DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
HAWAII STATE DEPARTMENT OF LAND
AND NATURAL RESOURCES
DIVISION OF WATER AND LAND DEVELOPMENT

GROUND-WATER STATUS REPORT, LAHAINA DISTRICT, MAUI, HAWAII, 1980

By
William R. Souza

WATER RESOURCES INVESTIGATIONS
81-549

OPEN-FILE REPORT
1981

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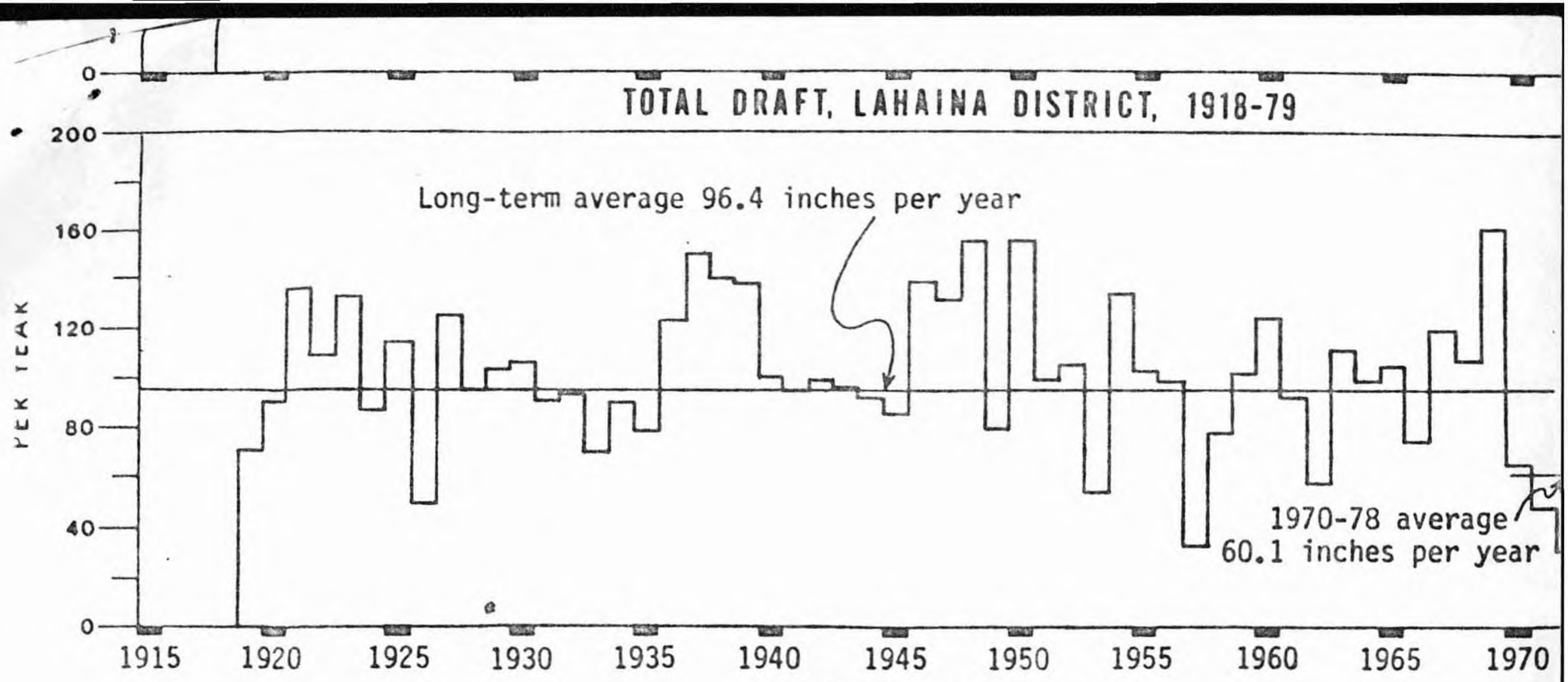
GROUND-WATER STATUS REPORT, LAHAINA DISTRICT, MAUI, HAWAII, 1980

