RECONNAISSANCE OF POTENTIAL FOR POTABLE GROUND-WATER SUPPLY AT KIPAHULU DISTRICT HALEAKALA NATIONAL PARK, MAUI, HAWAII

U.S. GEOLOGICAL SURVEY

Open-File Report 79-749

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Prepared in cooperation with the

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CONVERSION TABLE

Inch-pound units have been used throughout this report. The following table converts measurements in the inch-pound system to the International System of Units (SI).

Multiply inchpound units	By	To obtain SI units
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
acre-foot (acre-ft)	1233	cubic meter (m^3)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
gallons per minute (gal/min)	0.06309	liter per second (L/s)
gallons per minute per foot [(gal/min)/ft]	0.207	liter per second per meter [(L/s)/m]

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ABSTRACT

Kipahulu Valley drains an area of 12.7 square miles on the southeast side of the island of Maui. The aquifer underlying the lower reaches of the valley comprises recent lava flows.

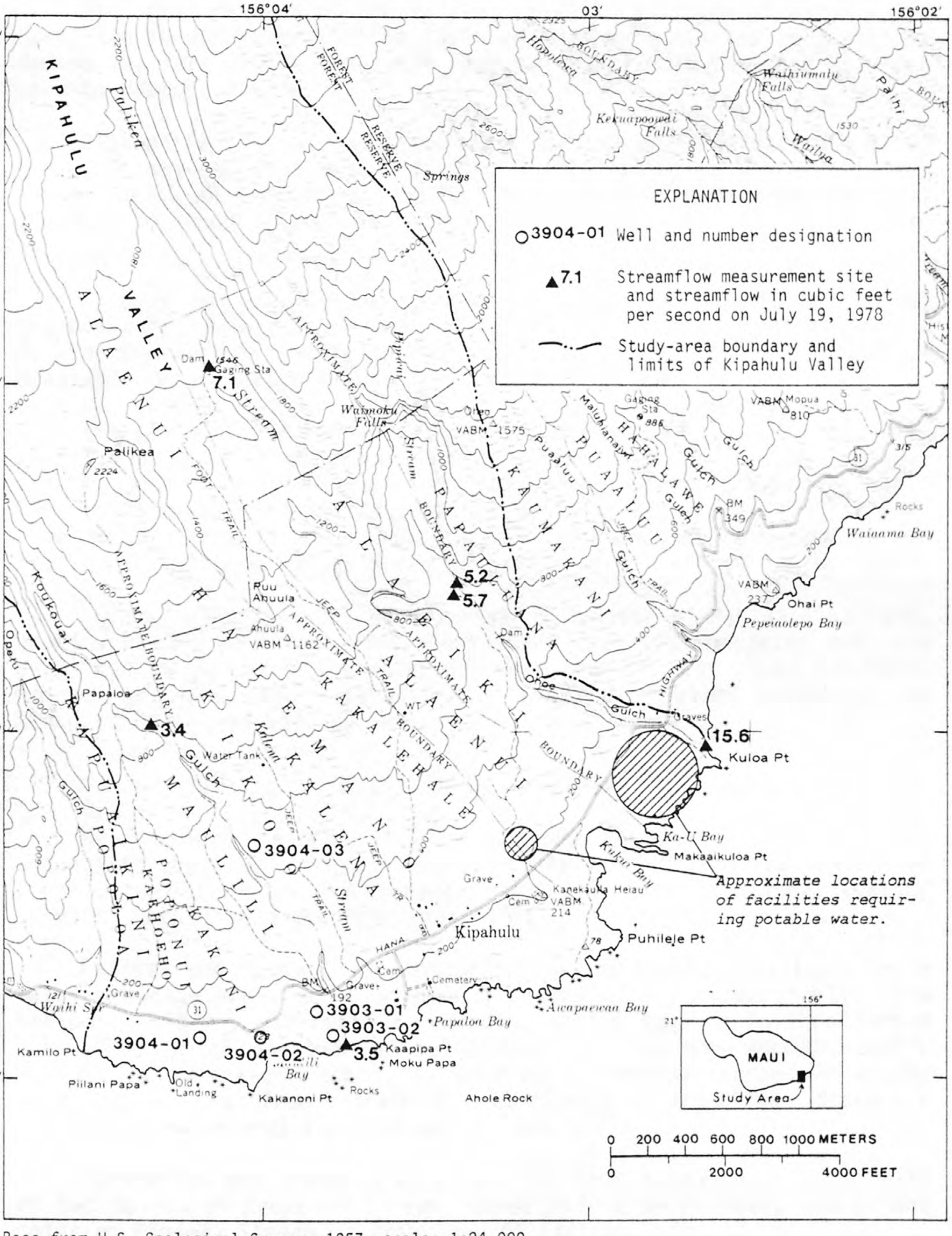
Fresh ground water occurs in the aquifer as a thin basal lens, which discharges as diffuse seeps along the shore. Measured basal-water heads were 1.3 and 2.4 feet at respective distances of 600 and 3,500 feet from the shore. Chemical analyses of ground-water samples indicate that the water is potable.

