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[12] ABSTRACT (PURPOSE, METHOD, RESULTS, CONCLUSIONS)

In response to the need to identify and describe aquifers for each island of the state of Hawaii to serve as a framework for groundwater protection strategy, a program was initiated to classify and assign codes to the principal aquifers of the state. This sixth report provides Aquifer Codes and Status Codes for the island of Hawaii. The Aquifer Codes incorporate locational and descriptive indices, whereas the Status Codes indicate the developability, utility, quality, uniqueness, and vulnerability to contamination of the groundwater resources. The codes were generated for Hawaiian conditions of groundwater occurrence and behavior in preference to using the DRASTIC approach suggested by the U.S. Environmental Protection Agency. Each Aquifer Type within an Aquifer System is assigned an Aquifer Code consisting of an eight-digit number. An Aquifer Code is unique and non-repeatable in the State. Accompanying the Aquifer Code is a Status Code of five digits. A Status Code is specific to an Aquifer Code. The Hawaii classification includes 9 Aquifer Sectors, 24 Aquifer Systems, and 68 Aquifer Codes.

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AQUIFER IDENTIFICATION AND CLASSIFICATION FOR THE ISLAND OF HAWAI'I:
Groundwater Protection Strategy for Hawai'i

John F. Mink
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Technical Report No. 191

May 1993

Project Completion Report
for
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ABSTRACT

In response to the need to identify and describe aquifers for each island of the state of Hawai'i to serve as a framework for groundwater protection strategy, a program was initiated to classify and assign codes to the principal aquifers of the state. This sixth report provides Aquifer Codes and Status Codes for the island of Hawai'i.

The Aquifer Codes incorporate locational and descriptive indices, whereas the Status Codes indicate the developability, utility, quality, uniqueness, and vulnerability to contamination of the groundwater resources. The codes were generated for Hawaiian conditions of groundwater occurrence and behavior in preference to using the DRASTIC approach suggested by the U.S. Environmental Protection Agency.

Each Aquifer Type within an Aquifer System is assigned an Aquifer Code consisting of an eight-digit number. An Aquifer Code is unique and non-repeatable in the State. Accompanying the Aquifer Code is a Status Code of five digits. A Status Code is specific to an Aquifer Code. The Hawai'i classification includes 9 Aquifer Sectors, 24 Aquifer Systems, and 68 Aquifer Codes.

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INTRODUCTION

The aquifer classification protocol was originated to provide a framework within which to identify and describe groundwater resources throughout the state of Hawai'i. The framework is necessary because a standard locational and descriptive nomenclature has not been uniformly applied by investigators when referring to groundwater resources. By employing a common reference, the classification allows hydrologists, engineers, decision makers, and laymen to avoid misunderstandings and confusion.

The intent of the classification is to simplify groundwater hydrology so that discussion at all levels of scientific-engineering comprehension can take place. It is designed for practical application; therefore, boundaries for the subdivisions must be drawn, even though the boundaries are not exact because conditions of actual groundwater occurrence and behavior are generally only poorly understood. For example, where hydrogeological conditions have not been unraveled, boundaries are drawn along topographic divides to encompass entire drainage areas, even though these divides most often are weak expressions of subsurface hydrogeology. On Hawai'i most boundaries for the classification are along surface geologic contacts and topographic divides. Additionally, boundaries formerly assigned to hydrographic units are retained as the boundaries of Aquifer Sectors and Systems wherever reasonable.

AQUIFER CLASSIFICATION

Aquifer Codes

The classification scheme reported by Mink and Lau (1990 rev.) is the starting point for developing an Aquifer Code for the island of Hawai'i. The classification is based on a hierarchy of descriptors beginning with general location by Island and Sector, to which belongs a set of Aquifer Systems, within which are a variety of Aquifer Types. Sectors primarily reflect broad hydrogeological features and, secondarily, geography. Aquifer Systems are more specifically defined by hydrogeological continuity, in particular hydraulic connections among units; Aquifer Types are differentiated by distinctive features of hydrology and geology. Not identified but following Aquifer Type in the hierarchy is the Aquifer Unit, which is defined as an identifiable unit within an Aquifer Type.

In brief, the hierarchy is as follows:

a. Island—the global factor
b. Sector—a large region with hydrogeological similarities
c. System—an area within a Sector showing hydrogeological continuity
d. Type—portions of a System having the same hydrological and geological features

Islands are coded by number in conformance with the first digit of the Hawai'i State well numbering system originated by the U.S. Geological Survey (1976). Each Sector is coded with a two-digit number and by a Hawaiian geographic name except where locational confusion might result, in which case the general locators North, South, East, West, and Central, or a traditional geographic term such as Windward, are used. A two-digit number is applied to each Aquifer System, which also can be referred to by a geographic name. Three digits describe fundamental hydrology and geology to constitute the Aquifer Type.

The form of the numerical code is 1 01 01 111, in which the first number is the Island, the next two the Sector, the following two the System, and the last three the Type. Island numbers are 1 (Ni'ihau), 2 (Kaua'i), 3 (O'ahu), 4 (Moloka'i), 5 (Lāna'i), 6 (Maui), 7 (Kaho'olawe), and 8 (Hawai'i). Sector numbers start at 01 for each Island. Similarly, System numbers start at 01 for each Sector.

Hydrology is uniquely described by a pair of digits and geology by a single digit. Identifying characteristics with their codes are as follows.

HYDROLOGY. Aquifer Types are defined as either basal or high-level, and as either unconfined or confined. Their numbers with brief descriptions are as follows:

NO.	TYPE	DESCRIPTION
1	Basal	Fresh water in contact with seawater
2	High Level	Fresh water not in contact with seawater
1	Unconfined	Where the water table is the upper surface of the saturated aquifer
2	Confined	Aquifer is bounded by impermeable or poorly permeable formations; top of the saturated aquifer is below the surface of the groundwater (piezometric surface)
3	Confined or Unconfined	Where the actual condition is uncertain

Using the above coding, groundwater can be 11 (basal, unconfined) or 12 (basal, confined), or 21 (high level, unconfined) or 22 (high level, confined). Where confining conditions are unclear, the second digit is given as 3 (confined or unconfined).

GEOLOGY. Aquifers are categorized as occurring in the flank lavas of volcanic domes, in rift zones characterized by dikes, on poorly permeable perching members, or within the sedimentary sequence. Flank aquifers normally are horizontally extensive and display the lowest heads and usually carry basal water; rift aquifers are segmented into compartments by dikes; perched aquifers lie on impermeable formations but are not ordinarily very extensive; and sedimentary aquifers are comprised of alluvial and marine sediments deposited by erosion and biogenic processes. The geologic codes are as follows:

NO.	TYPE	DESCRIPTION
1	Flank	Horizontally extensive lavas
2	Dike	Aquifers in dike compartments
3	Flank/Dike	Indistinguishable
4	Perched	Aquifer on an impermeable layer
5	Dike/Perched	Indistinguishable
6	Sedimentary	Non-volcanic lithology

One of the above numbers attached to the two hydrology numbers completes the Aquifer Type.

The sequence of all numbers from island through geology is called the Aquifer Code. Each Aquifer Code, comprised of eight digits, is unique. An example of an Aquifer Code for groundwater occurrence in Hawai'i is

8	Hawai'i (Island)
04	Northeast Mauna Loa (Aquifer Sector)
01	Hilo (Aquifer System)
111	Basal, unconfined, flank (Aquifer Type)

The Aquifer Code for the above is 8 04 01 111. There can be no duplication of this number for an aquifer located elsewhere in the state.

A variety of important information related to the aquifers can be appended to each Aquifer Code. Certain hydrogeologic parameters and quantities—such as rainfall, infiltration, sustainable yield, and storage—can be appended to the code to expand its utility. For example, items relevant to groundwater contamination can be expressed as a separate numerical code and attached to the Aquifer Code.

Sixty-eight Aquifer Codes have been assigned to the island to describe 24 Aquifer Systems in 9 Aquifer Sectors (Fig. 1 and App. Figs.). Table 1 lists the Aquifer Codes, along with the Aquifer Sector and System names, for Hawai'i. Also listed is the Status Code for each Aquifer Type. The Status Code, which is described in the next section, summarizes elements crucial to the groundwater protection strategy.

Status Code: Groundwater Protection

Concepts of EPA's groundwater classification conforming to Hawaiian conditions are used to devise a groundwater Status Code that describes development stage, utility, salinity, uniqueness, and vulnerability to contamination of the aquifers. The Status Code is conveniently

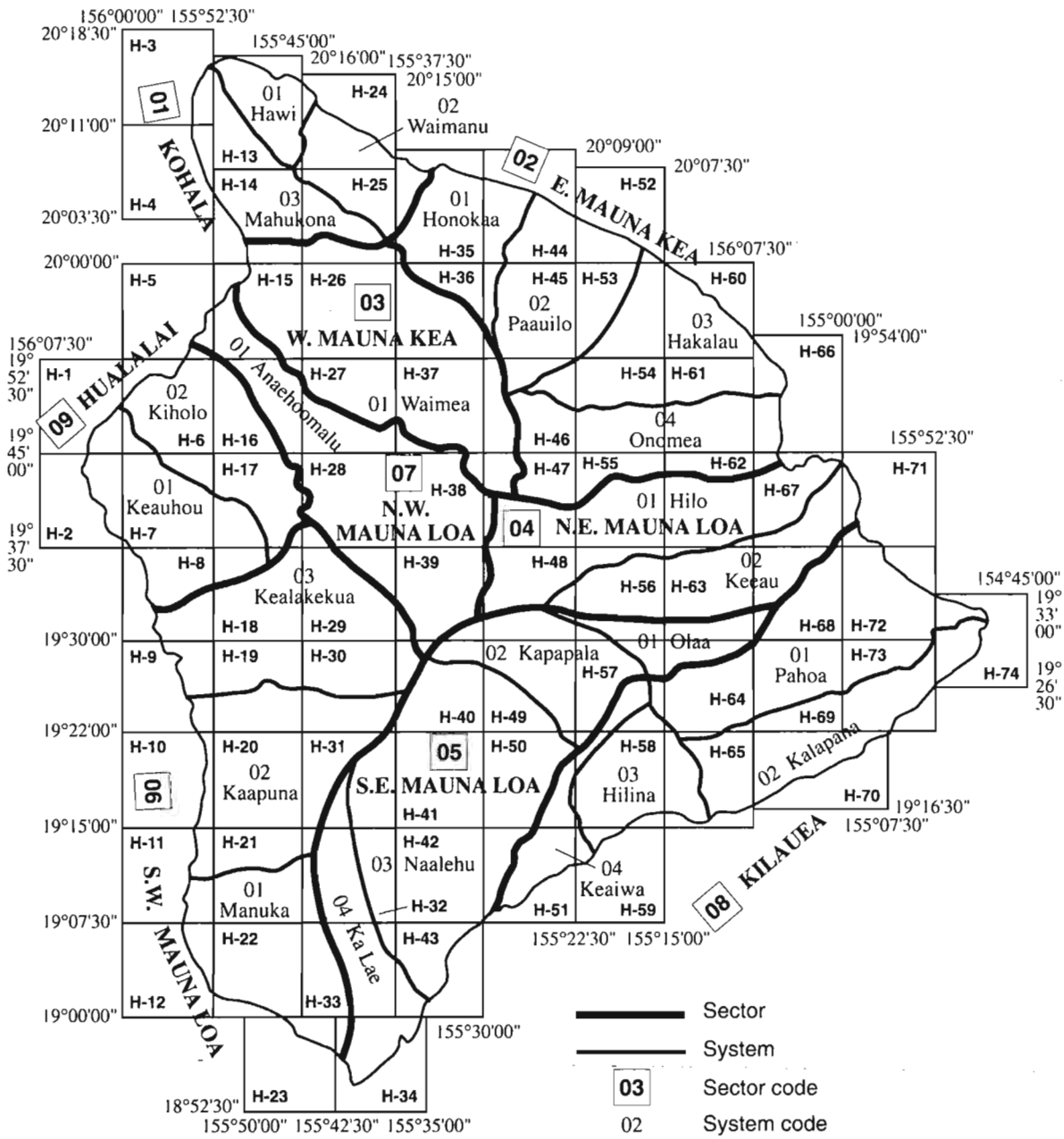

Figure 1. Aquifer codification by Sector and System for the island of Hawai'i, Hawai'i

TABLE 1. AQUIFER AND STATUS CODES FOR THE ISLAND OF HAWAI'I, HAWAI'I

Hawai'i		Aquifer Sector		Aquifer System	Aquifer Type	Aquifer Code	Status Code	Quadrangle No.
8	01	Kohala	01	Hawi	111	80101111	11111	3, 13, 24
					213	80101213	21111	13, 24
					214 212	80101214 80101212	21111 21112	13, 14
			02	Waimanu	111	80102111	21111	24
					212	80102212	11111	13, 14, 24, 25, 35
					216 212	80102216 80102212	11111 21111	35
					214 212	80102214 80102212	21111 21112	13, 14, 24, 25, 35
			03	Mahukona	111	80103111	11211	3, 4, 13, 14
					213	80103213	11111	13, 14, 25
					214 212	80103214 80103212	21111 21112	13, 14, 25
	02	East Mauna Kea	01	Honokaa	214 111	80201214 80201111	21111 11112	35, 36, 44, 45
					214 212	80201214 80201212	21111 21112	25, 35, 36, 45
			02	Paauilo	214 111	80202214 80202111	21111 11112	44, 45, 52, 53
					214 212	80202214 80202212	21111 21112	45, 46, 53
			03	Hakalau	214 111	80203214 80203111	21111 11112	52, 53, 54, 60, 61, 66
					214 212	80203214 80203212	21111 21112	45, 46, 53, 54
			04	Onomea	214 111	80204214 80204111	21111 11112	54, 55, 61, 62, 66, 67
					214 212	80204214 80204212	21111 21112	46, 47, 54, 55
	03	West Mauna Kea	01	Waimea	111	80301111	11211	14, 15
					213	80301213	21111	14, 15, 16, 25, 26, 27
					212	80301212	21111	16, 25, 26, 27, 36, 37
					214 212	80301214 80301212	11111 21112	25, 26, 35, 36, 37, 38, 45, 46, 47

TABLE 1—*Continued*

Hawai'i	Aquifer Sector		Aquifer System		Aquifer Type	Aquifer Code	Status Code	Quadrangle No.
8	04	Northeast Mauna Loa	01	Hilo	111	80401111	11111	62, 67
					213	80401213	11111	55, 56, 62, 63
					212	80401212	21111	38, 39, 47, 48, 55, 56
			02	Keaau	111	80402111	11111	67, 68, 71
					213	80402213	11111	56, 62, 63, 67, 68
					212	80402212	21111	48, 56
	05	Southeast Mauna Loa	01	Olaa	213	80501213	21111	56, 57, 63, 64, 68
					212	80501212	21111	48, 56, 57
			02	Kapapala	213	80501213	21111	49, 50, 57, 58
					212	80502212	21111	39, 40, 48, 49, 56, 57
			03	Naalehu	111	80503111	11111	42, 43, 51
					214	80503214	21111	31, 32, 33, 41,
					213	80503213	21112	42, 43, 49, 50, 51, 58
					212	80503212	21111	30, 31, 32, 40, 41, 49, 50
			04	Ka Lae	111	80504111	21111	33, 34, 43
					213	80504213	21111	32, 33, 43
					212	80504212	21111	31, 32, 33
	06	Southwest Mauna Loa	01	Manuka	111	80601111	11211	11, 12, 21, 22, 23, 33, 34
					213	80601213	21111	21, 22, 32, 33
					212	80601212	21111	21, 32, 33
			02	Kaapuna	111	80602111	11211	9, 10, 11, 19, 20, 21
					213	80602213	21111	10, 11 19, 20, 21, 30, 31
					212	80602212	21111	20, 21, 30, 31, 32, 40
			03	Kealakekua	111	80603111	11211	8, 9, 19
					213	80603213	11111	8, 9, 17, 18, 19, 28, 29, 30
					212	80603212	21111	29, 30, 39, 40

TABLE 1—*Continued*

Hawai'i		Aquifer Sector		Aquifer System	Aquifer Type	Aquifer Code	Status Code	Quadrangle No.
8	07	Northwest Mauna Loa	01	Anaehoomalu	111	80701111	21211	5, 15, 16
					213	80701213	11111	15, 16, 17, 27, 28, 29
					212	80701212	21111	27, 28, 29, 37, 38, 39, 40, 47
	08	Kilauea	01	Pahoa	111	80801111	11111	67, 68, 69, 71, 72, 73, 74
					112	80801112	11211	72, 73, 74
					212	80801212	21111	57, 64, 65, 69, 73
					213	80801213	21111	63, 64, 68, 69, 73
			02	Kalapana	111	80802111	11211	65, 69, 70, 73, 74
					112	80802112	11211	72, 73, 74
					212	80802212	21111	64, 65, 69, 70, 73
			03	Hilina	111	80803111	21211	58, 59, 65
					212	80803212	21111	50, 57, 58, 64, 65
			04	Keaiwa	111	80804111	21211	50, 51, 58, 59
					112	80804112	11111	51
					212	80804212	21111	50, 51, 57, 58
	09	Hualalai	01	Keauhou	111	80901111	11211	1, 2, 6, 7, 8
					213	80901213	11111	6, 7, 8, 18
					212	80901212	21111	6, 7, 8, 17, 18
			02	Kiholo	111	80902111	11211	1, 5, 6, 15, 16
					213	80902213	11111	6, 16
					212	80902212	21111	6, 7, 16, 17, 18, 28

NOTE: See Aquifer Classification Explanation, p. 33.

attached to the Aquifer Code, and the combination is an efficient representation of location, hydrology, geology, utility, water quality, and contamination potential of groundwater resources in every part of the island.

The five-digit Status Code consists of a single number from each of five separate descriptive categories. The categories and their status elements with identifying numbers are a follows:

CATEGORY	NO.	STATUS ELEMENT
Development Stage	1	Currently used
	2	Potential use
	3	No potential use
Utility	1	Drinking
	2	Ecologically important
	3	Neither
Salinity (mg/l Cl^-)	1	Fresh (<250)
	2	Low (250–1,000)
	3	Moderate (1,000–5,000)
	4	High (5,000–15,000)
	5	Seawater (>15,000)
Uniqueness	1	Irreplaceable
	2	Replaceable
Vulnerability to Contamination	1	High
	2	Moderate
	3	Low
	4	None

Only one number from each major category listed above is allowable in the Status Code. For instance, a currently developed groundwater source (1), used for drinking (1), having a salinity of less than 250 mg/l Cl^- (1), being irreplaceable (1), and being highly vulnerable to contamination (1) would have the Status Code 11111. If it were ecologically important but not suitable for drinking with a salinity of 750 mg/l Cl^-, other categories being the same, the code would be 12211.

The categories and their elements are derived from U.S. EPA (1984) groundwater classifications modified by fundamentals of the Hawai'i groundwater environment. Application of a detailed vulnerability assessment, such as a modified form of DRASTIC, could be used in the vulnerability to contamination category.

Brief explanations of the Status Code categories and their elements are as follows.

DEVELOPMENT STAGE. Aquifers are differentiated according to those already being used (currently used), those with potential utility (potential use), and those having no potential developability.

UTILITY. Aquifers are identified by use. Groundwater classed as drinking may also be ecologically important, but that classed as ecologically important may not be used for drinking. Drinking takes precedence over ecologically important.

SALINITY. The gradation of groundwater from fresh to seawater is a feature of all basal aquifers in Hawai'i. Basal aquifers comprise, by far, the most voluminous sources of

groundwater. Chloride content, rather than total dissolved solids, is the class definer because it is routinely reported in the Hawai'i literature. The class limits are inevitably somewhat arbitrary but incorporate the following logic:

1. Fresh (<250 mg/l). The upper limit of the standard for drinking water is 250 mg/l Cl^-.
2. Low (250–1,000 mg/l). Much agriculture, in particular sugarcane, can be irrigated with water containing up to 1,000 mg/l Cl^-.
3. Moderate (1,000–5,000 mg/l). Brackish water of this salinity may serve as feed water for desalinization in the future.
4. High (5,000–15,000 mg/l). The high-salinity class, not yet seawater, is arbitrarily designated for water that is between potentially economically valuable water and seawater.
5. Seawater. True seawater has a chloride content of 18,980 mg/l.

UNIQUENESS. The classes irreplaceable and replaceable are direct EPA derivatives. Over the long term, virtually all potable water in Hawai'i should be considered irreplaceable.

VULNERABILITY TO CONTAMINATION. In Hawai'i, aquifers can be described simply as being either vulnerable or not vulnerable to contamination because of the geographical limits of the resources, interconnection among groundwater sources, and relatively rapid time of groundwater travel. Most unconfined aquifers are vulnerable; confined aquifers may or may not be. A refinement in the degree of vulnerability may be instituted by using some modified form of the DRASTIC, or similar, index. The one used in this classification (high, moderate, low, none) is based on familiarity with environmental conditions.

Aquifer Classification Maps

In summary, a groundwater classification scheme, which includes source as well as status information, has been created. The Aquifer Code consists of locators, hydrology, and geology and reads as follows: Island-Aquifer Sector-Aquifer System-Aquifer Type. The code consists of eight digits: one for the island, two each for sector and system, and three for type (two for hydrology, one for geology).

The Status Code contains five digits and combined with the Aquifer Code results in a 13-digit code. For example, the code 80401111 (11111) defines an aquifer in Hawai'i, Northeast Mauna Loa Sector, Hilo System, in which the groundwater is basal and unconfined in flank lavas. The five digits within parentheses indicate that the aquifer is currently used to supply drinking water having less than 250 mg/Cl^- and is an irreplaceable source that is highly vulnerable to pollution.

Accompanying the explanation of Aquifer Codes and Status Codes for Hawai'i are aquifer classification maps with sector, system, and type boundaries plotted on U.S. Geological

Survey base quadrangles (reduced 1:24,000 scale). Within each Aquifer Type area is an Aquifer Code to which is appended the Status Code within parentheses.

Where aquifers occur in vertical sequence, Aquifer and Status Codes for each aquifer are separated by a division line. The numerator code indicates the upper aquifer and the denominator, the lower aquifer.

GENERAL GEOLOGY AND HYDROLOGY OF THE ISLAND OF HAWAI'I

The island of Hawai'i is the youngest and most southeasterly of the emerged volcanic edifices of the Hawaiian Archipelago. The island is composed of five large shield volcanoes, one rising to nearly 14,000 ft (4 267.2 m) above sea level. The oldest is Kohala, and the youngest is Kīlauea. Kohala and perhaps Mauna Kea are essentially dormant, but Hualālai, Mauna Loa, and Kīlauea have been active in historic time.

Total land area of the island is 4,035 miles^2 (10 449.8 km^2), more than twice the combined area of all other islands of the chain. Because of the sparse hydrogeological database for so large an island, the Aquifer Sectors and Systems had to be drawn vastly larger than those for the other islands. Several of the Sectors exceed the entire area of the island of O'ahu (610 miles^2, or 1 579.8 km^2). In the absence of subsurface hydrogeological information, Sector and System boundaries rely to a large extent on surface geological contacts and topographic divides.

The geology of the island is being studied virtually continuously because of spectacular volcanic activity. The U.S. Geological Survey is re-mapping the island and updating the geological identification nomenclature. In the descriptions of the geology of the Sectors and Systems the new formation names are employed. "Volcanics" and "Basalt" are primary terms used to describe a combination of volcanic rocks and a continuum of basaltic lavas, respectively.

Because of the island's recent geological history, the impact of erosion on the volcanic shields is muted except in the case of the Kohala Volcano. Perennial streams are absent, except in Kohala and the very high rainfall region on the Hamakua coast north of Hilo. Structually, Mauna Kea and Hualālai have reached the post-caldera stage, whereas Mauna Loa and Kīlauea have advanced only to caldera development and filling.

The ages of the five shield volcanoes, determined by radioactive dating, imply that volcanic activity was contemporaneous among them over periods of time. Kohala, the oldest, has been dated at 700,000 years. For Hualālai the oldest accessible rocks are 120,000 years. Rocks of the Laupahoehoe Volcanics of Mauna Kea have been dated as young as 3,600 years, but the

older Hamakua Volcanics of the same volcano are as old as 375,000 years. The oldest rocks of Mauna Loa, the Ninole Basalt, have a date of 540,000 years, but the youngest are just a few years old. The oldest rocks found in Kīlauea are about 25,000 years.

The island has been divided into 9 Aquifer Sectors and 24 Aquifer Systems. This coarse a classification is a result of our limited knowledge about the hydrogeology of this large land mass. The elemental identification and description of the geology and hydrology of the island of Hawai'i are the work of Stearns and Macdonald (1946).

AQUIFER SECTOR: KOHALA (801)

The Kohala Aquifer Sector encompasses all of Kohala Volcano on the northwest extremity of the island of Hawai'i. The southern boundary is close to the Kawaihae to Waimea road where the Kohala lavas meet the Mauna Kea lavas. From Waimea the boundary goes northward along Lālākea, ending at Waipi'o Bay. Total area is approximately 200 miles^2 (517.96 km^2).

Kohala is a shield volcano composed of two principal rock units. The older is the Pololu Basalt, a tholeiitic basalt that constitutes the basement; the other is the Hawi Volcanics, consisting of alkalic basalts separated from the Pololu Basalt by an unconformity.

Within the Kohala Sector are three aquifer systems: Hawi, Waimanu, and Mahukona.

Aquifer System: Hawi (80101)

BOUNDARIES. The Hawi Aquifer System extends from Pu'u Pili, peaking at 4,676 ft (1 425 m), northwest along the crest of the mountain range to the extremity of the island between Puakea Point and 'Upolu Point. The east boundary is the western divide of Pololū Valley.

GEOLOGY. The Hawi Volcanics overlie the Pololu Basalt in the interior. Both formations include numerous pyroclastic deposits. Even though Kohala is the oldest volcano in the island, sediments other than recent alluvium are absent.

HYDROLOGY. Average annual rainfall ranges from 20 in. (508 mm) at 'Upolu Point to 125 in. (3 175 mm) in Pololū Valley. Streams draining off the Hawi Volcanics, perennial in places, have carved moderately deep gulches between Hāwī and Pololū. Between Hāwī and 'Upolu the gulches are shallower and the streams non-perennial.

GROUNDWATER. Where rainfall is substantial and the Hawi Volcanics overlie the Pololu Basalt, perched water occurs. High-level dike water also occurs inland in the rift zone. Over a distance of 2 to 3 miles (3.2 to 4.8 km) inland of the coast, the Pololu Basalt contains a basal lens.

ENVIRONMENT. Much of the high-rainfall region falls within the conservation district. The slopes of the volcanic shield are gentle enough to have allowed sugarcane cultivation, now discontinued, and small farms. Ranching continues, but residential subdivisions have become established.

Aquifer System: Waimanu (80102)

BOUNDARIES. The Waimanu Aquifer System starts at the western divide of Pololū Valley and extends eastward to Lālākea where the Hawi Volcanics meet the Mauna Kea rocks. The crest of the range is the inland boundary.

GEOLOGY. The deeply incised canyons of Pololū, Honokāne Nui, Waimanu, Kawainui, Alakahi, Koa'e, Waimā, and Waipi'o, along with many smaller canyons, are included in the aquifer system. Hawi Volcanics blanket the Pololu Basalt near the summit, but the canyons cut through the cover and expose the Pololu Basalt. Sediments cover the floor of the canyons and may reach a thickness of a hundred feet or so at the mouths of Waimanu and Waipi'o streams. Most of the region is in the rift zone.

HYDROLOGY. Rainfall is high, averaging 75 to 175 in. (1 905 to 4 445 mm)/yr. The streams, which are perennial, are fed by high-level groundwater. Ditch systems divert the perennial flows. The largest is Lower Hāmākua Ditch, which has an average flow of about 27 mgd (1.18 m^3/s) and a minimum of about 18 mgd (0.79 m^3/s).

GROUNDWATER. The premier occurrence of groundwater is in dike compartments toward the head of the canyons. Perched water lies on the Hāwī formation. Basal water probably occurs in sediments and dike compartments at the mouths of the major canyons.

ENVIRONMENT. The aquifer system is uninhabited except for a few houses in lower Waipi'o. Virtually all of it is in the conservation district. However, the major ditch systems—Lower Hāmākua and Kohala—divert up to 50 mgd (2.19 m^3/s) out of the aquifer system, and smaller ditches—Upper Hāmākua and Kehena—divert a few million gallons a day.

Aquifer System: Mahukona (80103)

BOUNDARIES. The Mahukona Aquifer System embraces the leeward side of Kohala Volcano from the crest to the sea. The southern boundary follows the contact between Kohala rocks and those of Mauna Kea, which is close to the road connecting Kawaihae with Waimea.

GEOLOGY. The Hawi Volcanics cover the Pololu Basalt over much of the area far inland. The cover thins seaward, and the Pololu Basalt is exposed on the northwest and south. Only thin recent sediments occur.

HYDROLOGY. The bulk of the aquifer system is arid. Average annual rainfall increases from a mere 10 in. (254 mm) at the coast to 75 in. (1 905 mm) at the Kohala crest. The 60-in. (1 524-mm) isohyet lies about along the road between Waimea and Pu'u Nale, where it turns toward Hāwī. Waikoloa Stream is perennial in its headwaters and may have been all the way to the coast before diversion structures were built. Every other gulch is dry except during heavy rain storms.

GROUNDWATER. Perched water is held up by the Hawi Volcanics toward the mountain crest. High-level dike water occurs in the rift zone and may reach as far seaward as the 1,000-ft (304.8-m) elevation level where a few wells have struck high-level water. The basal zone, which is several miles (1 mile = 1.6 km) wide, is brackish.

ENVIRONMENT. Kawaihae port and the town of Waimea are the main economic centers. Surface water from the wettest part of the aquifer system in the mountains near Waimea is diverted for domestic and farm use. Wells supply domestic water to upscale subdivisions in the dry area between Kawaihae and Māhukona. Cattle graze on the slopes of the volcano.

AQUIFER SECTOR: EAST MAUNA KEA (802)

The boundary of the East Mauna Kea Aquifer Sector follows a topographic divide from the peak of Mauna Kea northwest to Waimea, then northerly along Lālākea where the Mauna Kea and Kohala rocks meet, to Kukuihaele above Waipi'o Bay. The southern boundary follows the Mauna Loa/Mauna Kea contact from Humū'ula Saddle along the Wailuku River to Hilo. The aquifer sector is restricted to rocks of the Mauna Kea Volcano, the basement of which is the Hamakua Volcanics. Covering the Hamakua Volcanics in many places, especially inland toward the poorly defined rift zones, are the Laupahoehoe Volcanics. The early Hāmākua lavas are tholeiitic, but later flows in the series are alkalic. The Laupāhoehoe lavas are alkalic. Pahala Ash blankets a portion of the aquifer sector. The only sediments in this sector are recent alluvium.

Included in the East Mauna Kea Aquifer Sector are the Honokaa, Paauilo, Hakalau, and Onomea aquifer systems. Total area of this sector is 604 miles^2 (1 564 km^2), which is as large as the entire island of O'ahu.

Aquifer System: Honokaa (80201)

BOUNDARIES. The eastern boundary follows the divide between Kahā'upu Gulch and Kahawaili'ili'i Gulch from the aquifer sector boundary connecting Mauna Kea peak with Waimea. Its western limit is Lālākea, and on the east it terminates at Pā'auhau.

GEOLOGY. The Hāmākua lavas are exposed throughout the aquifer system but in places are covered by Laupahoehoe Volcanics, mostly at higher elevations. Pahala Ash blankets much of the region. In addition, many local ash beds are layered within the main formations. No substantial sediments occur. Cliffs rise several hundred feet at the coast.

HYDROLOGY. At the coast the average annual rainfall is about 60 in. (1 524 mm). It increases to 120 in. (3 048 mm) at an elevation of about 3,500 ft (1 066.8 m), then diminishes to 20 in. (508 mm) at higher elevations. Streams are perennial in their upper reaches where they are fed by perched water, but most are non-perennial at the coast. Virtually no stream flow measurements have been made.

GROUNDWATER. Perched groundwater occurs on ash beds, and dike water at considerable depths probably occurs as the rift zones are approached. However, basal groundwater is the principal resource. The zone of basal water is about 10 miles (16 km) wide. It is fresh and easily developed by deep wells.

ENVIRONMENT. Small communities along the belt highway have been dependent on sugarcane plantations for about a century, but cane cultivation will cease soon. The upper slopes not planted with sugarcane are used for ranching. Macadamia orchards have been established.

Aquifer System: Paauilo (80202)

BOUNDARIES. The eastern boundary follows Ka'ula Gulch from Mauna Kea peak to the coast near 'O'ōkala. The area is roughly rectangular, about 10 by 15 miles (1.6 by 24.1 km).

GEOLOGY. Surface exposures are about equally distributed between the Hāmākua and Laupāhoehoe formations. The Hāmākua formation is dominant below about 4,000 ft (1 219.2 m); the Laupāhoehoe, above 7,000 ft (2 133.6 m). Numerous volcanic vents and cones dot the surface above 6,000 ft (1 828.8 m). Pahala Ash covers portions of the aquifer system. Sediments are unimportant.

HYDROLOGY. Annual rainfall at the coast is 90 in. (2 286 mm). It increases to 160 in. (4,064 mm), then falls back to 15 in. (381 mm) at the Mauna Kea peak. Where fed by perched water, streams are perennial, but data are sparse.

GROUNDWATER. Perched aquifers are common in the high-rainfall area. At an undetermined depth high-level dike water probably occurs in the region of the rift zones. A very large and voluminous basal aquifer at least 6 miles (9.7 km) wide is the principal water resource. The basal water is being exploited with two infiltration galleries and several wells, but its potential is hardly touched.

ENVIRONMENT. Sugarcane cultivation, the dominant commercial activity at one time, has ceased. The few towns along the belt highway are small. A forestry industry is anticipated. Macadamia nut orchards have sprung up. Ranching is practiced.

Aquifer System: Hakalau (80203)

BOUNDARIES. The Hakalau Aquifer System is roughly triangular, with a base along the coast of 15 miles (24.1 km) and a height reaching to Mauna Kea peak of about 18 miles (29 km). The southern terminus at the coast is Pepe'ekeo.

GEOLOGY. Surface exposures are a mixture of Hamakua Volcanics and Laupahoehoe Volcanics, with Hamakua Volcanics being the main formation. Ash beds are common, but sediments are restricted to recent alluvium.

HYDROLOGY. Rainfall below about 3,500 ft (1 066.8 m) is very high, averaging 200 in. (5 080 mm)/yr. At the coast the average is 140 in. (3 556 mm). The maximum reached inland is about 280 in. (7 112 mm), and the minimum is 15 in. (381 mm) toward the top of Mauna Kea. Streams are perennial in the high-rainfall zone, and many are perennial all the way to the coast.

GROUNDWATER. Perched water on ash beds is common, and dike water probably exists inland in the rift zones. The most voluminous resource is basal water. No attempts have been made to develop it yet, however.

ENVIRONMENT. As along all of the Hāmākua coast, sugarcane cultivation, which was the main economic activity for the past century, has been abandoned. Macadamia orchards have been introduced, and some ranching takes place. The population is small and concentrated along the belt highway. Attempts are being made to preserve native forests. Commercial forestry is anticipated as well.

Aquifer System: Onomea (80204)

BOUNDARIES. The Onomea Aquifer System is roughly the shape of a rectangle with a coast to inland boundary length of 24 miles (38.6 km) and a width along the coast of 7 miles (11.3 km). The southern boundary is the contact between the Mauna Loa and Mauna Kea lavas; it runs closely parallel with the Wailuku River. The river lies mainly in the aquifer system. The extent along the coast is from Pepe'ekeo to Hilo. The inland boundary goes from Humū'ula Saddle to the peak of Mauna Kea.

GEOLOGY. Hamakua Volcanics and Laupahoehoe Volcanics are about equally distributed. Exposures of Hamakua Volcanics dominate at lower elevations. Numerous volcanic cones lie

inland of above 8,500 ft (2 590.8 m). Ash beds are common, but sediments are rare. Much of the Wailuku River is emplaced on Laupahoehoe Volcanics.

HYDROLOGY. Average annual rainfall increases from 140 in. (3 556 mm) at the coast to a maximum of 280 in. (7 112 mm), then decreases to 15 in. (381 mm) on the highest slopes of Mauna Kea. Many streams are perennial, sustained by both rainfall and perched water. The Wailuku River is one of the state's major water courses.

GROUNDWATER. Aquifers are perched on ash beds and perhaps dense lava flows. Dike water exists far inland. The basal aquifer is very large but has yet to be explored.

ENVIRONMENT. The high-rainfall region is covered with forests. Sugarcane cultivation, once the main economic activity, has been discontinued. Small communities are strung along the belt highway, but the total population is modest. Commercial forestry is being discussed. Orchards have been planted. Some ranching goes on.

AQUIFER SECTOR: WEST MAUNA KEA (803)

The Waimea Aquifer System comprises the entire West Mauna Kea Aquifer Sector, which has an area of 270 miles^2 (699.25 km^2). The southern boundary from Puakō Point to the Humū'ula Saddle is the trace of the Mauna Loa/Mauna Kea geologic contact, whereas the northern boundary from Kawaihae to Waimea follows the Mauna Kea/Kohala contact. From Waimea the boundary strikes southeasterly along a weak rift zone to the summit of Mauna Kea. All exposed rocks belong to the Mauna Kea Volcano. At high elevations the Laupahoehoe Volcanics cover the Hamakua Basalt; lower down, the Hamakua Basalt is exposed. Sediments have no hydrological importance.