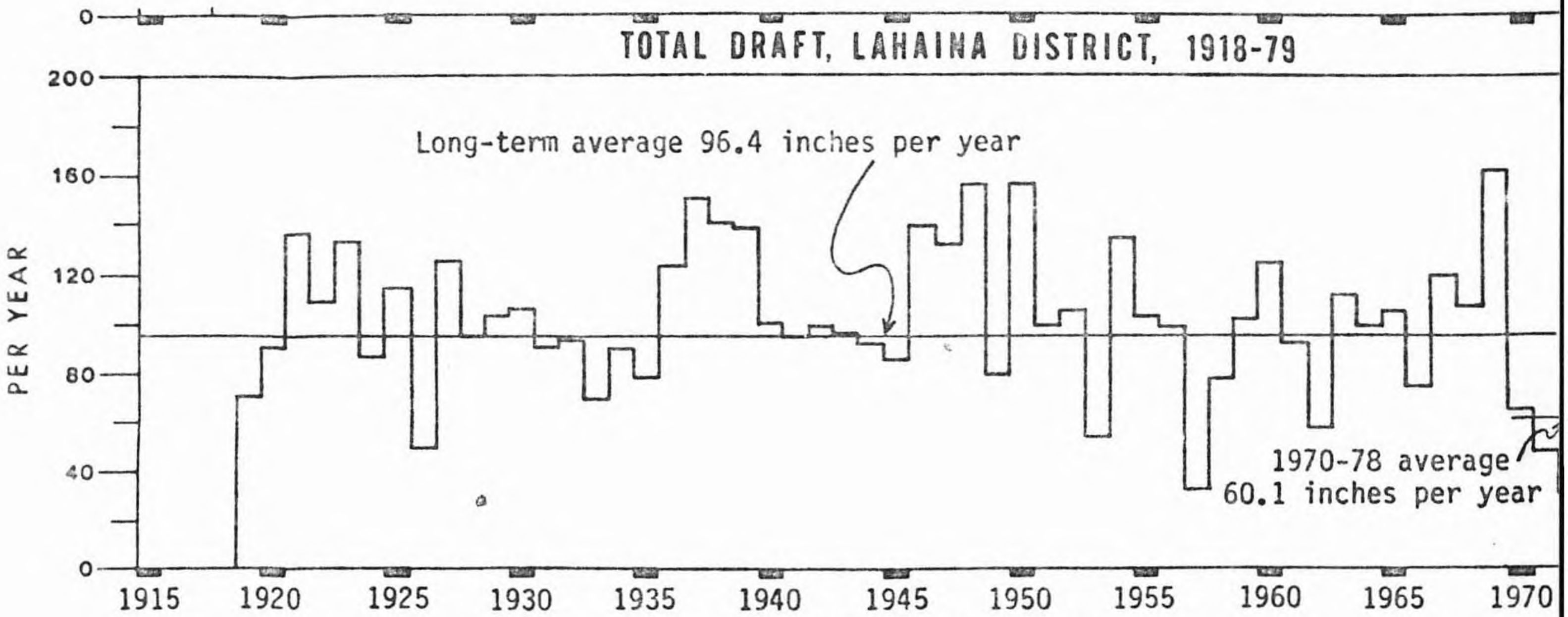
by William R. Souza

Sheet 1 of 2: Lower left corner--graph titled "RAINFALL, RG-361," please change to "RAINFALL, RG-374". (Sample attached. Adhesive tape with correction attached to sample.)



RAINFALL, RG-361

(Source: National Oceanic and Atmospheric Administration, Climatological Data, Annual Summaries.)



RAINFALL, RG-374

(Source: National Oceanic and Atmospheric Administration, Climatological Data, Annual Summaries.)

RG-374

Prepared in cooperation with the
HAWAII STATE DEPARTMENT OF LAND AND NATURAL RESOURCES
DIVISION OF WATER AND LAND DEVELOPMENT

WATER RESOURCES INVESTIGATIONS 81-549
OPEN-FILE REPORT (SHEET 1 OF 2)

LAHAINA DISTRICT GROUND-WATER STATUS REPORT

Introduction

During the past two decades, Hawaii's growth has increased the demand for water of domestic quality, and focused attention on areas in the State's freshwater aquifer systems where problems may develop. The Lahaina District of West Maui has grown rapidly as a new major tourist destination. This growth, in addition to a large water demand by agriculture and drought conditions during the 1970's, severely strained the water resources of that area.

The U.S. Geological Survey, in cooperation with the State of Hawaii, has a continuing program to collect, analyze and interpret ground-water data within the State. This report on the Lahaina District of Maui is the second in a series of ground-water status reports planned as part of this program.

The following tasks are part of the investigation:

1. Review and compilation of ground-water data.
2. Selection of representative wells for water-quality and water-level measurement to determine present ground-water conditions.
3. Two mass measurements of water levels, and collection of water samples for water-quality determination.
4. Preparation of maps depicting the above data and comparison of these maps with others prepared previously.

This report, in graphic format, is intended to show changes in water use, supply, and quality during the past 20 years that affect the present status of the ground-water resource. It consists of two sheets, each having a map of the area, an explanatory text, and graphs presenting a summary of selected data on pumpage, ground-water levels, and water quality through 1979.

Records of ground-water data used in this report are available in the files of the Hawaii District, U.S. Geological Survey, Honolulu, Hawaii.

Previous Studies

The water resources of the Lahaina District have been the subject of several reports. The first extensive description of the geology and water resources of Maui was made by Stearns and Macdonald (1942). The local hydrology, as related to agriculture, was studied by Stearns (1964) and Broadbent (1969). A general reconnaissance report of the water resources of the Lahaina District was made by Yamanaga and Huxel (1969). Also in 1969, a comprehensive water-development plan for the Lahaina District was prepared and published by the State of Hawaii (Belt, Collins and Assoc., 1969).

Geographic Setting

The area under study comprises the Lahaina District, or approximately the western half of West Maui. The boundary between the Lahaina and Wailuku Districts runs along the central north-south ridge, which is also an approximate surface-water divide. The Lahaina District is also Maui hydrographic area I as originally designated by the Hawaii Water Authority (1959). Following a division by Yamanaga and Huxel (1969), the area is further divided into subareas A, B, and C as shown on the accompanying map.

The subarea division defines the major land uses in the Lahaina District. Subarea A has had limited urban development but is now a major growth and new water-development area. The major land use is agriculture, with about 3,500 acres of pineapple. Subarea B is the most developed and the major user of water. The water requirement of 9,000 acres of sugarcane is about 90 Mgal/d (million gallons per day) and exceeds the available supply from both ground water and stream diversions. Subarea C has had limited urban development and low water use. The major land use is 800 acres of sugarcane.

