

CONSTRUCTION AND GEOLOGIC LOG OF THE SOUTH WAILUA MONITOR WELL (STATE WELL 2-0121-01), LIHUE, KAUAI, HAWAII

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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

	Multiply	By	To obtain
	inch (in.)	2.54	centimeter
	foot (ft)	0.3048	meter
	cubic foot per minute (ft ³ /min)	0.02832	cubic meter per minute
	gallon per minute (gal/min)	3.785	liter per minute
	mile, statute (mi)	1.609	kilometer

Other Useful Conversions

$$1 \text{ ft}^3/\text{s} = 448.8 \text{ gal/min}$$

$$1 \text{ ft}^3/\text{s} = 0.6463 \text{ Mgal/d}$$

Vertical datum

All elevations in this report are referenced relative to mean sea level.

Abbreviation:

μS/cm, microsiemens per centimeter at 25 degrees Celsius.

Construction and Geologic Log of the South Wailua Monitor Well (State Well 2-0121-01), Lihue, Kauai, Hawaii

By Scot K. Izuka and Stephen B. Gingerich

Abstract

The South Wailua monitor well, located in the Lihue basin near the western slope of Kalepa Ridge, was drilled in 1995 to study the hydrology and geology in an area where no other well information is available. The well was drilled to an elevation of -854 feet from a ground elevation of about 289 feet and penetrated a 1,143-foot section of mafic lava flows (which may include nephelinite, melilitite, basanite, and alkalic basalt, in part highly weathered), alluvial gravel, clay, and a layer of mudstone (possibly weathered ash) with wood fossils. Little water was found during drilling. An aquifer test was attempted but the pump became clogged with mud. A water-level elevation of 13.9 feet was measured before the test.

INTRODUCTION

The Lihue basin is the center of population, government, and industry for Kauai. Recent population growth in the basin has greatly increased the demand for water in the area. The economic setback caused by Hurricane Iniki in 1993 slowed growth on Kauai and may have kept the water supply from reaching a critical stage; however, an ample water supply is needed for the island's economic recovery. Pre-Iniki studies placed Lihue's supply at the highest priority in Kauai's water plans (Commission on Water Resources Management, 1990).

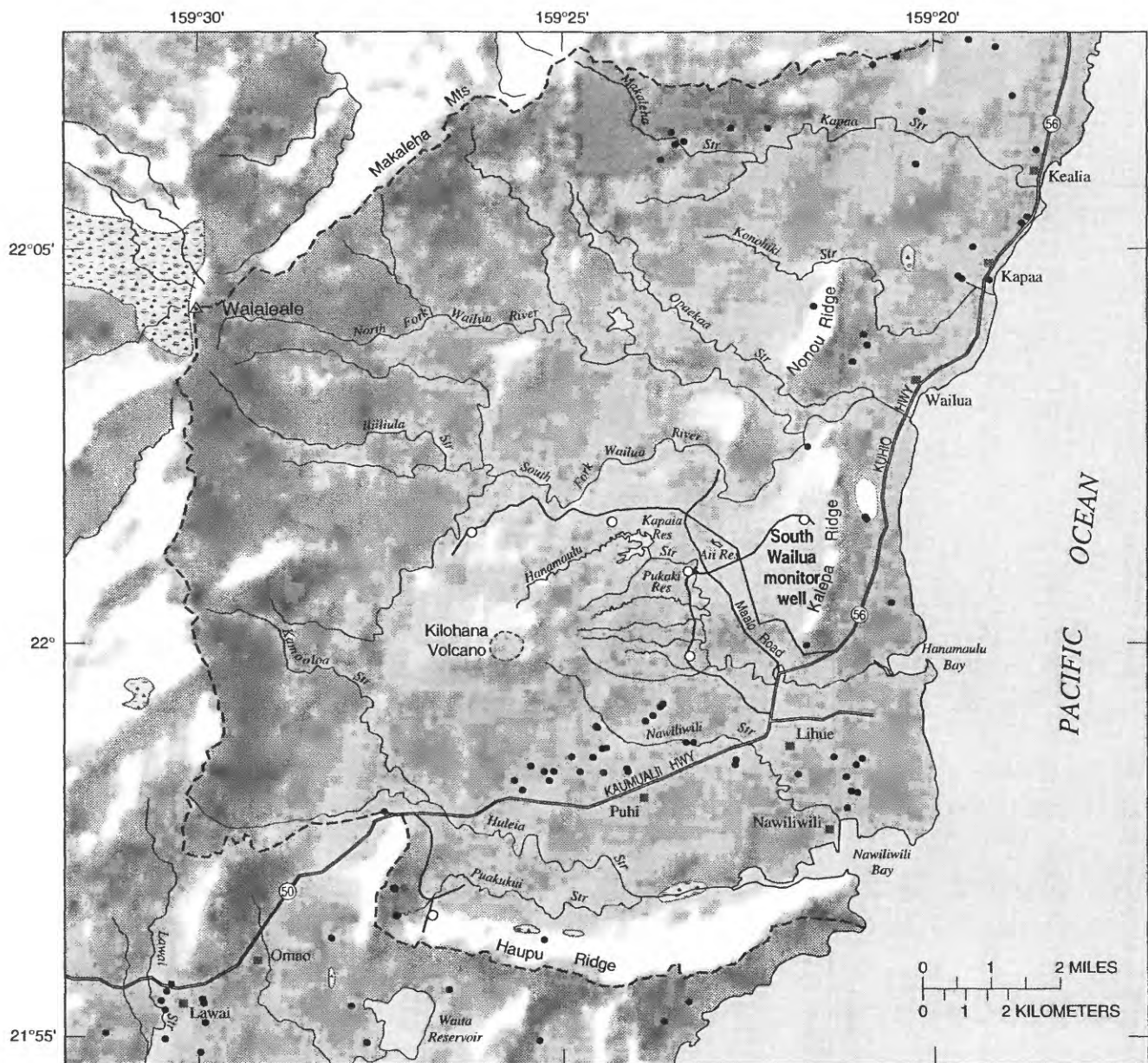
The South Wailua monitor well (State well 2-0121-01) is one of six monitor wells drilled in the period from April 1995 to April 1996 by the U.S. Geo-

logical Survey (USGS) in cooperation with the County of Kauai Department of Water to study the availability of ground water in the southern Lihue basin (fig. 1). The six monitor wells were sited in areas where no wells had been drilled and no subsurface information was available. Five of the six monitor wells were drilled in the central part of the Lihue basin. The sixth well was drilled in the southern part of the basin. The South Wailua monitor well is about 1 mi from the nearest previously existing wells and provides data for defining the regional ground-water system of the Lihue basin. The Department of Water considers the South Wailua area as a potential site for future ground-water exploration and development.