Wells to develop the basal water should be located at least 1,000 feet from shore. Well penetration should be limited to the upper half of the basal lens, and drawdown caused by pumping should not be greater than half of the head above sea level in order to avoid the risk of contamination by underlying saline water.

INTRODUCTION

The number of visitors to the Kipahulu District of Haleakala National Park increased more than six-fold between 1970 and 1976. In order to accommodate this increased visitor load, the National Park Service prepared a development plan and is now beginning to design the facilities needed. The U.S. Geological Survey was asked by the Park Service to investigate the potential for providing potable water supplies from the ground-water resources of the area.

The study area is on the southeast coast of the island of Maui within Kipahulu Valley (fig. 1). The valley contains two major streams, Palikea and Koukouai, which drain a combined area of 12.7 square miles, reaching into the caldera area of Haleakala Volcano at an altitude of 8,100 feet. Kipahulu Valley has steep sides and a flat floor with two levels, the deeper one being the northeast side.



Base from U.S. Geological Survey, 1957, scale: 1:24,000

Figure 1. Study area showing well locations, streamflow measurement sites, and planned facility locations.

The upper reaches of the valley, above an altitude of about 1,300 feet, are forest reserve. The lower reaches were planted in sugarcane during the late 1800's and early 1900's. Since then the land has been used to pasture cattle.

Planned facilities requiring water include an administrative site, intensive day-use zone, and a camping/night-fishing zone. These sites are all below an altitude of 250 feet and within 4,000 feet southwest of Oheo Gulch. About 20,000 gallons of potable water will be required per day.

Purpose and scope.--The purpose of this study was to assess the ground-water resources of the lower parts of Kipahulu Valley and to provide the Park Service with recommendations regarding development of available ground water within the park boundaries.

The scope of the investigation consisted of a study of the availability and quality of ground water in the lower reaches of Kipahulu Valley, particularly at locations convenient to the planned National Park facilities. Examinations of the geology, measurements of streamflow and inferred relationships to ground water, and measurements and testing of existing wells, where possible, were included in the study.

Acknowledgments.--Mr. Robert Haskin, manager of Mahina Aina Farm, graciously shared information about their recently completed well and permitted us to sample the water produced from it. Mr. John Hanchett, manager of Hana Ranch, permitted access and provided directions to Koukouai Gulch and well 3904-01.

PRECIPITATION AND RUNOFF

Mean annual rainfall at the planned National Park facilities amounts to about 100 inches. Annual rainfall in Kipahulu Valley ranges from 70 to 170 inches and averages about 115 inches (National Weather Service, unpublished isohyetal map, 1955).

Palikea and Koukouai Streams drain most of Kipahulu Valley. Their total drainage areas are 8.2 and 4.5 square miles, respectively. The Geological Survey maintains a recording stream gage on Palikea Stream (16501000) at an altitude of 1,546 feet and the mean annual runoff, based on 42 years of record, is 57.7 cubic feet per second or 41,800 acre-feet per year from a drainage area of 6.29 square miles. There are no streamflow records for Koukouai Stream.

Streamflow measurements were made for this study on July 19, 1978 at two points on Koukouai Stream, three points on Palikea, and at one point on Pipiwai Stream, a tributary of Palikea (fig. 1).

GEOLOGIC SETTING OF GROUND-WATER RESERVOIRS

Kipahulu Valley, now flat-bottomed and filled with recent lavas, was once a deep, wide canyon cut into Haleakala. Deep erosion of Kipahulu Valley occurred during the long period of volcanic quiescence, which followed the mountain-building phase of Haleakala. Recent lava flows from renewed volcanic activity from at least two eruptive episodes flooded the deep canyon to form the existing flat-bottomed floor of the valley and the delta-shaped apron at the shore. Because of the subsidence of Haleakala and lower stands of the sea in the past, much of these recent lavas near the coast now are below sea level. These recent lavas are the main reservoir of ground water in the area.

