouts during drilling by use of BOP equipment, cemented casing, available water to cool and quench the hole, and standard drilling safety procedures. After drilling, the hole will be capped with a wellhead valve.

The SOHs are to be inspected within 48 hours of earthquakes registering 6 or greater on the Richter scale and/or within 48 hours after an eruption within 10 kilometers of an SOH site.

Reports

SOH 4 is the first site being drilled. A status report to the county's Planning Commission was made within the second stage of drilling at SOH 4 and prior to drilling SOHs 1 and 2.

Monthly and quarterly reports to the DLNR and county Planning Department include: startup, shutdown, and

operational status of the SOHs; instrumentation operation and maintenance; description of work undertaken or proposed; air quality and noise monitoring results; complaint log; financial report; and other pertinent information.

PROGRESS TO DATE

Drilling commenced at SOH 4 on December 13, 1989, and continued to December 20, before a 16-day Christmas break. Drilling resumed on January 3, 1990, and is expected to be completed by mid-April 1990. SOH 1 is tentatively scheduled as the next hole..

CONCLUSIONS

To demonstrate that geothermal reservoirs may exist in other areas of the Kilauea East Rift Zone and the Haleakala Southwest Rift Zone, additional research holes must be drilled to test the geological conditions of rock type, alteration, zoning, temperature, fluid pressure, and permeability, and to determine what critical measurements must be made in future scientific observation holes and production wells.

REFERENCES

Hawaii Natural Energy Institute, et al. 1989 (August). Drilling Plan Approval, Letter to Hawaii Natural Energy Institute et al. from Board of Land and Natural Resources.

Horii, R.T. 1989 (September). SOH 3 Approval, Letter to R.T. Horii from Department of Land and Natural Resources.

Olson, H.J. 1988. Hawaiian Program for the Confirmation and Stimulation of Geothermal Resources Development. Geothermal Resources Council, *Transactions*, 12:193-196.

Olson, H.J. 1989 (August). Geothermal Resources Permit Approval, Letter to H. Olson from County of Hawaii Planning Commission.

Thomas, D.T. 1987. A geochemical model of the Kilauea east rift zone. U.S. Geological Survey Prof. Paper 1350, Volcanism in Hawaii, Vol. 2, Chap. 56, p. 1507-1525.