The objectives of this study were met by analysis of data collected during and after the drilling operation. These data included (1) the driller's description of the drilling history and well-construction details, (2) water levels monitored as the well was deepened, (3) a caliper log of the uncased well boring, and (4) a description of the geology from rock chips (cuttings) brought to the surface during drilling. This report documents the location, drilling history, construction details, and geologic log of the South Wailua monitor well.

Setting

The South Wailua monitor well (State well 2-0121-01) is located in the Lihue basin, a large depression bounded on the west by the high mountains of central Kauai, on the south by Haupu Ridge, and on the north by the Makaleha Mountains (fig. 1). The area has undergone substantial stream erosion, weathering, and faulting followed by rejuvenated, sporadic, scattered volcanism. Two major stratigraphic units are found in the Lihue basin (fig. 2): (1) the Waimea Canyon Basalt



Base modified from U.S. Geological Survey digital data, 1:24,000, 1983, Albers equal area projection, standard parallels 21°55'40" and 22°10'20", central meridian 159°32'30". Relief from U.S. Geological Survey digital elevation models, 1:250,000

EXPLANATION

- BOUNDARY OF LIHUE BASIN
- MONITOR WELL
- EXISTING WELL
- ▨ SWAMP
- SPRING

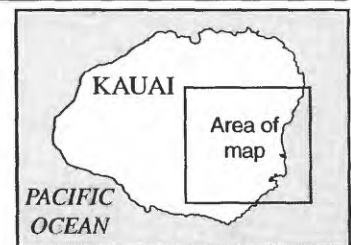


Figure 1. Location of the South Wailua monitor well (State well 2-0121-01) and existing wells in the Lihue basin, Kauai, Hawaii.

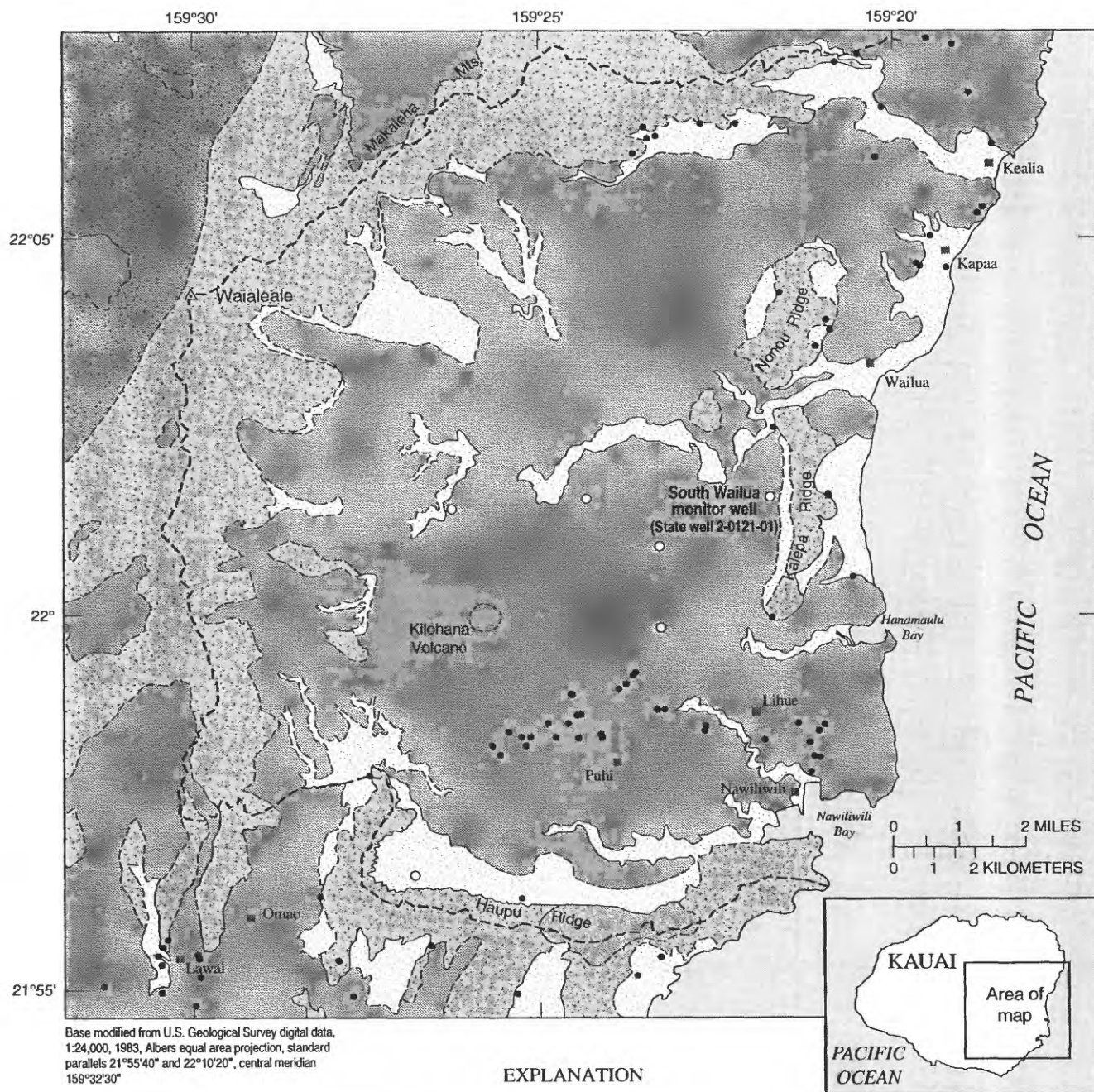


Figure 2. Geology of the Lihue basin area, Kauai, Hawaii (modified from Macdonald and others, 1960).

of Pliocene and Miocene (?) age which was erupted during the main shield-volcano-building stage of Kauai and forms the bulk of the island, including the mountains surrounding the Lihue basin, and (2) the Koloa Volcanics of Pleistocene and Pliocene age which include the rejuvenated-stage lava flows and sedimentary units that partly cover and fill the floor of the basin (Hinds, 1930; Stearns, 1946; Macdonald and others, 1960). Both the Waimea Canyon Basalt and the Koloa Volcanics have been given formational rank (Langenheim and Clague, 1987).