Aquifer System: Waimea (80301)

BOUNDARIES. The boundaries are described above.

GEOLOGY. The geology of the sector-system is described above. Toward the summit of Mauna Kea are many cinder-and spatter cones. Rift zones radiating from the summit are poorly defined. Large sections of the mid-elevations are covered with Pahala Ash.

HYDROLOGY. Average annual rainfall ranges from 10 to 50 in. (254 to 1 270 mm). The aquifer system is dry, but Waikoloa Stream, which rises in the Kohala Mountains, flows across Mauna Kea lavas near the northern boundary. Before diversions were constructed starting more than a century ago, Waikoloa may have been perennial all the way to the sea.

GROUNDWATER. A basal lens reaches to about 4 miles (6.4 km) inland. Beyond, the water becomes high-level, although the mode of occurrence is not understood. Wells at about the

1,200-ft (365.8-m) elevation develop fresh water. Near Waiki'i and also near Waimea the groundwater level stands about 1,500 ft (457.2 m) above sea level. Slightly thermal basal water is found along the Kawaihae to Waimea road below an elevation of 1,000 ft (304.8 m). At the coast basal springs discharge brackish water.

ENVIRONMENT. Along the coast large tourist hotels complete with golf courses have been built. Residential subdivisions exist at Waikoloa and are planned elsewhere in the aquifer system. Waimea and Kawaihae are population centers. Most of the aquifer system is open ranch land. Diversified farming is practiced near Waimea.

AQUIFER SECTOR: NORTHEAST MAUNA LOA (804)

The northern boundary of the Northeast Mauna Loa Aquifer Sector is the contact between the Mauna Loa and Mauna Kea rocks, which is nearly coincident with the Wailuku River. The inland boundary is a north-south trace along the saddle between the northeast rift zone of Mauna Loa and the meeting of Mauna Loa and Mauna Kea. The southern boundary starts at the summit of Mauna Loa, follows the rift zone, then bends toward Mountain View along the Kīlauea/Mauna Loa contact, reaching the sea at Kea'au. Total area is about 400 miles^2 (1 035.9 km^2) divided between the Hilo Aquifer System and the Keaau Aquifer System.

All rocks originated from Mauna Loa. The oldest series is the Kahuku Basalt, on top of which the Pahala Ash occurs in many places. The youngest formation, the Kau Basalt, lies on the Pahala Ash. The Kau Basalt includes recent and historic lava flows.

Aquifer System: Hilo (80401)

BOUNDARIES. The Mauna Loa/Mauna Kea contact along the Wailuku River is the northern boundary. The southern boundary follows the northeast rift zone, then at Pu'u Kūlua strikes northeasterly along the trace between historic and pre-historic lavas to a point at the coast about 4 miles (6.4 km) east of Hilo at Leleiwi Point.

GEOLOGY. Virtually the entire region is covered with pre-historic lavas of the Kau Basalt, onto which long tongues of historic lavas from the northeast rift have flowed. Other than scanty recent alluvium, no sediments occur.

HYDROLOGY. Average annual rainfall starts at 120 in. (3 048 mm) at the coast, increases to a maximum of 300 in. (7 620 mm), then decays to 20 in. (508 mm) on the upper slopes of Mauna Loa. Despite the extraordinary rainfall, perennial streams do not exist south of Wailuku River. Rain easily infiltrates into the permeable basalt.

GROUNDWATER. A voluminous basal lens extends at least 4 miles (6.4 km) inland of the coast, beyond which high-level water has been encountered. The lens may reach farther inland, but it has hardly been explored. Toward the rift zone dike-impounded high-level water probably occurs. Elsewhere the high-level water is likely to be perched. The flux of groundwater in the basal lens is enormous; the fresh water springs at Hilo-Waiākea have been measured at 150 mgd (6.57 m^3/s). The gradient is about 5 ft/mile (0.9 m/km), and the permeability of the basalt is probably at least 5,000 ft (1 524 m)/day.

ENVIRONMENT. The main city on the island, Hilo, is in the aquifer system. Most of the region is unsettled, heavily vegetated in the high-rainfall zone, and semi-arid above about the 5,000-ft (1 524-m) elevation. Diversified farming and aquaculture are practiced, as well as grazing. The potentially developable groundwater resource far exceeds expected demand.

Aquifer System: Keaau (80402)

BOUNDARIES. The Hilo Aquifer System lies to the north. The southern boundary starts at Pu'u Kūlua on the northeast rift zone and eventually connects with the contact between the Kau Basalt and Kahuku Basalt, following it to the sea at Kea'au.

GEOLOGY. The surface consists mostly of pre-historic flows of Kau Basalt. The original slopes are barely etched by erosion. Sediments are rare and sparse.

HYDROLOGY. Average annual rainfall reaches a maximum of about 200 in. (5 080 mm). At higher elevations it is 50 in. (1 270 mm) or less, and at the coast it is about 100 in. (2 540 mm). The drainage network is weak, and perennial streams are absent.

GROUNDWATER. A large basal lens apparently transitions into unknown forms of high-level water several miles inland. In the rift zone dike-impounded water probably occurs at depth. Large basal springs break out along the coast. Groundwater flux is extremely high.

ENVIRONMENT. A few small towns are scattered in this large area. Much of the land is designated a forest reserve, and a part is included in the Hawaii Volcanoes National Park. Sugarcane cultivation was abandoned about 20 years ago. Diversified agriculture and some aquaculture take up a small portion of the land and water.

AQUIFER SECTOR: SOUTHEAST MAUNA LOA (805)

The area of the Southeast Mauna Loa Aquifer Sector is about 700 $miles^2$ (1 812.86 km^2), greater than that of O'ahu by 100 $miles^2$ (258.98 km^2). The most inland boundary begins near Mountain View, follows the northeast rift to the summit of Mauna Loa, then proceeds down the southwest rift all the way to the Kahuku Pali at Ka Lae (South Point). The inland boundary

nearest the coast follows the trace of the Kīlauea/Mauna Loa contact from Mountain View southward all the way to Nāhuluhulu Point near Punalu'u. Exposed in the aquifer sector are the Ninole Volcanics (the oldest Mauna Loa rocks), Kahuku Basalt, Pahala Ash, Kau Basalt, and mudflow and landslide debris near Pāhala. Ash beds are common between Pāhala and Nā'ālehu. Except for sparse recent alluvium, sediments are restricted to the landslide-mudflow region near Pāhala. The aquifer sector includes four aquifer systems: Olaa, Kapapala, Naalehu, and Ka Lae.

Aquifer System: Olaa (80501)

BOUNDARIES. The northern boundary follows the Kau Basalt/Kahuku Basalt contact from Mountain View, then crosses the Kau Basalt to the northeast rift at Pu'u 'Ula'ula. From there it strikes southeast to the Kīlauea/Mauna Loa contact about 2 miles (3.2 km) from Kīlauea Crater.

GEOLOGY. About half of the aquifer system is covered by Kahuku Basalt; the other half, by Kau Basalt. The Kahuku Basalt is blanketed with Pahala Ash. Sediments are trivial.

HYDROLOGY. Maximum average annual rainfall is 200 in. (5 080 mm) at about an elevation of 3,500 ft (1 066.8 m). It decreases upslope to about 15 in. (381 mm). No perennial streams exist, and the drainage network is weak.

GROUNDWATER. No groundwater data exist. Neither producing nor exploratory borings have been drilled. Undoubtedly the resource is great and consists of both high-level and basal water, but the cost of development would be high.

ENVIRONMENT. Except for the town of Mountain View, most of the aquifer system is forest, brush, and grass lands. A large portion is included in Hawaii Volcanoes National Park. Elsewhere ranching is done.

Aquifer System: Kapapala (80502)

BOUNDARIES. The area is roughly a rectangle 16 miles (25.7 km) long from Kīlauea Crater to the summit of Mauna Loa and 7 miles (11.3 km) across. The Kīlauea/Mauna Loa contact is the seaward boundary; the northeast rift of Mauna Loa, the most inland boundary.

GEOLOGY. The entire area is covered with Kau Basalt, mostly pre-historic but with narrow sections of recent flows (1880, 1975, and 1984). Exposed ash occurs toward Kīlauea. The Kaoiki Fault Zone lies parallel to and near the seaward boundary. Sediments are insignificant.

HYDROLOGY. Rainfall is meager to moderate, 15 to 75 in. (381 to 1 905 mm)/yr. The slopes are uneroded, and streams are absent.

GROUNDWATER. Nothing significant is known about groundwater occurrences. Very likely high-level water, both perched and dike-impounded, constitute the principal resources.

ENVIRONMENT. Much of the region is included in Hawaii Volcanoes National Park. Slopes outside the park are grazed.

Aquifer System: Naalehu (80503)

BOUNDARIES. The western boundary is along the southwest rift from the summit of Mauna Loa for 10 miles (16.1 km), then toward Wai'ōhinu and on to Waikapuna Bay at Manāka'a Point. The eastern boundary is the Kīlauea/Mauna Loa contact. The aquifer system was drawn to include the region between Pāhala and Nā'ālehu.

GEOLOGY. Kau Basalt covers most of the Mauna Loa slope, but large exposures of Kahuku Basalt and smaller ones of Ninole Volcanics occur below the 6,500-ft (1 981.2-m) elevation. Pahala Ash covers the older formations. Landslide sediments, which occur north of Pāhala, have a local hydrological effect. Kau Basalt forms most of the coast.

HYDROLOGY. The lowest rainfall of 15 in. (381 mm)/yr occurs at the highest elevations. In the sector between Pāhala and Nā'ālehu at about the 3,500-ft (1 066.8-m) elevation the maximum rainfall is 150 in. (3 810 mm)/yr. Streams flow off the Pahala Ash and are weakly perennial in the high rainfall area but lose base flow before reaching the sea.

GROUNDWATER. Within about 2 miles (3.2 km) of the coast the groundwater is basal and developable as fresh water. Inland high-level water occurs perched on ash beds and perhaps impounded by geologic structures. Dike water probably is found far inland toward the rift zone at great depth. Large basal springs discharge at Punalu'u. Both basal and high-level groundwaters are developed for domestic and irrigation uses.

ENVIRONMENT. Sugarcane cultivation continues but faces an uncertain future. Many cane fields are in high-rainfall areas where little irrigation is required. Large acreage is devoted to macadamia nut orchards. A tourist destination is located in the coastal region at Punalu'u.

Aquifer System: Ka Lae (80504)

BOUNDARIES. The western boundary of the Ka Lae Aquifer System is the rift zone, then traces Kahuku Pali to the sea. To the east is the Naalehu Aquifer System.

GEOLOGY. Kahuku Basalt is exposed from Kahuku south to Ka Lae in a zone parallel to Kahuku Pali and as patches between Ka Lae and Pakea. Elsewhere the surface consists of Kau Basalt. The trace of the Kahuku Fault at the western terminus of the aquifer system is 8 miles (12.9 km) long and is expressed as the Kahuku Pali.

HYDROLOGY. Rainfall reaches an annual average maximum of 75 in. (1 905 mm) at about the 3,500-ft (1 066.8-m) elevation. This average decays to 20 in. (508 mm) toward both the coast and the upper slopes of Mauna Loa. Streams are poorly established, and none are perennial.

GROUNDWATER. Basal groundwater, most of it brackish, reaches to about 5 miles (8 km) inland. Beyond, the groundwater is high-level, probably perched in the lower slopes and dike-impounded as well as perched in the vicinity of the rift zone.

ENVIRONMENT. Except for ranching the land is mostly unoccupied.

AQUIFER SECTOR: SOUTHWEST MAUNA LOA (806)

The Southwest Mauna Loa Aquifer Sector is very large, about 638 miles^2 (1 652.29 km^2). It embraces the southwest and western flank of Mauna Loa over a stretch of 50 miles (80.5 km) from Ka Lae to Kuamo'o Point just south of Keauhou. The northern boundary is the contact between the Mauna Loa Volcanics and Hualalai Volcanics. The interior boundary starts at the farthest inland penetration of the contact, strikes southeast to the summit of Mauna Loa, then follows the southwest rift zone to Ka Lae. The entire aquifer sector is covered with Kau Basalt. Included in this aquifer sector are three aquifer systems: Manuka, Kaapuna, and Kealakekua.

Aquifer System: Manuka (80601)

BOUNDARIES. The Manuka Aquifer System is separated from the Kaapuna Aquifer System by a line drawn east from Miloli'i at Moku o Kaha'ilani Rock on the coast to Pu'u Ke'oke'o on the southwest rift zone. It extends from the Kahuku Pali for about 25 miles (40.2 km) along the coast to Miloli'i.

GEOLOGY. Kau Basalt is universal in the aquifer system. Most is pre-historic, but stringers of recent lavas descend from the rift zone. The topography is youthful, and sediments are rare.

HYDROLOGY. Average annual rainfall is only 20 in. (508 mm) at the coast, but increases to a maximum of 70 in. (1 778 mm) at about an elevation of 3,500 ft (1 066.8 m) before decaying back to 20 in. at higher elevations. Drainage is poorly established on the rough lava ground. No watercourses are perennial.

GROUNDWATER. Several wells drilled about 6 miles (9.7 km) inland encountered basal water. Farther inland high-level water may occur, but nothing is known about this region. Dike water at considerable depth could be expected near the rift zone. Along the coast basal springs with varying degrees of brackishness discharge.

ENVIRONMENT. A few scattered residences and the fishing village of Miloli'i account for the population. Macadamia orchards are common, and ranching has been a traditional activity.

Aquifer System: Kaapuna (80602)

BOUNDARIES. The northern boundary is an easterly line connecting Hōnaunau Bay at Pu'uhonua Point with Lua Hou near Pōhaku in the southwest rift zone. The coastal length between Miloli'i and Hōnaunau is about 17 miles (27.4 km). The southwest rift is the inland boundary.

GEOLOGY. All rocks belong to the Kau Basalt. Lavas generated in 1919 and 1926 cover the southern part of the aquifer system. The Kaholo Fault System runs for about 16 miles (25.7 km) along the coast.

HYDROLOGY. Annual rainfall increases from 25 in. (635 mm) at the coast to a maximum of 70 in. (1 778 mm) at an elevation of 3,500 ft (1 066.8 m), then decays to 20 in. (508 mm) at high elevations. During the day a zone of fog sets in at an elevation between about 3,500 and 6,500 ft (1 066.8 and 1 981.2 m). No perennial streams exist. The drainage pattern is weak.

GROUNDWATER. Scattered drilling sites suggest that high-level water starts about 2 miles (3.2 km) inland. The basal lens is variably brackish towards the coast. The high-level water may be held up by geologic structures in addition to perching on ash beds. Near the rift zone dike water probably occurs.

ENVIRONMENT. The population is small and scattered. Ranching and coffee cultivation are traditional activities. Except where displaced by ranching, the high-rainfall and fog belt is forested.

Aquifer System: Kealakekua (80603)

BOUNDARIES. The northern boundary follows the Mauna Loa/Hualālai contact from Kuamo'o Point on the coast to the most inland reach of the contact trace, then strikes southeasterly to the summit of Mauna Loa. To the south is the Kaapuna Aquifer System.

GEOLOGY. Except at the rift zone, few historic flows of Kau Basalt occur. The Kealakekua Fault System borders Kealakekua Bay. Sediments are insignificant.

HYDROLOGY. At the coast average annual rainfall is 20 in. (508 mm); by the 3,500-ft (1 066.8-m) elevation it increases to 80 in. (2 032 mm). At higher elevations it diminishes to 20 in., but a fog belt is common between 3,500 and 6,500 ft (1 066.8 and 1 981.2 m). There are no perennial streams.

GROUNDWATER. Recent drilling suggests that high-level groundwater starts about 2 miles (3.2 km) inland. The basal lens is brackish at the coast but freshens moving inland. The high-

level water may be perched or impounded by geological structures. Dike water is expectable near the rift zone.

ENVIRONMENT. Several towns concentrate a few thousand people in the vicinity of Kealakekua Bay. Macadamia nut and coffee farming, along with ranching, are the basic economic activities. Tourism is important.

AQUIFER SECTOR: NORTHWEST MAUNA LOA (807)

A single aquifer system constitutes the Northwest Mauna Loa Aquifer Sector. Within the sector boundaries reaching from the 7-mile (11.3-km) length of coast to the summit of Mauna Loa and the saddle between Mauna Loa and Mauna Kea, all rocks belong to the Kau Basalt. These Mauna Loa lavas are younger than the Mauna Kea rocks that form the northern boundary of the sector. Most are younger than the bulk of the Hualalai Volcanics, although some older flows may lie beneath the peripheral exposures of the Hualalai Volcanics. Virtually all of the Kau Basalt consists of flank lava flows. Total length of the sector is 37 miles (59.5 km) from the coast to the saddle, the first 18 miles (29 km) of which is a narrow corridor between the Hualālai and Mauna Kea volcanoes. The width of the corridor is about 5 miles (8 km).

Aquifer System: Anaehoomalu (80701)

BOUNDARIES. The Anaehoomalu Aquifer System comprises the entire Northwest Mauna Loa Aquifer Sector, whose boundaries are described above. Total area is 291 miles^2 (753.63 km^2).

GEOLOGY. Only Kau Basalt is exposed. Sediments are insignificant.

HYDROLOGY. Rainfall is very low, the average annual accounting for just 10 in. (254 mm) at the coast and 20 in. (508 mm) inland. The mean for the aquifer system is about 16 in. (406 mm). Little erosion is evident, and there are no perennial water courses.

GROUNDWATER. High-level groundwater likely occurs at elevations greater than 1,200 ft (365.8 m), although this has not been shown yet. The basal lens, extending about 4 to 5 miles (6.4 to 8.0 km) inland, is brackish except, perhaps, near the inland periphery. Basal springs and anchialine ponds are common along the coast.

ENVIRONMENT. Tourism is important along the coast. Ranching occurs inland, but grazing opportunities are sparse. Few people live in the region.

AQUIFER SECTOR: KILAUEA (808)

The entire region to the east of the Kīlauea/Mauna Loa geologic contact belongs to the Kilauea Aquifer Sector. All of the exposed rocks of Kīlauea volcano are in the sector. The inland boundary traces the contact from Nāhuluhulu Point near Punalu'u on the south to Kea'au on the north coast of the island. The length of the sector is about 62 miles (99.8 km), and the maximum width is 15 miles (24.1 km). Three formations constitute the geologic succession. The oldest formation is the Hilina Basalt. It is covered in many places by the Pahala Ash. The youngest formation, which is still being effused from Kīlauea volcano, is the Puna Basalt. The Kilauea Aquifer Sector includes four aquifer systems: Pahoa, Kalapana, Hilina, and Keaiwa.

Aquifer System: Pahoa (80801)

BOUNDARIES. The Pahoa Aquifer System lies north of the Kīlauea east rift zone, which stretches from Kīlauea Crater to Cape Kumukahi. The northern boundary is the Kīlauea/Mauna Loa contact, which touches the sea at Kea'au.

GEOLOGY. Recent Puna Basalt covers the entire surface. Ash and cinder blown out of vents along the rift are common.

HYDROLOGY. Average annual rainfall increases from 100 in. (2 540 mm) at the coast to 180 in. (4 572 mm) before diminishing to 60 in. (1 524 mm). Noticeable erosion has not occurred; the volcano is still building.

GROUNDWATER. Off the rift zone high-level and basal waters occur in great volume. Except near the coast the basal water is fresh. Near the rift zone geothermal conditions prevail. Perched and dike water may occur. Along the coast basal springs discharge the basal lens.

ENVIRONMENT. Scattered communities are spread in the Puna District. Farms and orchards are common, but most of the region is still carpeted with a rain forest. Geothermal energy is being developed along the rift zone.

Aquifer System: Kalapana (80802)

BOUNDARIES. The Kalapana Aquifer System lies south of the rift zone between 'Āpua Point and Cape Kumukahi. From 'Āpua Point the boundary strikes north to Kīlauea Crater.

GEOLOGY. Volcanism is active along the rift zone, sending lava flows toward the sea down the flanks of the shield. Cinder and ash often accompany the lava extrusions. The lavas belong to the Puna Basalt, but the older Hilina Basalt is exposed where extensive faulting along the Hilina Fault is active.

HYDROLOGY. Maximum average annual rainfall is 120 in. (3 048 mm), and the minimum is 75 in. (1 095 mm). Volcanic accretion is taking place. Erosion is insignificant. Streams have not developed.

GROUNDWATER. High-level groundwater occurs in the rift zone. Basal water extends an unknown distance inland. Along the coast basal springs are frequent. Geothermal conditions prevail in and near the rift zone.

ENVIRONMENT. Some farming is practiced, including grazing. The population is small. Lavas from the rift zone have destroyed some houses. The western half of the aquifer system is in Hawaii Volcanoes National Park

Aquifer System: Hilina (80803)

BOUNDARIES. The coast of the aquifer system extends for 12 miles (19.3 km) from ʻĀpua Point to Nāliʻikakani Point. The western boundary is an arc passing through the Kaʻū Desert from Nāliʻikakani to Kīlauea Crater. On the east the aquifer system shares the boundary with the Kalapana Aquifer System.

GEOLOGY. Puna Basalt is the dominant land cover, but Hilina Basalt appears along the Hilina Fault. Pahala Ash has been identified overlying the Hilina Basalt. Dikes have been mapped south of the crater and the rift zone, as well as seaward of the Hilina Fault Scarp.

HYDROLOGY. Average annual rainfall is just 20 in. (508 mm) at the coast but increases to a maximum of 60 in. (1 524 mm) before dropping to 30 in. (762 mm). Volcanism is still active, and erosion is slight. Streams do not exist.

GROUNDWATER. Basal groundwater, both in flank lavas and in dike compartments, probably reaches several miles (1 mile = 1.6 km) inland. Near the rift zone and the crater the groundwater is high-level. Geothermal conditions prevail inland. Groundwater exploration has not taken place.

ENVIRONMENT. The topography is rugged, and the land is virtually vacant. It is not accessible by ordinary roads. The entire area is in the Hawaii Volcanoes National Park.

Aquifer System: Keaiwa (80804)

BOUNDARIES. The western boundary is the contact between the Kīlauea and Mauna Loa rocks from Punaluʻu to Kīlauea Crater. On the east is the Hilina Aquifer System.

GEOLOGY. The aquifer system follows the southwest rift of Kīlauea to the sea and incorporates the Great Crack. Some lava flows occurred in recent time. Dikes parallel to the Great Crack have been identified. Puna Basalt covers the surface. The Great Crack is about

14 miles (22.5 km) long, 50 ft wide (15.2 m), and up to 70 ft (21.3 m) deep. The 1823 lava flow is associated with it.

HYDROLOGY. Average annual rainfall is low, ranging from 20 to 40 in. (508 to 1 016 mm). Wind erosion is active. Streams have not formed.

GROUNDWATER. To the west of the Great Crack in the vicinity of Pāhala a substantial groundwater resource exists and is tapped by several large-capacity wells. The water is probably high-level, although the head is about 9 ft (2.7 m). It is very fresh. To the east of the Great Crack brackish basal water probably occurs. It has not been explored. Beyond several miles inland high-level water likely occurs on both sides of the Great Crack.

ENVIRONMENT. Except near Pāhala where macadamia nuts are grown, the region is barren of activity. Much of it is included in Hawaii Volcanoes National Park.

AQUIFER SECTOR: HUALALAI (809)

The Hualalai Aquifer Sector encloses the Hualālai Volcano as traced along the Hualālai/Mauna Loa contact. Shaped roughly like half a circle, its north-south distance is 22 miles (35.4 km) and its east-west distance is 20 miles (32.2 km). It is composed exclusively of Hualalai Volcanics. All surface exposures belong to the alkalic basalt series; the basement basalt is not exposed. Included among the rock units is the Waawaa Trachyte, which emanated from the Pu'u Wa'awa'a vent. The volcano is still active, having erupted as recently as 1801. Two aquifer systems constitute the Hualalai Aquifer Sector: Keauhou and Kiholo.

Aquifer System: Keauhou (80901)

BOUNDARIES. The boundary starts at Kuamo'o Point, follows the geological contact inland to the crest of the rift zone, then follows the rift zone to the sea at Papiha Point.

GEOLOGY. All rocks belong to the Hualalai Volcanics, including the 1801 lava flow just north of Keāhole Point. The rift zone is marked by cinder and spatter cones. Sediment accumulations are insignificant.

HYDROLOGY. The minimum average annual rainfall of 20 in. (508 mm) occurs at the coast and near the summit of the volcano. Rainfall reaches a maximum of about 80 in. (2 032 mm)/yr inland of Kailua. The high-rainfall belt at the 3,500-ft (1 066.8-m) elevation transitions into a fog belt that reaches to about the 6,500-ft (1 981.2-m) elevation. Most flanks of the volcano are weakly eroded, but one stream, Wai'aha, often carries water.

GROUNDWATER. Within about 2 miles (3.2 km) of the coast the groundwater is basal and generally brackish. High-level water occurs farther inland. High-level water was discovered in

recent years, but its mode of occurrence is not understood. Along the rift zone dike-impounded water probably occurs at depth. Basal springs discharge brackish, cool water at the coast.

ENVIRONMENT. Kailua is the largest population center in west Hawaii. A vibrant tourist industry exists. Keāhole Point is an energy research center devoted to devising alternate sources of energy, in particular OTEC (ocean thermal energy conversion). Cattle graze the slopes, and toward the summit the land is placed in forest reserve.

Aquifer System: Kiholo (80902)

BOUNDARIES. The Kiholo Aquifer System comprises the north half of Hualālai and is separated from the Keauhou Aquifer System by the trace along the crest of the rift zone. The northern boundary is the Hualālai/Mauna Loa contact.

GEOLOGY. The Waawaa Trachyte and Pu'u Wa'awa'a constitute a small section of the aquifer system near the northern boundary. Along this boundary the Hualalai Volcanics are covered by the 1859 Mauna Loa lava flow. Many cinder and spatter cones line the rift zone, and a number appear to be associated with Pu'u Wa'awa'a.

HYDROLOGY. Rainfall is low, reaching a maximum of 40 in. (1 016 mm)/yr. At the coast the annual average is only 10 in. (254 mm), and high on the slopes of the mountain it is 20 in. (508 mm). The mid-altitude fog belt occurs in the southern portion of the aquifer system. Erosion has been minor, and no perennial streams occur.

GROUNDWATER. Up to 4 miles (6.4 km) inland the groundwater is basal and mostly brackish. High-level water has recently been discovered farther inland. The extent of and why high-level water occurs is not known. Brackish basal springs drain at the coast. Anchialine ponds in the coastal zone are common.

ENVIRONMENT. Along the coast tourism is being promoted. Ranching occupies much of the upper slopes. Few people live in the region.

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U.S. Environmental Protection Agency. 1984. Ground-water protection strategy. Office of Ground-Water Protection, Washington, D.C. 20460 (August). 56 pp. + unpaginated Attachments I–VI.

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APPENDIX

CONTENTS

Figures

AQUIFER CLASSIFICATION EXPLANATION

AQUIFER AND STATUS CODES

	Aquifer Code	=	Island
		+	Aquifer Sector
		+	Aquifer System
		+	Aquifer Type
Thus,	80401111	=	Aquifer Code
where	8	=	Hawai'i
	04	=	Northeast Mauna Loa
	01	=	Hilo
	1	=	basal
	1	=	unconfined
	1	=	flank
and			
	(11111)	=	Status Code
where	1	=	currently used
	1	=	drinking
	1	=	fresh, <250 mg/l Cl^-
	1	=	irreplaceable
	1	=	high vulnerability to contamination

ISLAND	AQUIFER SECTOR		AQUIFER SYSTEM	
8	01	Kohala	01	Hawi
			02	Waimanu
			03	Mahukona
	02	East Mauna Kea	01	Honokaa
			02	Paauilo
			03	Hakalau
			04	Onomea
	03	West Mauna Kea	01	Waimea
	04	Northeast Mauna Loa	01	Hilo
			02	Keaau
	05	Southeast Mauna Loa	01	Olaa
			02	Kapapala
			03	Naalehu
			04	Ka Lae
	06	Southwest Mauna Loa	01	Manuka
			02	Kaapuna
			03	Kealakekua
	07	Northwest Mauna Loa	01	Anaehoomalu
	08	Kilauea	01	Pahoa
			02	Kalapana
			03	Hilina
			04	Keaiwa
	09	Hualalai	01	Keauhou
			02	Kiholo

AQUIFER TYPE:	Hydrology*
1 Basal	Fresh water in contact with seawater
2 High Level	Fresh water not in contact with seawater
1 Unconfined	Where water table is upper surface of saturated aquifer
2 Confined	Aquifer bounded by impermeable or poorly permeable formations; top of saturated aquifer is below groundwater surface
3 Confined or Unconfined	Where actual condition is uncertain

AQUIFER TYPE:	Geology†
1 Flank	Horizontally extensive lavas
2 Dike	Aquifers in dike compartments
3 Flank/Dike	Indistinguishable
4 Perched	Aquifer on an impermeable layer
5 Dike/Perched	Indistinguishable
6 Sedimentary	Non-volcanic lithology

*First two digits from hydrologic descriptors (pts. 1, 2).
†Last digit from geologic descriptor.

STATUS CODE (GROUNDWATER)

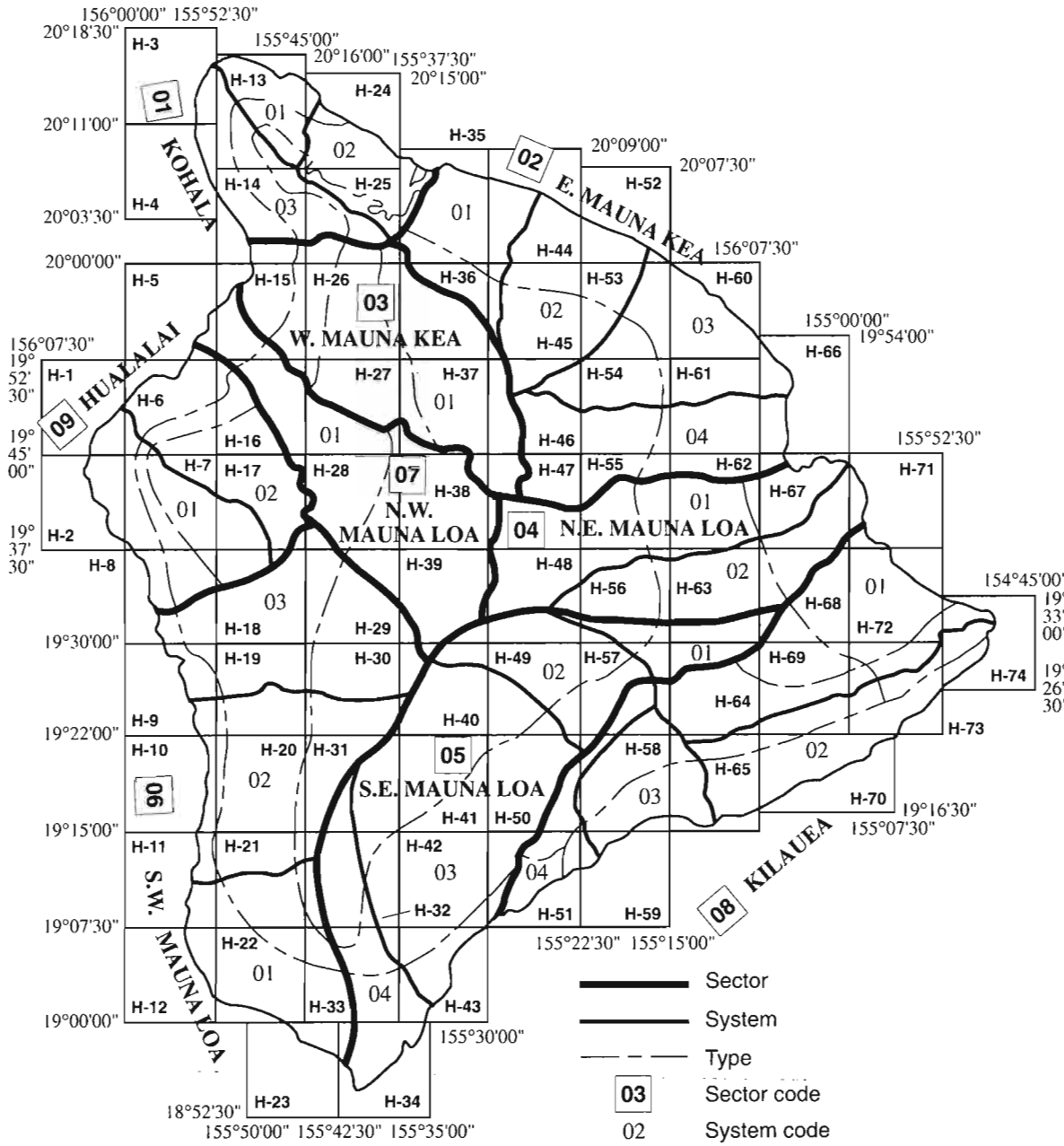
Development Stage
1 Currently used
2 Potential use
3 No potential use

Utility
1 Drinking
2 Ecologically important
3 Neither

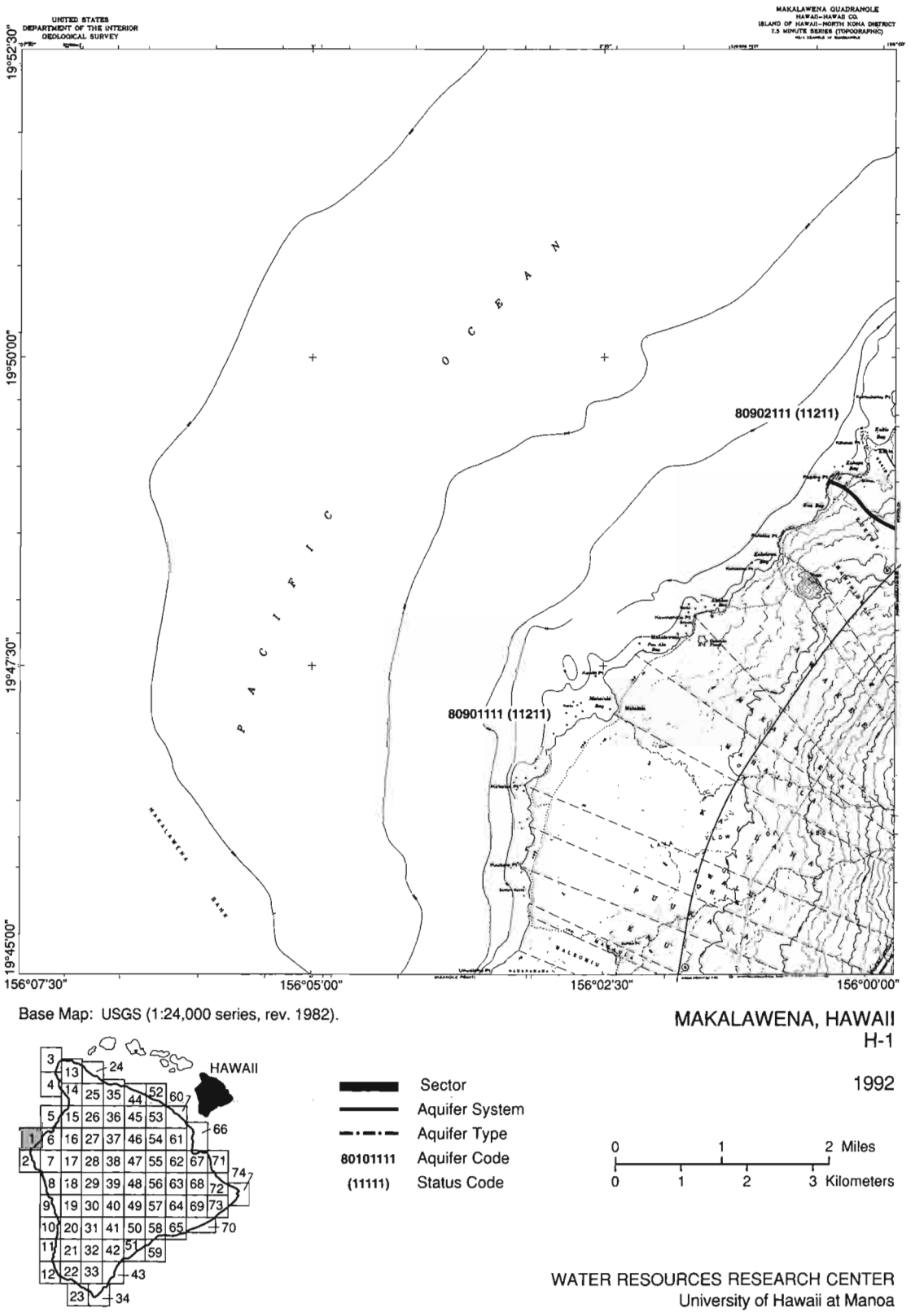
Salinity (mg/l Cl^-)
1 Fresh (<250)
2 Low (250–1,000)
3 Moderate (1,000–5,000)
4 High (5,000–15,000)
5 Seawater (>15,000)