Older lava flows, which represent the last stages of the mountain-building phase of Haleakala, are exposed on the steep sides of the valley and beyond. These lava flows, although not as permeable as the flat-lying recent lavas in Kipahulu Valley, also are an important reservoir. This reservoir is generally less productive than the reservoir in the recent lavas.

Alluvium, mostly derived from the older lavas, occurs at the ground surface and is interbedded with the recent lavas near Kukui Bay. Alluvium on either side of the bay lies above the lavas; that at the head of the Bay is covered by the lavas. The alluvium probably represents valley-fill material of a former channel of Pipiwai Stream, the lower part of which was buried by the recent lavas. The alluvium, by itself, does not form a reservoir for ground water, but it could be a factor in determining the occurrence of ground water in the lavas lying above or below it.

Ground-water occurrence.--Most ground water in the area occurs as basal water, that is, in a freshwater lens that floats on saline ground water. Most of the easily developable basal water occurs near and below sea level in the recent lava flows underlying Kipahulu Valley. Less easily developable supplies occur in the older lavas, which comprise the steep valley sides and beyond.

Recharge to basal water underlying Kipahulu Valley takes place in the wetter upper reaches of the valley. Discharge occurs along the shore.

Ground water also occurs in the recent and older lavas as perched water in saturated zones above the basal water. This water is separated from the basal reservoirs by unsaturated rocks. The water may be perched on layers of low-permeability rocks, such as massive lava flows, fine-grained alluvium, and altered ash or cinders. Observations and measurements of Palikea Stream indicate that the stream intercepts perched water bodies. During periods of low flow, Palikea Stream may cease flowing over the top of a waterfall at about the 800-foot altitude, the flow being lost to infiltration between there and the gaging station at an altitude of 1,546 feet. Most of this lost flow, however, reenters the stream from the lower half of the face of the falls. The water issues from contacts between dense valley-filling lava flows. Also, based on the streamflow measurements of July 19, 1978, between the confluence of Palikea and Pipiwai Streams and the mouth of Palikea, flow increases by about 50 percent. This increase in flow is probably due to the interception of perched water.

Although perched water can be an important source of supply in other areas of the state, in Kipahulu it is not considered to be as dependable a source as the basal water.

BASAL WATER

There are five wells west of the National Park in Kipahulu Valley. The locations are shown in figure 1. Wells 3903-01 and 3903-02 are now filled with mud above the water level. Wells 3904-01 and 3904-02 are presently unused. Well 3904-03 was recently completed and was pump-tested during the field reconnaissance for this study.

Water levels were measured in wells 3904-01 and 3904-03. In well 3904-01 located 600 feet from the shore, the water level stood at 1.3 feet above mean sea level on July 20, 1978. In well 3904-03 located 3,500 feet from the shore, the water level was 2.4 feet above mean sea level on May 23, 1978.

Based on meager pumptest data from wells in the recent lavas at Hana and Kipahulu, specific capacities range from about 200 to 2,000 gallons per minute per foot of drawdown.

Freshwater was observed seeping from the rocks at the shore northeast of Ka-U Bay during low tide on May 23, 1978. Local residents reported other coastal springs in the Kipahulu area; however, these could not be verified during our field reconnaissance because of dangerous high-surf conditions.

GROUND-WATER QUALITY

None of the five wells in the Kipahulu area (fig. 1), was in use during our field reconnaissance. The Survey occasionally sampled well 3903-01 from 1972 to 1976. Analyses of those samples showed chloride concentrations of between 8 and 121 mg/L.

A sample was obtained from well 3904-01 with a Foerst-type, depth sampler. Chemical analysis of the sample showed it to be slightly brackish (1050 mg/L, dissolved solids).

At the time of the field reconnaissance, well 3904-03 was being pump tested. A sample of the pumped water was collected, after 50 minutes of pumping, when the temperature and specific conductance of the discharge appeared to have stabilized. The water was potable. The results of chemical analyses for wells 3904-01 and 3904-03 are presented in table 1.

No data are available regarding the yields of the existing wells in the Kipahulu area.