Kilohana Volcano in the center of the Lihue basin is a prominent edifice of the Koloa Volcanics. Macdonald and others (1960) described the Lihue basin as a subsidiary caldera that formed to the east of a central main caldera of the Kauai shield volcano. Stearns (1946) described the basin as the result of advanced stream erosion and the coalescing of many amphitheater-headed valleys. Numerous subsequent geologic investigations include a gravity survey (Kivroy and others, 1965), petrologic and geochemical analyses (Macdonald, 1968; Feigenson, 1984; Clague and Dalrymple, 1988; Maaloe and others, 1992), and radiometric dating (Clague and Dalrymple, 1988). These studies have advanced the understanding of the geology of Kauai, yet the origin of the Lihue basin remains an enigma.

Ground-water exploration in the Lihue basin has been only moderately successful, owing in part to the basin's complex ground-water hydrology. Most of the ground water in the Lihue basin is developed from wells in the Koloa Volcanics, which cover almost the entire basin floor. The Koloa Volcanics are generally considered to have low to moderate permeabilities (Macdonald and others, 1960), but specific capacities of wells in this unit are highly variable. Water levels during drilling in many of these wells declined with depth in the aquifer, indicating substantial vertical head gradients. At the base of the Koloa Volcanics and resting unconformably on the underlying Waimea Canyon Basalt, are the weathered rocks and sedimentary deposits that formed during the period of erosion between the shield-volcano eruptions and the rejuvenated volcanism. These deposits probably have low permeabilities and may retard the flow of water between the Koloa Volcanics and the Waimea Canyon Basalt.

The Waimea Canyon Basalt in the Lihue basin is represented by the Napali Member, the thick accumulations of thin lava flows that formed on the flank of the Kauai shield volcano. In western Kauai, the Napali

Member is extensive and forms the most permeable aquifers on Kauai, but in the Lihue basin, the Napali Member crops out only in the mountains encircling the basin. It is not certain whether any of the wells drilled thus far in the center of the basin have penetrated through the Koloa Volcanics and into the underlying Napali Member. Therefore, the thickness of the Koloa Volcanics and the hydrologic properties of the underlying Napali Member are unknown.

Location

The South Wailua monitor well (State well 2-0121-01) is located in the Lihue basin between sugarcane fields near the western slope of Kalepa Ridge (fig. 1, table 1). The site is on the western shoulder of a sugar plantation road, about 1.7 mi east of the intersection with Maalo Road. The well was assigned the well number 2-0121-01 by the State of Hawaii Commission on Water Resources Management using the State well numbering system.

Table 1. Location, elevation, and State number of the South Wailua monitor well, Kauai, Hawaii
[Datum is mean sea level]

Latitude	22°01'31"N
Longitude	159°21'47"W
Ground elevation at brass plate in concrete pad	289.22 feet
Measuring-point elevation at top of 4-inch well casing	290.16 feet
Distance and direction from Lihue	3.2 miles north
Distance and direction from nearest shoreline	1.4 miles west
State well number	2-0121-01

The area within a 1 mi radius of the well is covered by a network of artificial and natural surface-water bodies. The Wailua River is within 0.8 mi northwest of the well and a swamp lies 0.9 mi to the east on the other side of Kalepa Ridge. The well is located about 1.4 mi inland from the eastern coast of Kauai.

Acknowledgments

The construction, data collection, and testing of the South Wailua monitor well was made possible with the cooperation and assistance of Mr. Murl Nielsen, Manager and Chief Engineer, and the staff of the County of Kauai Department of Water. We are grateful to Mr. Sam Lee, Hawaii State Department of Land and Natural

Table 2. Summary of construction of the South Wailua monitor well (State well 2-0121-01), Kauai, Hawaii
 [Datum for water-level and bottom-of-hole elevations is mean sea level. Land surface elevation is about 289 ft above mean sea level; ft, feet]

Date		Significant events
August 1995	12	Drilling began
	15	Surface casing installed to 152 ft elevation
	24	Continued drilling to -8 ft elevation
	25	Increase of water lifted out of well at -33 ft and -88 ft elevation; continued drilling to -168 ft elevation
	26	Attempt to log hole with caliper, blockage discovered at -33 ft elevation
	28	Water level 13.9 ft elevation and bottom-of-hole elevation -168 ft
	30	Attempt aquifer tests, pump clogged with mud at -108 ft elevation
September 1995	22	Water level 14.8 ft elevation and bottom-of-hole elevation -168 ft
	24	Water level before drilling 14.7 ft elevation and bottom-of-hole elevation -168 ft; resume drilling to -251 ft elevation
October 1995	6	Possible increase in water lifted out of well at -327 ft elevation; continued drilling to -330 ft elevation
	7	Possible increase in water lifted out of well at -432 to -552 ft elevation; continued drilling to -552 ft elevation
	8	Continued drilling to -754 ft elevation
	9	Drilling terminated at -854 ft elevation (total depth of 1,143 ft)
	17	Logged upper 640 ft of hole with caliper, blockage at -351 ft elevation discovered; began installing perforated casing
	19	Completed well construction

Resources, for helping acquire permission to drill the well on State land and to Mr. Michael Furukawa for permitting the construction of the well on a part of the State land leased by Amfac/JMB Hawaii, Lihue Plantation. Drilling, aquifer-test, and elevation information were drawn extensively from the notes of G. Wayne Heick of the U.S. Geological Survey.

DRILLING METHODS AND HISTORY

The well was bored by rotary drilling with a 9-7/8-in. diameter tungsten-carbide bit from the surface (289 ft elevation) to an elevation of -251 ft, and an 8-3/4-in. diameter tungsten-carbide bit from -251 ft to -854 ft. Air and foam were injected down through the hollow drill stem and circulated back up the space between the stem and the well boring to remove water and cuttings from the hole. Greater lifting power was needed as the drilling penetrated deeper below the water table. The depth of drilling was thus limited by the capacity of the air compressor to provide the circulation. Table 2 summarizes the construction history of the well.

The drillers reported wet clay from the surface, but no standing water until they had drilled 15 ft and the bottom of the hole was at 274 ft elevation. The drillers estimated that the amount of water lifted out of the hole by the compressor was at most only about 50 gal/min, which indicates that little water was flowing into the

well from the aquifer. The drillers also reported many unconsolidated sediment (especially clay) layers. Drilling was halted temporarily to attempt an aquifer test while the hole bottom was at an elevation of -168 ft. A water-level elevation of 13.9 ft was measured prior to the test. The pump immediately became clogged with mud so the test was halted. Drilling resumed from -168 ft elevation and was terminated when the bottom of the hole was at an elevation of -854 ft (1,143 ft total drilling depth). A caliper tool was run down the hole on October 17, 1995 to record the caliper arm extension, an indication of the variation in hole diameter with depth. At -351 ft elevation a blockage was discovered; casing was installed through the blockage down to an elevation of -561 ft and the well was completed on October 19, 1995. The elevation of a brass plate in the concrete pad at the well is 289.22 ft and the elevation of the measuring point at the top of the casing is 290.16 ft. Construction details of the finished well are shown in figure 3. Plans to conduct aquifer tests after the completion of the well were abandoned because of the small amount of water found during drilling and the likelihood that the pump would again become clogged with sediment.