Uniqueness
1 Irreplaceable
2 Replaceable

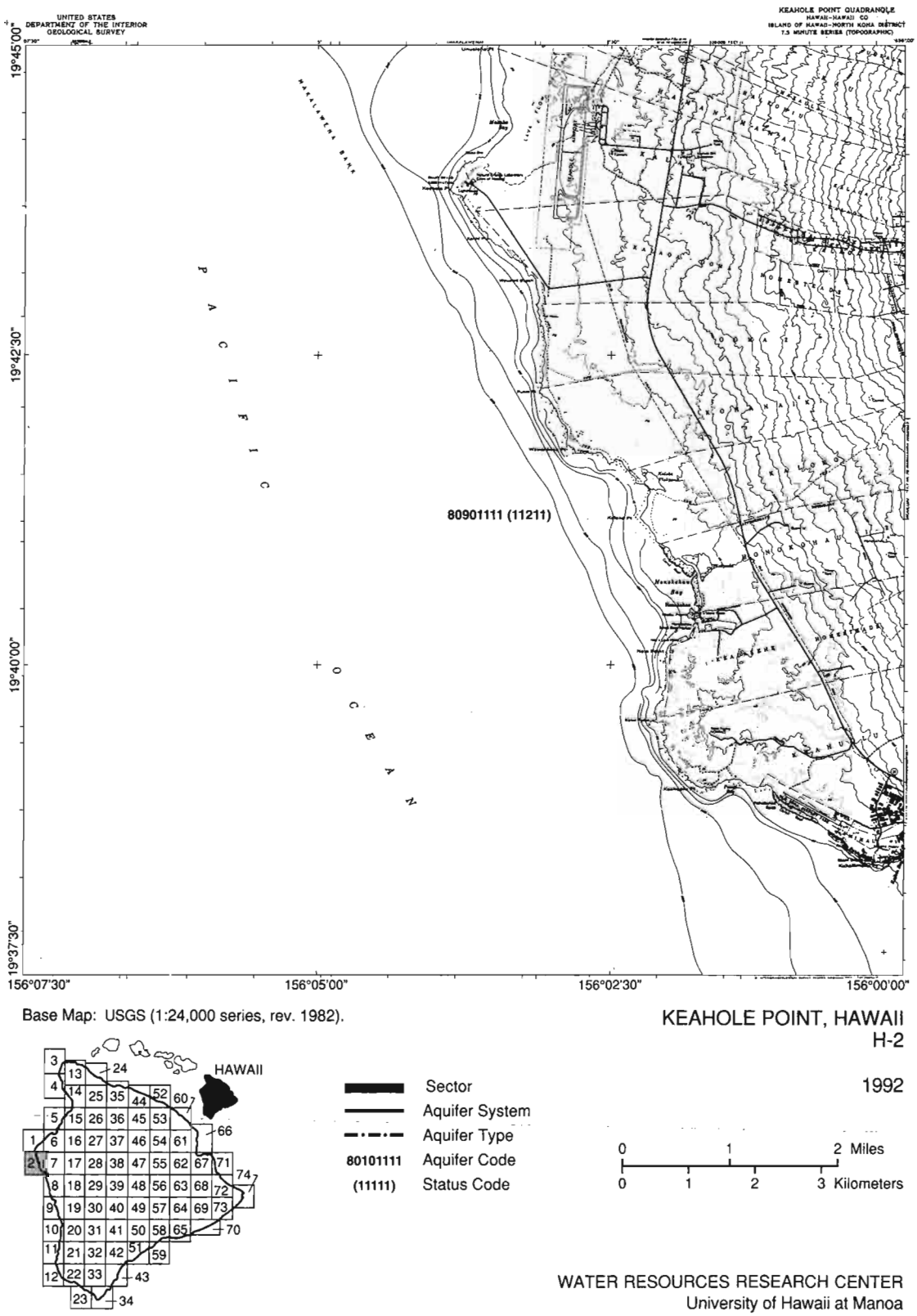
Vulnerability to Contamination
1 High
2 Moderate
3 Low
4 None



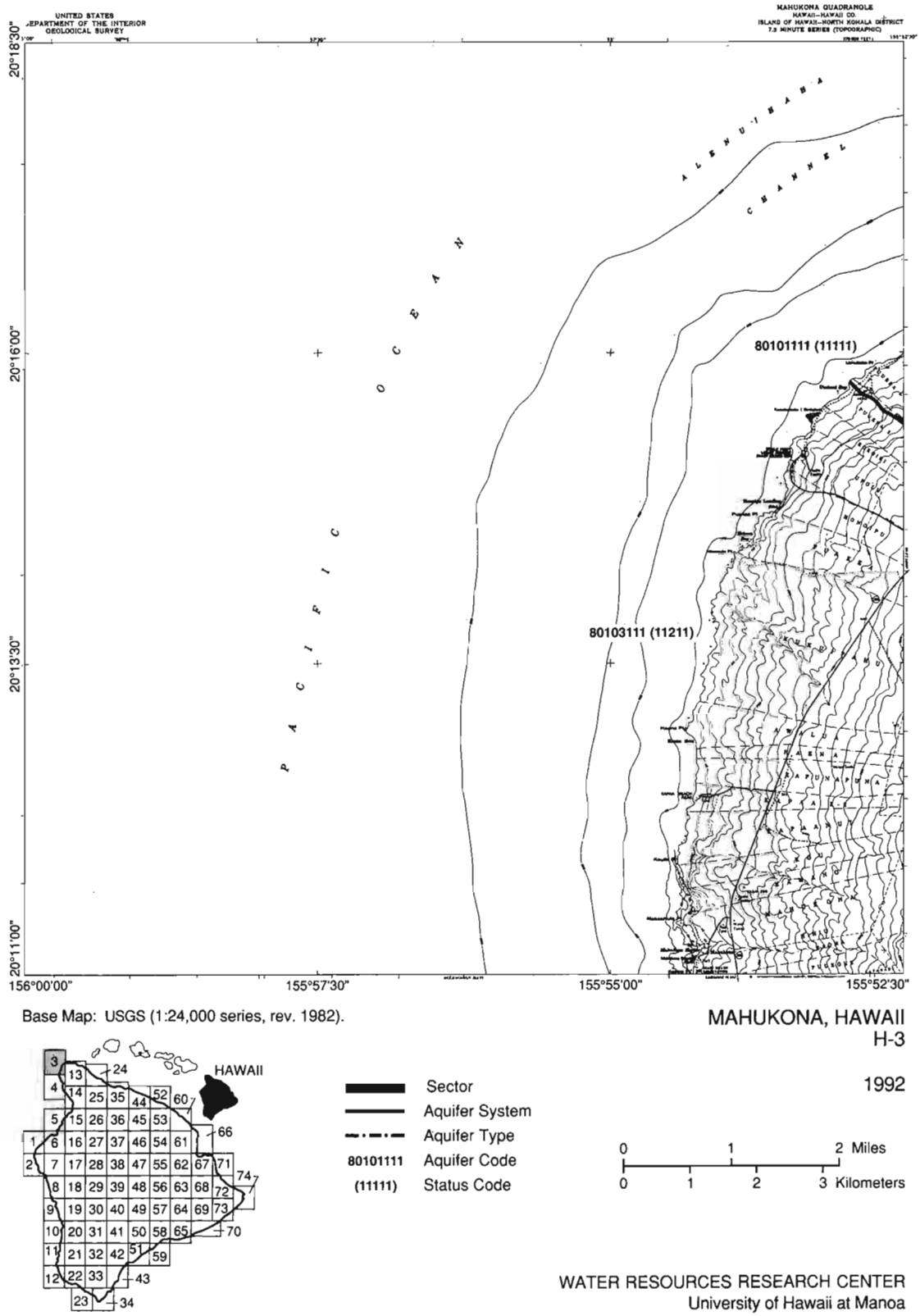
Appendix Figure 1.0. Layout of Sectors, Systems, and Types for the island of Hawai'i, Hawai'i



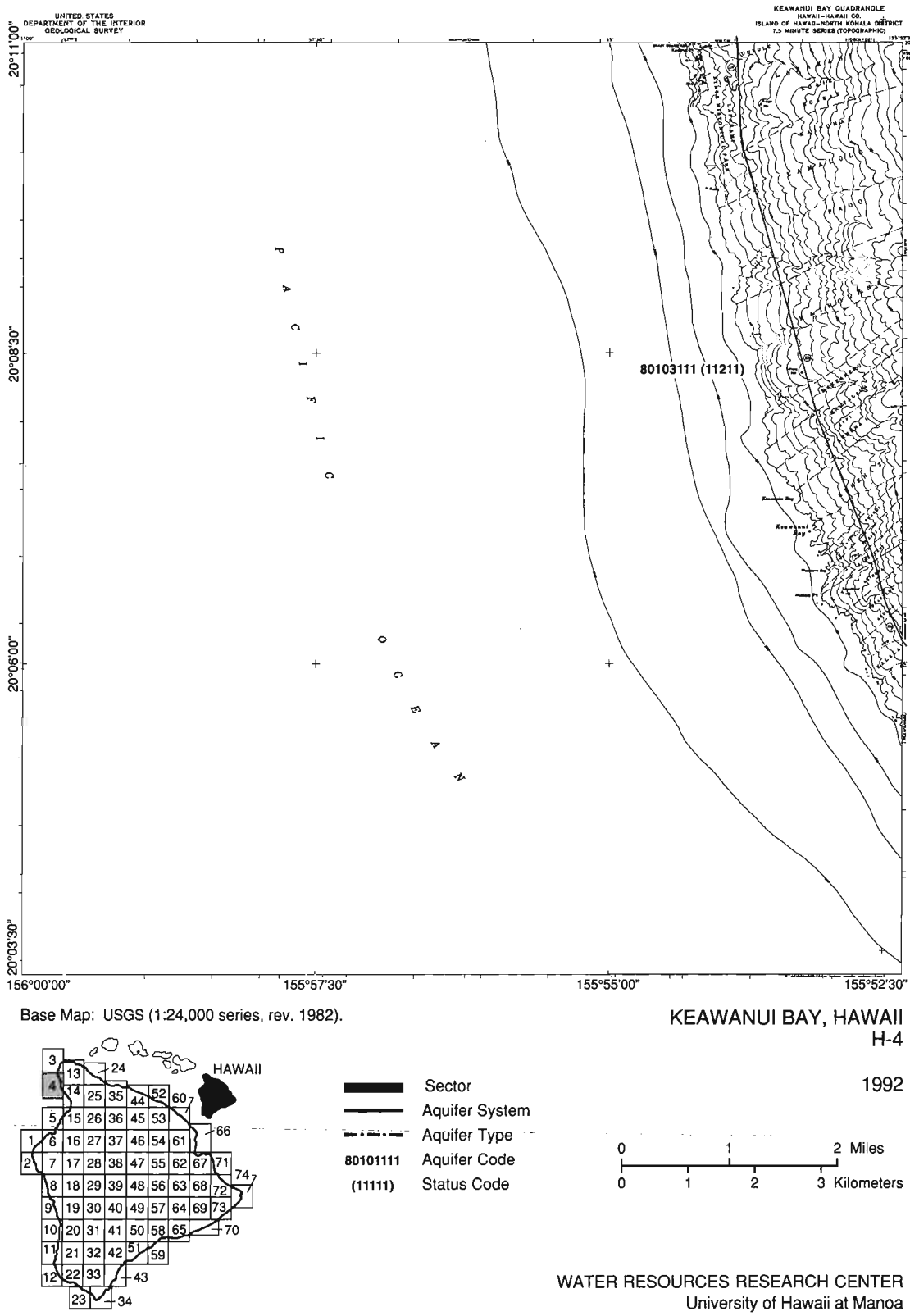
Appendix Figure A.1.1. Aquifer classification map, Makalawena, Hawai'i



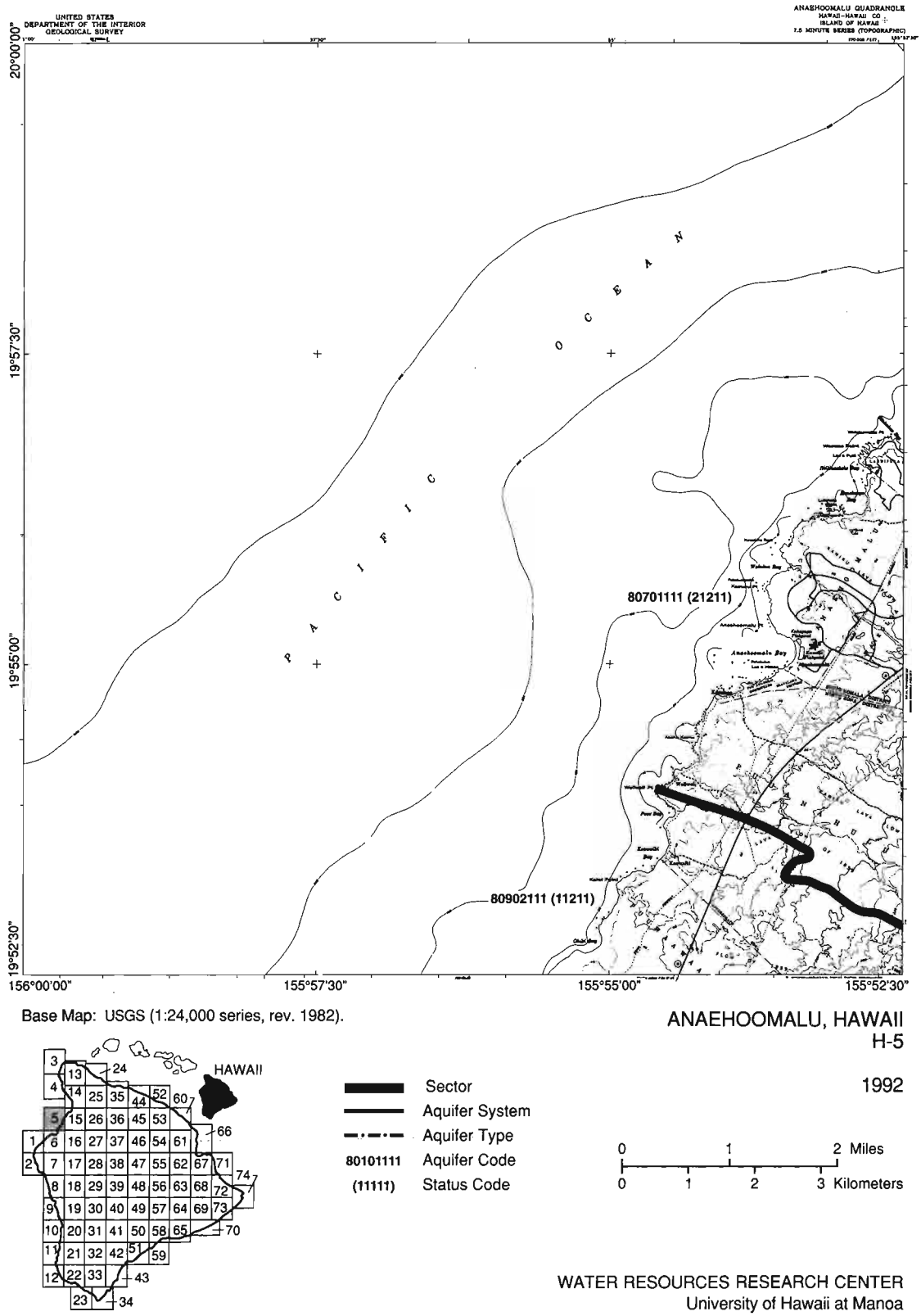
Appendix Figure A.1.2. Aquifer classification map, Keahole Point, Hawai'i



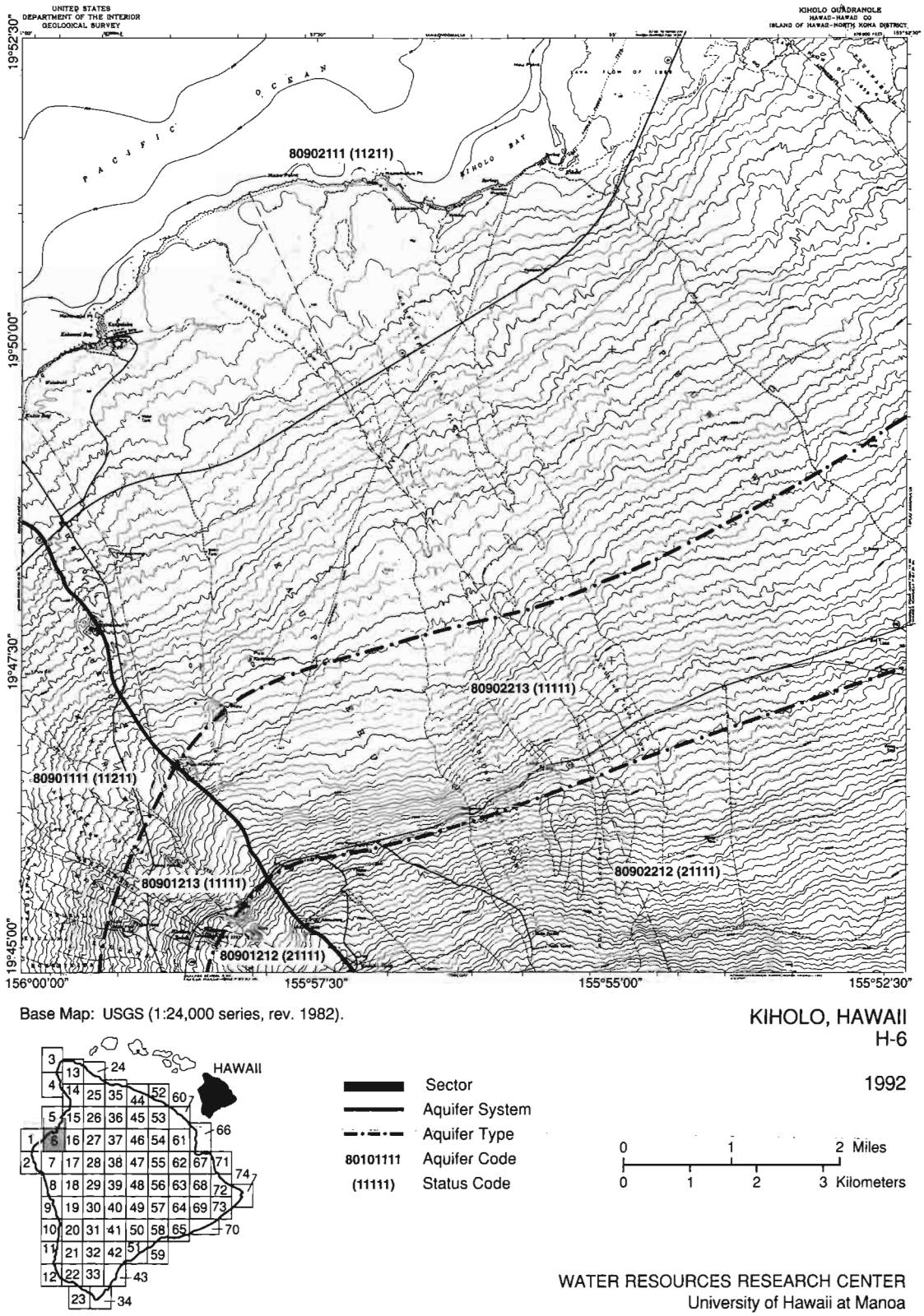
Appendix Figure A.1.3. Aquifer classification map, Mahukona, Hawai'i



Appendix Figure A.1.4. Aquifer classification map, Keawanui Bay, Hawai'i



Appendix Figure A.1.5. Aquifer classification map, Anaehoomalu, Hawai'i

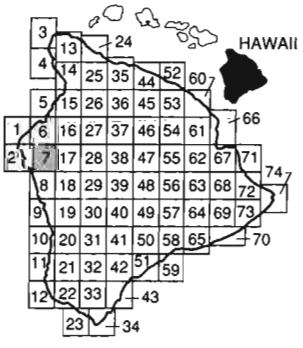


Appendix Figure A.1.6. Aquifer classification map, Kiholo, Hawai'i

Base Map: USGS (1:24,000 series, rev. 1982).

KAILUA, HAWAII
H-7

1992



Sector
Aquifer System
Aquifer Type
80101111 Aquifer Code
(11111) Status Code

0 1 2 Miles
0 1 2 3 Kilometers

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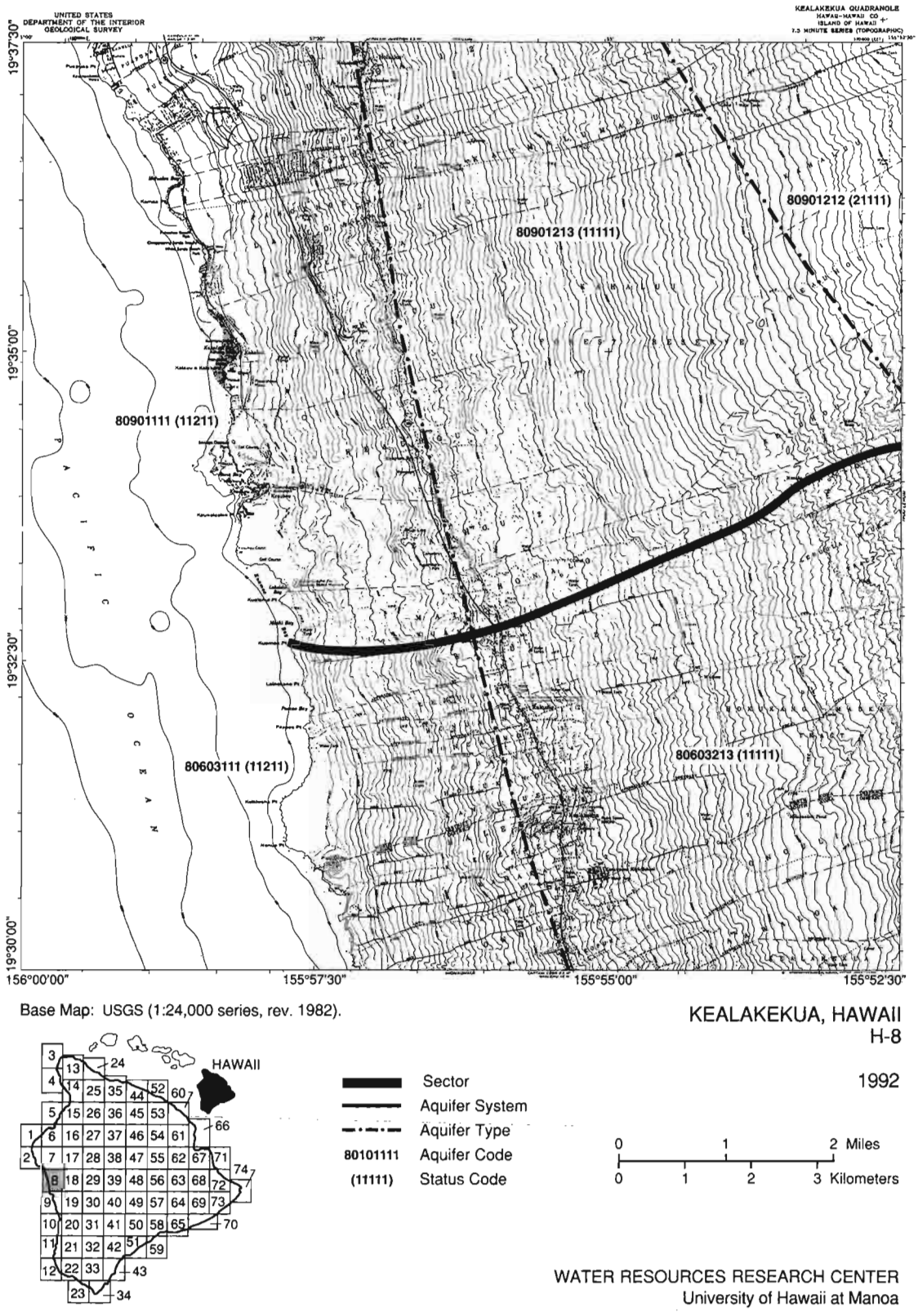
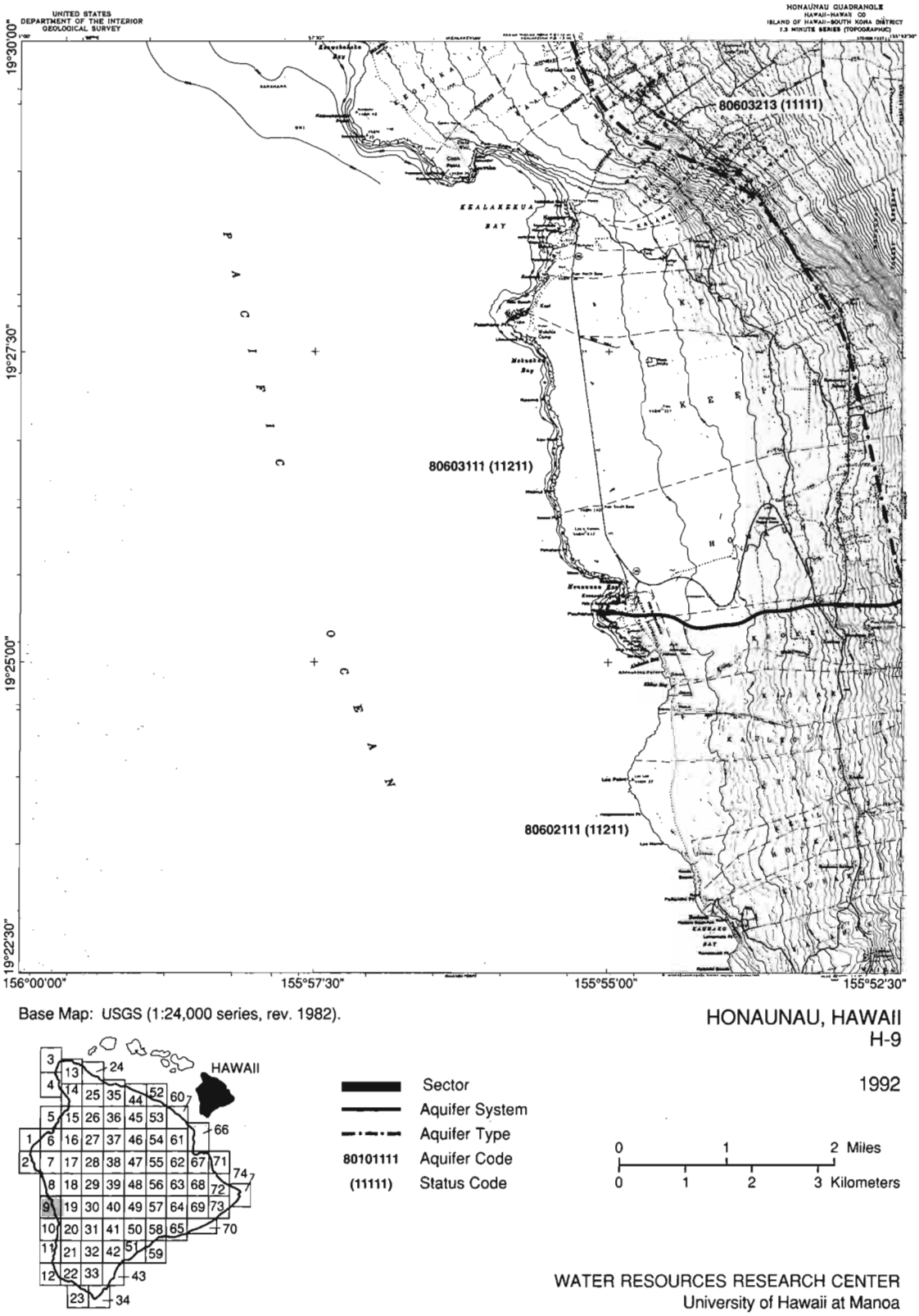
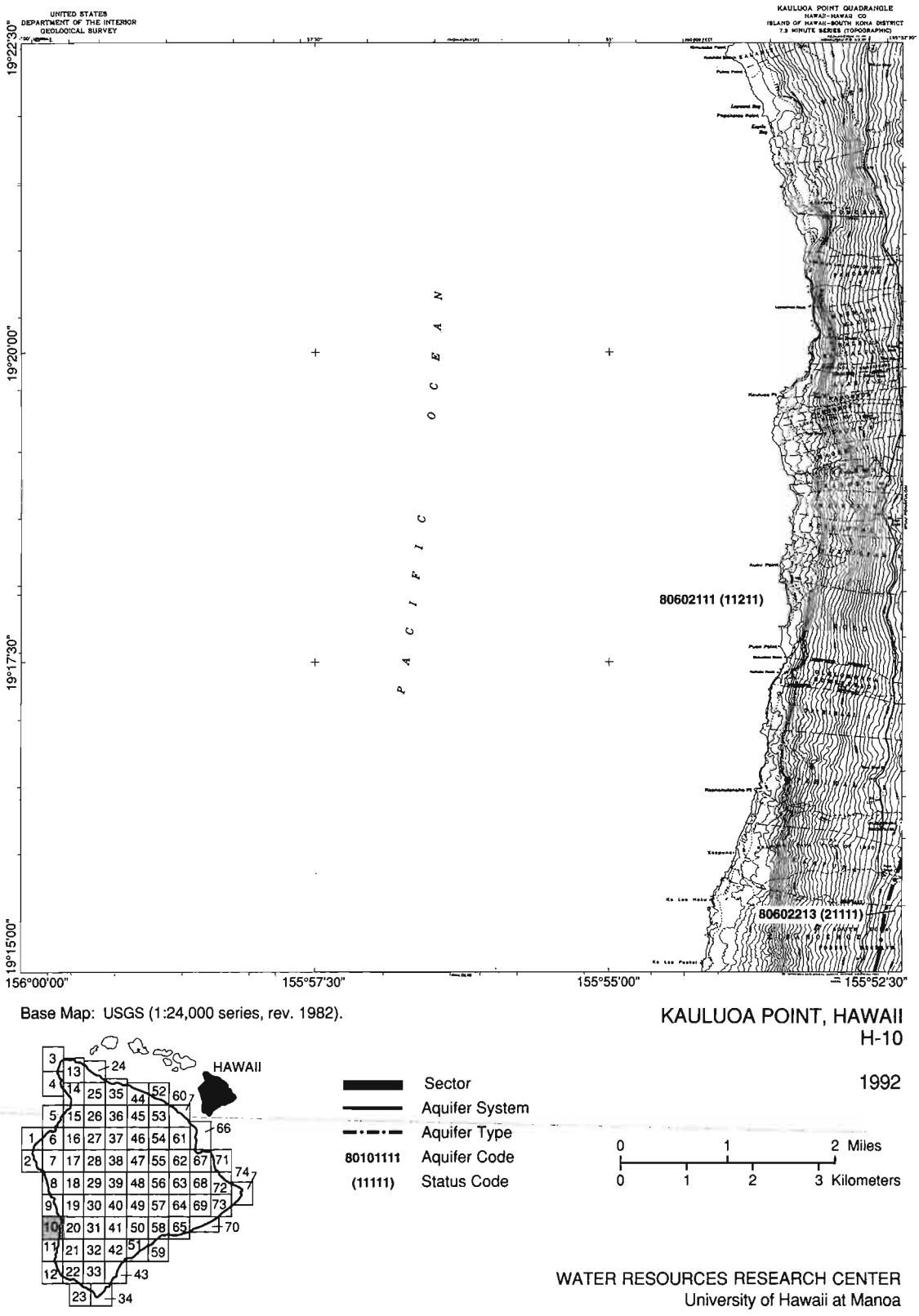
Appendix Figure A.1.7. Aquifer classification map, Kailua, Hawai'i



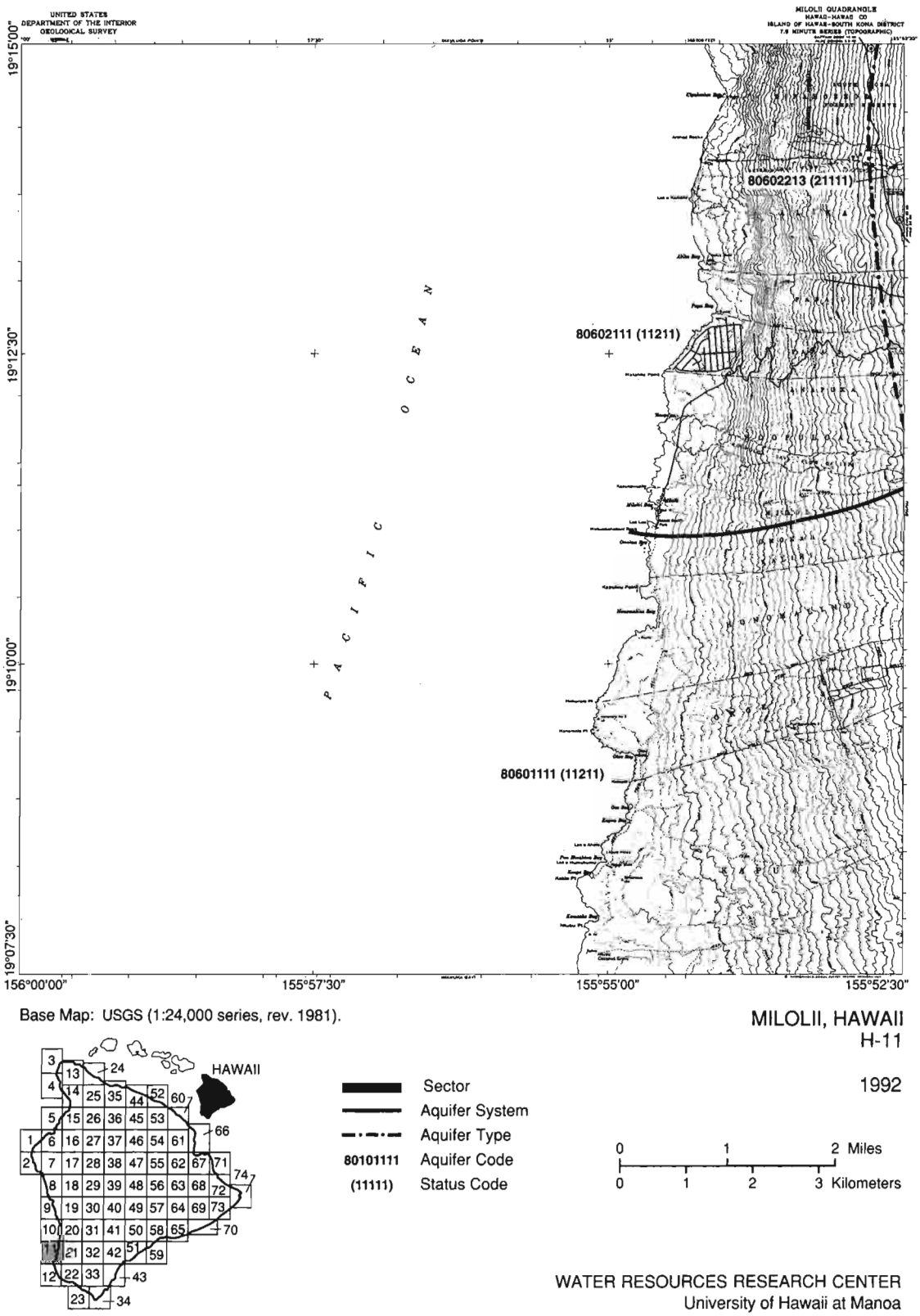
Appendix Figure A.1.8. Aquifer classification map, Kealakekua, Hawai'i



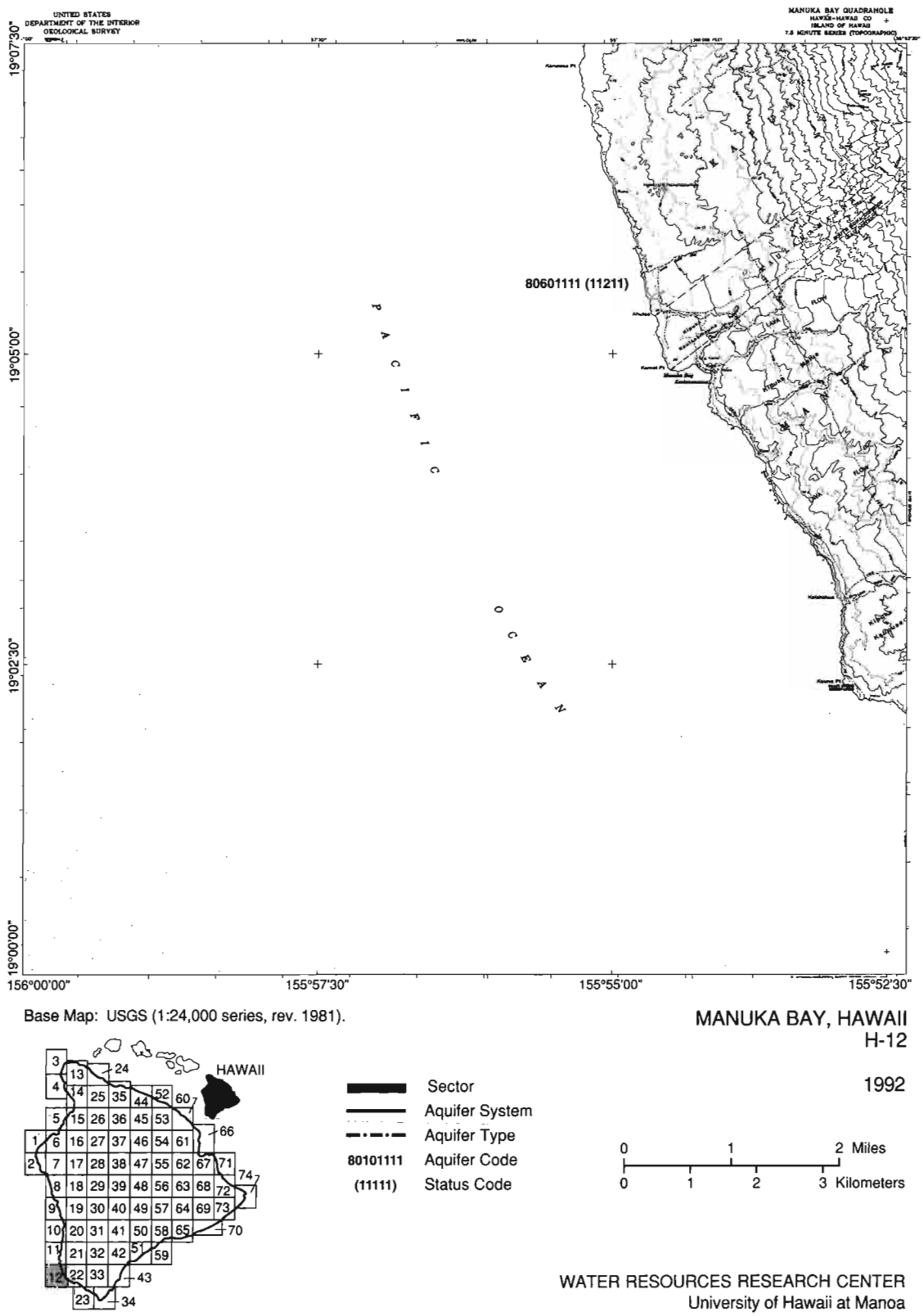
Appendix Figure A.1.9. Aquifer classification map, Honaunau, Hawai'i



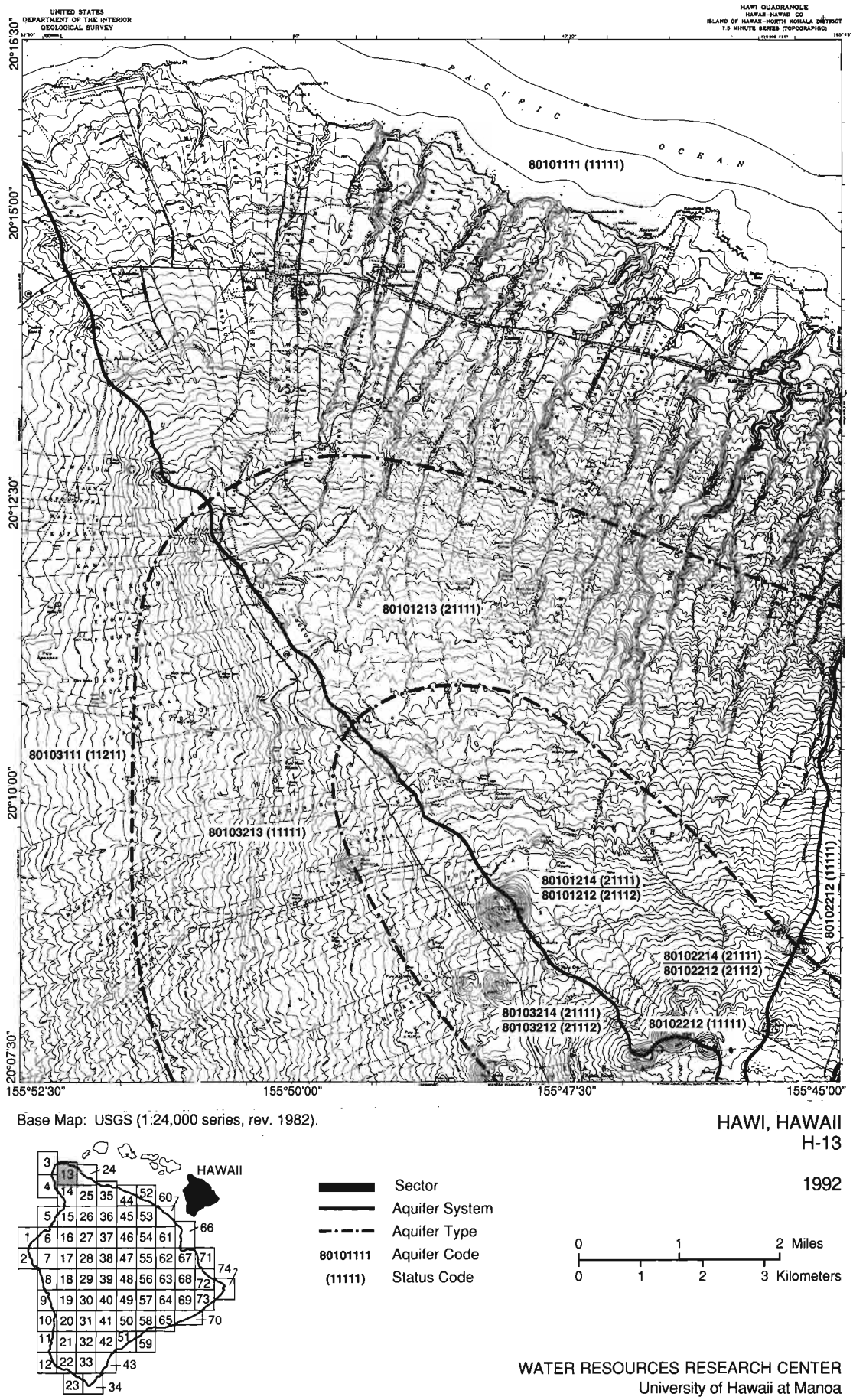
Appendix Figure A.1.10. Aquifer classification map, Kauluoa Point, Hawai'i



Appendix Figure A.1.11. Aquifer classification map, Milolii, Hawai'i



Appendix Figure A.1.12. Aquifer classification map, Manuka Bay, Hawai'i



Base Map: USGS (1:24,000 series, rev. 1982).