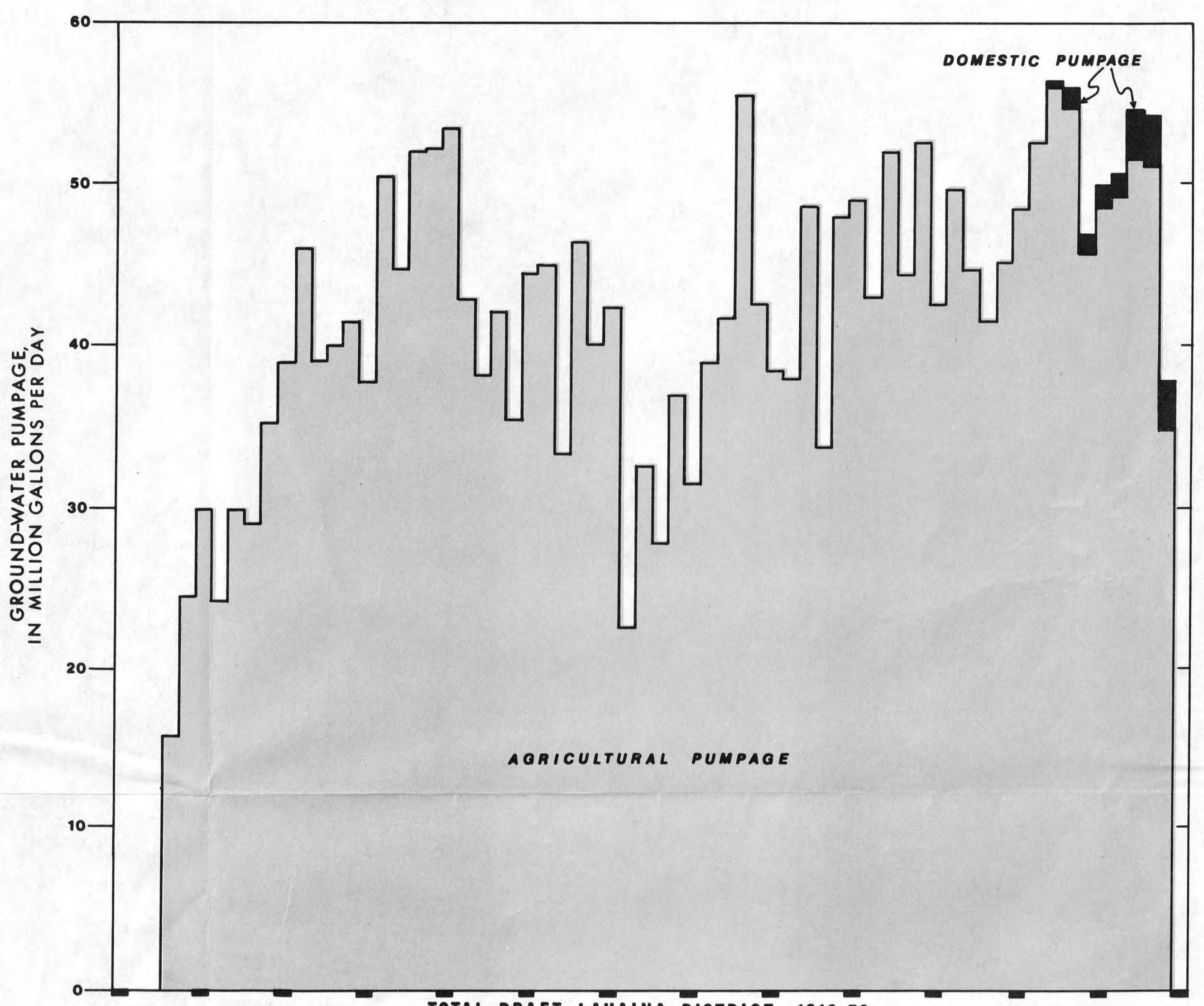
Ground-Water Levels

The Lahaina District is typical of low-head coastal areas where little or no coastal sediment impedes the flow of freshwater to the ocean. This type of basal-water body has only small storage capacity and consistent, heavy rainfall is necessary to maintain a usable ground-water supply. Water levels range from a few inches to a few feet above sea level, up to a maximum of about 8 feet, 3 miles inland.

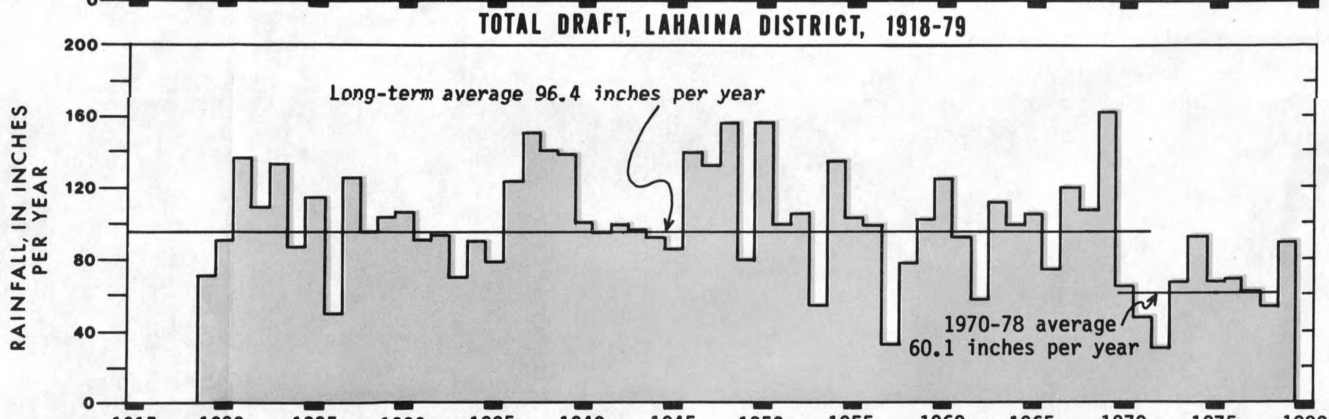
Ground-water levels have not changed significantly since the 1930's. Typical of the basal irrigation wells, the recorded static water level in well 5340-02 ranged from 1.8 to 3.7 feet (sheet 2) from 1935 to 1963, and in February 1979 was measured to be 3.3 feet. However, seasonal fluctuations may occur and declines of 1 to 2 feet during dry years and during heavy pumping have been reported (Stearns and Macdonald, 1942). The map shows results of mass measurements of water levels taken during February 1979 and February 1980 at the end of the heavy irrigation season. No long-term trends are evident in ground-water levels.

Acknowledgments

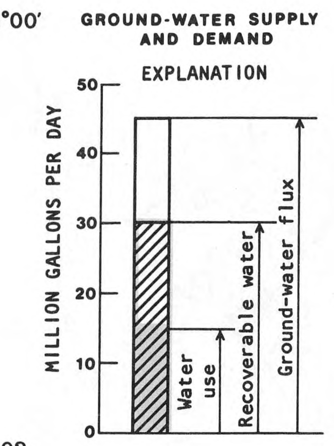
The assistance of Pioneer Mill Co. in providing unpublished material and access to its wells and shafts is gratefully acknowledged.