GEOLOGIC LOG

The geologic log of the South Wailua monitor well was compiled by examination of cuttings brought to the

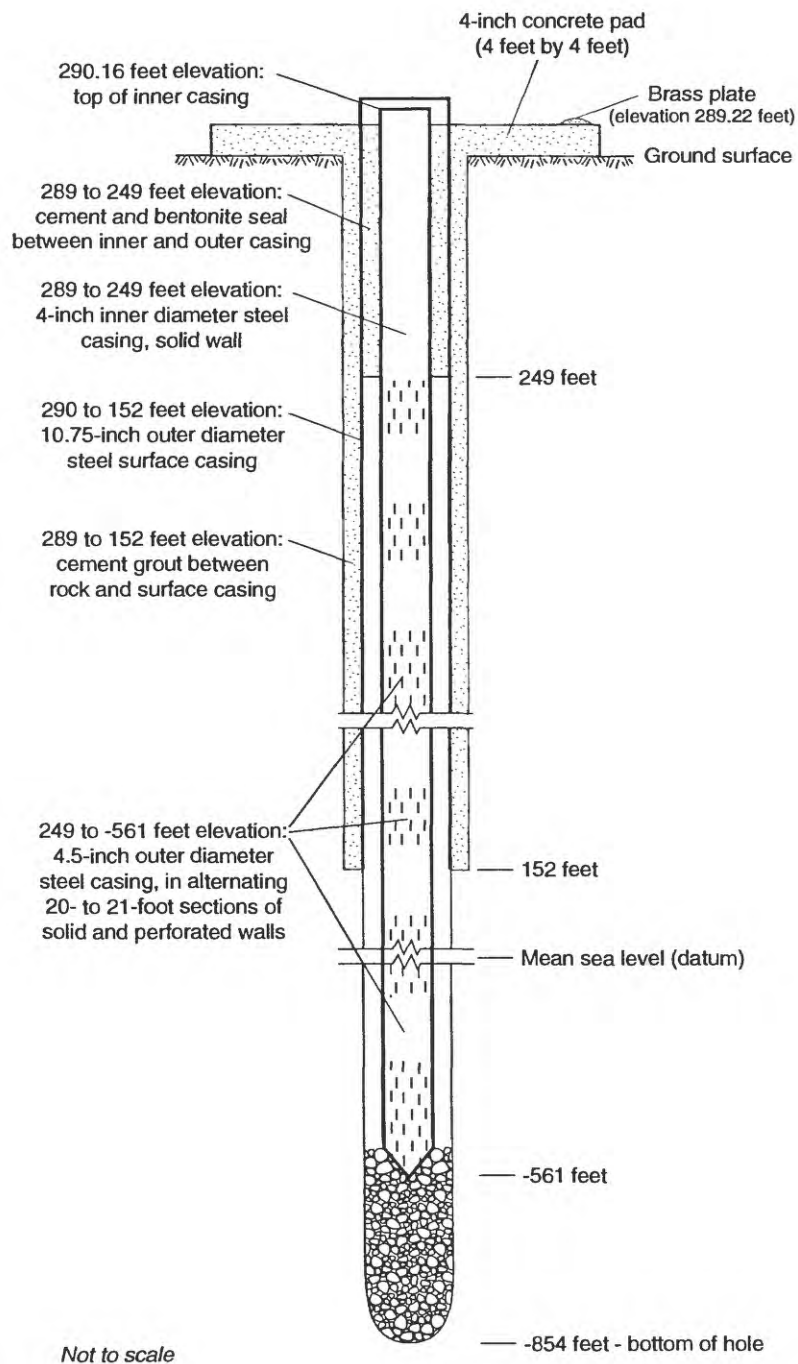


Figure 3. Construction details of the South Wailua monitor well (State well 2-0121-01), Kauai, Hawaii.

surface by the air and foam circulated through the well bore. Samples were collected at 5-ft depth intervals and air dried before being examined macroscopically. The complete lithologic descriptions appear in appendix 1; the geologic log is shown in figure 4.

The South Wailua monitor well penetrated a 1,143-ft section of mafic lava flows and alluvium ("mafic rock" in this report includes nephelinite, melilitite, basanite, and alkalic basalt, all of which are dark, fine-grained, igneous rocks but have specific compositions that are not distinguishable in hand specimen). The uppermost part of the section consists of a 30-ft layer of moist, sticky clay. Underlying the clay is a 165-ft-thick section of lava flows (in part highly weathered), alluvium, and clay. This section is underlain by 35-ft layer of mudstone (possibly weathered ash) with wood fossils. Underlying the fossiliferous mudstone is a 395-ft-thick section composed mostly of dense, aphyric mafic rock but also containing some sparsely vesicular mafic rock, amygdaloidal mafic rock, ash, clay, and alluvial gravel. The remaining 525 ft of rock penetrated by the well is composed almost entirely of alluvial gravel except for a few, thin, intercalated lava flows.

The caliper log of the South Wailua monitor well (fig. 4) shows intervals where the hole deviates from the drill-bit diameter. Rock layers that are unconsolidated or thin tend to crumble and cave to produce enlargements in the well boring. In contrast, rocks that are hard, massive, and thick tend to hold the shape of the boring, and thus give a smoother, unvarying log. Below the surface casing (surface casing shows as the smooth upper 130 ft of the caliper log), the log shows an enlargement between -21 and -31 ft elevation and another between -331 ft and -341 ft elevation that correspond approximately with some of the unconsolidated sedimentary layers shown in the geologic log. The well boring is slightly enlarged from an elevation of about -361 ft down to the bottom of the hole, which corresponds to the thick layers of unconsolidated sediments shown at the base of the geologic log.

SUMMARY

The South Wailua monitor well (State well 2-0121-01) is located in the Lihue basin between sugarcane fields near the western slope of Kalepa Ridge. The well was constructed during the period from August 12 to October 19, 1995 to study the hydrology and geology

in an area where no other well information is available. The ground elevation at the well is 289 feet and the well is 1,143 feet deep (bottom is at -854 feet elevation) and has a boring diameter of 9 to 10 inches. Flush-jointed 4-inch (outer diameter) steel casing, with perforated sections between the water table and the bottom, was installed in the hole.