HAWI, HAWAII
H-13

1992

Sector
Aquifer System
Aquifer Type
80101111 Aquifer Code
(11111) Status Code

0 1 2 Miles
0 1 2 3 Kilometers

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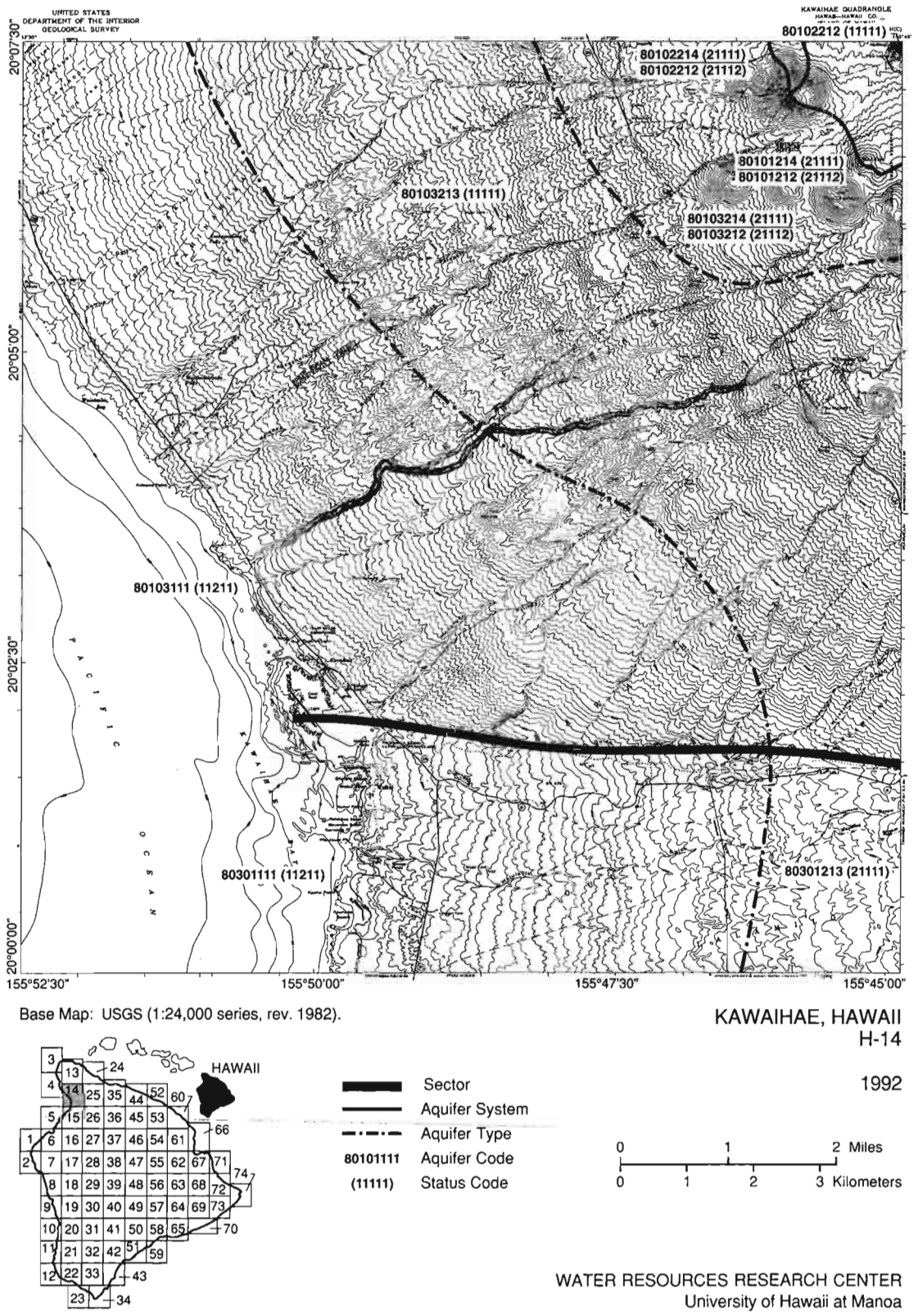
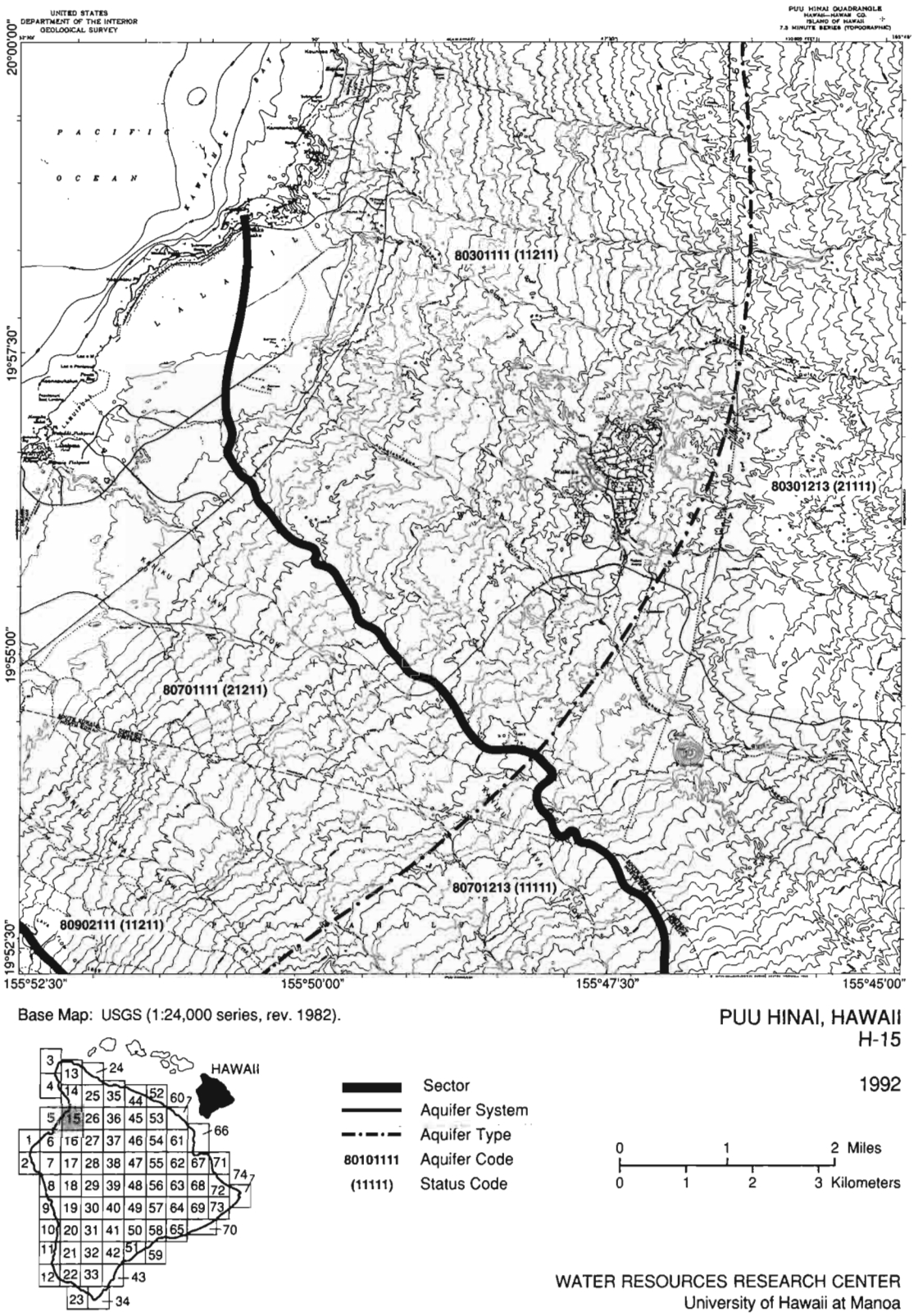
Appendix Figure A.1.13. Aquifer classification map, Hawi, Hawai'i



Appendix Figure A.1.14. Aquifer classification map, Kawaihae, Hawai'i



Base Map: USGS (1:24,000 series, rev. 1982).

PUU HINAI, HAWAII
H-15

1992

Sector
Aquifer System
Aquifer Type
80101111 Aquifer Code
(11111) Status Code

0 1 2 Miles
0 1 2 3 Kilometers

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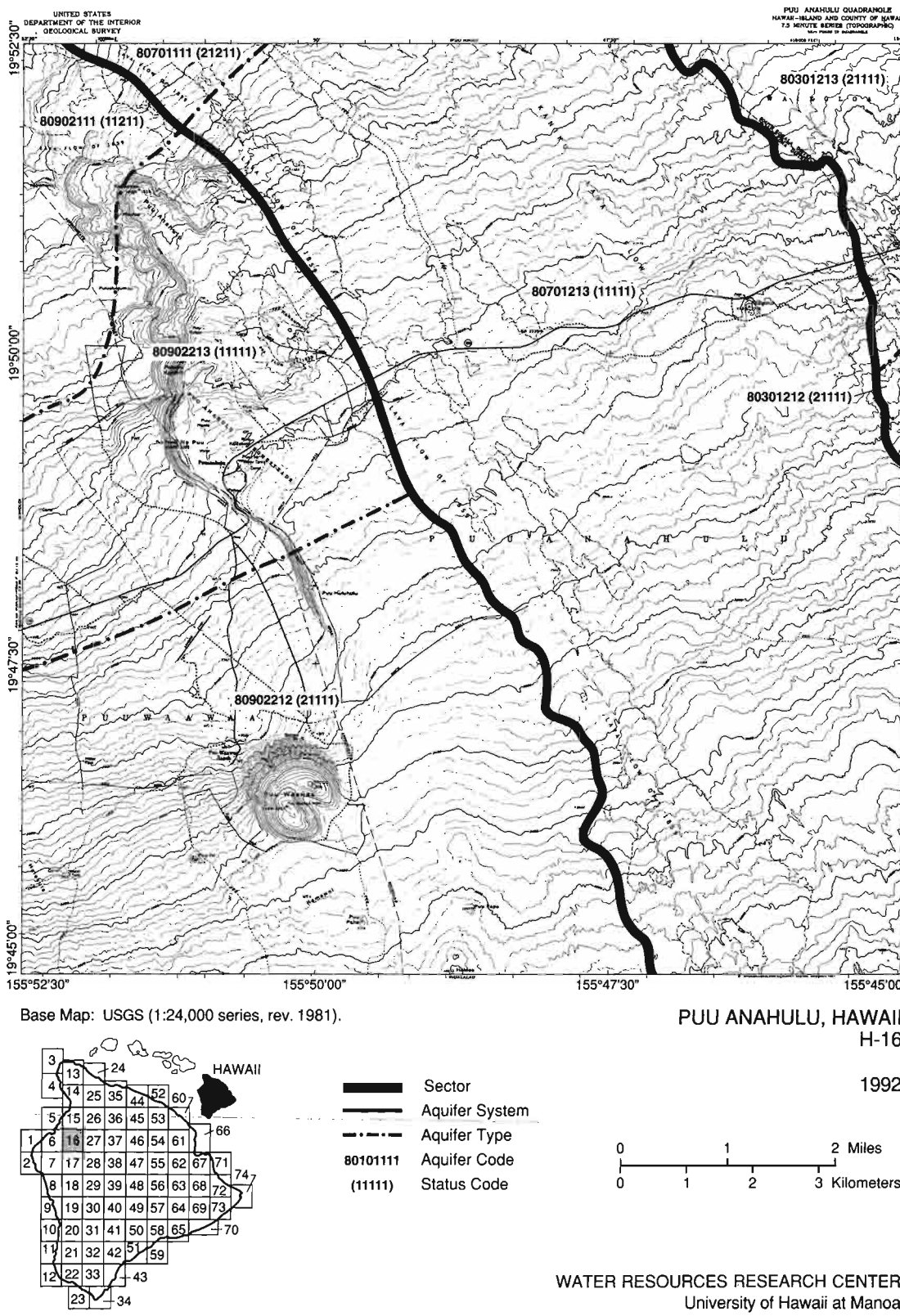
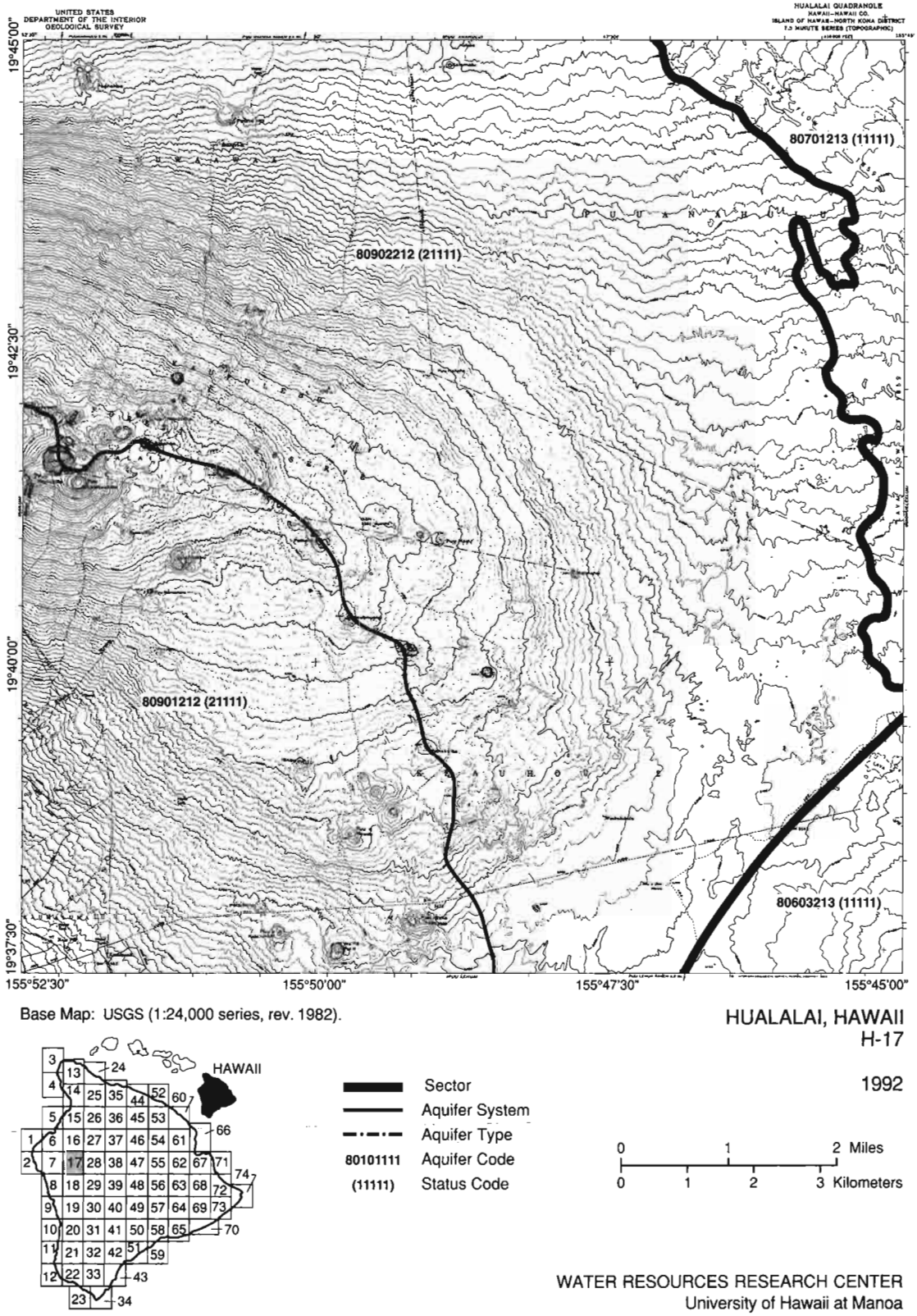
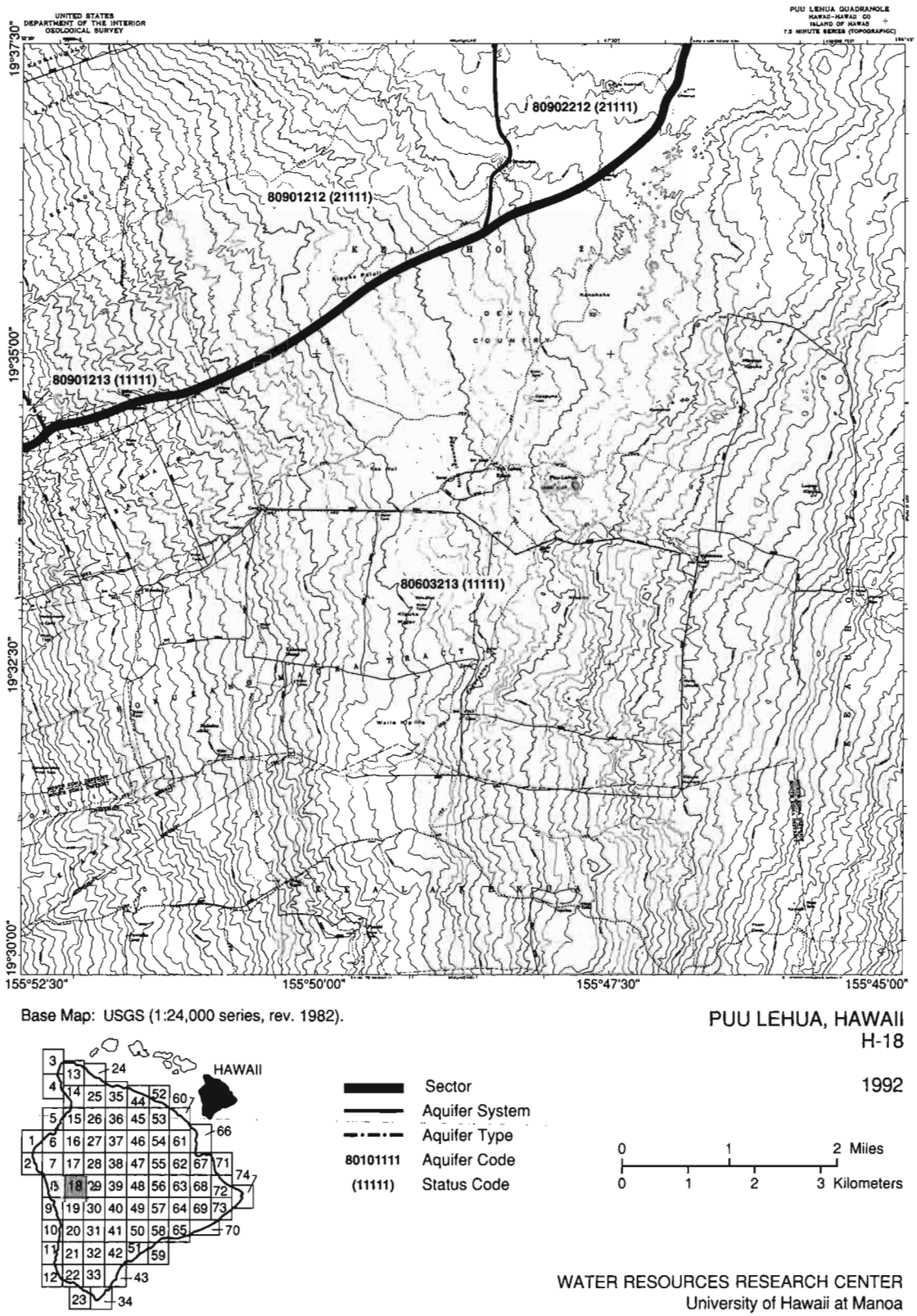
Appendix Figure A.1.15. Aquifer classification map, Puu Hinai, Hawai'i



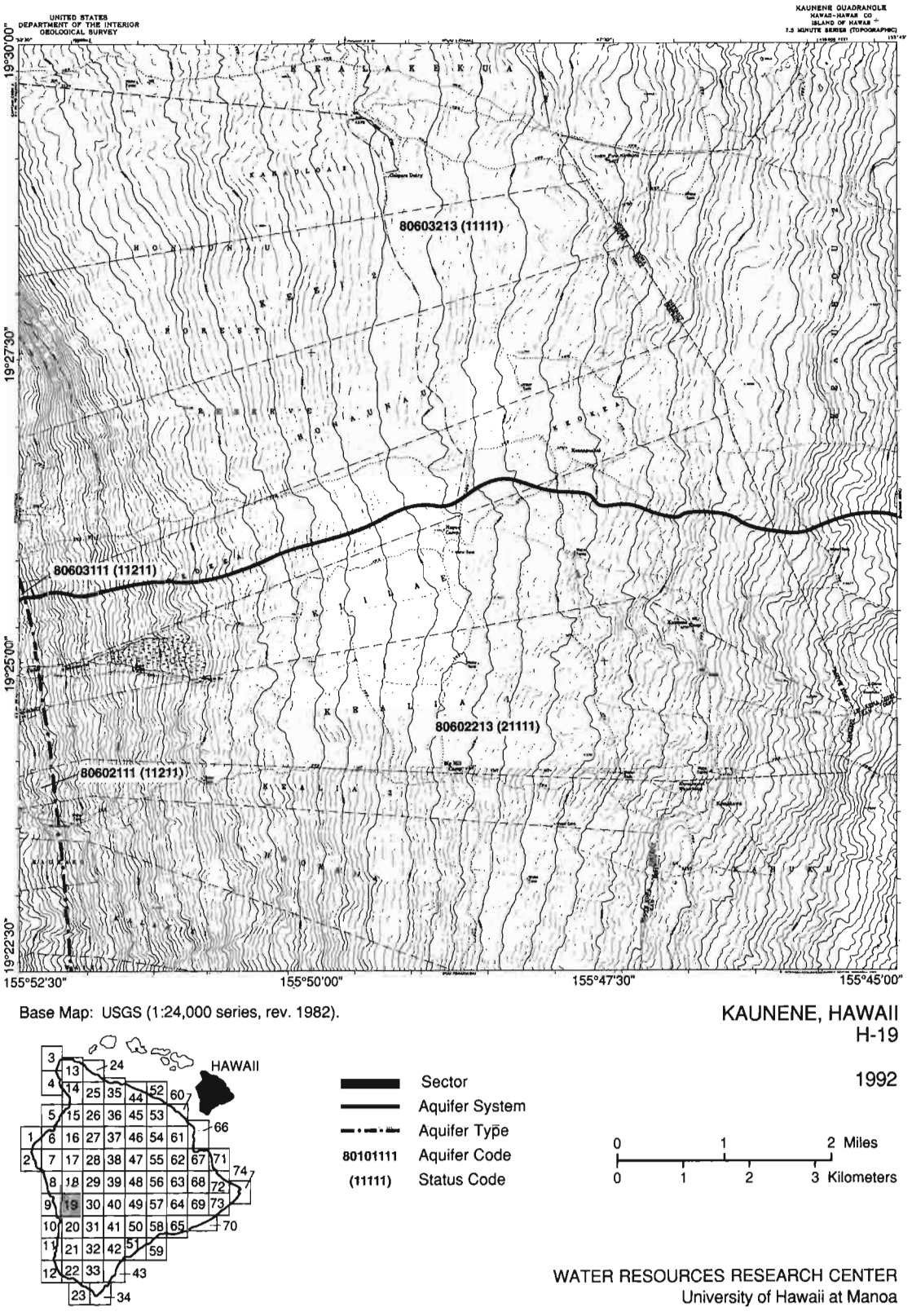
Appendix Figure A.1.16. Aquifer classification map, Puu Anahulu, Hawai'i



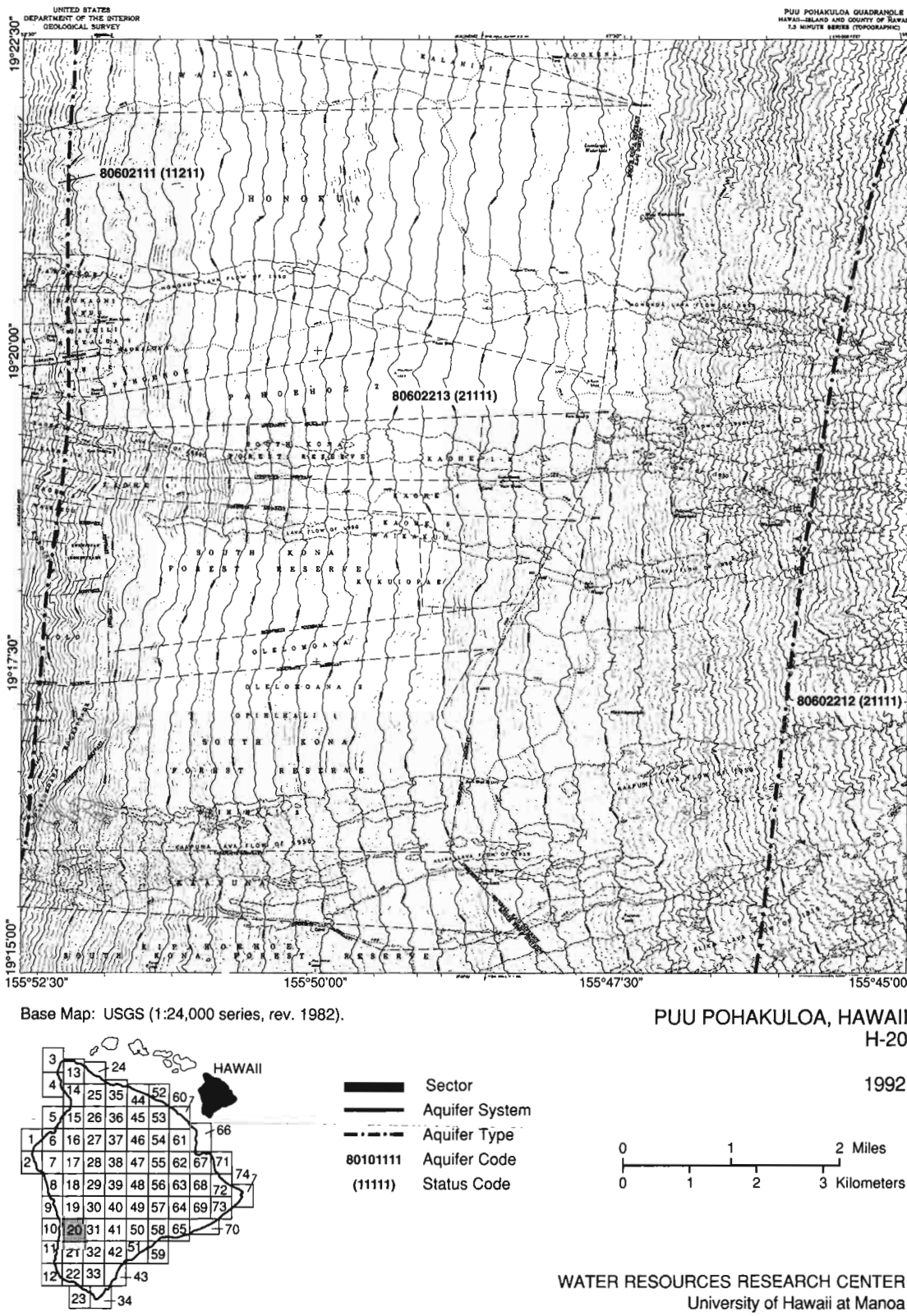
Appendix Figure A.1.17. Aquifer classification map, Hualalai, Hawai'i



Appendix Figure A.1.18. Aquifer classification map, Puu Lehua, Hawai'i



Appendix Figure A.1.19. Aquifer classification map, Kaunene, Hawai'i

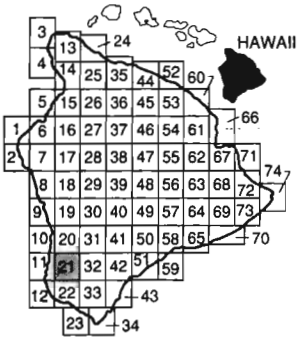


Appendix Figure A.1.20. Aquifer classification map, Puu Pohakuloa, Hawai'i

Base Map: USGS (1:24,000 series, rev. 1981).

PAPA, HAWAII
H-21

1992



Sector
Aquifer System
Aquifer Type
80101111 Aquifer Code
(11111) Status Code

0 1 2 Miles
0 1 2 3 Kilometers

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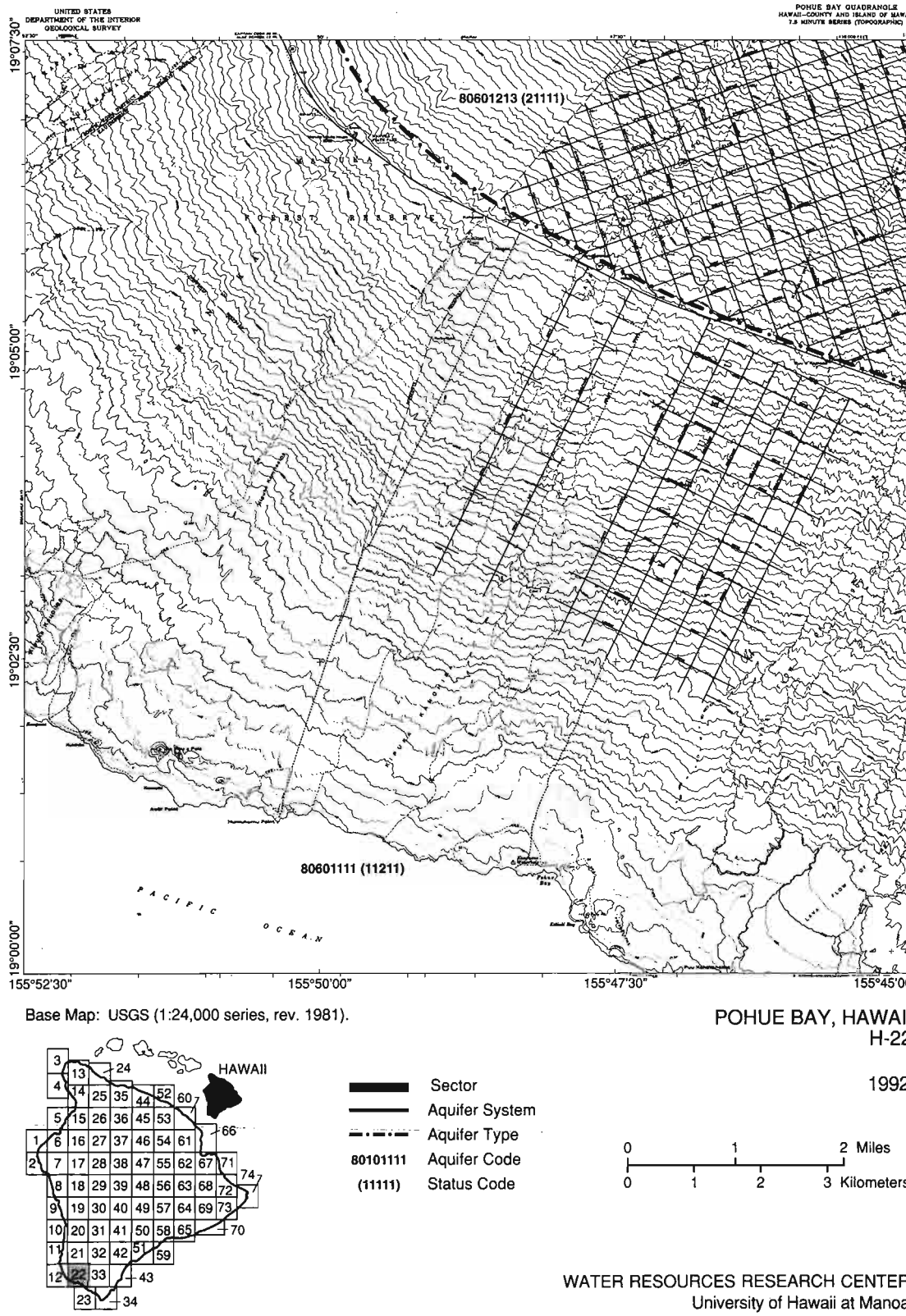
Appendix Figure A.1.21. Aquifer classification map, Papa, Hawai'i



Base Map: USGS (1:24,000 series, rev. 1981).