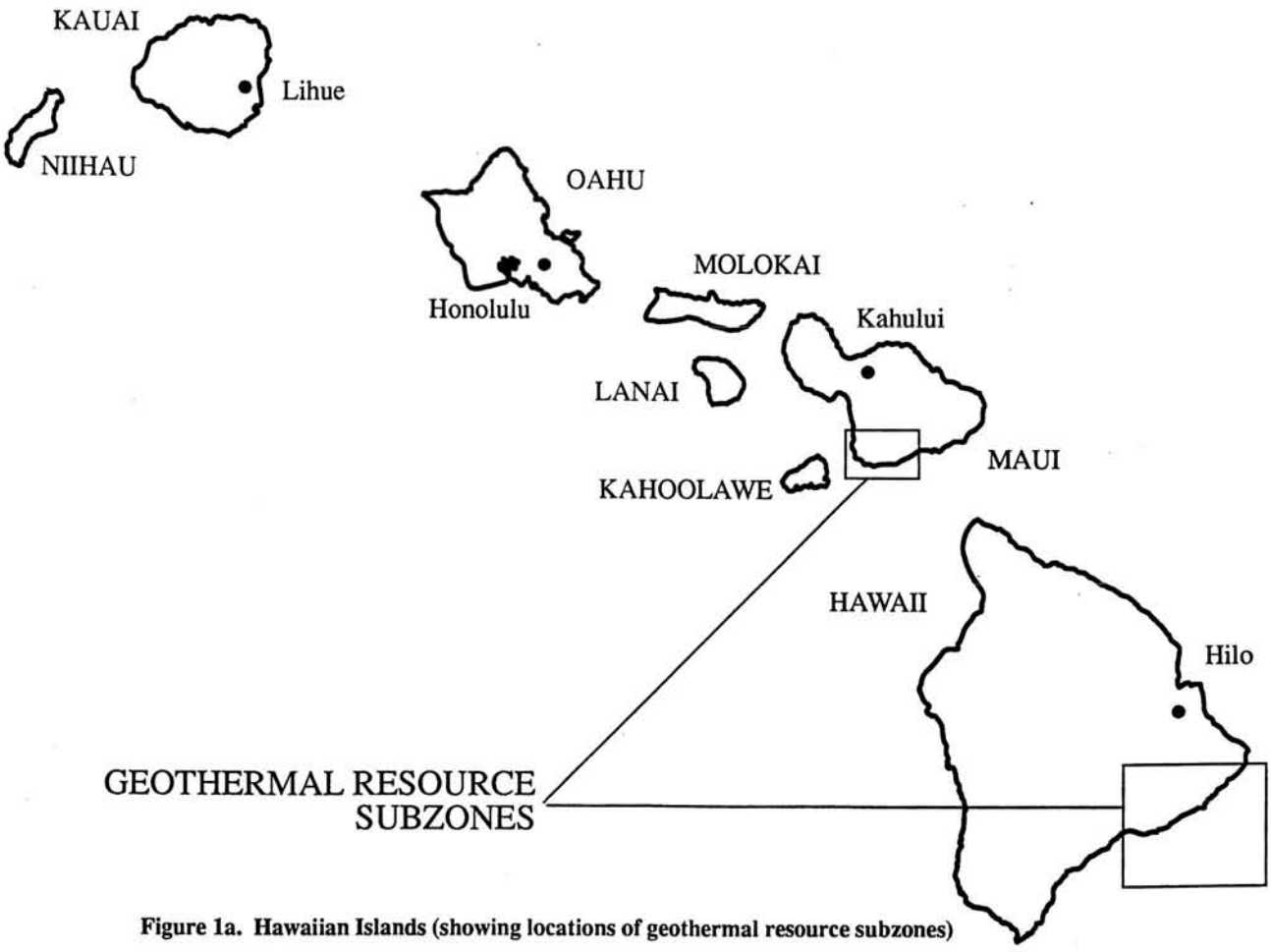

Figure 1a. Hawaiian Islands (showing locations of geothermal resource subzones)