The amount of water lifted out of the hole during drilling was at most only about 50 gallons per minute, which indicates that little water was flowing into the well from the aquifer. An aquifer test was attempted while the hole bottom was at an elevation of -168 feet. The pump immediately became clogged with mud so the test was halted. A water-level elevation of 13.9 feet was measured prior to the test. At -351 feet elevation a blockage was discovered; casing was installed through the blockage down to an elevation of -561 feet.

The South Wailua monitor well penetrated a 1,143-foot section of mafic lava flows (in part highly weathered), alluvial gravel, clay, and a layer of mudstone (possibly weathered ash) with wood fossils.

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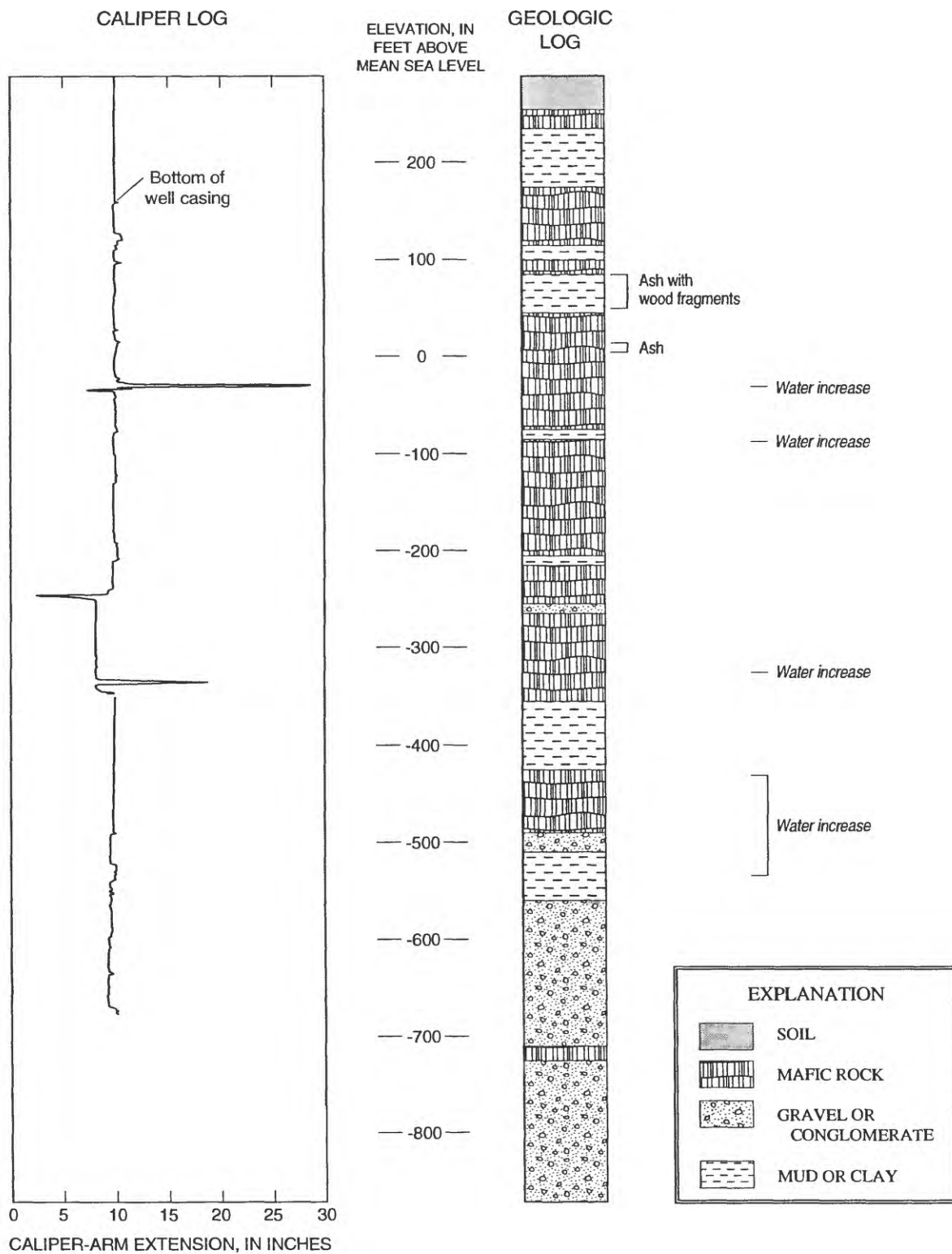


Figure 4. Geologic log and caliper-arm extension with depth in the South Wailua monitor well (State well 2-0121-01), Kauai, Hawaii.

Appendix 1. Lithologic descriptions of drill cuttings from the South Wailua monitor well (State well 2-0121-01), Kauai, Hawaii
 [Datum is mean sea level; depth measured from about 289 feet above sea level]