POHUE BAY, HAWAII
H-22

1992

Sector
Aquifer System
Aquifer Type
80101111 Aquifer Code
(11111) Status Code

0 1 2 Miles
0 1 2 3 Kilometers

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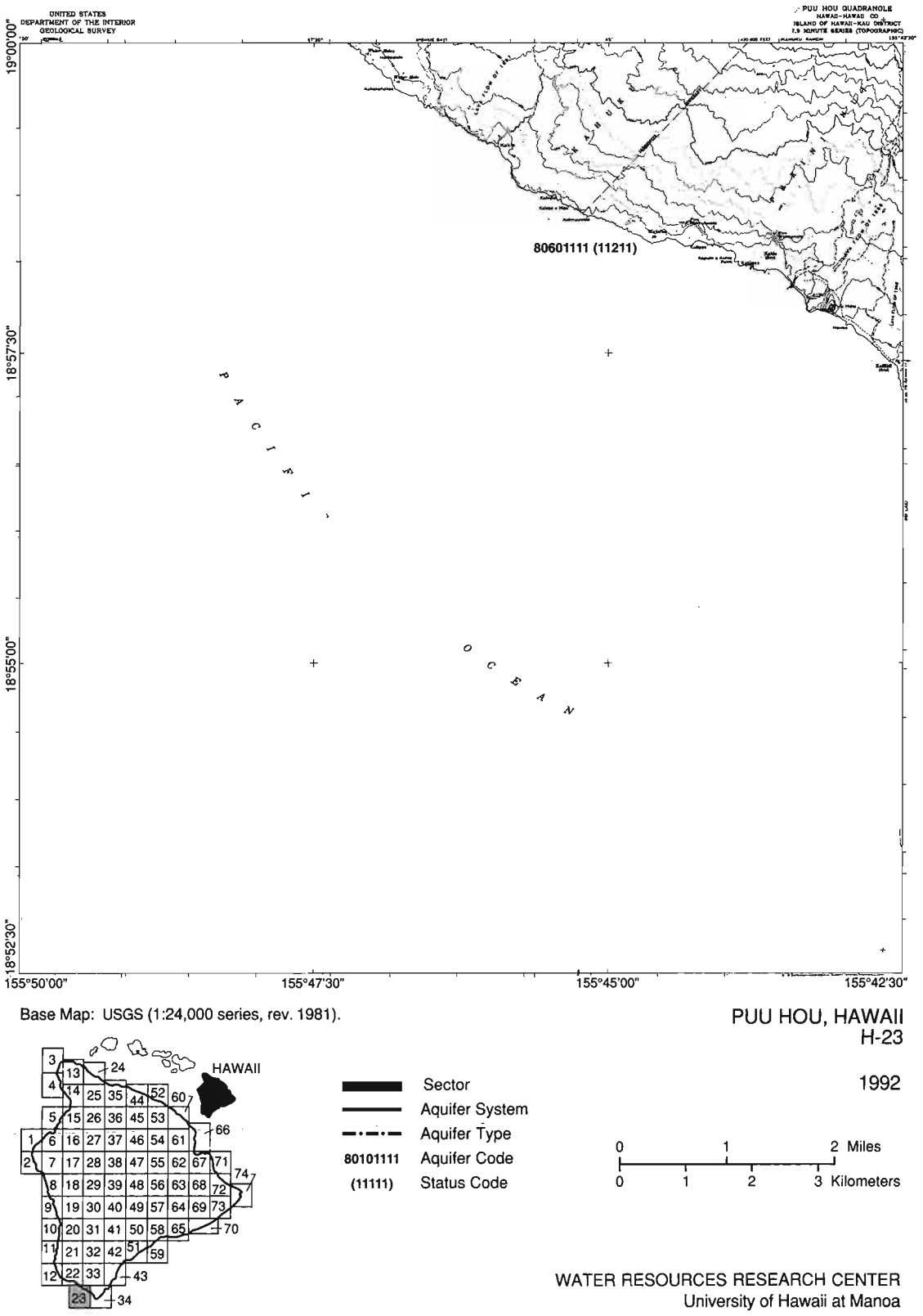
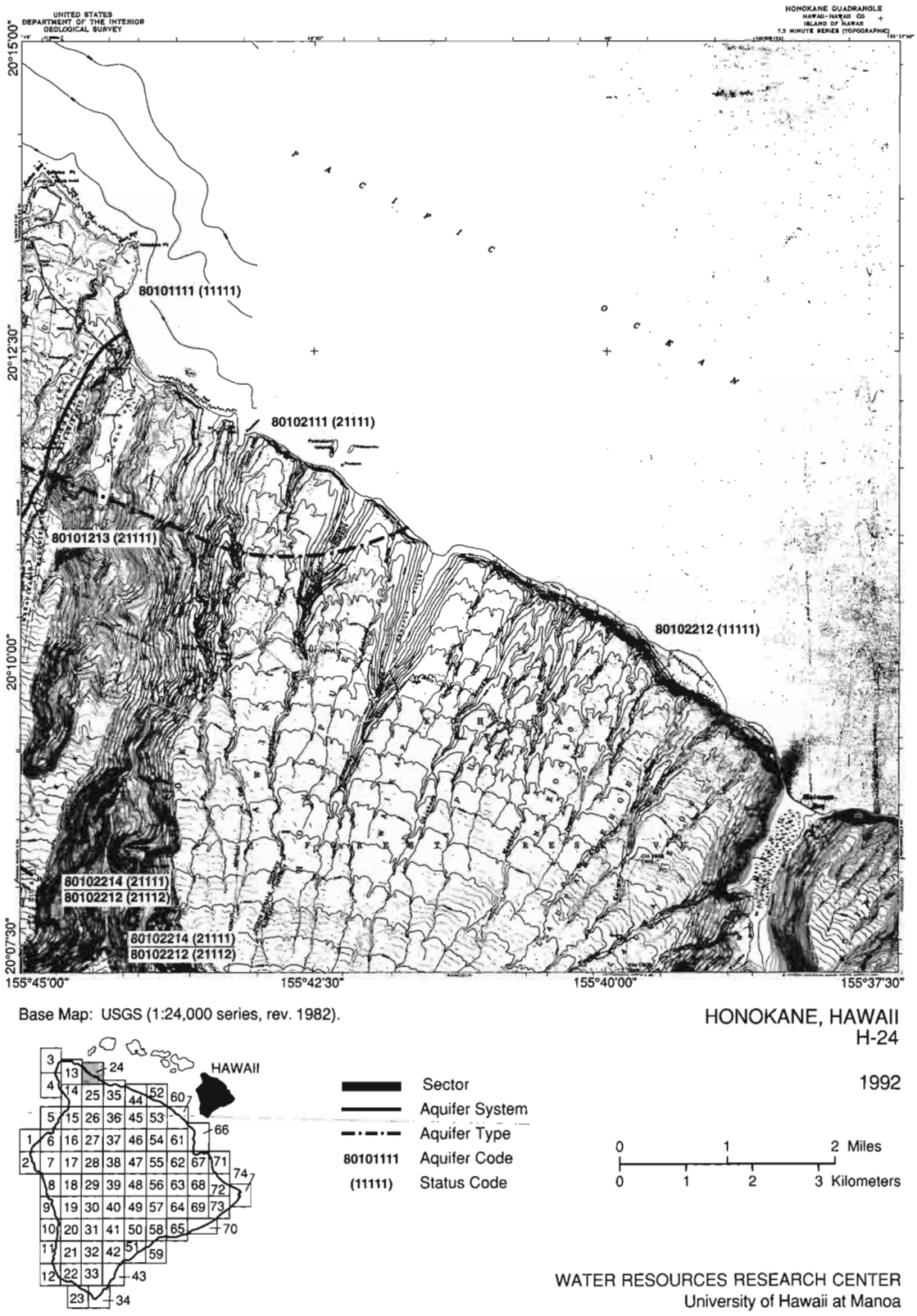
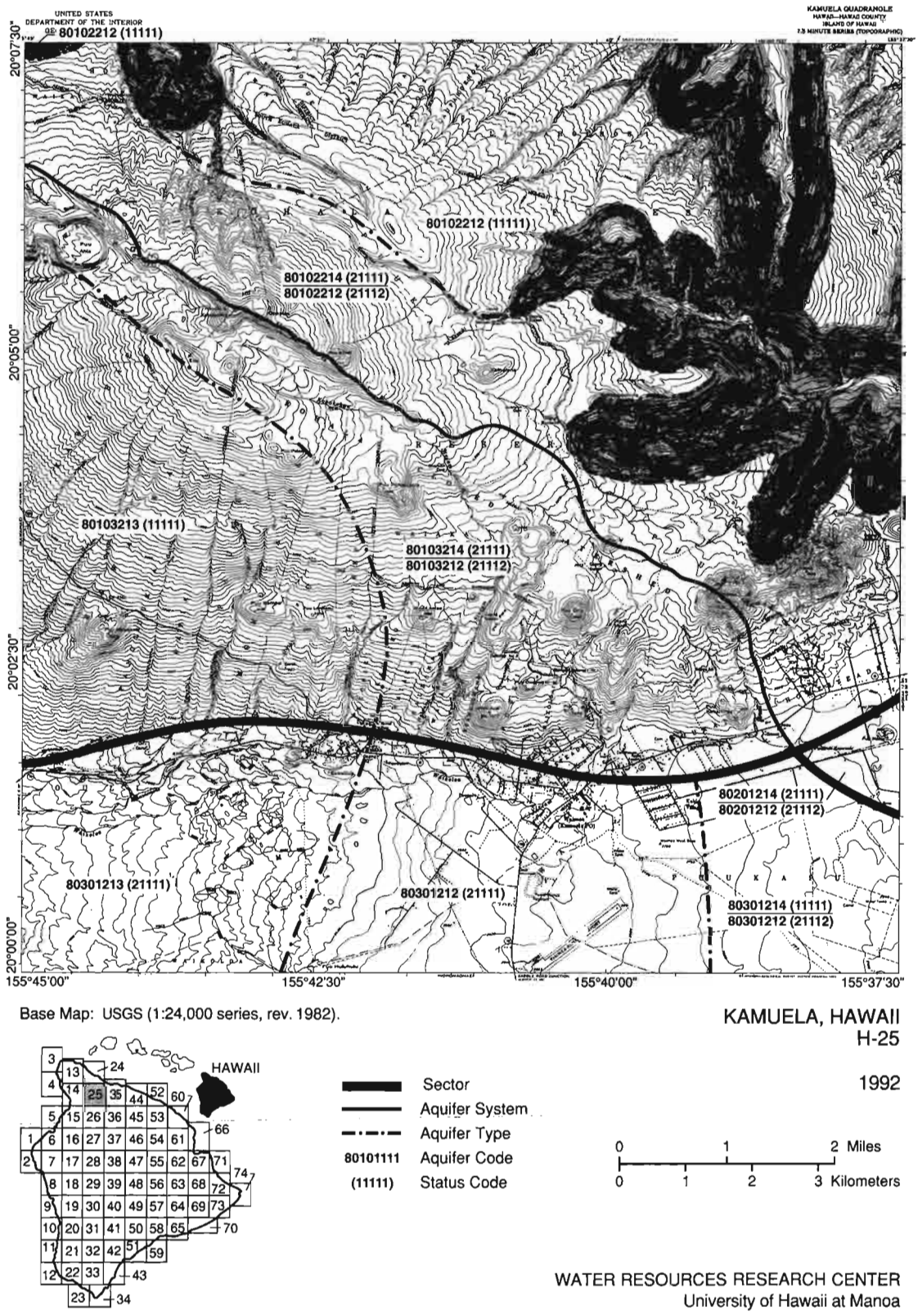
Appendix Figure A.1.22. Aquifer classification map, Pohue Bay, Hawai'i



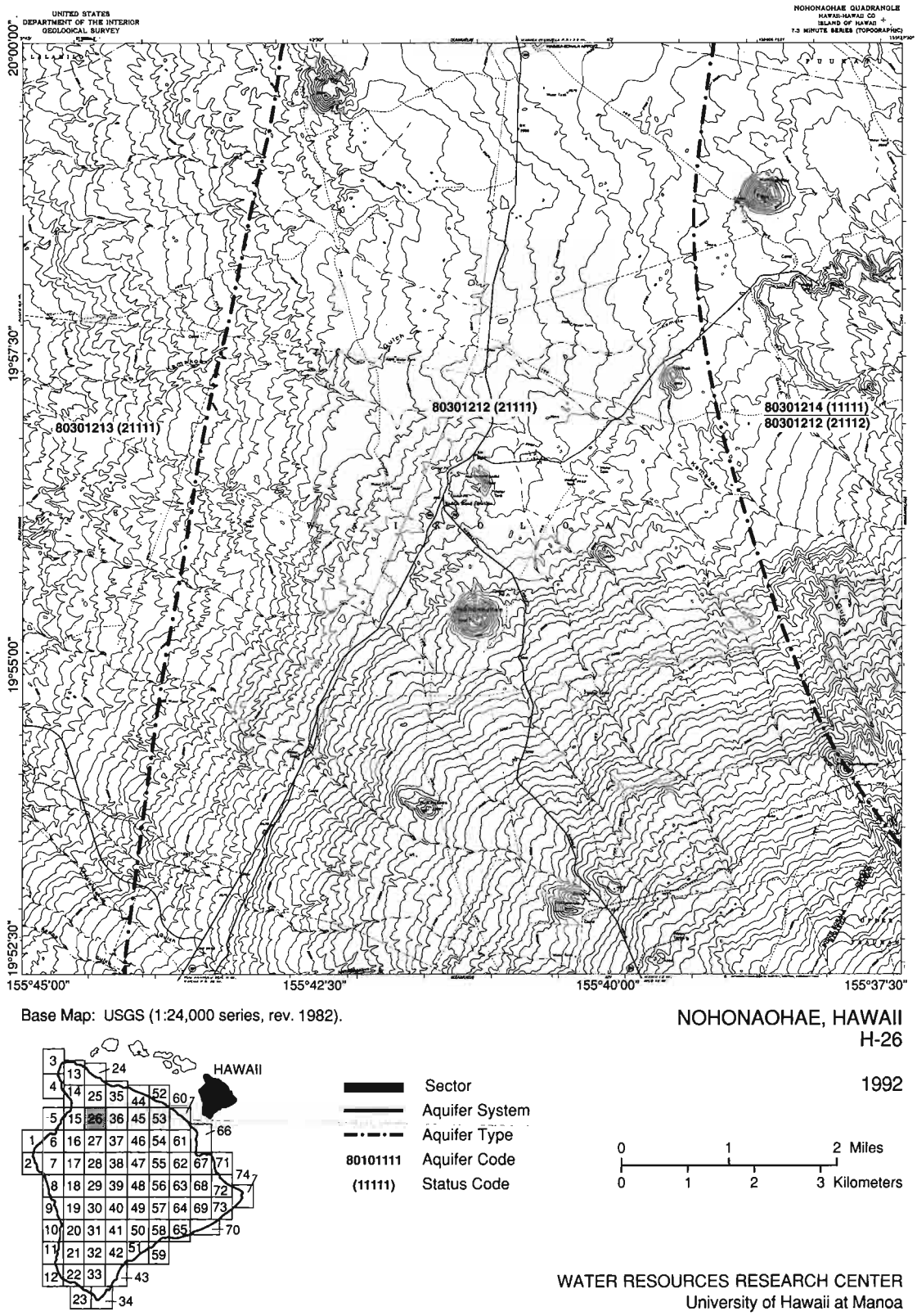
Appendix Figure A.1.23. Aquifer classification map, Puu Hou, Hawai'i



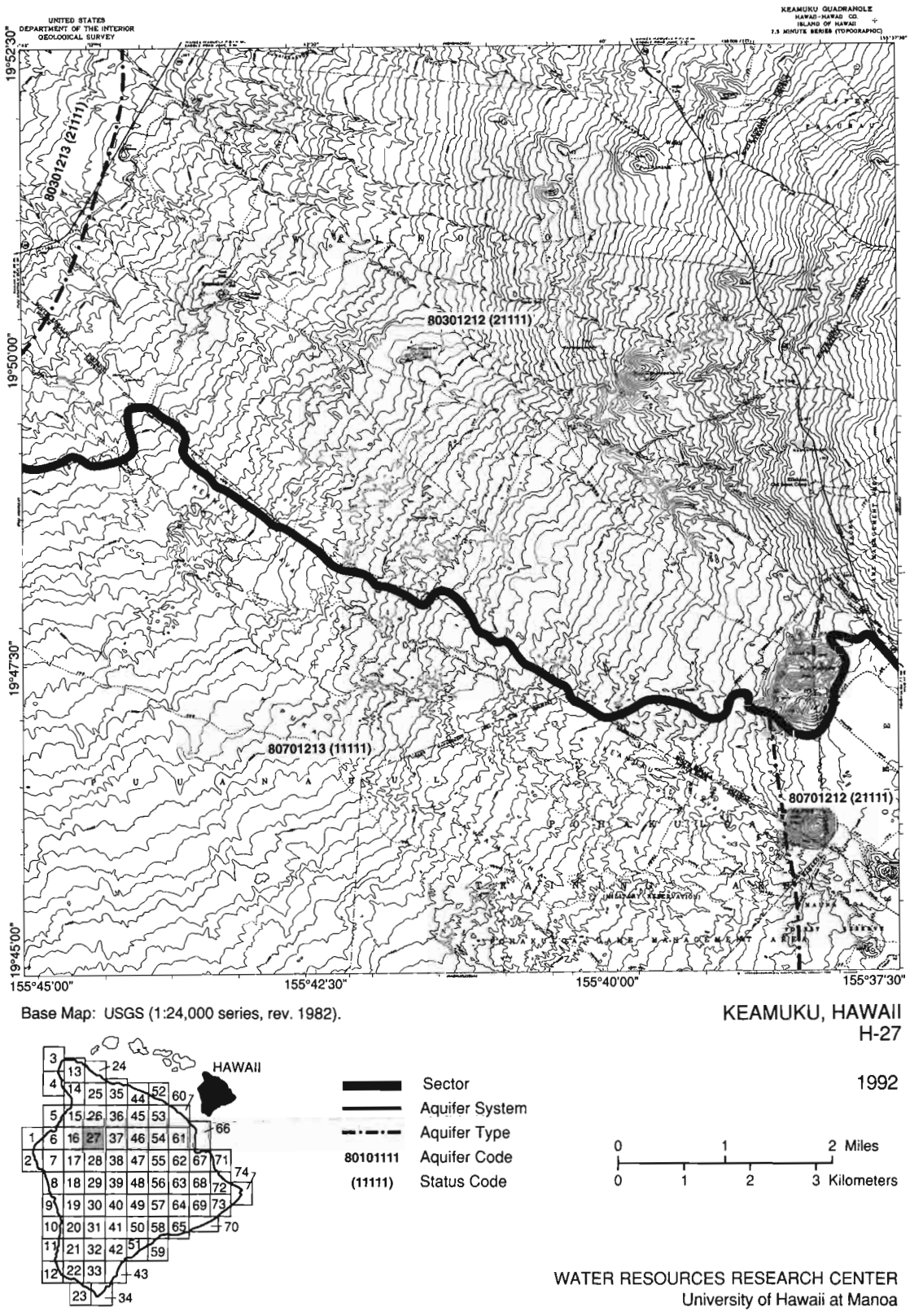
Appendix Figure A.1.24. Aquifer classification map, Honokane, Hawai'i



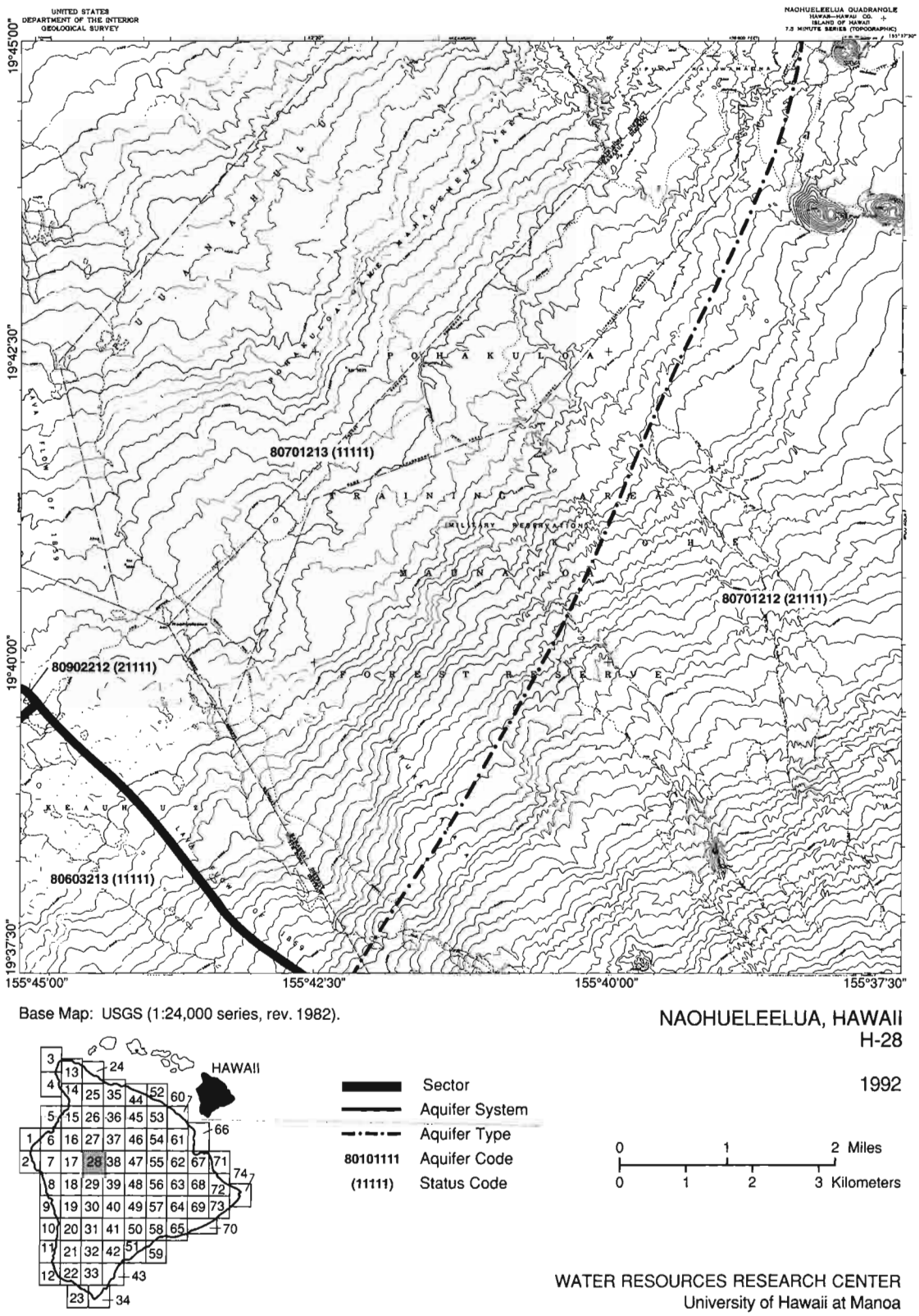
Appendix Figure A.1.25. Aquifer classification map, Kamuela, Hawai'i



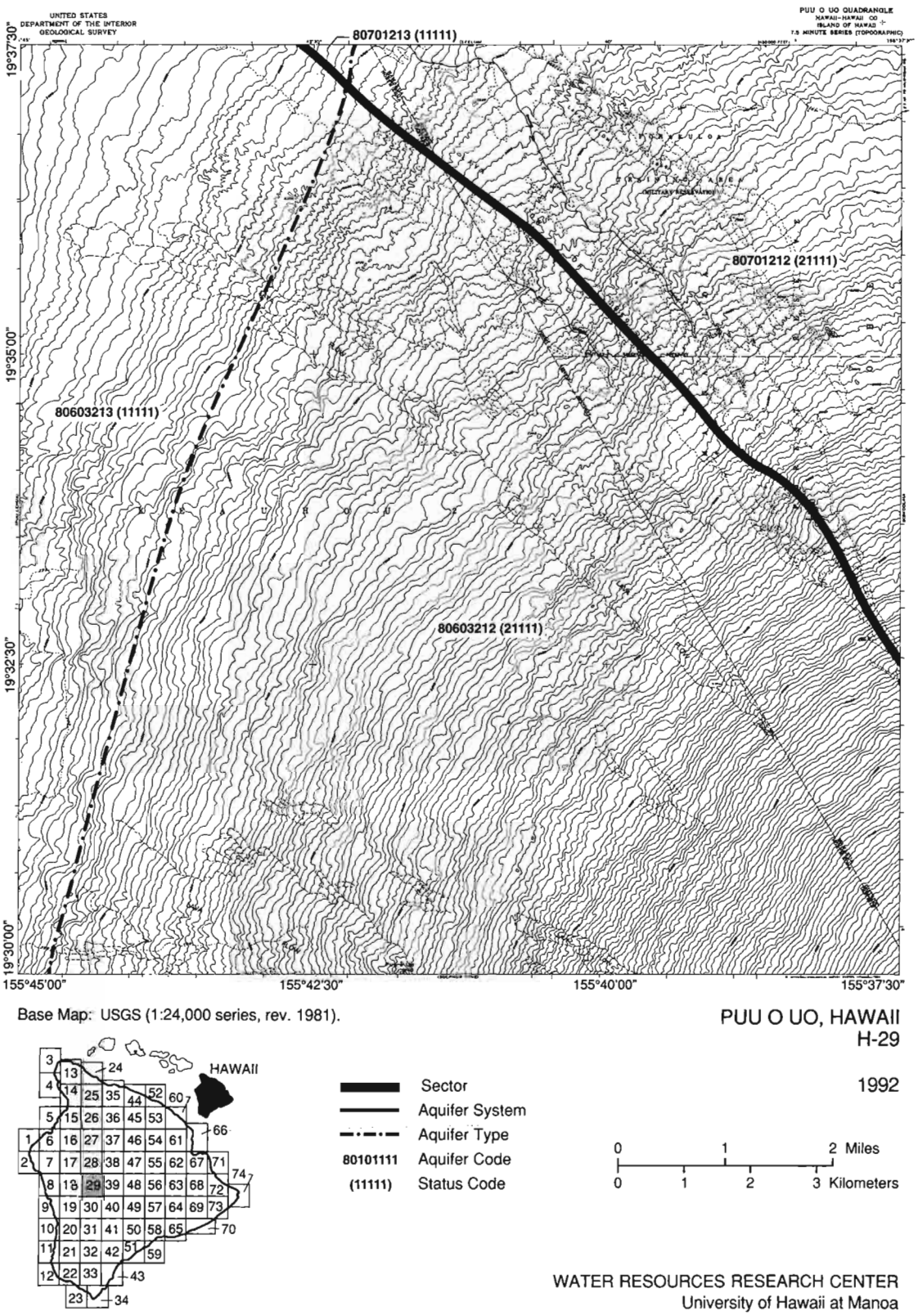
Appendix Figure A.1.26. Aquifer classification map, Nohona o Hae, Hawai'i



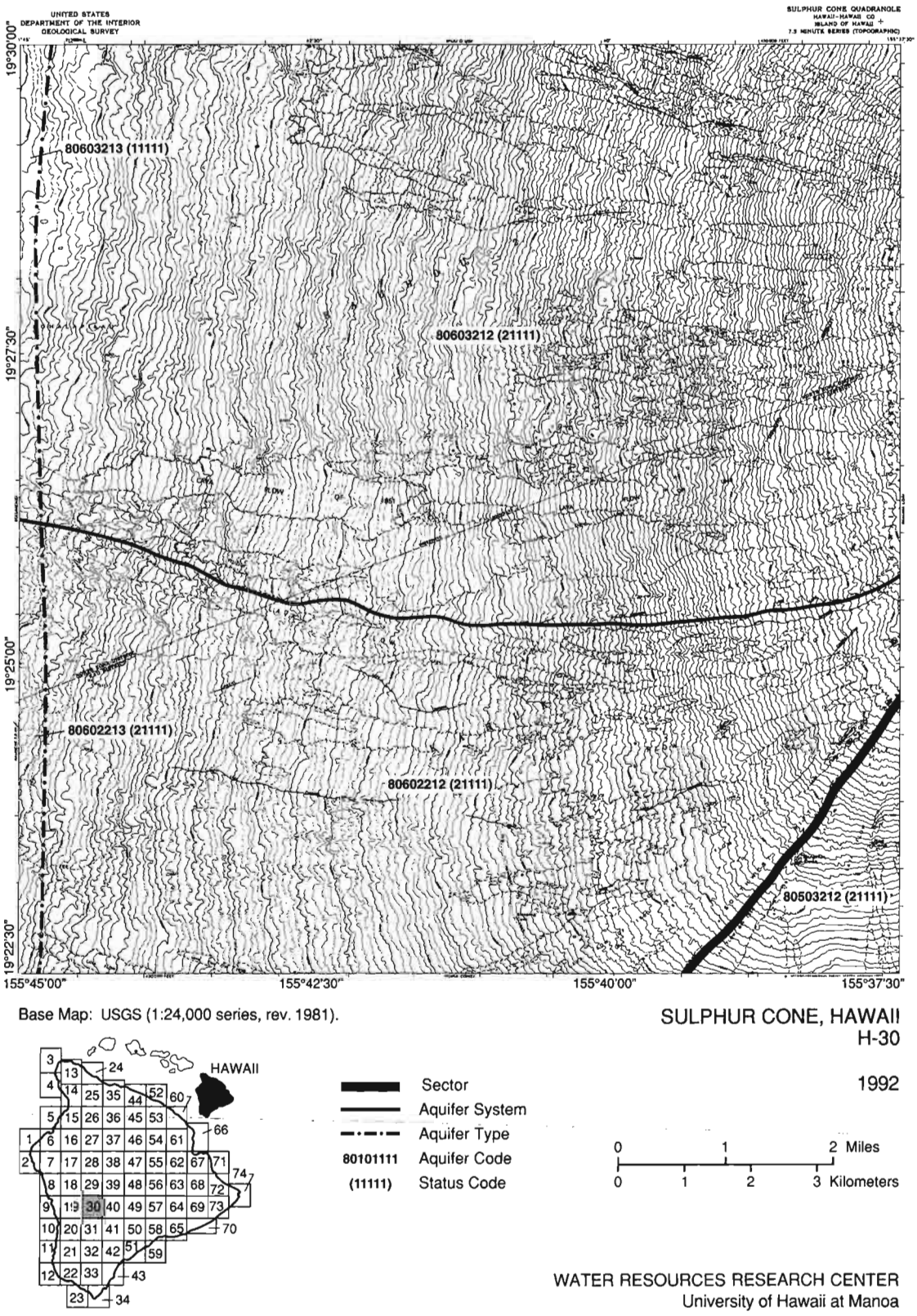
Appendix Figure A.1.27. Aquifer classification map, Keamuku, Hawai'i



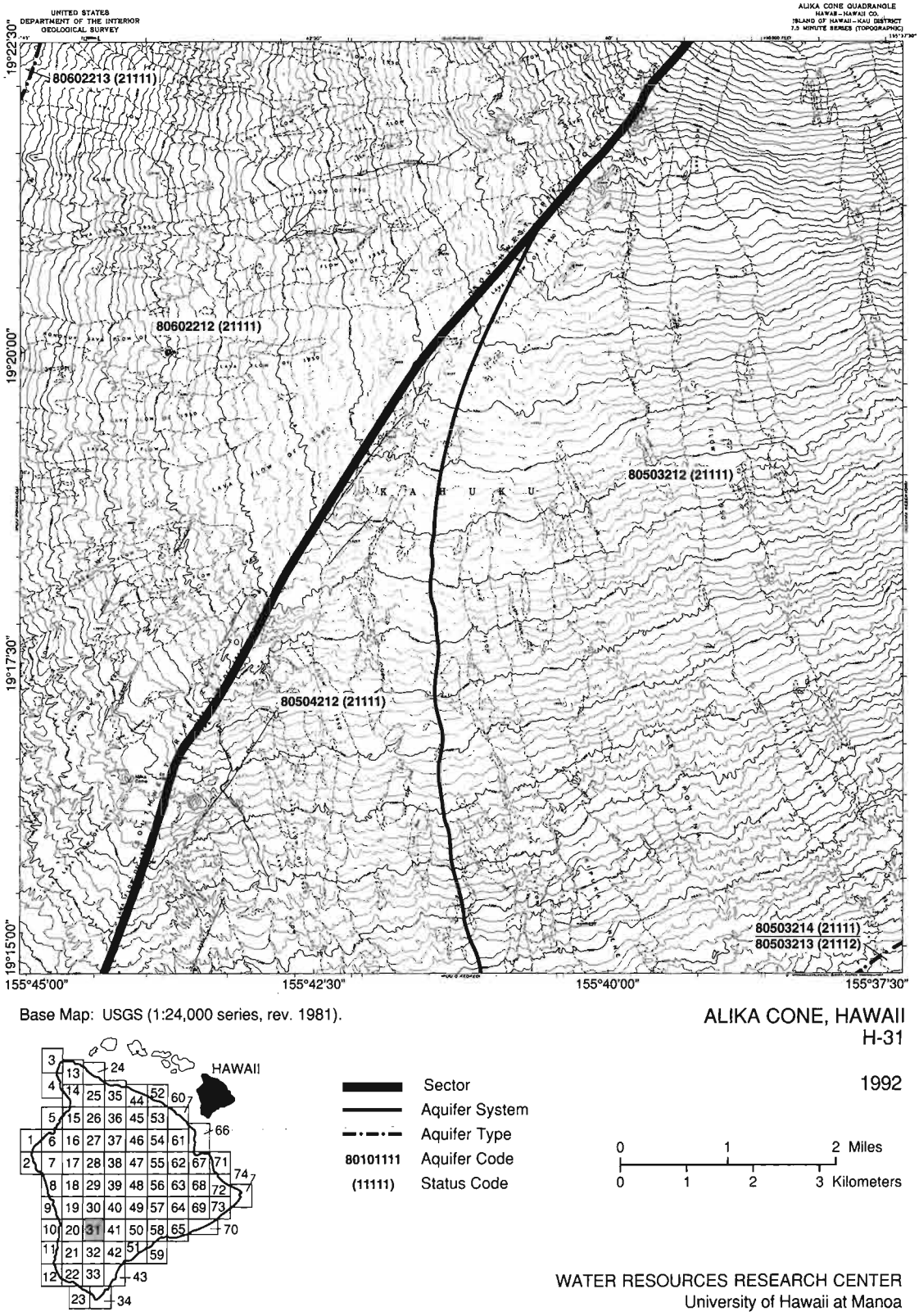
Appendix Figure A.1.28. Aquifer classification map, Naohueleelua, Hawai'i



Appendix Figure A.1.29. Aquifer classification map, Puu o Uo, Hawai'i



Appendix Figure A.1.30. Aquifer classification map, Sulphur Cone, Hawai'i



Base Map: USGS (1:24,000 series, rev. 1981).