DISCUSSION

The observations made during the study indicate that most of the fresh ground water occurs as a basal lens in the lower reaches of Kipahulu Valley. Recharge of the ground water takes place in high-rainfall areas in the middle and upper reaches of the valley and discharge is from diffuse zones along the shore. The surface of the freshwater lens rises from about mean sea level at the shore to at least 2.4 feet above sea level in wells inland of the shore. Based on the two waterlevel measurements, the head gradient is slightly more than one foot per mile. In accordance with the Ghyben-Herzberg principle, the thickness of a freshwater lens is approximately 41 times the basal-water head.

This is the theoretical relationship between basal-water head and lens thickness and is based on static conditions and a sharp immiscible interface between the freshwater and the saline water. The fresh and saline waters are miscible, however, and tides, variations in recharge rate, and pumping stresses create a brackish zone grading from fresh to saline at the base of the freshwater lens. The thickness of the brackish transition zone can be determined only by direct measurement. Therefore, the developable thickness of the freshwater lens will always be less than the theoretical thickness.

Table 1. Water-quality data

[Concentration units are milligrams per liter, unless otherwise noted.]

Constituent	Concentration: Well 3904-01 July 20, 1978 8:50 a.m.	Concentration: Well 3904-03 July 20, 1978 2:35 p.m.
Temperature (°C)	19.0	19.0
Specific conductance (µmho/cm at 25°C)	2000	85
pH (units)	7.6	8.3
Hardness (Ca, Mg)	220	0
Calcium, dissolved (Ca)	27	4.1
Magnesium, dissolved (Mg)	46	2.5
Sodium, dissolved (Na)	300	9.2
Sodium-adsorption-ratio (SAR)	8.1	0.9
Potassium, dissolved (K)	12	1.7
Bicarbonate (HCO_3)	40	38
Carbonate (CO_3)	0	0
Alkalinity as $CaCO_3$	33	31
Sulfate, dissolved (SO_4)	75	2.3
Chloride, dissolved (Cl)	550	5.9
Fluoride, dissolved (F)	0.0	0.0
Silica, dissolved (SiO_2)	18	17
Dissolved solids (sum of constituents)	1050	63
Nitrate, dissolved (N)	.38	.25
Orthophosphorus, dissolved (P)	.02	.03
Iron, dissolved (Fe) (µg/L)	30	10
Manganese, dissolved (Mn) (µg/L)	10	0

Ground water may also occur above the basal water perched on dense lava flows, such as that discharging from the face of the waterfall in Palikea Stream. The location, distribution, and quantity of such perched water would be virtually impossible to predict, however, and the long-term capacity of a perched source would not be as dependable as basal water.

The low observed head gradient in the area and high estimated specific capacities (200 to 2000 gallons per minute per foot of drawdown) of wells in the recent lavas indicate an aquifer of high permeability. The potential for developing small to moderate quantitities of potable water, such as needed by the Park Service, appears to be good.

RECOMMENDATIONS FOR DEVELOPMENT

The basal-water lens thickens inland from the shore, and tidal action, which creates a brackish zone at the bottom of the lens, decreases inland from the shore. Therefore, the farther inland that a well can be located, the less the risk of producing saline-contaminated water. Wells should be sited a minimum of 1,000 feet from the shore.

The depth of well penetration and the drawdown of the water surface due to pumping can seriously affect the quality of water produced. Wells should not penetrate deeply into the lens because pumping may draw brackish or saline water into them. Also, for each foot of drawdown caused by pumping, there is a potential for saline water to rise 40 feet from below. Because of these considerations, it is recommended that well penetration depths be limited to the upper half of the lens and drawdown restricted to less than one half of the head above sea level. Drawdowns, for the pumping rate required for the Park Service's facilities (10-15 gal/min) can be expected to be on the order of a quarter of a foot and are not likely to cause degradation of water quality.

The yield of wells will depend on bore size, penetration depth, and other factors. Yield for a single well in the lower reaches of Kipahulu Valley probably will be on the order of several hundred gallons per minute. It is likely that chloride concentration will be the limiting factor in regard to pumping rate. Drawdown and chloride concentration should be closely monitored during pumping tests.

Sufficient data are not available at this time to estimate the sustainable ground-water yield of the study area.

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Takasaki, K. J., 1971, Preliminary report on the water resources of southeast Maui: Hawaii Division of Water and Land Development Circular C58, 37 p.