Elevation (feet)			Depth (feet)		Sample description ¹
289	to	284	0	to 5	red-brown, sticky clay
284	to	279	5	to 10	red-brown, sticky clay
279	to	274	10	to 15	red-brown, sticky clay
274	to	269	10	to 20	red-brown, sticky clay
269	to	264	20	to 25	red-brown, sticky clay
264	to	259	25	to 30	no sample
259	to	254	30	to 35	red-brown, sticky clay
254	to	249	35	to 40	dark-gray, vesicular mafic clinker
249	to	244	40	to 45	dark-gray, vesicular mafic clinker
244	to	239	45	to 50	dark-gray, vesicular mafic clinker
239	to	234	50	to 55	dark-gray, dense, aphyric mafic rock
234	to	229	55	to 60	red-brown, sticky clay
229	to	224	60	to 65	red sticky clay, no gravel
224	to	219	65	to 70	red sticky clay, no gravel
219	to	214	70	to 75	brown, sandy, gravelly mud
214	to	209	75	to 80	brown, sandy, gravelly mud
209	to	204	80	to 85	brown, sandy, gravelly mud
204	to	199	85	to 90	brown, sandy, gravelly mud
199	to	194	90	to 95	light-brown, sandy clay with flecks of white minerals
194	to	189	95	to 100	light-brown, sandy clay with flecks of white minerals
189	to	184	100	to 105	light-brown, sandy clay with flecks of white minerals
184	to	179	105	to 110	light-brown, sandy clay with flecks of white minerals
179	to	174	110	to 115	light-brown, sandy clay with flecks of white minerals
174	to	169	115	to 120	purplish-gray, weathered, vesicular mafic rock with white clay
169	to	164	120	to 125	purplish-gray, weathered, vesicular mafic rock with white clay
164	to	159	125	to 130	purplish-gray, slightly weathered, vesicular mafic rock
159	to	154	130	to 135	purplish-gray, slightly weathered, vesicular mafic rock
154	to	149	135	to 140	purplish-gray, slightly weathered, vesicular mafic rock
149	to	144	140	to 145	purplish-gray, slightly weathered, vesicular mafic rock
144	to	139	145	to 150	no sample
139	to	134	150	to 155	dark-gray, moderately vesicular, amygdaloidal mafic rock
134	to	129	155	to 160	dark-gray, moderately vesicular, amygdaloidal mafic rock
129	to	124	160	to 165	dark-gray, moderately vesicular, amygdaloidal mafic rock
124	to	119	165	to 170	dark-gray, moderately vesicular, amygdaloidal mafic rock
119	to	114	170	to 175	light-gray, partly weathered, moderately vesicular mafic rock
114	to	109	175	to 180	red clay with some gravel and deeply weathered mafic rock clasts
109	to	104	180	to 185	red clay with some gravel and deeply weathered mafic rock clasts
104	to	99	185	to 190	brown, weathered sand with medium gray dense mafic rock
99	to	94	190	to 195	dark-gray, dense mafic rock with olivine phenocrysts
94	to	89	195	to 200	dark-gray, dense mafic rock with olivine phenocrysts
89	to	84	200	to 205	dark-gray, dense mafic rock with olivine phenocrysts
84	to	79	205	to 210	olive, consolidated mudstone with some wood fragments
79	to	74	210	to 215	olive, consolidated mudstone with some wood fragments
74	to	69	215	to 220	olive, consolidated mudstone with some wood fragments
69	to	64	220	to 225	olive, consolidated mudstone with some wood fragments
64	to	59	225	to 230	olive, consolidated mudstone with some wood fragments
59	to	54	230	to 235	olive, consolidated mudstone with some wood fragments
54	to	49	235	to 240	olive, consolidated mudstone with some wood fragments
49	to	44	240	to 245	weathered mafic rock with olive mud
44	to	39	245	to 250	weathered mafic rock with olive mud
39	to	34	250	to 255	gray, unweathered mafic rock
34	to	29	255	to 260	brownish-gray, slightly weathered, sparsely vesicular mafic rock
29	to	24	260	to 265	brownish-gray, slightly weathered, sparsely vesicular mafic rock

Appendix 1. Lithologic descriptions of drill cuttings from the South Wailua monitor well (State well 2-0121-01), Kauai, Hawaii

--Continued

[Datum is mean sea level; depth measured from about 289 feet above sea level]

Elevation (feet)			Depth (feet)		Sample description ¹
24	to	19	265	to 270	brownish-gray sand
19	to	14	270	to 275	medium-gray, aphyric vesicular mafic rock
14	to	9	275	to 280	medium-gray, aphyric vesicular mafic rock with ash
9	to	4	280	to 285	brownish-gray, fine sand size volcanic ash
4	to	-1	285	to 290	medium-gray, slightly weathered, dense mafic rock
-1	to	-6	290	to 295	medium-gray mafic rock with some amygdules
-6	to	-11	295	to 300	gray, unweathered, moderately vesicular, aphyric mafic rock
-11	to	-16	300	to 305	gray, unweathered, moderately vesicular, aphyric mafic rock
-16	to	-21	305	to 310	medium-gray, slightly weathered, sparsely vesicular mafic rock
-21	to	-26	310	to 315	medium-gray, dense mafic rock
-26	to	-31	315	to 320	medium-gray, dense mafic rock
-31	to	-36	320	to 325	medium-gray, partly weathered, aphyric, vesicular mafic rock
-36	to	-41	325	to 330	medium-gray, partly weathered, aphyric, vesicular mafic rock
-41	to	-46	330	to 335	yellow-brown clay and gravel
-46	to	-51	335	to 340	gray, dense mafic rock mixed with deeply weathered yellow-brown clay
-51	to	-56	340	to 345	gray, dense mafic rock mixed with deeply weathered yellow-brown clay
-56	to	-61	345	to 350	medium-gray, dense aphyric mafic rock
-61	to	-66	350	to 355	medium-gray, dense aphyric mafic rock
-66	to	-71	355	to 360	dense mafic rock mixed with red-brown clay
-71	to	-76	360	to 365	red-brown clay with dense mafic rock from above
-76	to	-81	365	to 370	red-brown clay with dense mafic rock from above
-81	to	-86	370	to 375	gray, slightly weathered, very-fine-grained dense mafic rock
-86	to	-91	375	to 380	gray, slightly weathered, very-fine-grained dense mafic rock
-91	to	-96	380	to 385	medium-yellowish-gray, slightly weathered, dense, aphyric mafic rock
-96	to	-101	385	to 390	medium-yellowish-gray, slightly weathered, dense, aphyric mafic rock
-101	to	-106	390	to 395	dark-gray, dense, aphyric mafic rock
-106	to	-111	395	to 400	dark-gray, dense, aphyric mafic rock
-111	to	-116	400	to 405	dark-gray, moderately vesicular amygdaloidal mafic rock
-116	to	-121	405	to 410	dark-gray, moderately vesicular amygdaloidal mafic rock
-121	to	-126	410	to 415	dark-gray, moderately vesicular amygdaloidal mafic rock
-126	to	-131	415	to 420	gray, sparsely vesicular, amygdaloidal mafic rock
-131	to	-136	420	to 425	gray, sparsely vesicular, amygdaloidal mafic rock
-136	to	-141	425	to 430	gray, sparsely vesicular, amygdaloidal mafic rock
-141	to	-146	430	to 435	gray, sparsely vesicular, amygdaloidal mafic rock
-146	to	-151	435	to 440	dark-gray, moderately vesicular amygdaloidal mafic rock
-151	to	-156	440	to 445	dark-gray, moderately vesicular amygdaloidal mafic rock
-156	to	-161	445	to 450	medium-gray, sparsely vesicular amygdaloidal mafic rock
-161	to	-166	450	to 455	medium-gray, sparsely vesicular amygdaloidal mafic rock
-166	to	-171	455	to 460	medium-gray, sparsely vesicular amygdaloidal mafic rock
-171	to	-176	460	to 465	medium-gray, sparsely vesicular amygdaloidal mafic rock
-176	to	-181	465	to 470	medium-gray, sparsely vesicular amygdaloidal mafic rock
-181	to	-186	470	to 475	gray, slightly weathered, aphyric dense mafic rock
-186	to	-191	475	to 480	gray, slightly weathered, aphyric dense mafic rock
-191	to	-196	480	to 485	dense mafic rock with some clay
-196	to	-201	485	to 490	medium-gray, dense aphyric mafic rock
-201	to	-206	490	to 495	gray-brown clay with gravel
-206	to	-211	495	to 500	gray-brown clay with gravel
-211	to	-216	500	to 505	weathered mafic rock and clay
-216	to	-221	505	to 510	weathered mafic rock and clay
-221	to	-226	510	to 515	dark-gray, sparsely vesicular, amygdaloidal mafic rock
-226	to	-231	515	to 520	dense amygdaloidal mafic rock with brown clay coatings
-231	to	-236	520	to 525	dense mafic rock with brown mud coatings
-236	to	-241	525	to 530	dense mafic rock with brown mud coatings