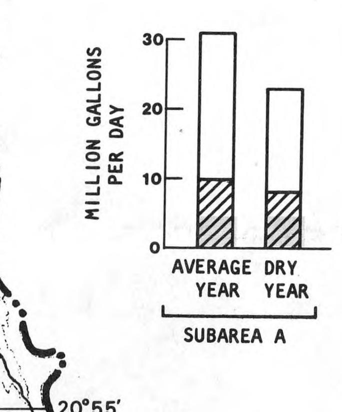


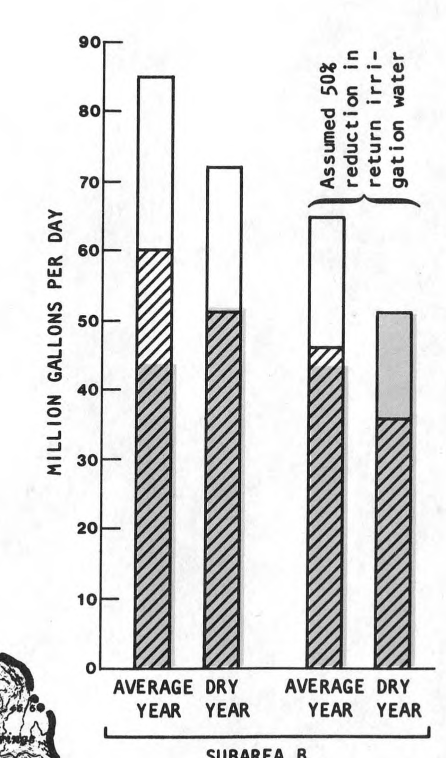
TOTAL DRAFT, LAHAINA DISTRICT, 1918-79

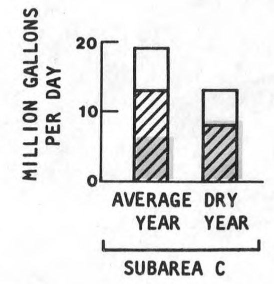


RAINFALL, RG-361
(Source: National Oceanic and Atmospheric Administration, Climatological Data, Annual Summaries.)









Ground-Water Availability and Use

Total water use in the Lahaina District is about 100 Mgal/d. Surface water, from stream diversion and the Honokohau ditch system, supplies about half the water needs for both agriculture and domestic use. Ground water is used to supplement the surface-water sources so that the greatest pumpage occurs during periods of low rainfall. Agriculture, by far the major water user, has required an average of 48 Mgal/d since 1959. Irrigated lands are concentrated in subarea B and account for 90 percent of all ground water pumped in the Lahaina District.

The use of ground water as a source of drinking water has increased steadily from about 1 Mgal/d in 1970 to 4 Mgal/d in 1979. During this period all new major domestic wells were located at elevations between 600 and 900 feet and 1 to 2 miles inland. These basal-ground-water sources have proven to be the most productive and reliable source of domestic water.

To estimate the availability of ground-water resources, modified water budgets from Wilson, Okamoto, and Assoc. (1977) and Belt, Collins and Assoc. (1969) were used to estimate the ground-water supply by subareas. In the ground-water supply graphs, the total ground-water flux for subareas B and C includes return irrigation water in amounts of 43 Mgal/d for subarea B and 6 Mgal/d for subarea C. The amount of recoverable water, as used here, is assumed to be the amount of water that can be taken from the ground-water system, suitable in quality for its intended use. That is, recoverable water includes slightly brackish water pumped for irrigation in subareas B and C. The figures for recoverable water are not intended to be estimates for a sustainable yield, because in this thin lens system, the entire useful supply of ground water could be depleted and replenished in a single yearly irrigation cycle.

In subarea A, the amount of recoverable water does not take into account return irrigation water, and is assumed to be 67 percent of the total ground-water flux. For subareas B and C, the amount of recoverable water is based on a modified water budget (subarea B) for the drought years 1970 to 1978. During this period, rainfall was calculated to be 25 percent below average, and the reduced total ground-water flux, 72 Mgal/d. The total water use was about 52 Mgal/d, and the chloride concentrations in the basal-water wells were at an all-time high (see sheet 2). If it is assumed, then, that further increases in pumping or extended drought would further deteriorate the majority of the basal-water wells to unacceptable levels, then the draft during this period would be a reasonable estimate for recoverable water.

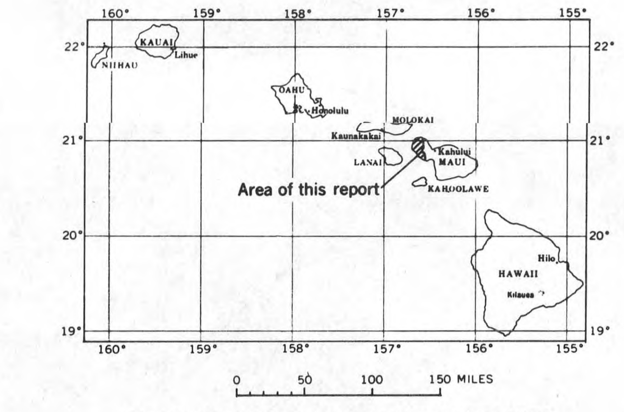
The present heavy draft for agricultural use is possible because of the effective recycling of large quantities of irrigation water to the ground-water system. Approximately half the applied water with furrow-irrigation methods is generally assumed to infiltrate beyond the root zone. However, in the newly developed drip-irrigation method, a lower application rate results in less water infiltrating and recharge to the basal water may be only half of that with furrow irrigation (Ekern, 1977). The high water demand of sugarcane exceeds the capacity of most furrow systems. Drip irrigation, through the efficient application of water, uses nearly all of the available agricultural water supply to meet sugarcane demands and thus total water use has not been reduced.