ALIKA CONE, HAWAII
H-31

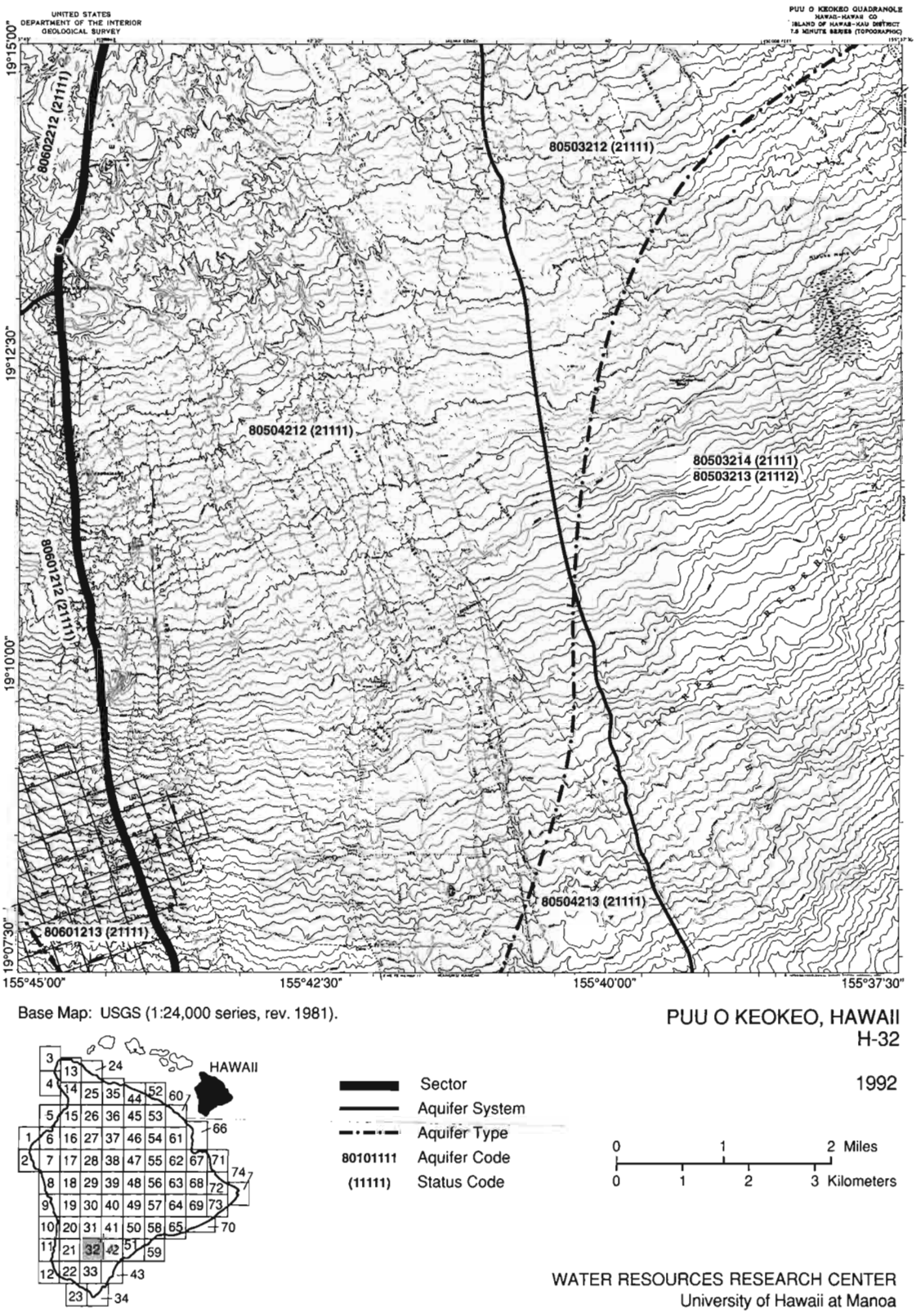
1992

Sector
Aquifer System
Aquifer Type
80101111 Aquifer Code
(11111) Status Code

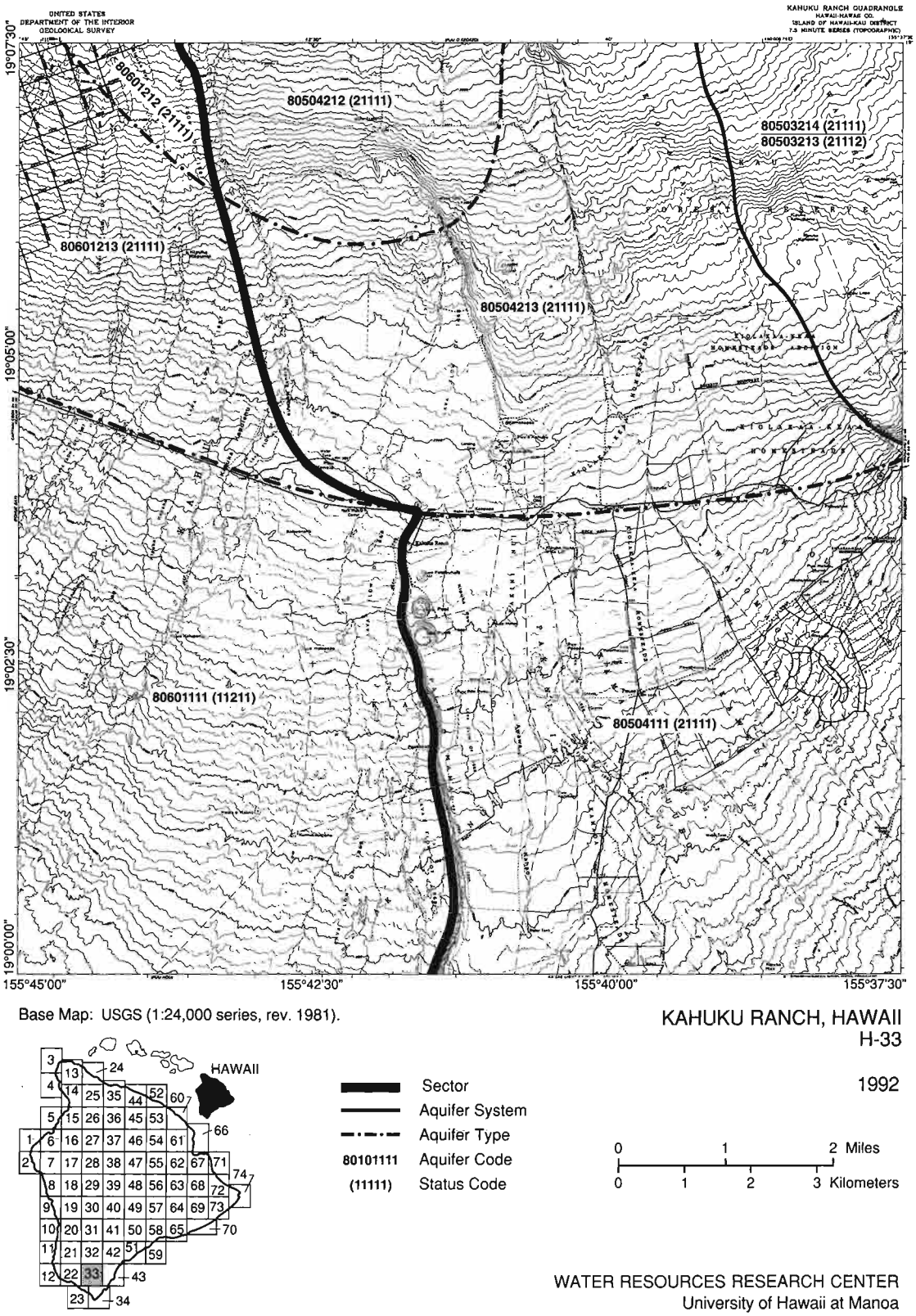
0 1 2 Miles
0 1 2 3 Kilometers

WATER RESOURCES RESEARCH CENTER
University of Hawaii at Manoa

Appendix Figure A.1.31. Aquifer classification map, Alika Cone, Hawai'i



Appendix Figure A.1.32. Aquifer classification map, Puu o Keokeo, Hawai'i



Base Map: USGS (1:24,000 series, rev. 1981).

KAHUKU RANCH, HAWAII
H-33

1992

Sector
Aquifer System
Aquifer Type
80101111 Aquifer Code
(11111) Status Code

0 1 2 Miles
0 1 2 3 Kilometers

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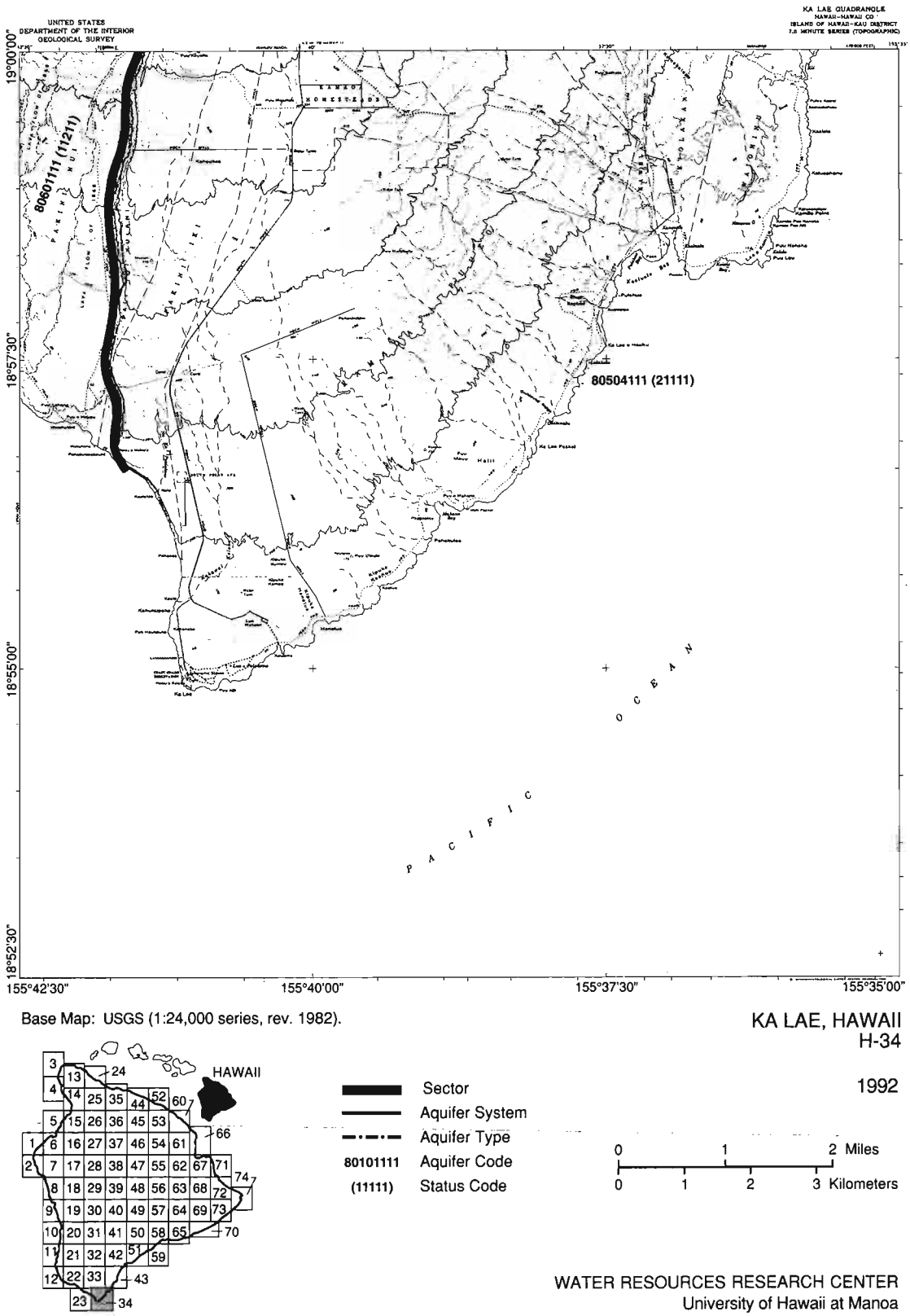
University of Hawaii at Manoa

Appendix Figure A.1.33. Aquifer classification map, Kahuku Ranch, Hawai'i

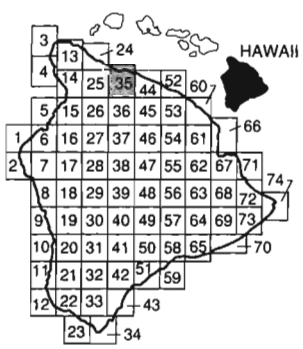


Appendix Figure A.1.34. Aquifer classification map, Ka Lae, Hawai'i

Base Map: USGS (1:24,000 series, rev. 1982).

KUKUIHAELE, HAWAII
H-35

1992



Sector
Aquifer System
Aquifer Type
80101111 Aquifer Code
(11111) Status Code

0 1 2 Miles
0 1 2 3 Kilometers

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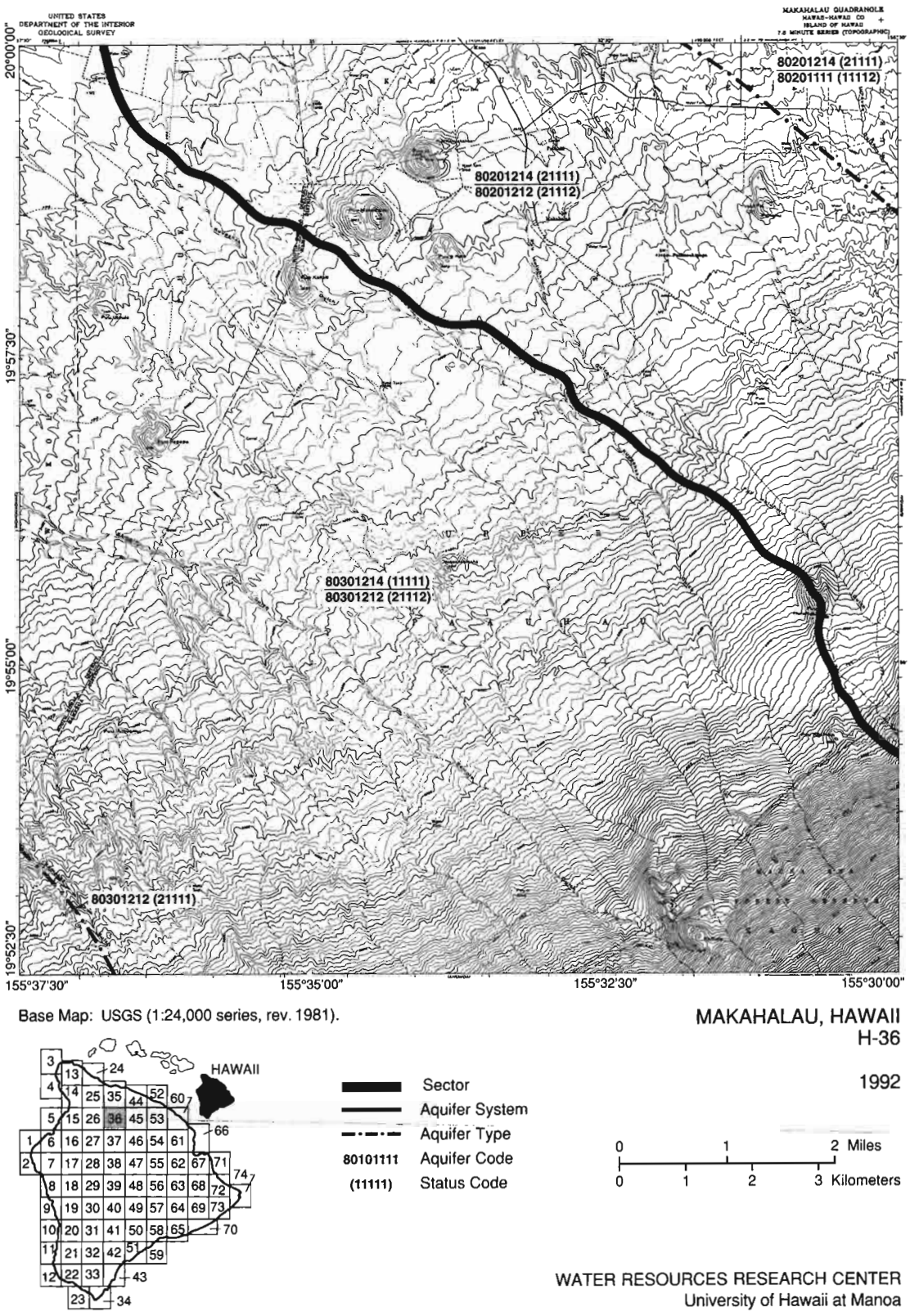
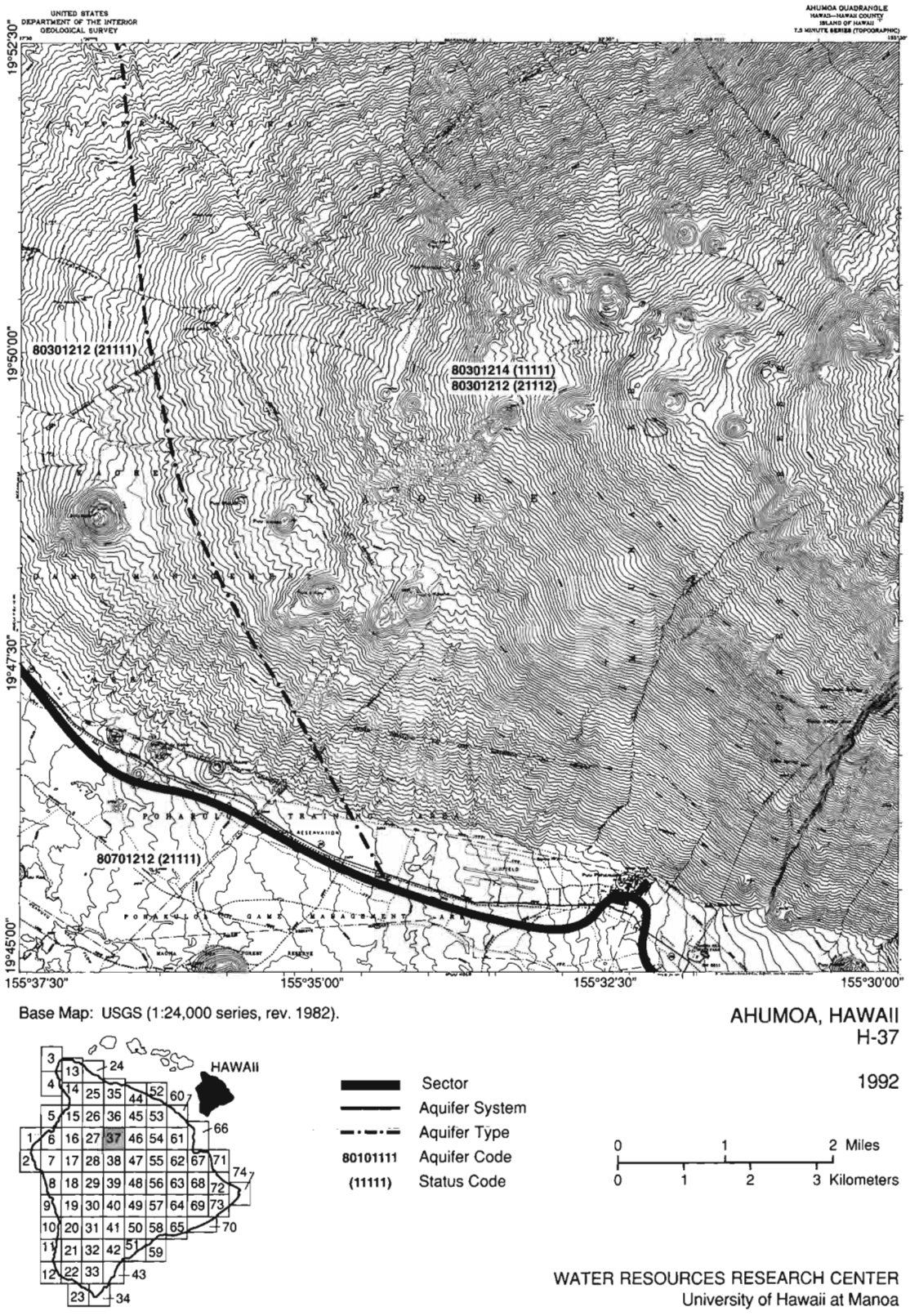
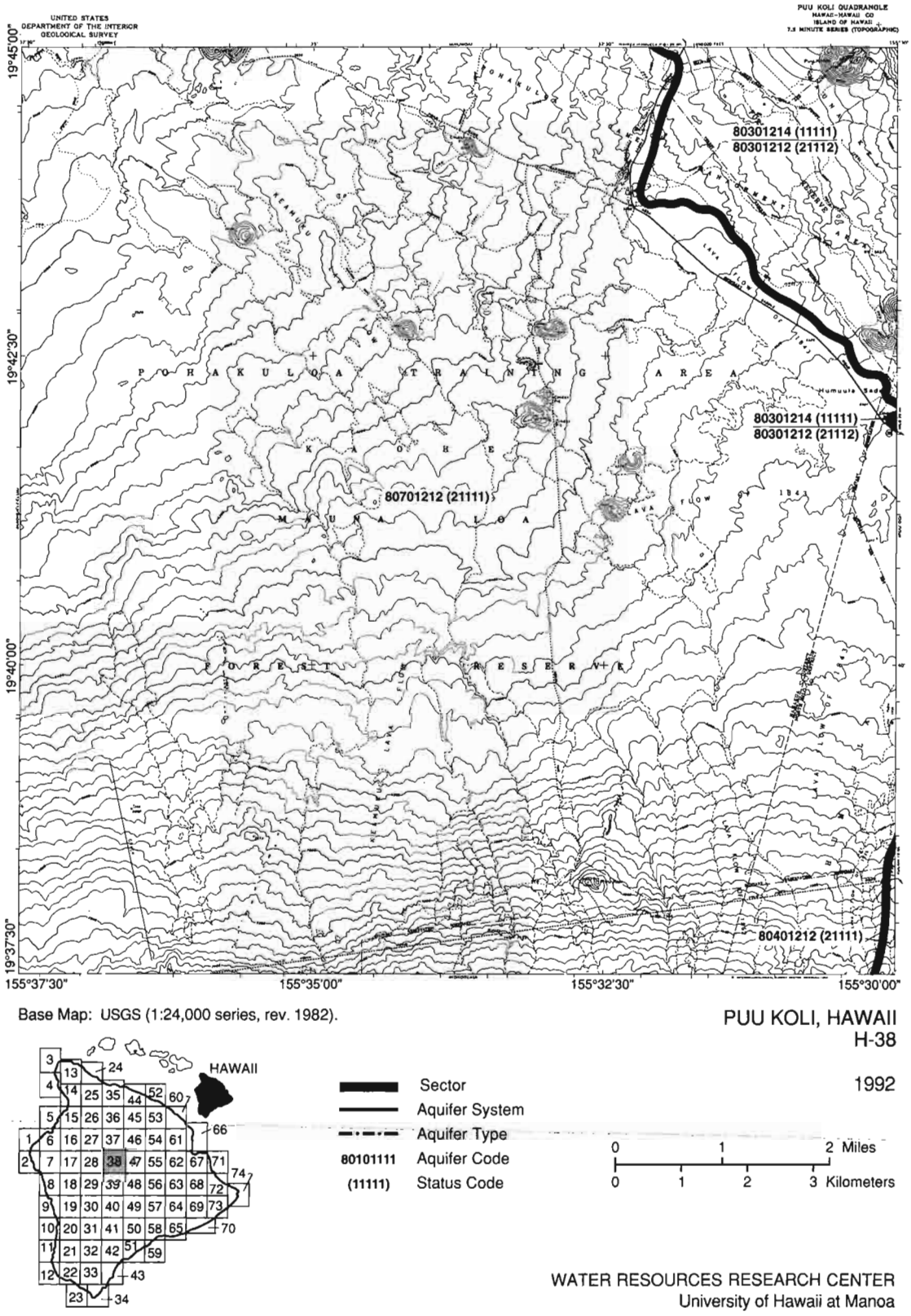
Appendix Figure A.1.35. Aquifer classification map, Kukuihaele, Hawai'i



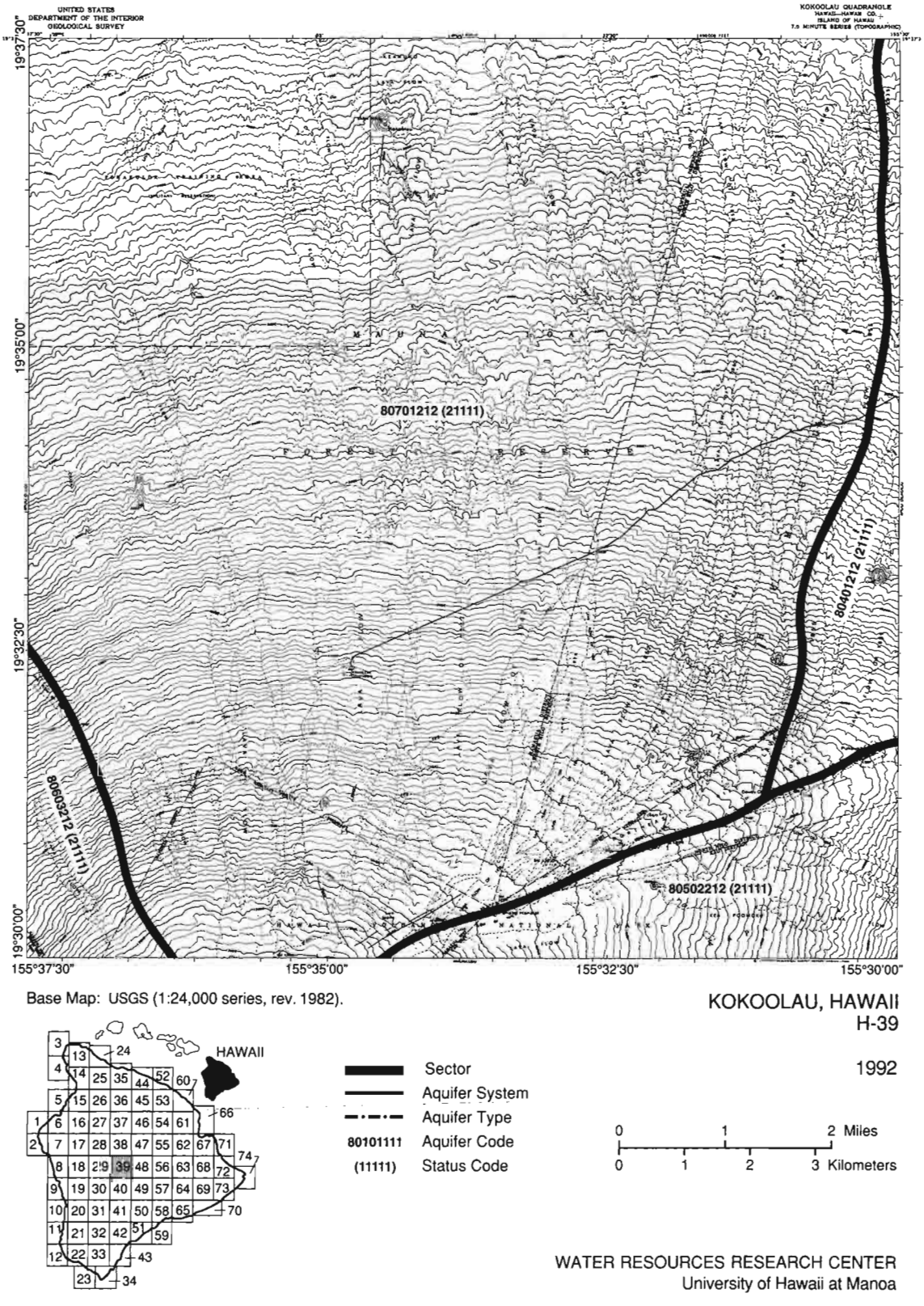
Appendix Figure A.1.36. Aquifer classification map, Makahalau, Hawai'i



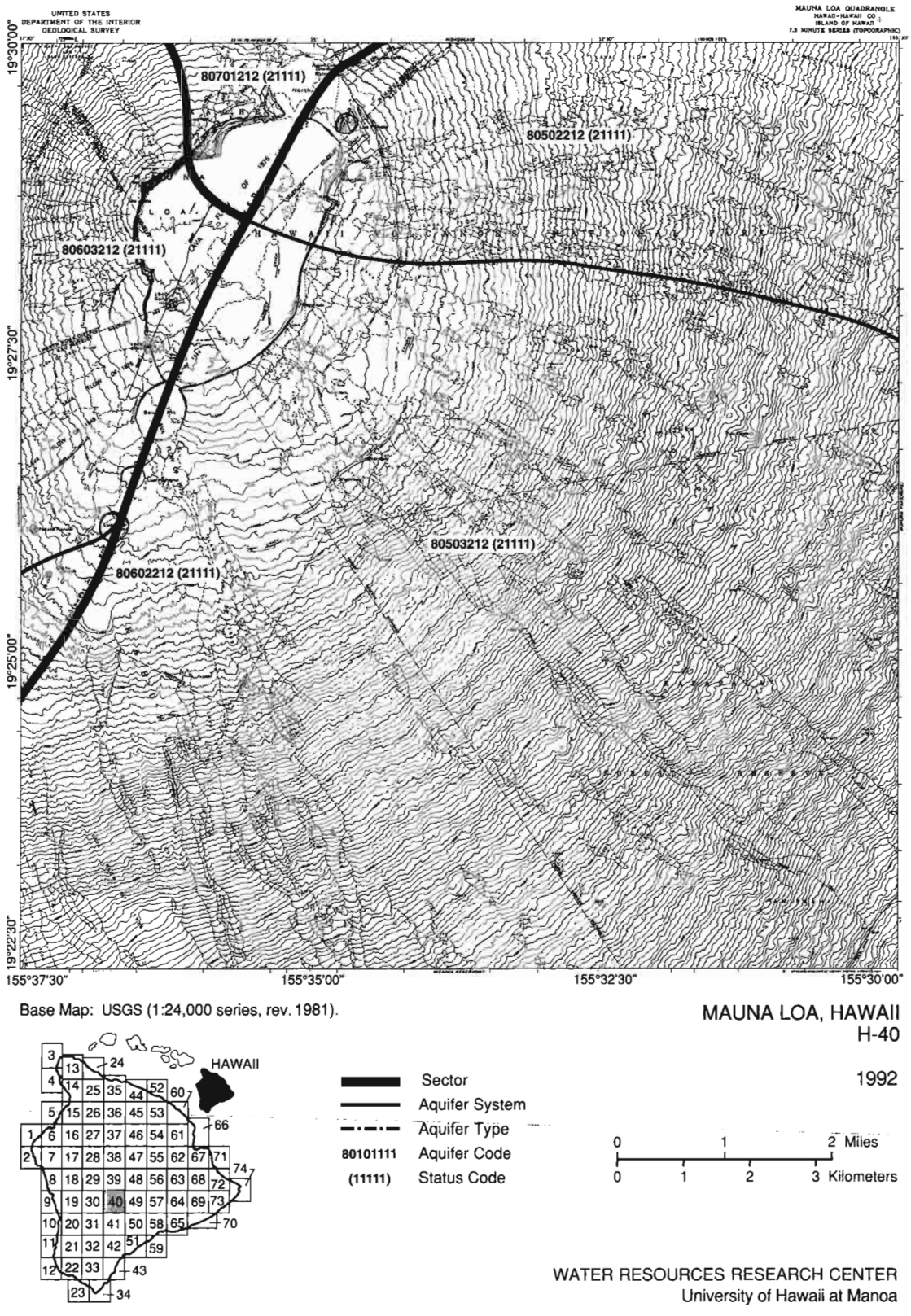
Appendix Figure A.1.37. Aquifer classification map, Ahumoa, Hawai'i



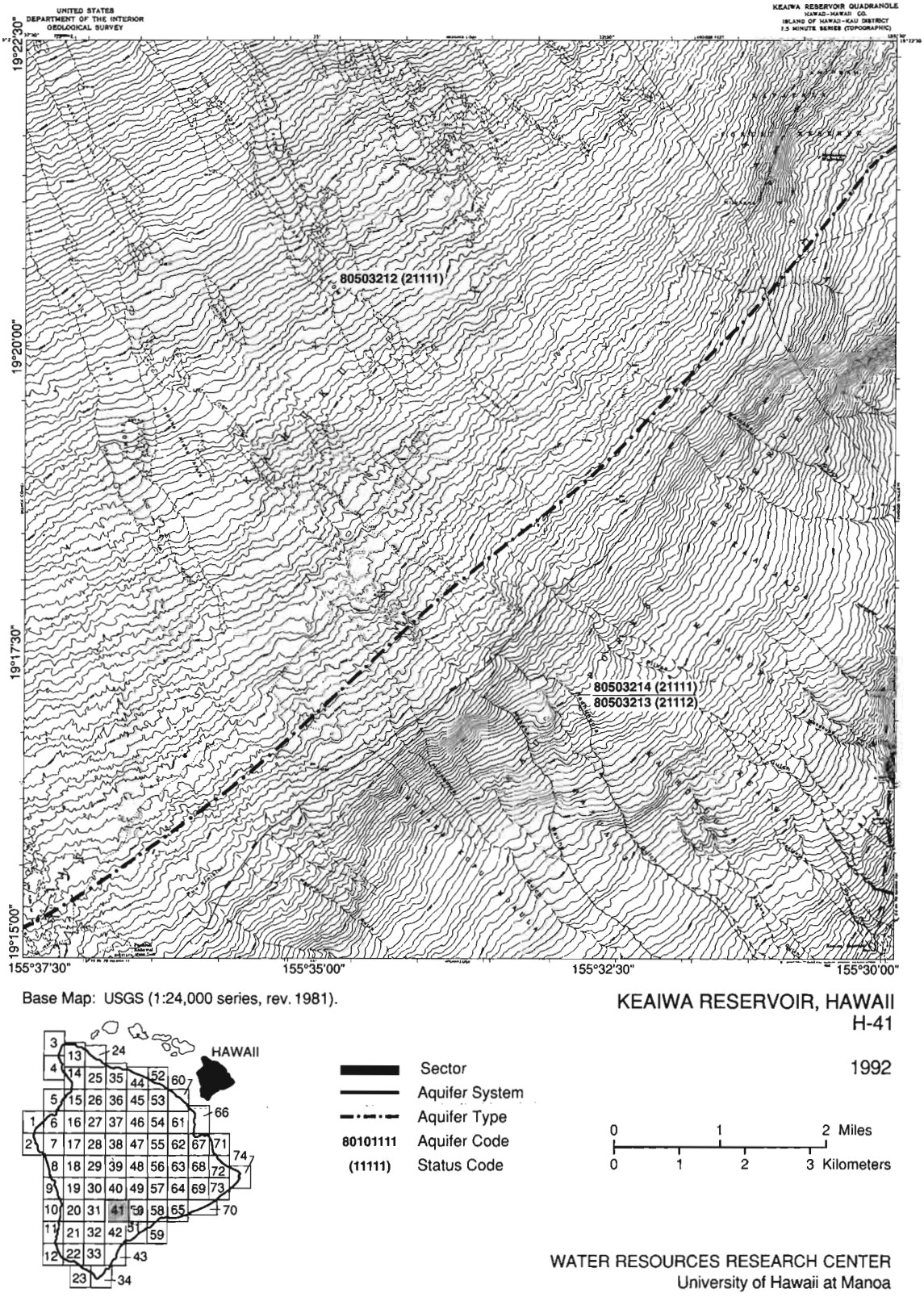
Appendix Figure A.1.38. Aquifer classification map, Puu Koli, Hawai'i



Appendix Figure A.1.39. Aquifer classification map, Kookoolau, Hawai'i



Appendix Figure A.1.40. Aquifer classification map, Mauna Loa, Hawai'i



Base Map: USGS (1:24,000 series, rev. 1981).

Sector
Aquifer System
Aquifer Type
80101111 Aquifer Code
(11111) Status Code

KEAIWA RESERVOIR, HAWAII
H-41

1992

0 1 2 Miles
0 1 2 3 Kilometers

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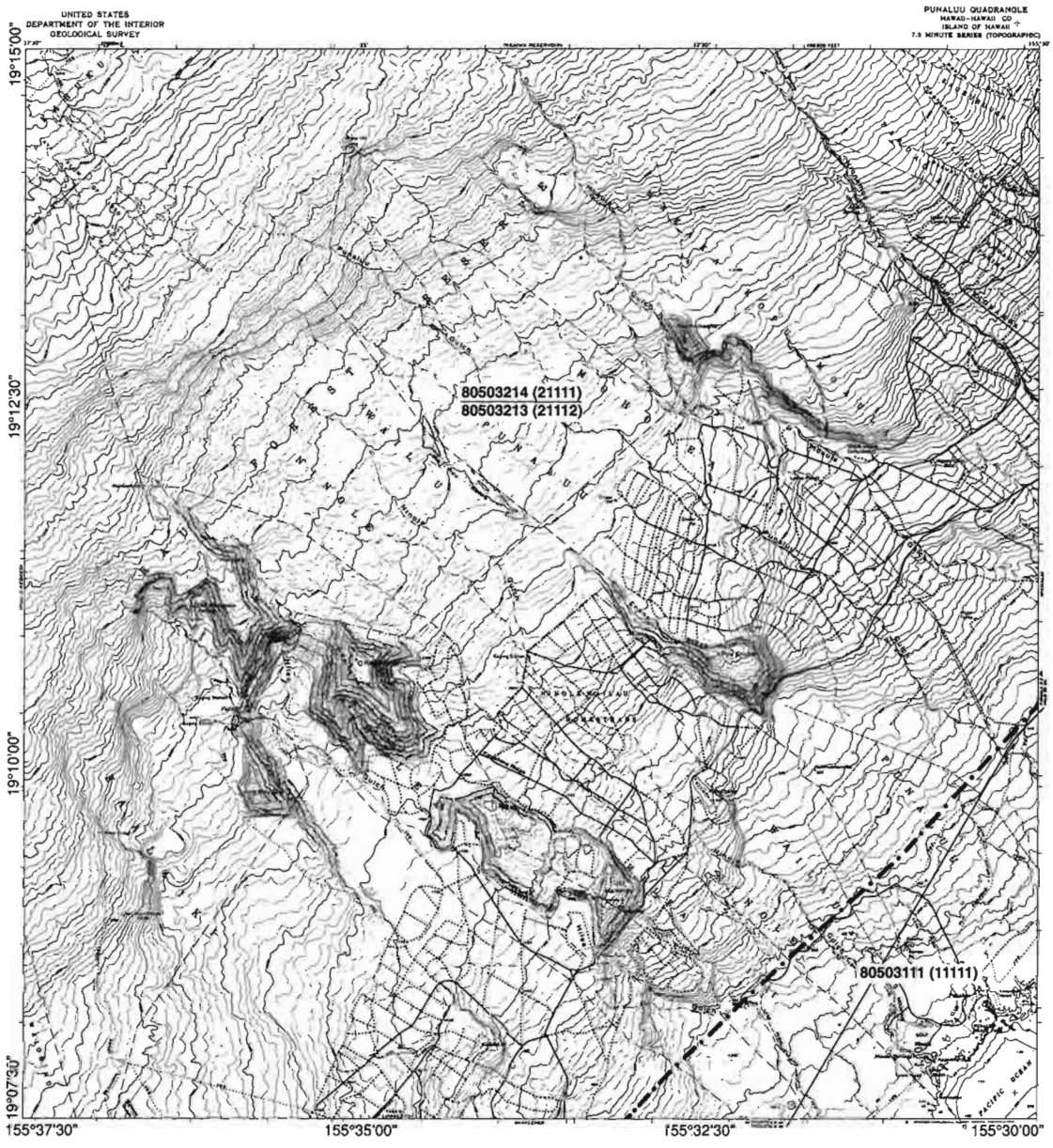
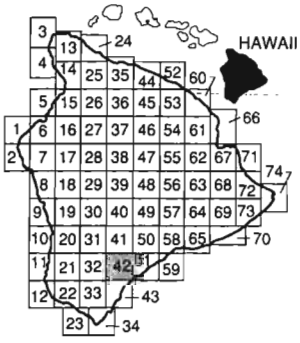
Appendix Figure A.1.41. Aquifer classification map, Keaiwa Reservoir, Hawai'i



Base Map: USGS (1:24,000 series, rev. 1982).