Appendix 1. Lithologic descriptions of drill cuttings from the South Wailua monitor well (State well 2-0121-01), Kauai, Hawaii
--Continued

[Datum is mean sea level; depth measured from about 289 feet above sea level]

Elevation (feet)		Depth (feet)		Sample description ¹
-241	to -246	530	to 535	medium-gray, slightly vesicular amygdaloidal mafic rock
-246	to -251	535	to 540	medium-gray, slightly vesicular amygdaloidal mafic rock
-251	to -256	540	to 545	brown, highly to moderately weathered, rounded pebbles with some clay
-256	to -261	545	to 550	brown, highly to moderately weathered, rounded pebbles with no clay
-261	to -266	550	to 555	brownish-gray, slightly weathered, dense, medium-fine crystalline mafic rock
-266	to -271	555	to 560	dark-gray, dense, medium-fine crystalline mafic rock
-271	to -276	560	to 565	brownish-gray, slightly weathered, medium-fine crystalline mafic rock
-276	to -281	565	to 570	medium-gray, dense mafic rock with small clinopyroxene crystals
-281	to -286	570	to 575	medium-gray, dense mafic rock with small clinopyroxene crystals
-286	to -291	575	to 580	medium-gray, dense mafic rock with small clinopyroxene crystals
-291	to -296	580	to 585	medium-gray, dense mafic rock with small clinopyroxene crystals
-296	to -301	585	to 590	medium-gray, dense mafic rock with small clinopyroxene crystals
-301	to -306	590	to 595	medium-gray, dense mafic rock with small clinopyroxene crystals
-306	to -311	595	to 600	medium-gray, dense mafic rock with small clinopyroxene crystals
-311	to -316	600	to 605	medium-gray, dense mafic rock with small clinopyroxene crystals
-316	to -321	605	to 610	dark-gray, dense, aphanitic mafic rock
-321	to -326	610	to 615	dark-gray, dense, aphanitic mafic rock
-326	to -331	615	to 620	dark-gray, dense, aphanitic mafic rock
-331	to -336	620	to 625	partially weathered mixture of mafic rock pebbles and yellow-brown tuff?
-336	to -341	625	to 630	dark-gray, dense, aphanitic mafic rock
-341	to -346	630	to 635	dark-gray, dense, aphanitic mafic rock
-346	to -351	636	to 640	dark-gray, dense, aphanitic mafic rock with dark, greenish-gray clay
-351	to -356	640	to 645	dark-brownish-gray sticky mud with gravel
-356	to -361	645	to 650	dark-brownish-gray sticky mud
-361	to -366	650	to 655	dark-brownish-gray sticky mud
-366	to -371	655	to 660	dark-brownish-gray sticky mud
-371	to -376	660	to 665	sand with dark-gray mud
-376	to -381	665	to 670	brownish-dark-gray sticky mud with rounded, weathered pebbles
-381	to -386	670	to 675	brownish-dark-gray sticky mud with rounded, weathered pebbles
-386	to -391	675	to 680	brownish-dark-gray sticky mud with rounded, weathered pebbles
-391	to -396	680	to 685	brownish-dark-gray sticky mud with rounded, weathered pebbles
-396	to -401	685	to 690	dark-gray sticky mud with coarse sand and gravel
-401	to -406	690	to 695	very-dark sticky mud with gravel
-406	to -411	695	to 700	very-dark sticky mud with gravel
-411	to -416	700	to 705	very-dark sticky mud with gravel
-416	to -421	705	to 710	very-dark sticky mud with gravel
-421	to -426	710	to 715	dark-gray, unweathered to slightly weathered, dense, aphanitic mafic rock
-426	to -431	715	to 720	dark-gray, unweathered to slightly weathered, dense, aphanitic mafic rock
-431	to -436	720	to 725	dark-gray, unweathered to slightly weathered, dense, aphanitic mafic rock
-436	to -441	725	to 730	dark-gray, weathered, mafic rock with gray mud
-441	to -446	730	to 735	dark-gray, weathered, mafic rock with gray mud
-446	to -451	735	to 740	medium-gray, moderately weathered, mafic rock
-451	to -456	740	to 745	dark-brown, weathered, mafic rock gravel
-456	to -461	745	to 750	dark-gray, slightly weathered, hard mafic rock
-461	to -466	750	to 755	medium-gray, moderately weathered, mafic rock
-466	to -471	755	to 760	medium-gray, moderately weathered, mafic rock
-471	to -476	760	to 765	medium-gray, moderately weathered, mafic rock
-476	to -481	765	to 770	mixed moderately to highly weathered rounded mafic rock gravel
-481	to -486	770	to 775	mixed moderately to highly weathered rounded mafic rock gravel
-486	to -491	775	to 780	rounded pebbles, coarse sand, and dark-brown mud
-491	to -496	780	to 785	rounded pebbles, coarse sand, and dark-brown mud
-496	to -501	785	to 790	rounded pebbles, coarse sand, and dark-brown mud
-501	to -506	790	to 795	rounded pebbles, coarse sand, and dark-brown mud

Appendix 1. Lithologic descriptions of drill cuttings from the South Wailua monitor well (State well 2-0121-01), Kauai, Hawaii
--Continued

[Datum is mean sea level; depth measured from about 289 feet above sea level]