A possible effect of reducing the return irrigation water without reducing water demand is a loss of usable water supply. The ground-water supply and demand graphs in subarea B show a potential deficit in the usable water supply during dry years assuming a 50 percent reduction in the amount of return irrigation water.

Table 1. Records of wells, shafts, and tunnels

(Elevation in feet above or below mean sea level.)

Well number: New (6-)	Well number: Old	Year completed	Present use	Elevation: Ground	Elevation: Bottom of well	Well type	Comments
			MAUI-TYPE SHAFTS/DUG WELLS				
4835-01	Shaft 12 Pump P	1934	Irrigation	79	-64	Inclined Maui shaft	Thermal water.
4837-01	Shaft 11 Pump O	1905	do.	20	0	Dug well	Tunnels in alluvium. 8 supplemental drilled wells.
4937-01	Shaft 10 Pump N	1933	do.	165	-135	Inclined Maui shaft	
5240-01	Shaft 7 Pump C	1897	Industrial	35	-5	Dug well	Used for mill waste water.
5240-02	Shaft 8 Pump B	1897	Irrigation	28	-1	do.	
5240-03	Shaft 9 Pump A	1897	do.	28	-1	do.	10 supplemental drilled wells.
5340-01	Shaft 6 Pump L	1897	do.	26	-1	do.	Converted to 2 Mgal/d pump for drip irrigation. 12 supplemental drilled wells.
5340-02	Shaft 5 Pump M	1933	do.	322	-1	Vertical shaft	
5541-01	Shaft 4 Pump G	1923	Unused	14		Dug well	Not in use since 1977.
5640-01	Shaft 36 Pump R	1951	Irrigation	314		Inclined Maui shaft	
5641-01	Shaft 3 Pump D	1897	do.	27	-1	Dug well	11 supplemental drilled wells.
5641-02	Shaft 2 Pump F	1921	do.	65	0	Inclined Maui shaft	12 supplemental drilled wells.
5839-01	Shaft 1	1934	do.	244	-1	do.	
			WATER TUNNELS				
5035-01	Tunnel 19	1912	Unused	775	-	High-level tunnel. Dry.	Sealed.
5134-01	Tunnel 13	Unknown	Irrigation	1,710	-	High-level tunnel. Free flowing.	
5136-01	Tunnel 15	do.	do.	1,425	-	do.	
5236-01	Tunnel 16	do.	do.	2,920	-	do.	
5436-01	Tunnel 19	do.	do.	2,350	-	do.	
5437-01	Tunnel 17	do.	Unused	1,923	-	do.	
5437-02	Tunnel 18	do.	Irrigation	1,984	-	do.	
5537-01	Tunnel 20-A	do.	do.	1,700	-	do.	
5537-02	Tunnel 20-B	do.	do.	1,600	-	do.	
5735-01	Tunnel 21	do.	do.	880	-	do.	
5735-02	Tunnel 22	do.	do.	900	-	do.	
			DRILLED WELLS/TEST HOLES				
5138-01	--	1979	Domestic/ irrigation	634	-44	Vertical drilled well	New well. No pump as of 6/80.
5237-01	--	1970	Observation	1,530	1,174	do.	High-level water.
5237-02	--	1970	do.	1,800	1,483	do.	Do.
5338-01	--	1970	do.	1,070	320	do.	Do.
5338-02	--	1970	do.	1,257	660	do.	Do.
5339-01	291	1962	Municipal	441	-56	do.	On line, 1966.
5339-02	292	1963	do.	441	-57	do.	On line, 1971.
5339-03	--	1971	do.	600	-52	do.	Deepened 1976. On line, 1978.
5339-04	--	1974	do.	654	-95	do.	On line, 1978.
5540-01	--	1971	Domestic	444	-28	do.	
5540-02	--	1971	Unused	450	--	do.	
5540-03	--	1971	Irrigation	480	-20	do.	
5637-01	--	1964	Observation	1,450	1,280	do.	High-level water.
5637-05	307	1965	Domestic	1,450	1,285	do.	Do.
5638-01	307-6	1965	Observation	776	524	do.	Do.
5638-02	307-7	1965	Observation	1,169	855	do.	Do.
5638-03	--	1976	Domestic	852	-43	do.	
5639-01	307-5	1965	Observation	560	-20	do.	
5639-02	307-8	1965	do.			do.	
5838-01	--	1971	Municipal	860	-33	do.	On line, 1977.
5838-02	--	1972	do.	883	-32	do.	
5838-03	--	1979	do.	911	-60	do.	
5838-04	--	1978	do.	912	-18	do.	
5839-02	318-1	1966		493	-31	do.	
5840-01	318	1964	Observation	257	-17	do.	



INDEX MAP SHOWING AREA OF THIS REPORT

GROUND-WATER AVAILABILITY AND USE, 1918-79

GROUND-WATER STATUS REPORT, LAHAINA DISTRICT, MAUI, HAWAII, 1980

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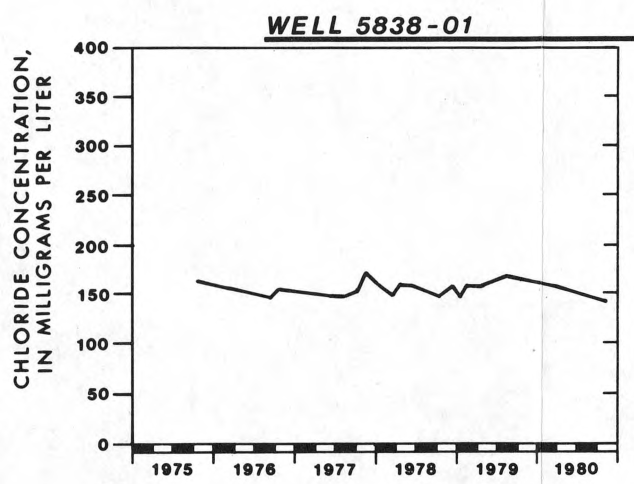
1981