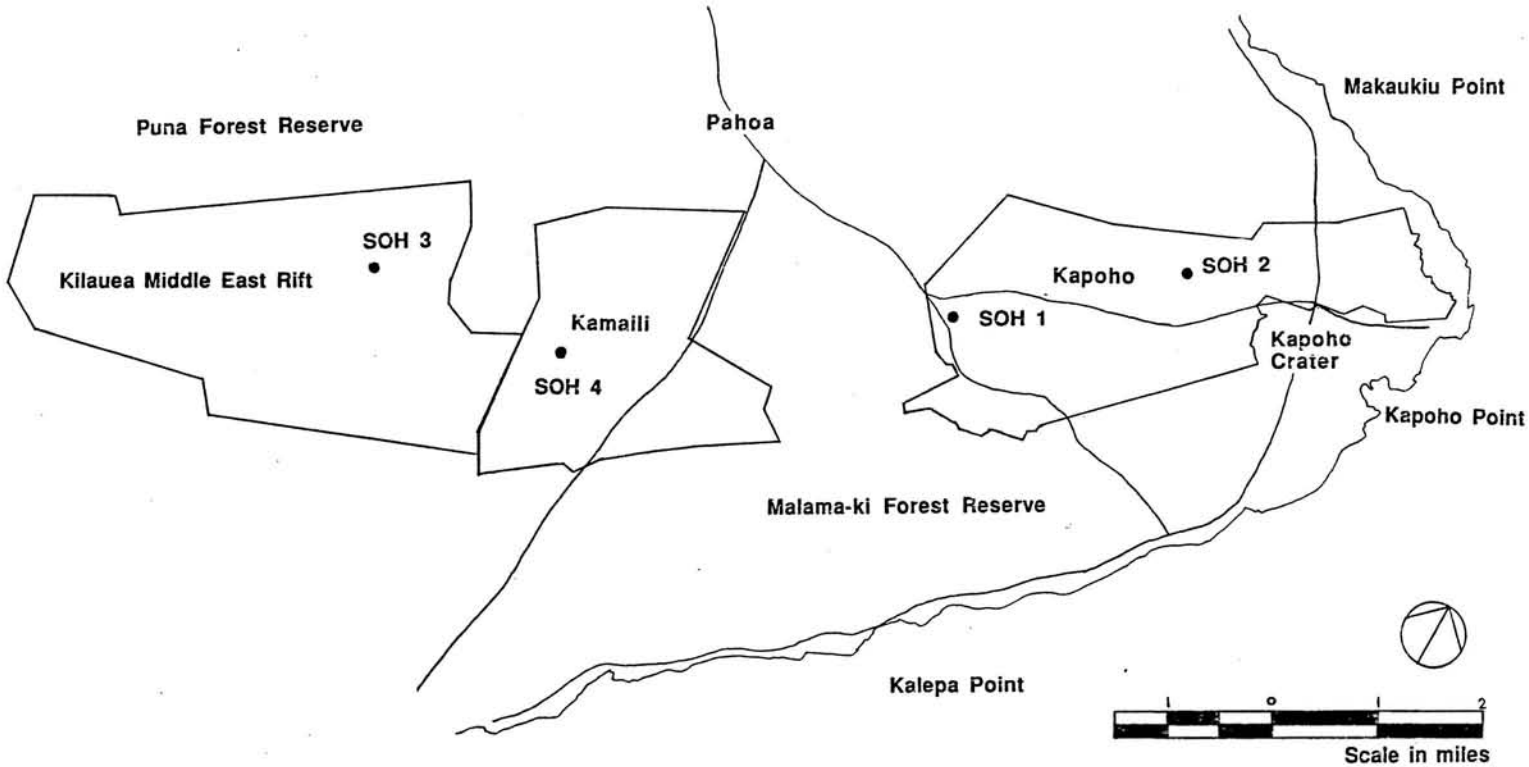

Figure 1b. Location of SOHs on the Big Island

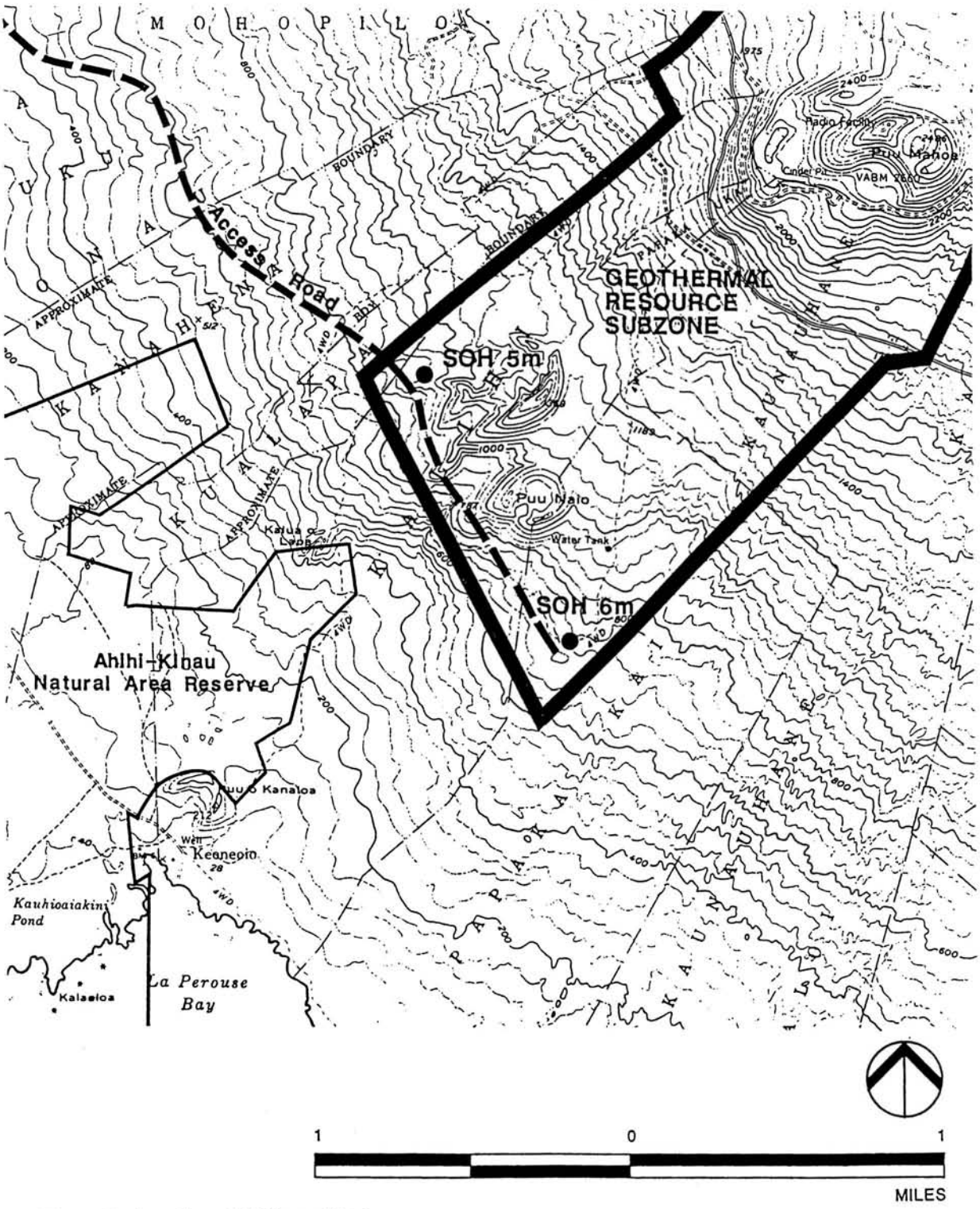