Elevation (feet)		Depth (feet)		Sample description ¹
-506	to -511	795	to 800	dark-brown, weathered, sticky clay with pebbles
-511	to -516	800	to 805	dark-brown, weathered, sticky clay with pebbles
-516	to -521	805	to 810	dark-brown, weathered, sticky clay with pebbles
-521	to -526	810	to 815	dark-brown, weathered, sticky clay
-526	to -531	815	to 820	dark-brown, weathered, sticky clay
-531	to -536	820	to 825	dark-brown, weathered, sticky clay
-536	to -541	825	to 830	dark-brown, weathered, sticky clay with few pebbles
-541	to -546	830	to 835	dark-brown, weathered, sticky clay with few pebbles
-546	to -551	835	to 840	red-brown, weathered, sticky clay
-551	to -556	840	to 845	red-brown, weathered, sticky clay
-556	to -561	845	to 850	weathered, rounded pebbles and coarse sand
-561	to -566	850	to 855	weathered, rounded pebbles and coarse sand
-566	to -571	855	to 860	weathered, rounded pebbles, coarse sand, and red-brown clay
-571	to -576	860	to 865	weathered, rounded pebbles, coarse sand, and red-brown clay
-576	to -581	865	to 870	weathered, rounded pebbles and dark-brown, sticky mud
-581	to -586	870	to 875	weathered, rounded pebbles and dark-brown, sticky mud
-586	to -591	875	to 880	weathered, rounded pebbles and dark-brown, sticky mud
-591	to -596	880	to 885	weathered, rounded pebbles and dark-brown, sticky mud
-596	to -601	885	to 890	weathered, rounded pebbles and dark-brown, sticky mud
-601	to -606	890	to 895	weathered, rounded pebbles and dark-brown, sticky mud
-606	to -611	895	to 900	weathered, rounded pebbles and dark-brown, sticky mud
-611	to -616	900	to 905	weathered, rounded pebbles and dark-brown, sticky mud
-616	to -621	905	to 910	weathered, rounded pebbles and dark-brown, sticky mud
-621	to -626	910	to 915	dark-brown pebbles, coarse sand, and highly weathered rounded gravel
-626	to -631	915	to 920	dark-brown pebbles, coarse sand, and highly weathered rounded gravel
-631	to -636	920	to 925	dark-brown pebbles, coarse sand, and highly weathered rounded gravel
-636	to -641	925	to 930	dark-brown pebbles, coarse sand, and highly weathered rounded gravel
-641	to -646	930	to 935	dark-brown pebbles, coarse sand, and highly weathered rounded gravel
-646	to -651	935	to 940	dark-brown pebbles, coarse sand, and highly weathered rounded gravel
-651	to -656	940	to 945	pebbles, coarse sand, dark-brown mud, and highly weathered rounded gravel
-656	to -661	945	to 950	pebbles, coarse sand, dark-brown mud, and highly weathered rounded gravel
-661	to -666	950	to 955	pebbles, coarse sand, dark-brown mud, and highly weathered rounded gravel
-666	to -671	955	to 960	pebbles, coarse sand, dark-brown mud, and highly weathered rounded gravel
-671	to -676	960	to 965	pebbles, coarse sand, dark-brown mud, and highly weathered rounded gravel
-676	to -681	965	to 970	pebbles, coarse sand, dark-brown mud, and highly weathered rounded gravel
-681	to -686	970	to 975	pebbles, coarse sand, dark-brown mud, and highly weathered rounded gravel
-686	to -691	975	to 980	pebbles, coarse sand, dark-brown mud, and highly weathered rounded gravel
-691	to -696	980	to 985	pebbles, coarse sand, dark-brown mud, and highly weathered rounded gravel
-696	to -701	985	to 990	pebbles, coarse sand, dark-brown mud, and highly weathered rounded gravel
-701	to -706	990	to 995	pebbles, coarse sand, dark-brown mud, and highly weathered rounded gravel
-706	to -711	995	to 1,000	black, very dense, aphyric mafic rock
-711	to -716	1,000	to 1,005	black, very dense, aphyric mafic rock
-716	to -721	1,005	to 1,010	black, very dense, aphyric mafic rock
-721	to -726	1,010	to 1,015	yellow-brown, weathered, rounded gravel
-726	to -731	1,015	to 1,020	yellow-brown, weathered, rounded gravel
-731	to -736	1,020	to 1,025	yellow-brown, weathered, rounded gravel
-736	to -741	1,025	to 1,030	yellow-brown, weathered, rounded gravel
-741	to -746	1,030	to 1,035	yellow-brown, weathered, rounded gravel
-746	to -751	1,035	to 1,040	yellow-brown, weathered, rounded gravel
-751	to -756	1,040	to 1,045	yellow-brown, weathered, rounded gravel
-756	to -761	1,045	to 1,050	yellow-brown, weathered, rounded gravel
-761	to -766	1,050	to 1,055	yellow-brown, weathered, rounded gravel
-766	to -771	1,055	to 1,060	yellow-brown, weathered, rounded gravel

Appendix 1. Lithologic descriptions of drill cuttings from the South Wailua monitor well (State well 2-0121-01), Kauai, Hawaii

--Continued

[Datum is mean sea level; depth measured from about 289 feet above sea level]

Elevation (feet)		Depth (feet)		Sample description ¹
-771	to -776	1,060	to 1,065	yellow-brown, weathered, rounded gravel
-776	to -781	1,065	to 1,070	yellow-brown, weathered, rounded gravel
-781	to -786	1,070	to 1,075	yellow-brown, weathered, rounded gravel
-786	to -791	1,075	to 1,080	yellow-brown, weathered, rounded gravel
-791	to -796	1,080	to 1,085	yellow-brown, weathered, rounded gravel
-796	to -801	1,085	to 1,090	yellow-brown, weathered, rounded gravel
-801	to -806	1,090	to 1,095	yellow-brown, weathered, rounded gravel
-806	to -811	1,095	to 1,100	yellow-brown, weathered, rounded gravel
-811	to -816	1,100	to 1,105	yellow-brown, weathered, rounded gravel
-816	to -821	1,105	to 1,110	yellow-brown, weathered, rounded gravel
-821	to -826	1,110	to 1,115	yellow-brown, weathered, rounded gravel
-826	to 831	1,115	to 1,120	yellow-brown, weathered, rounded gravel
831	to -836	1,120	to 1,125	yellow-brown, weathered, rounded gravel
-836	to -841	1,125	to 1,130	yellow-brown, weathered, rounded gravel
-841	to -846	1,130	to 1,135	yellow-brown, weathered, rounded gravel
-846	to -851	1,135	to 1,140	yellow-brown, weathered, rounded gravel
-851	to -856	1,140	to 1,145	yellow-brown, weathered, rounded gravel
-856	to -861	1,145	to 1,150	yellow-brown, weathered, rounded gravel
-861	to -866	1,150	to 1,155	yellow-brown, weathered, rounded gravel
-866	to -871	1,155	to 1,160	yellow-brown, weathered, rounded gravel