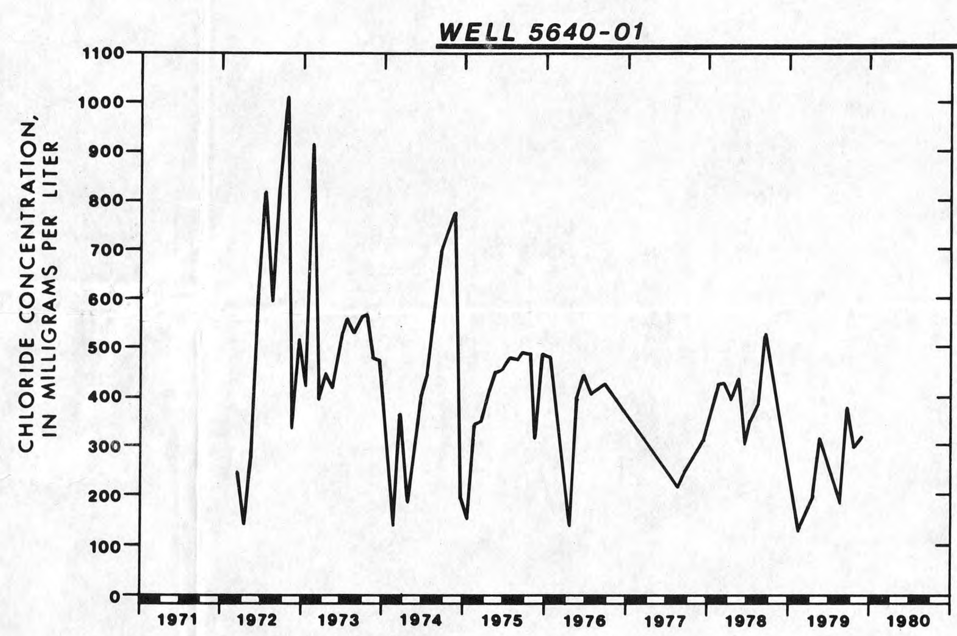
Water Quality

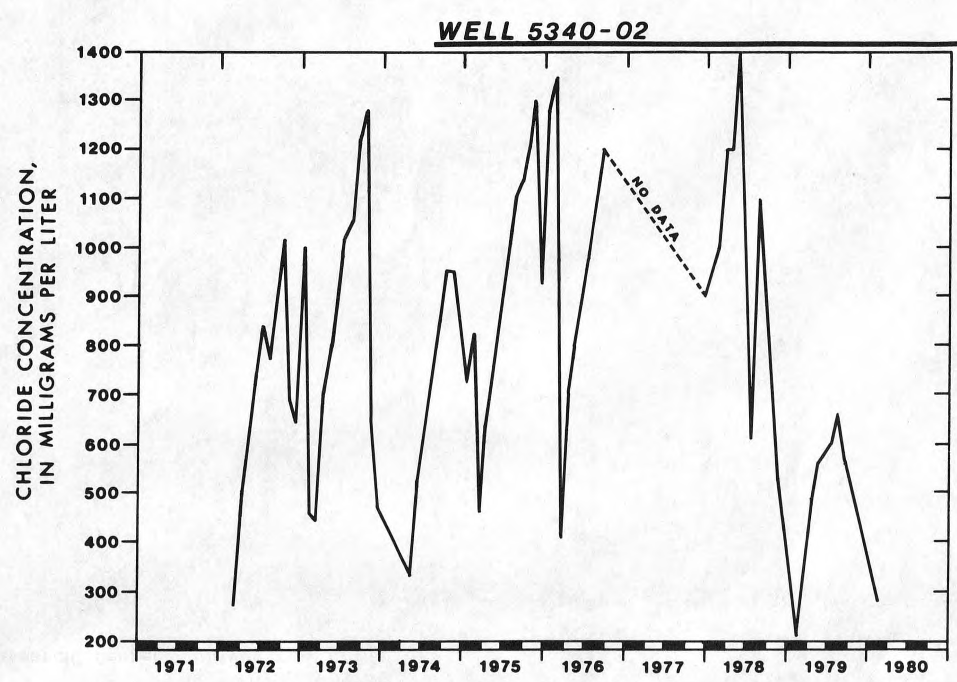
Long-term pumping for sugarcane irrigation has affected the quality of ground water over most of the Lahaina District. Major sources of pollution are from irrigation-water return and the intrusion of saline water. Historically, the chloride content of the basal-water irrigation wells is dependent upon the amounts of water pumped and is the single most reliable indicator to define the limits of usable water. The relation between pumping stress and chloride concentrations is shown for well 5340-02. During the period 1970-1978, the effect of higher pumpage and of drought conditions caused large increases in the chloride concentrations. However, normal rainfall during 1979 apparently reversed the trend. No long-term trends in chloride concentration are evident in basal-water irrigation wells, although large, but temporary increases occur during extended irrigation seasons. Chloride records for domestic wells are limited to recent years, so that long-term trends are not known.