Figure 2. Location of SOHs on Maui

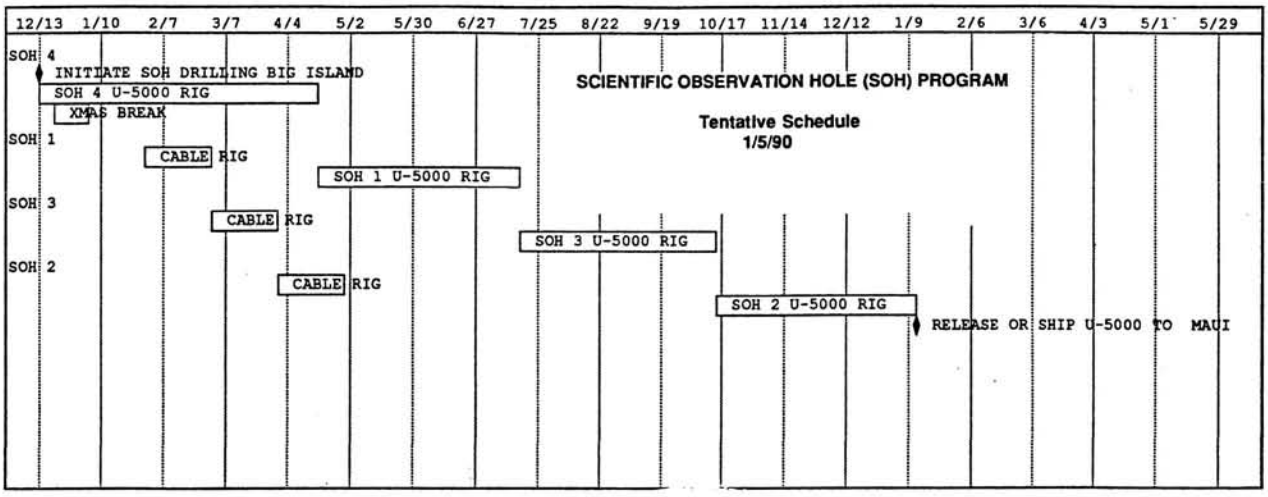

Figure 3. SOH drilling schedule

Drilling/Casing Plan