PUNALUU, HAWAII
H-42

1992



Sector
Aquifer System
Aquifer Type
80101111 Aquifer Code
(11111) Status Code

0 1 2 Miles
0 1 2 3 Kilometers

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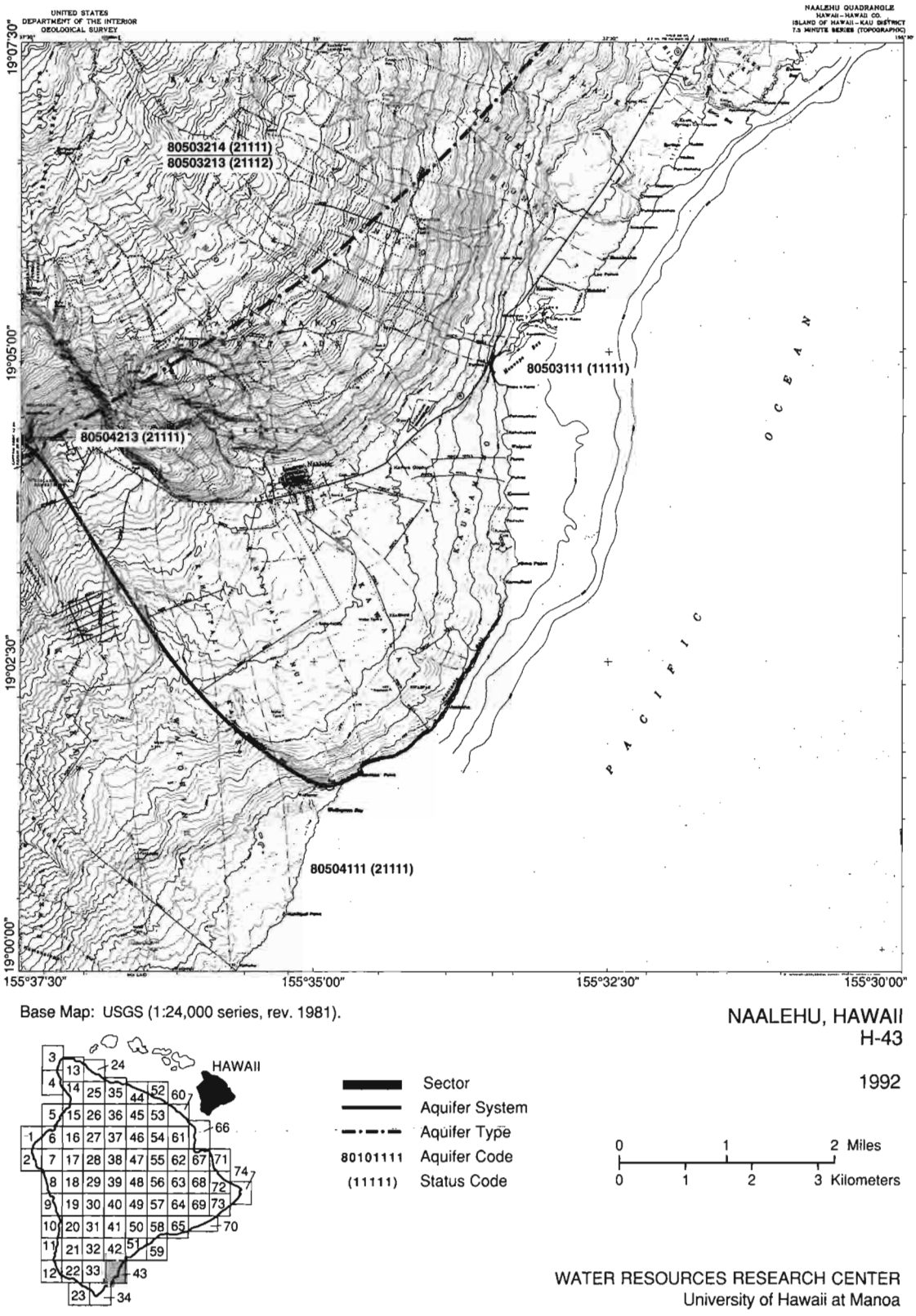
Appendix Figure A.1.42. Aquifer classification map, Punaluu, Hawai'i



Base Map: USGS (1:24,000 series, rev. 1981).

NAALEHU, HAWAII
H-43

1992

Sector
Aquifer System
Aquifer Type
80101111 Aquifer Code
(11111) Status Code

0 1 2 Miles
0 1 2 3 Kilometers

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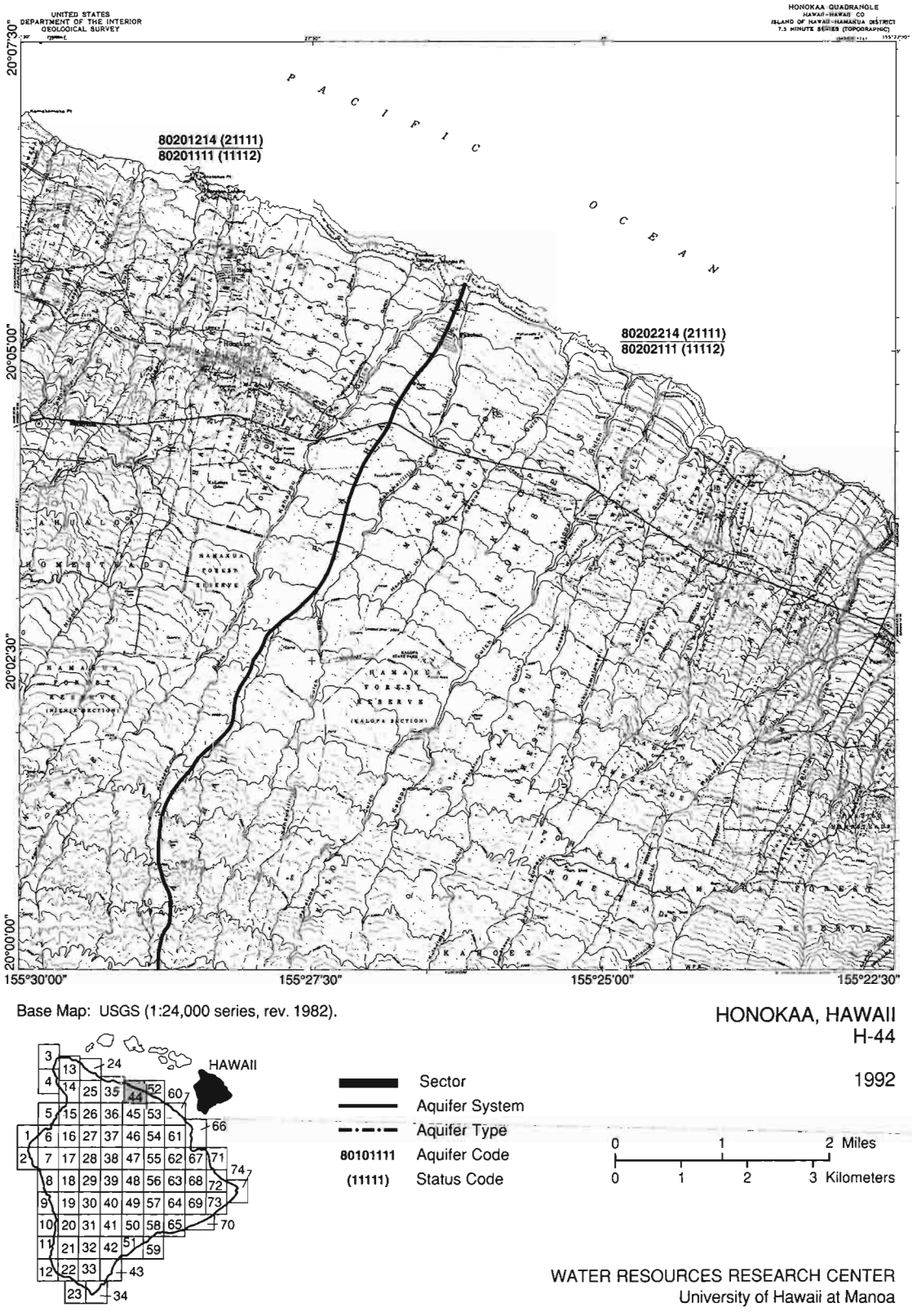
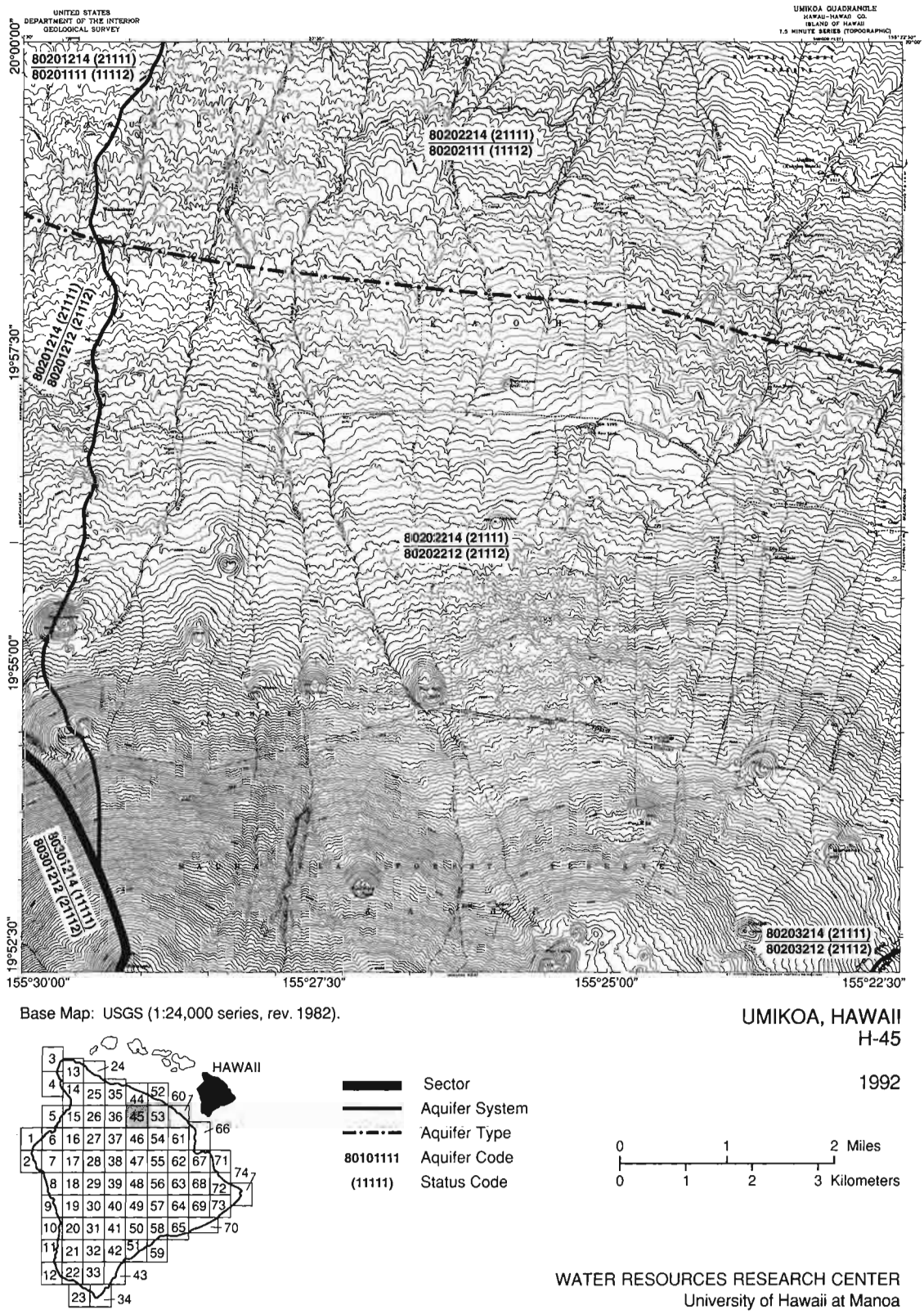
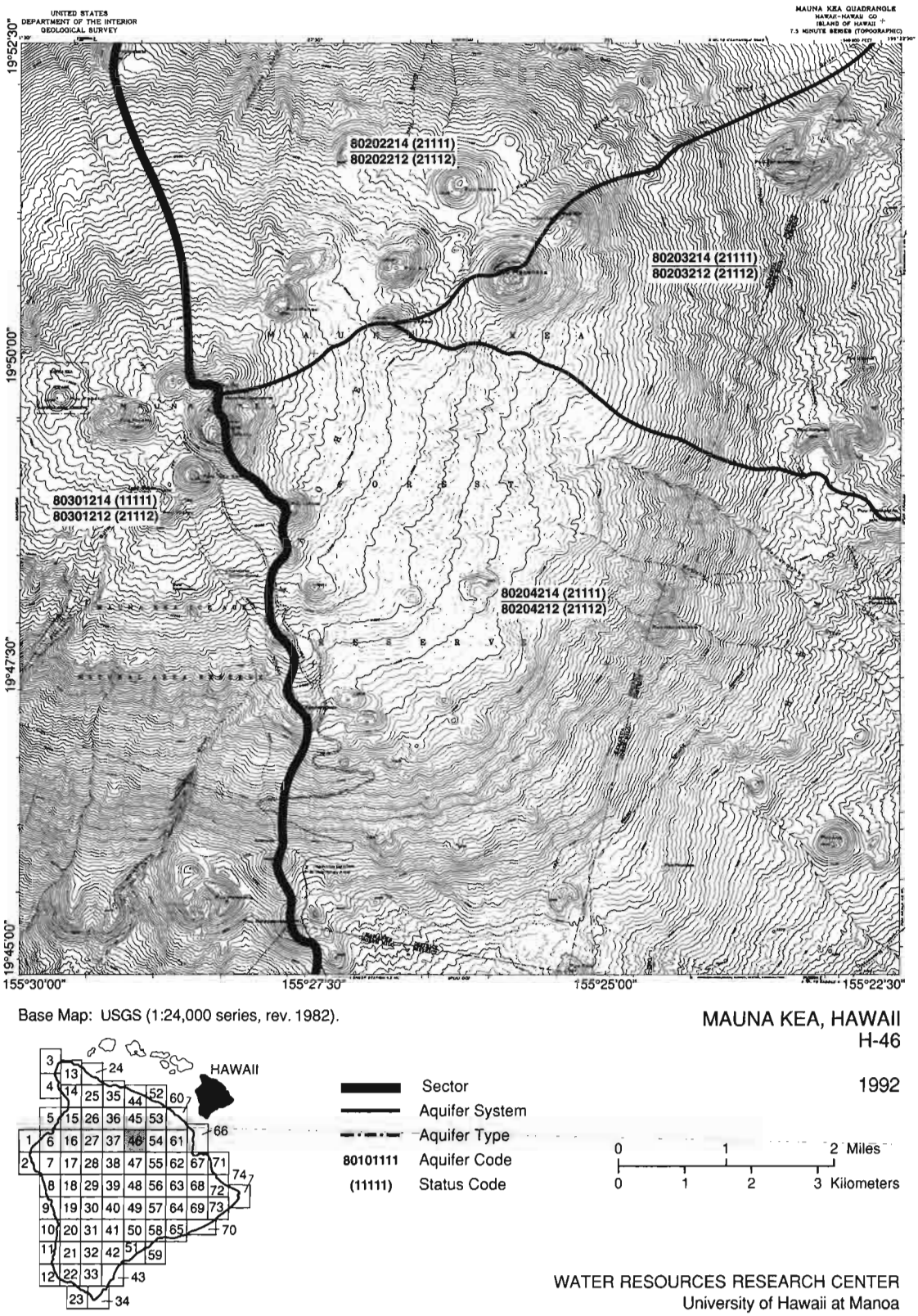
Appendix Figure A.1.43. Aquifer classification map, Naalehu, Hawai'i



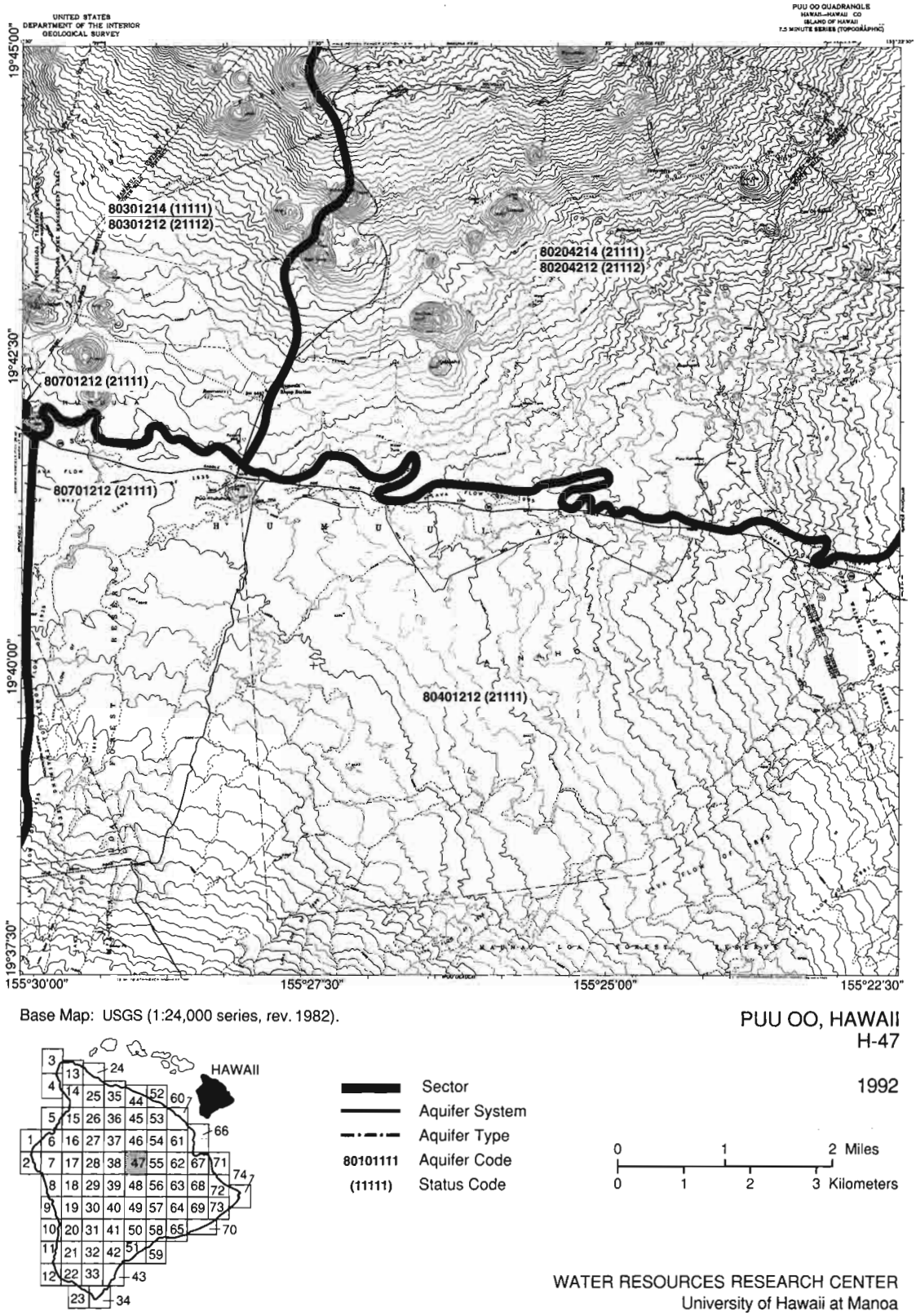
Appendix Figure A.1.44. Aquifer classification map, Honokaa, Hawai'i



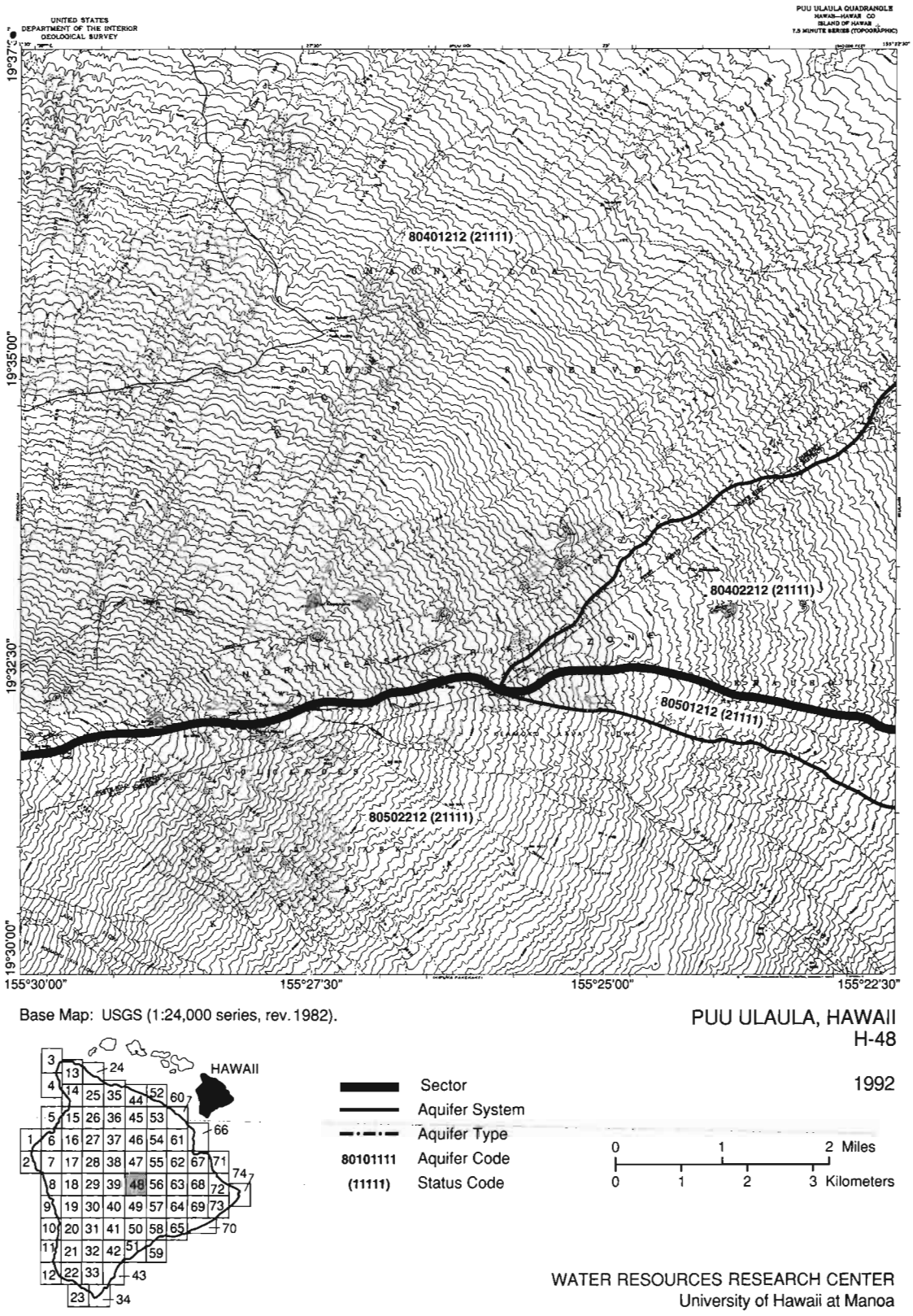
Appendix Figure A.1.45. Aquifer classification map, Umikoa, Hawai'i



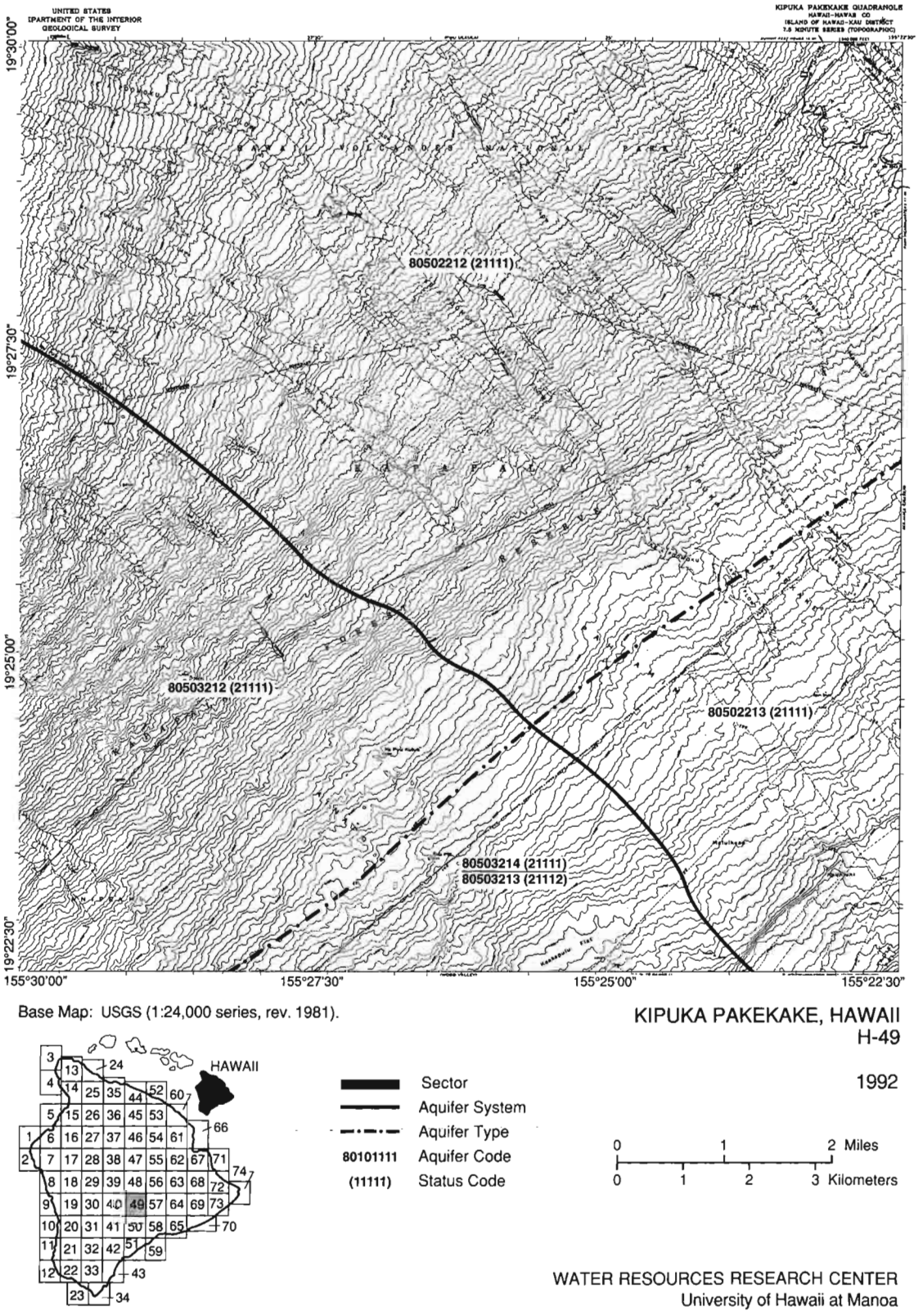
Appendix Figure A.1.46. Aquifer classification map, Mauna Kea, Hawai'i



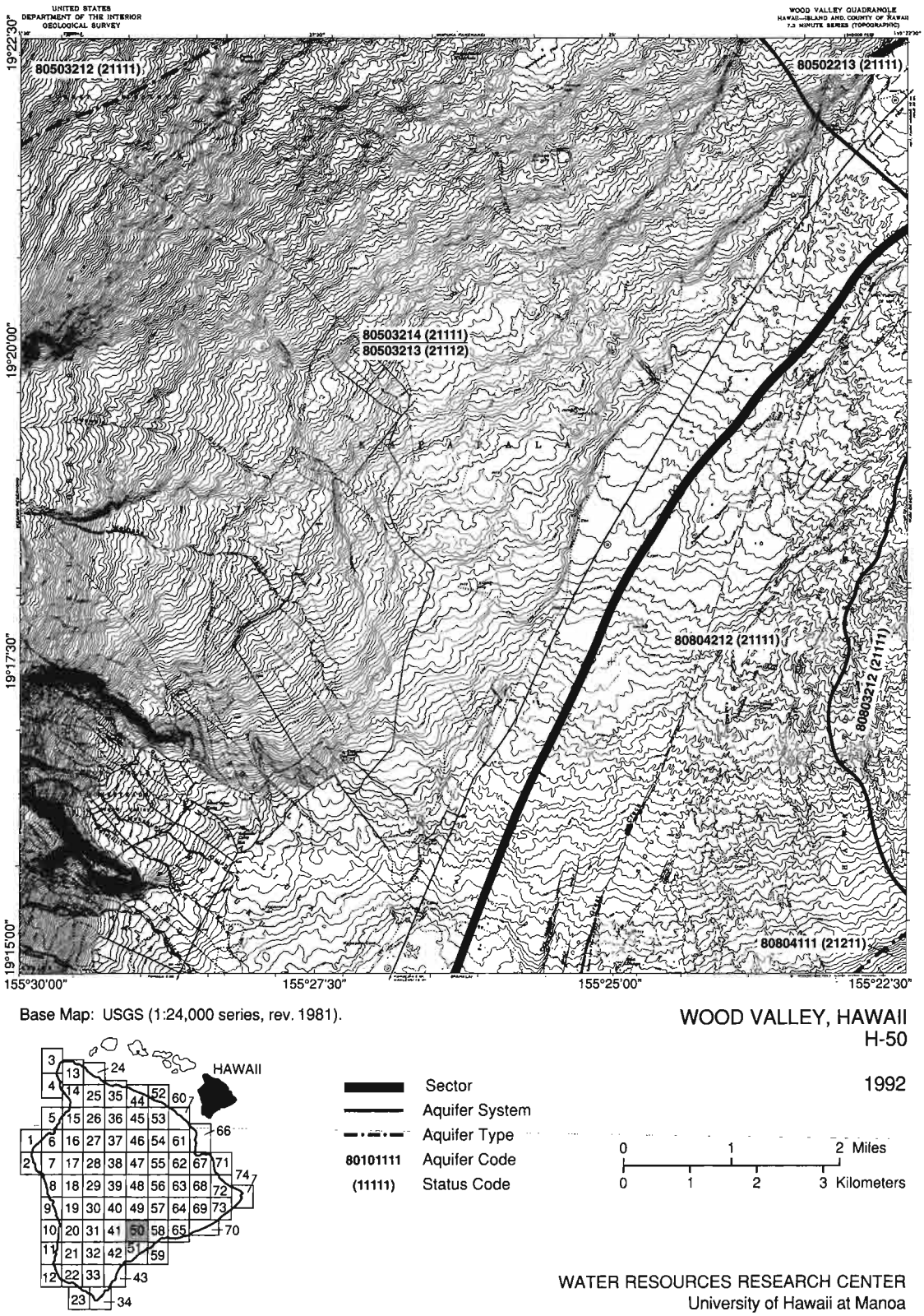
Appendix Figure A.1.47. Aquifer classification map, Puu Oo, Hawai'i



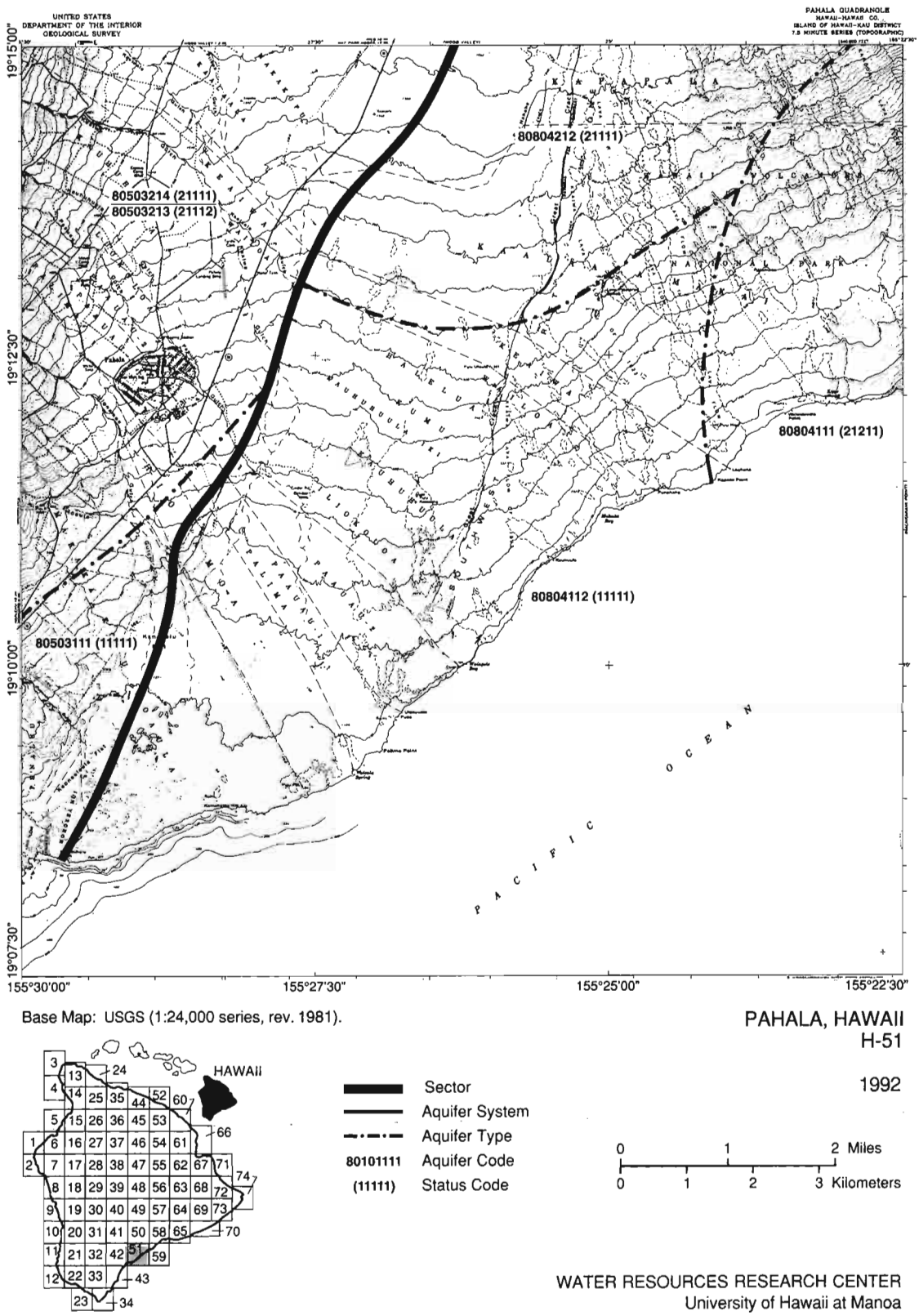
Appendix Figure A.1.48. Aquifer classification map, Puu Ulaula, Hawai'i