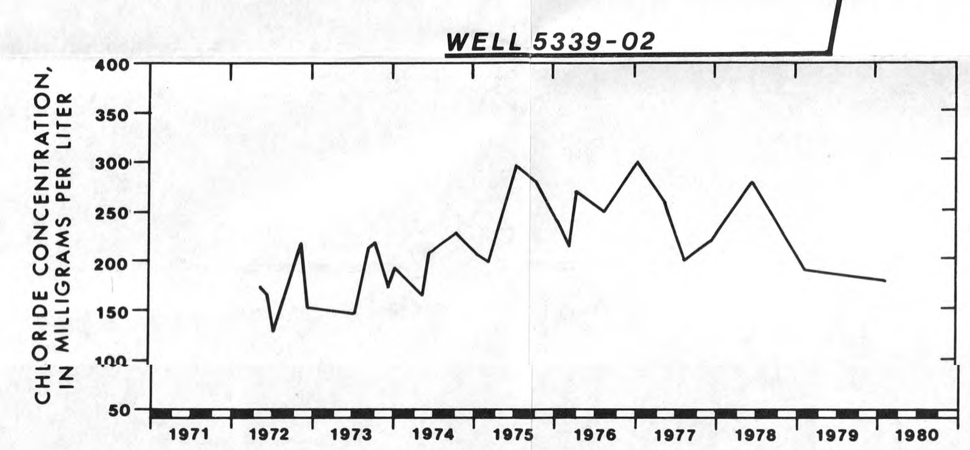
Chloride data showing seasonal trends have been plotted for selected wells. During the dry summer, the chloride concentration of the basal-water irrigation wells (wells 5340-02 and 5640-01) increases dramatically as a result of pumping an increasing admixture of seawater. Well 5339-02, a municipal well located near a pumping and irrigation center, shows a small yearly cycle, but no progressive change. Well 5838-01, outside the major pumping centers, shows little yearly fluctuation.

During February 1979 and February 1980, mass samples for water-quality analyses were taken at selected wells. The chloride concentrations are shown at the location of the sampling site along with isochlors from Swain (1973). The mass samples were taken during periods when there was no irrigation pumping and reflect, in general, minimum concentrations for each site.

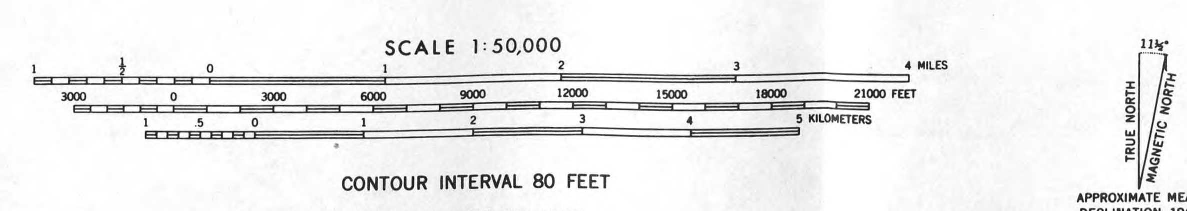


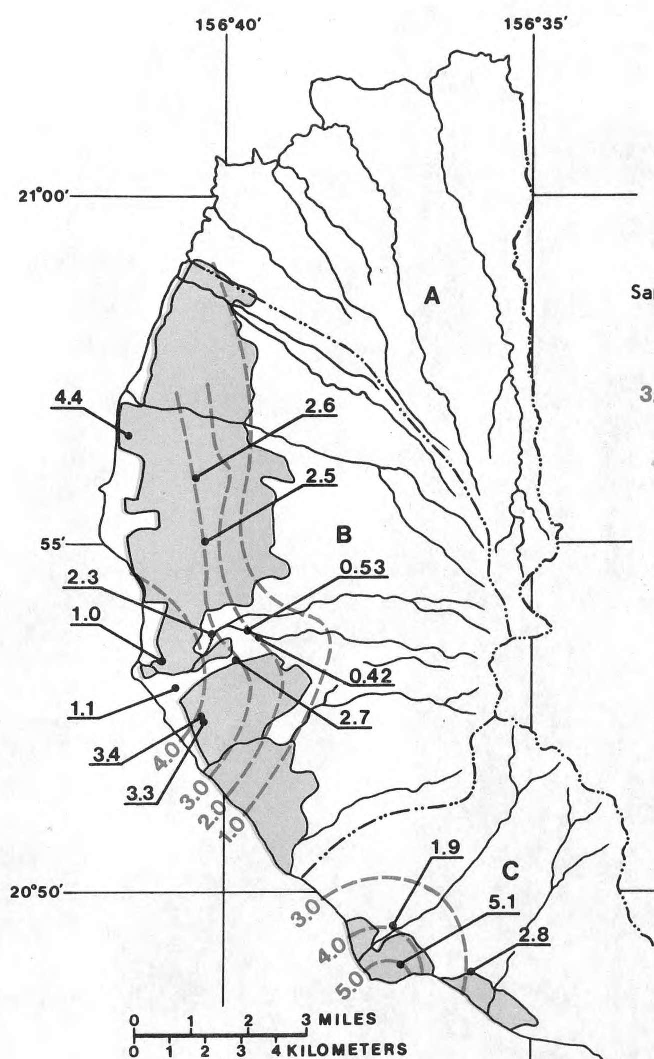






Base from U.S. Geological Survey
Island of Maui 1:62,500, 1957





EXPLANATION

Nitrate concentrations February 1980, in milligrams per liter

Sampling point

3.0 — Lines of equal nitrate concentration mg/L (as N) (Modified from Swain, 1973)

Approximate area of irrigated sugarcane land

Nitrate concentrations

Nitrate concentrations in ground water greater than 0.25 mg/L (milligrams per liter) may be considered a reliable indicator of return irrigation water (Swain, 1973). Nitrate concentrations obtained at selected locations during February 1980 are shown on the map. These values are within the range shown by the lines of equal nitrate concentration from Swain (1973).

Although none of the sources exceeded the drinking-water limit of 10 mg/L (as N), the map clearly shows the results of the application of large quantities of irrigation water. Approximately half the total 98 Mgal/d of applied irrigation water is assumed to infiltrate back to the freshwater body from the use of furrow irrigation. However, during the past few years, approximately half the sugarcane acreage has been converted to a drip-irrigation system. The long-term effects of the conversion to drip irrigation are not known. However, it is known that with drip irrigation, infiltration is reduced (see Sheet 1, Ground-Water Availability and Use). The lower nitrate concentrations at wells 5340-01 and 5240-01 may result from this use of drip irrigation. This significant loss of recharge may be the single most important change affecting the water supply in the Lahaina District. Careful monitoring of water quality throughout the Lahaina District is recommended.