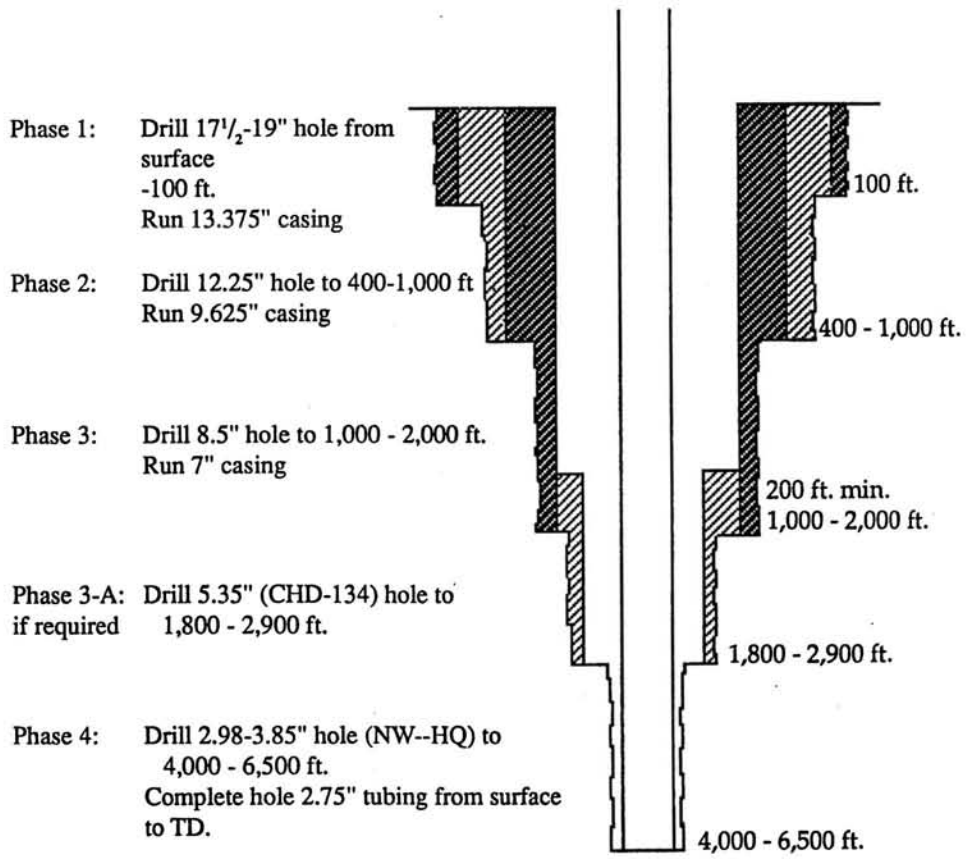

Figure 4. Drilling/casing design

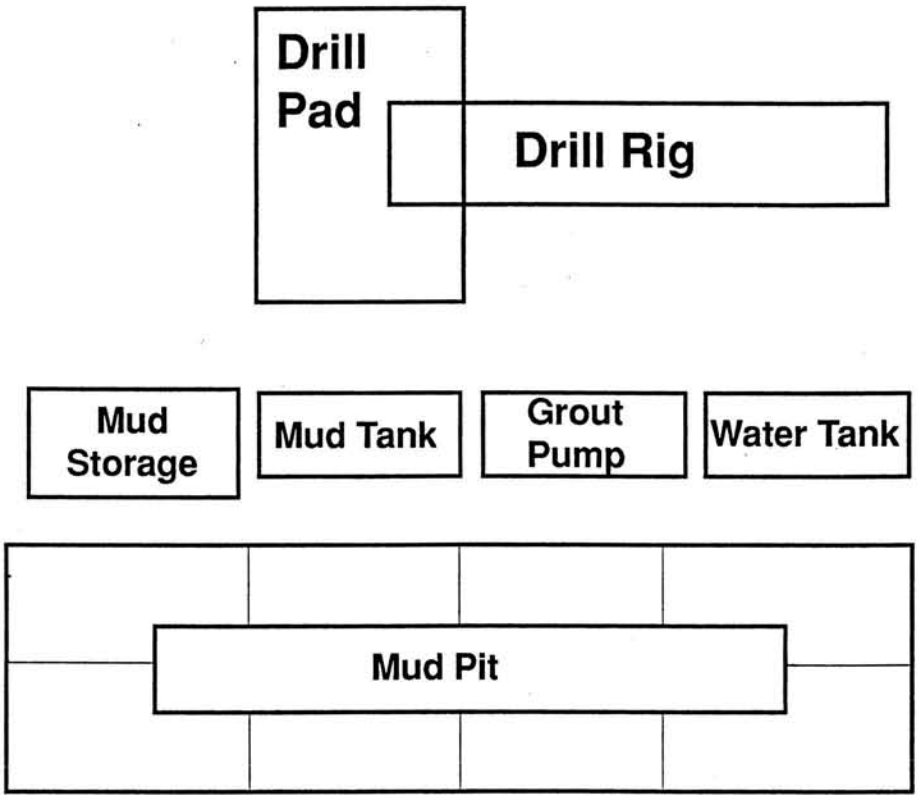

Figure 5. Drilling site layout