Index Map showing Study Area

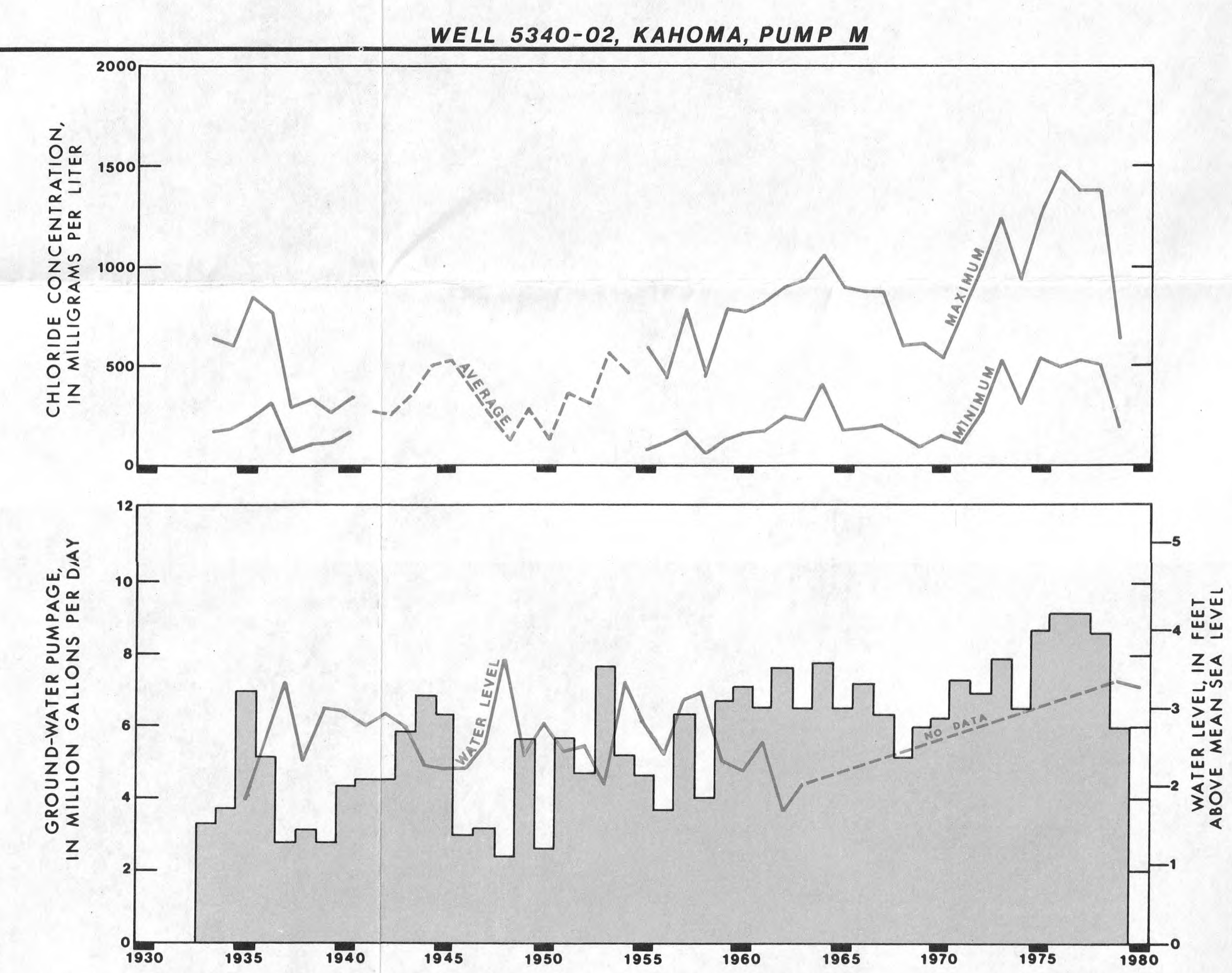
EXPLANATION

Sampling location — Chloride concentration, in milligrams per liter, February 1979 / Chloride concentration, in milligrams per liter, February 1980

300 — Line of equal chloride concentration, showing minimum concentration of pumped ground water (1956-66), milligram per liter interval is variable (from Yamanaga and Huxel, 1969)

Sugarcane irrigated by drip method

Sugarcane irrigated by furrow method



References

Belt, Collins, and Associates, 1969, A water source development plan for the Lahaina District, Island of Maui: Hawaii Division of Water and Land Development Report R33.

Broadbent, E. W., 1969, An estimate of present and future sources of water in the Lahaina-Kahana sector of West Maui: Manuscript report, Amfac Properties, 29 p.

Ekern, P. C., 1977, Drip irrigation of sugarcane measured by hydraulic lysimeters, Kunia, Oahu: Water Resources Research Center, University of Hawaii, Honolulu, Technical Report No. 109, 99 p.

Hawaii Water Authority, 1959, Water resources in Hawaii: Honolulu, Hawaii, 148 p.

Stearns, H. T., 1964, Groundwater supplies for Pioneer Mill Company, Maui: Consultant report.

Stearns, H. T., and Macdonald, G. A., 1942, Geology and ground-water resources of the island of Maui, Hawaii: Hawaii Division of Hydrography Bulletin 7, 344 p.

Swain, L. A., 1973, Chemical quality of ground water in Hawaii: Ha-waii Division of Water and land Development Report R48, 54 p.

Wilson, Okamoto and Associates, Inc., 1977, Kahakuloa water study: Hawaii Division of Water and Land Development Report R54, 84 p., App. A-G.

Yamanaga, George, and Huxel, C. J., 1969, Preliminary report on the water resources of the Lahaina District, Maui: Hawaii Division of Water and Land Development Circular C51, 47 p.

GROUND-WATER QUALITY, LAHAINA DISTRICT

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