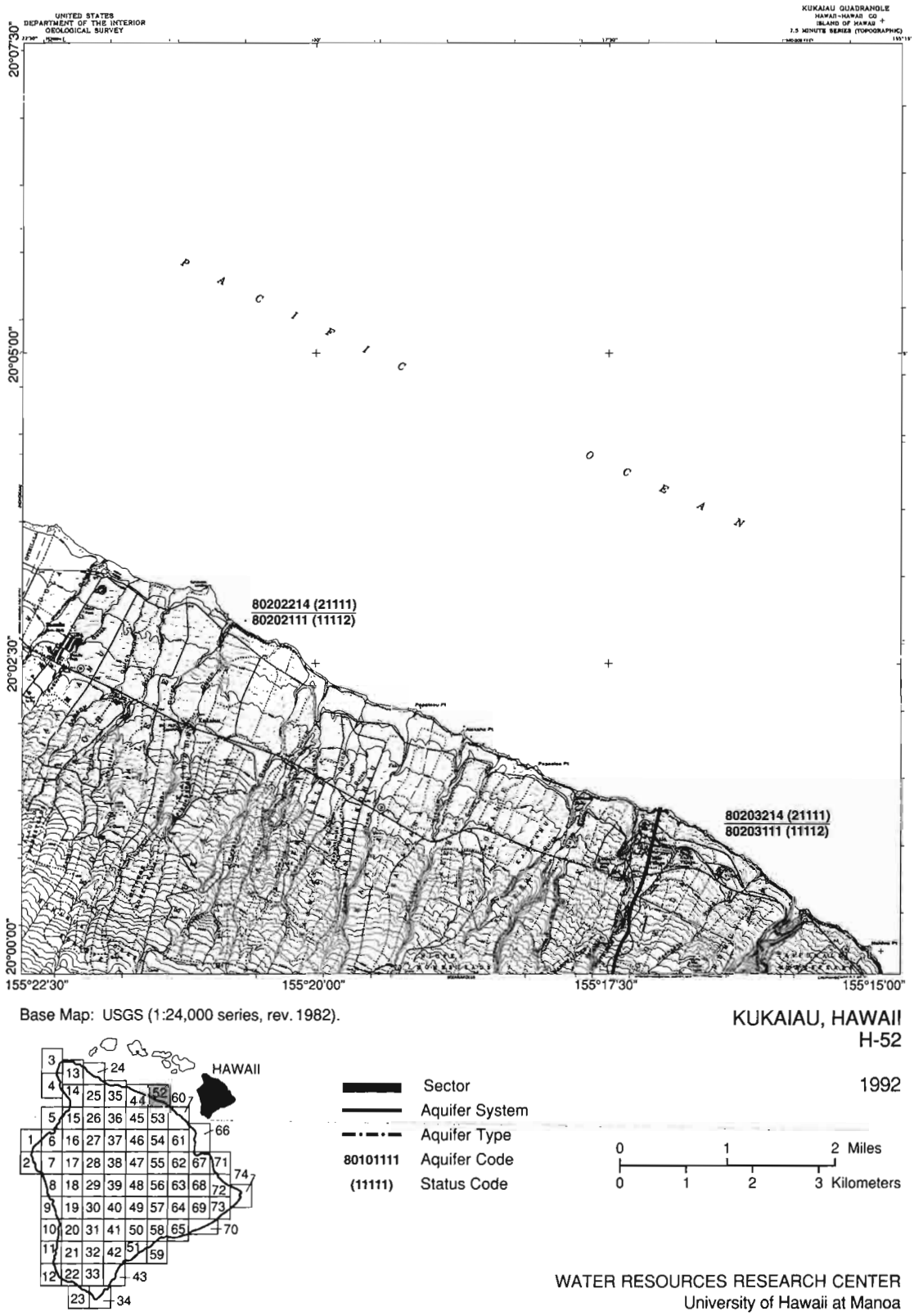
Appendix Figure A.1.49. Aquifer classification map, Kipuka Pakekake, Hawai'i



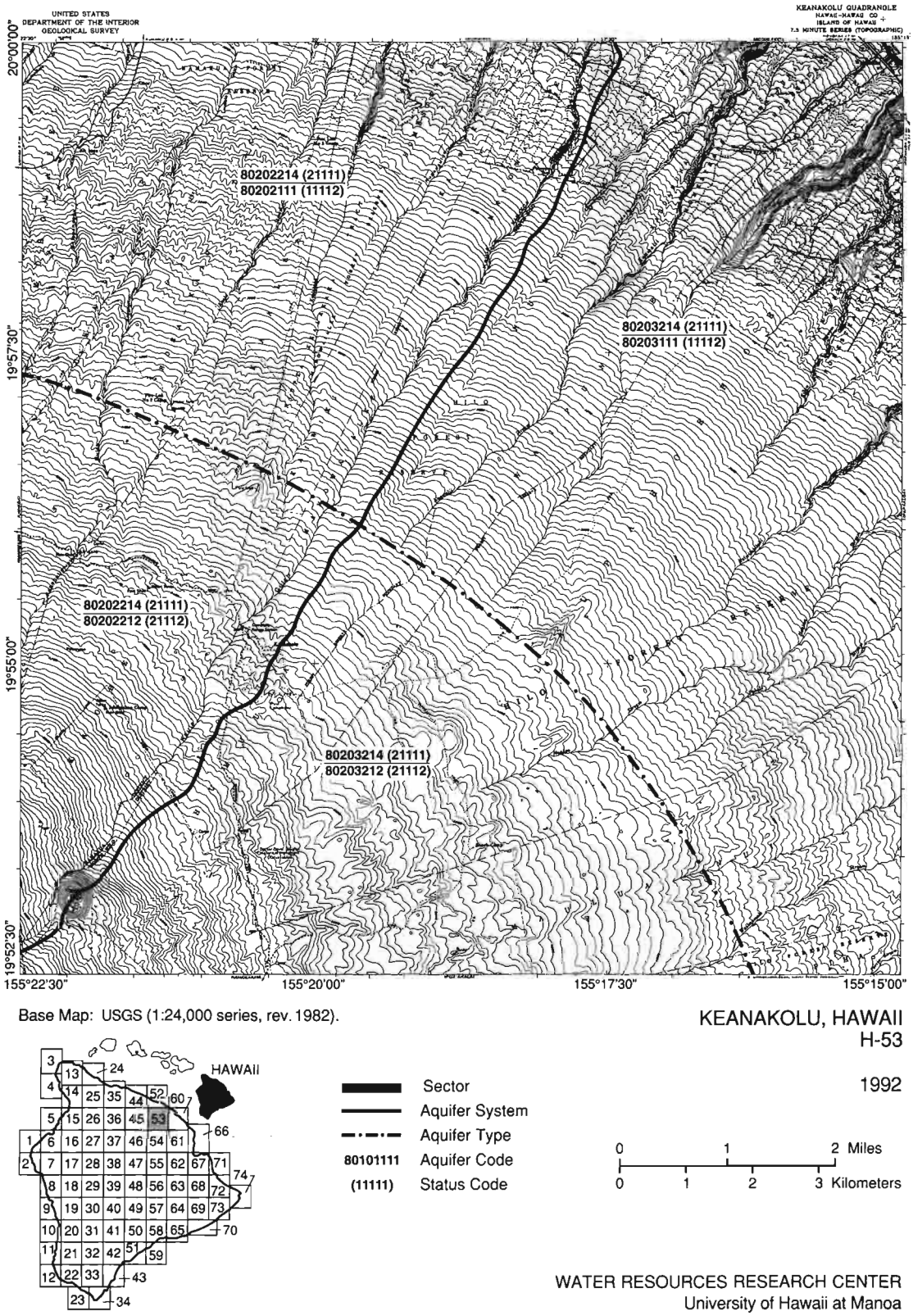
Appendix Figure A.1.50. Aquifer classification map, Wood Valley, Hawai'i



Appendix Figure A.1.51. Aquifer classification map, Pahala, Hawai'i



Appendix Figure A.1.52. Aquifer classification map, Kukaiau, Hawai'i



Base Map: USGS (1:24,000 series, rev. 1982).

KEANAKOLU, HAWAII
H-53

1992

Sector
Aquifer System
Aquifer Type
80101111 Aquifer Code
(11111) Status Code

0 1 2 Miles
0 1 2 3 Kilometers

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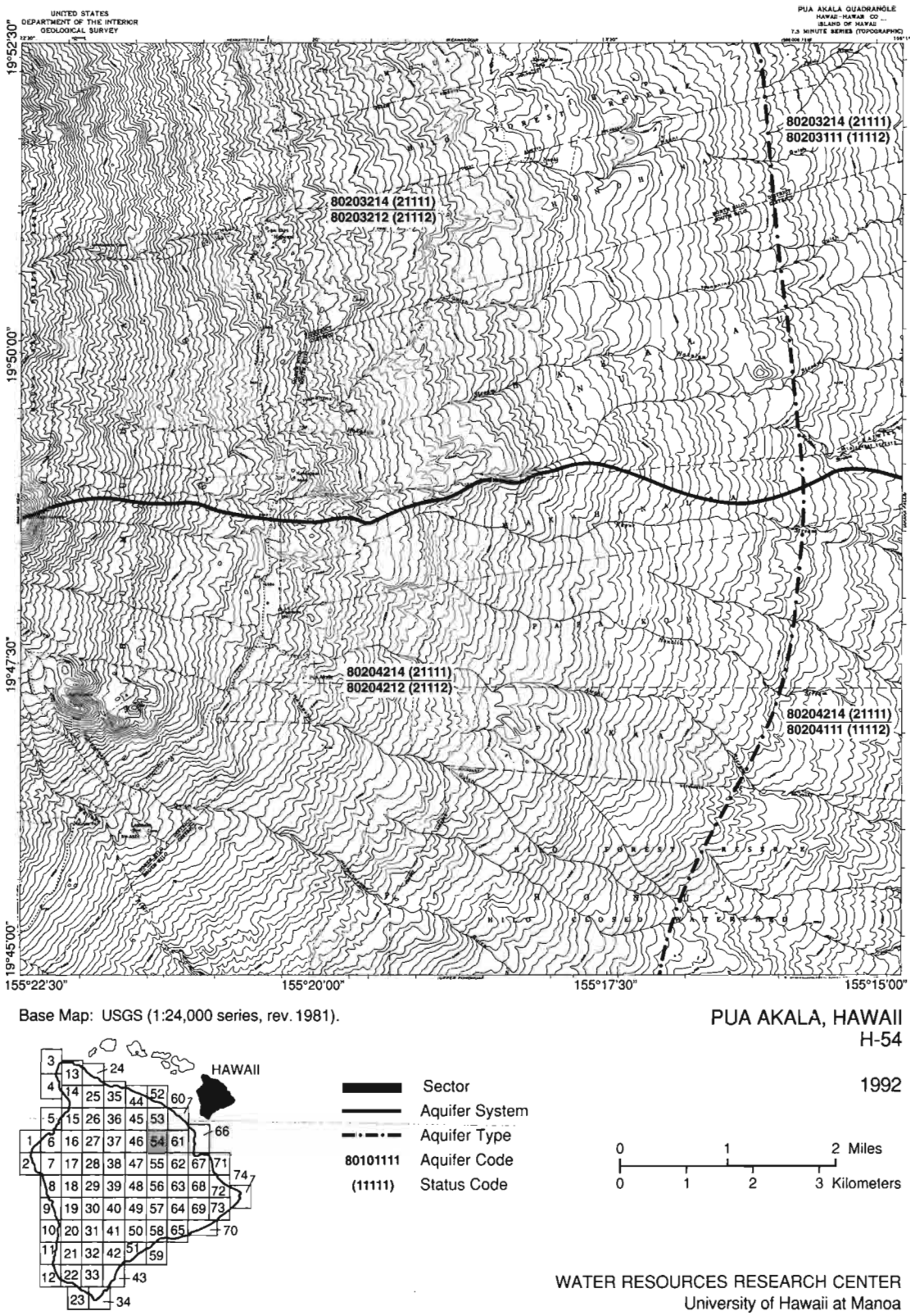
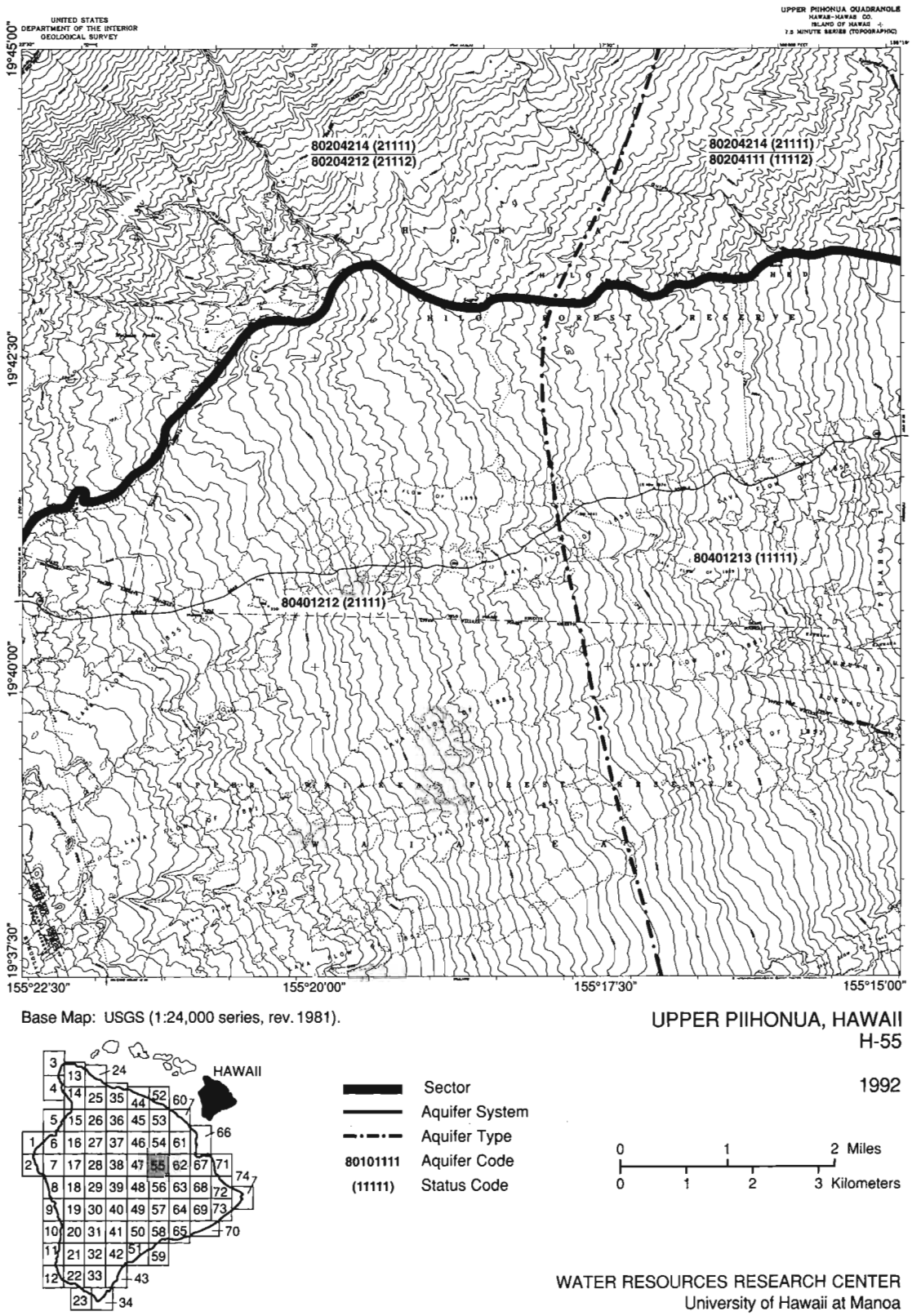
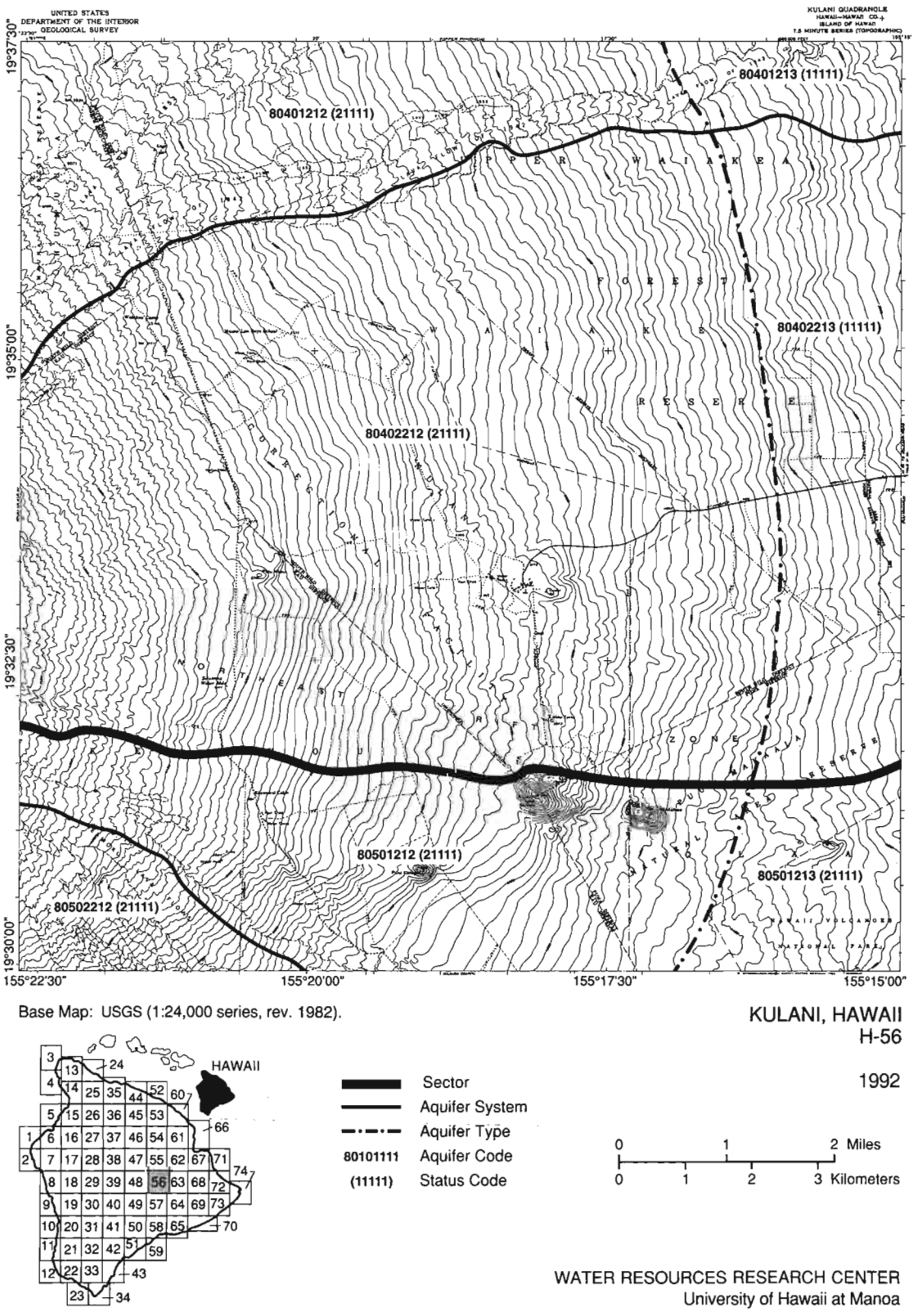
Appendix Figure A.1.53. Aquifer classification map, Keanakolu, Hawai'i



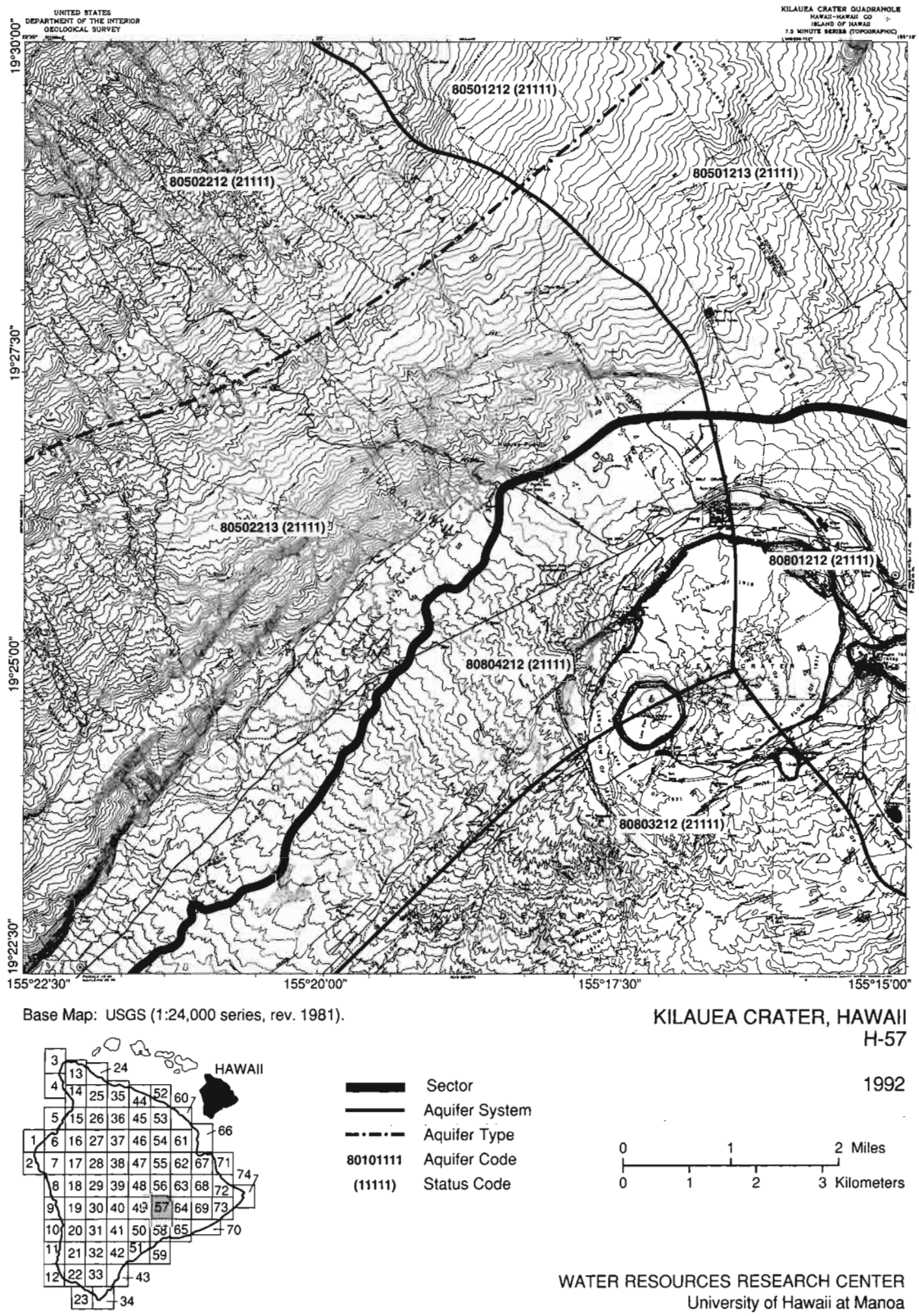
Appendix Figure A.1.54. Aquifer classification map, Puu Akala, Hawai'i



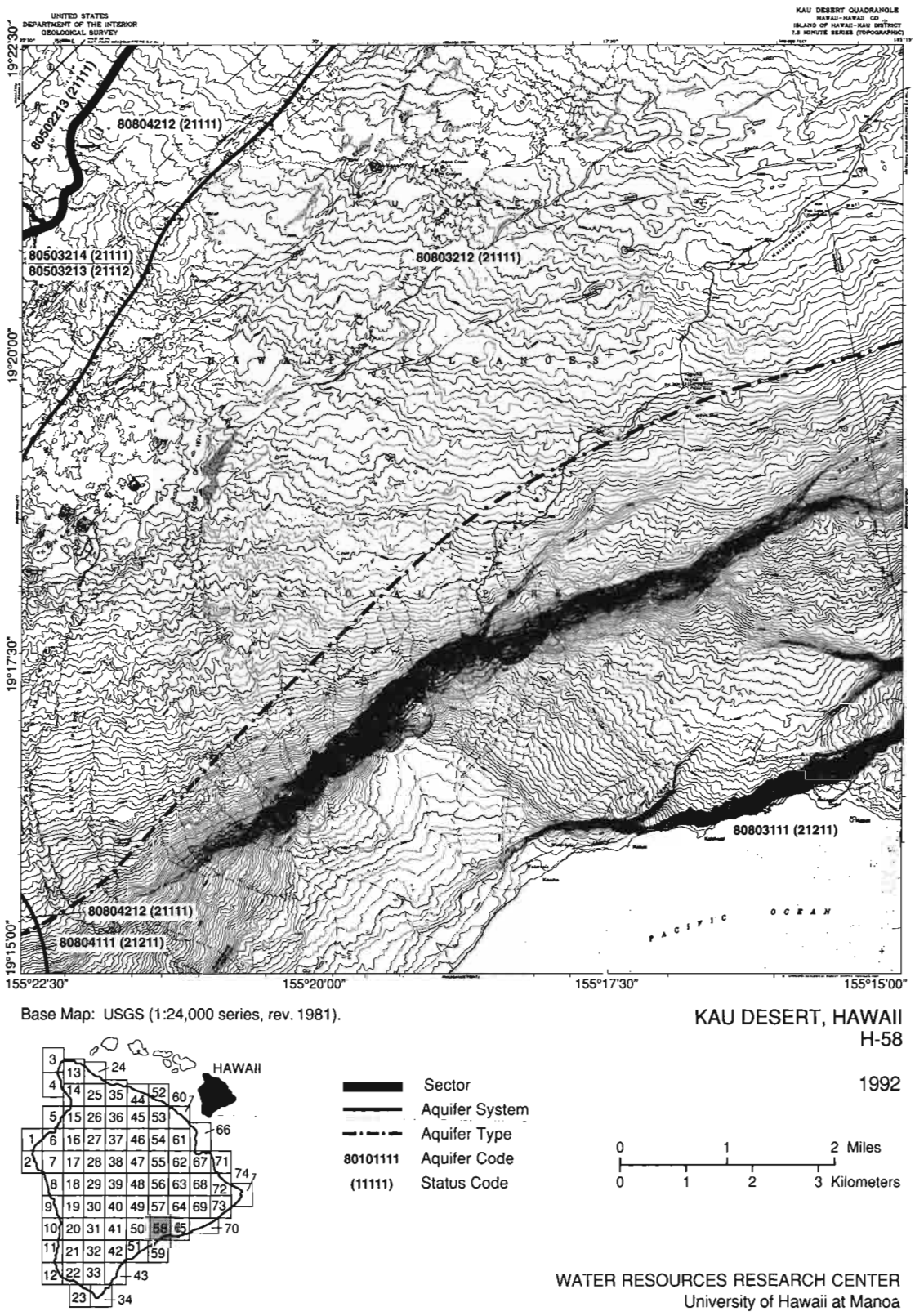
Appendix Figure A.1.55. Aquifer classification map, Upper Piihonua, Hawai'i



Appendix Figure A.1.56. Aquifer classification map, Kulani, Hawai'i



Appendix Figure A.1.57. Aquifer classification map, Kilauea Crater, Hawai'i



Base Map: USGS (1:24,000 series, rev. 1981).

KAU DESERT, HAWAII
H-58

1992

Sector
Aquifer System
Aquifer Type
80101111 Aquifer Code
(11111) Status Code

0 1 2 Miles
0 1 2 3 Kilometers

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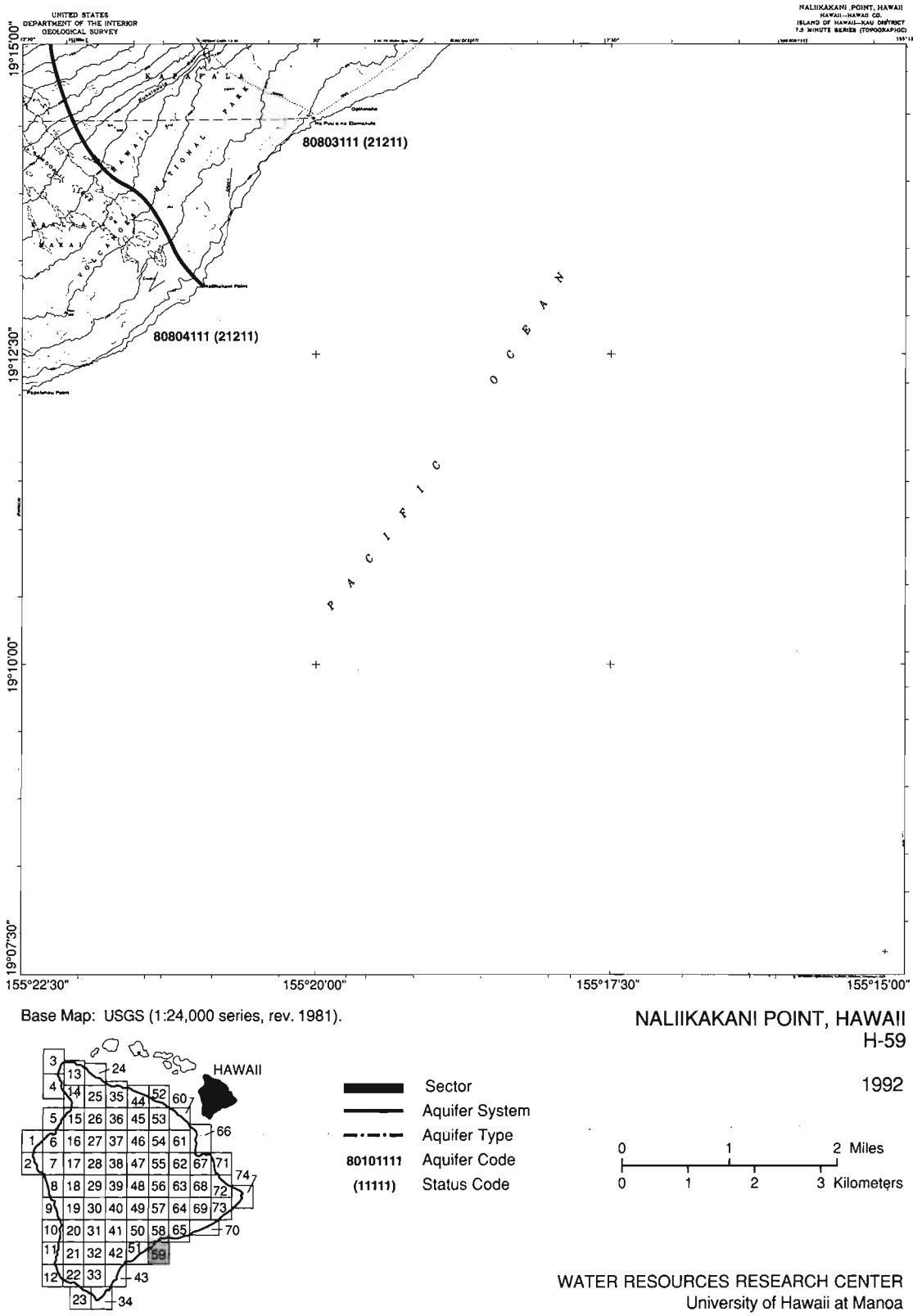
Appendix Figure A.1.58. Aquifer classification map, Kau Desert, Hawai'i



Base Map: USGS (1:24,000 series, rev. 1981).

NALIIKAKANI POINT, HAWAII
H-59

1992

Sector
Aquifer System
Aquifer Type
80101111 Aquifer Code
(11111) Status Code

0 1 2 Miles
0 1 2 3 Kilometers

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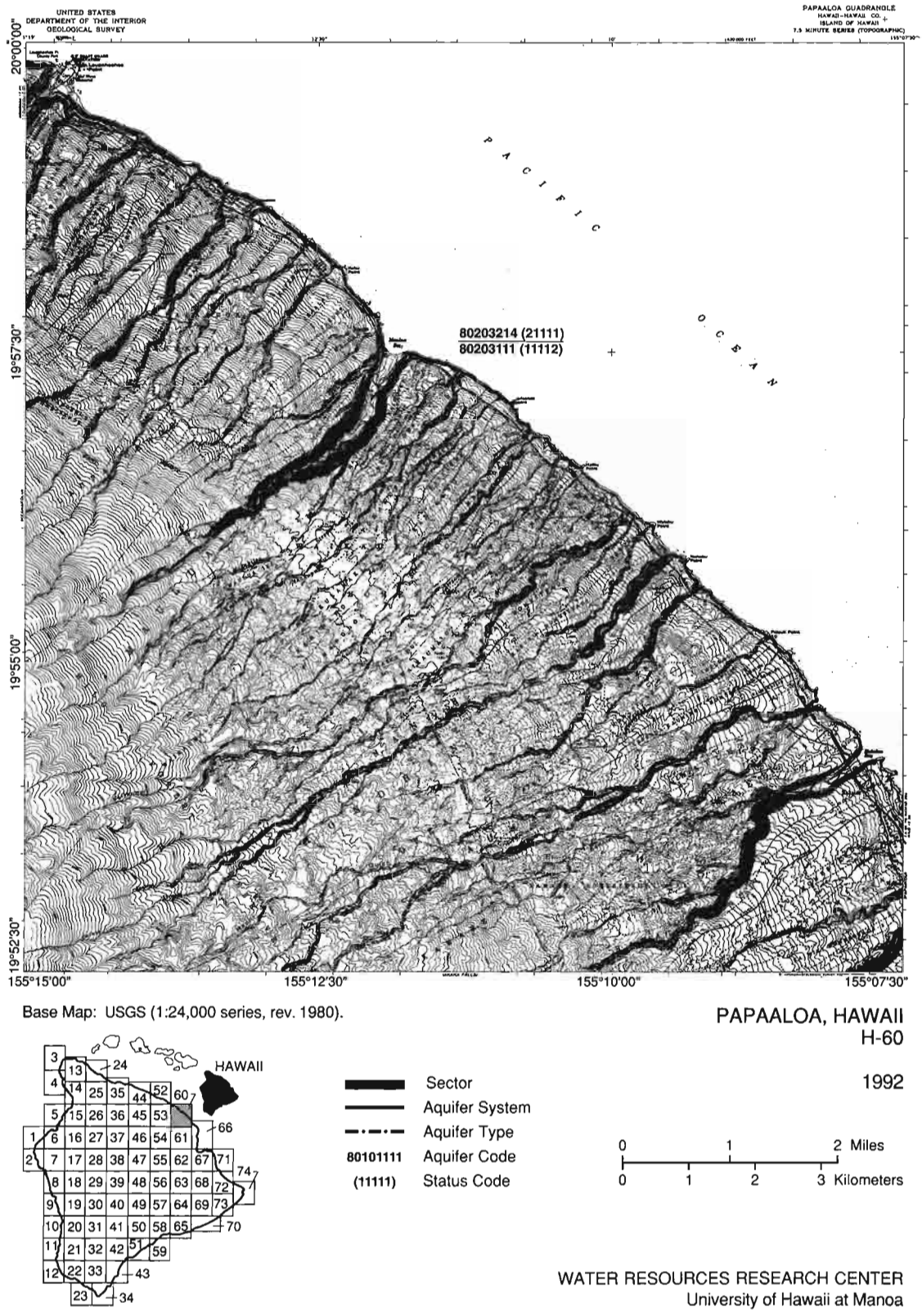
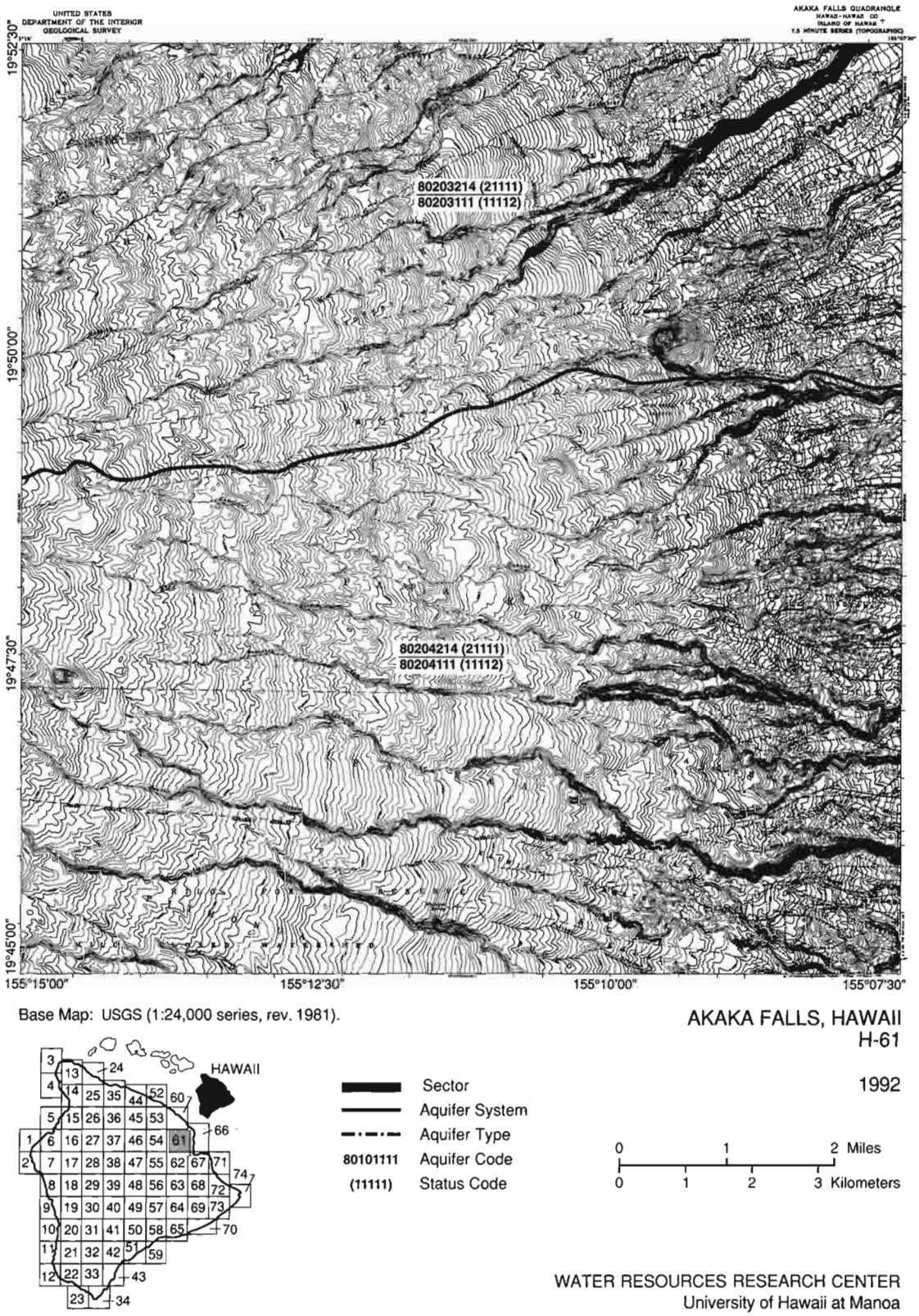
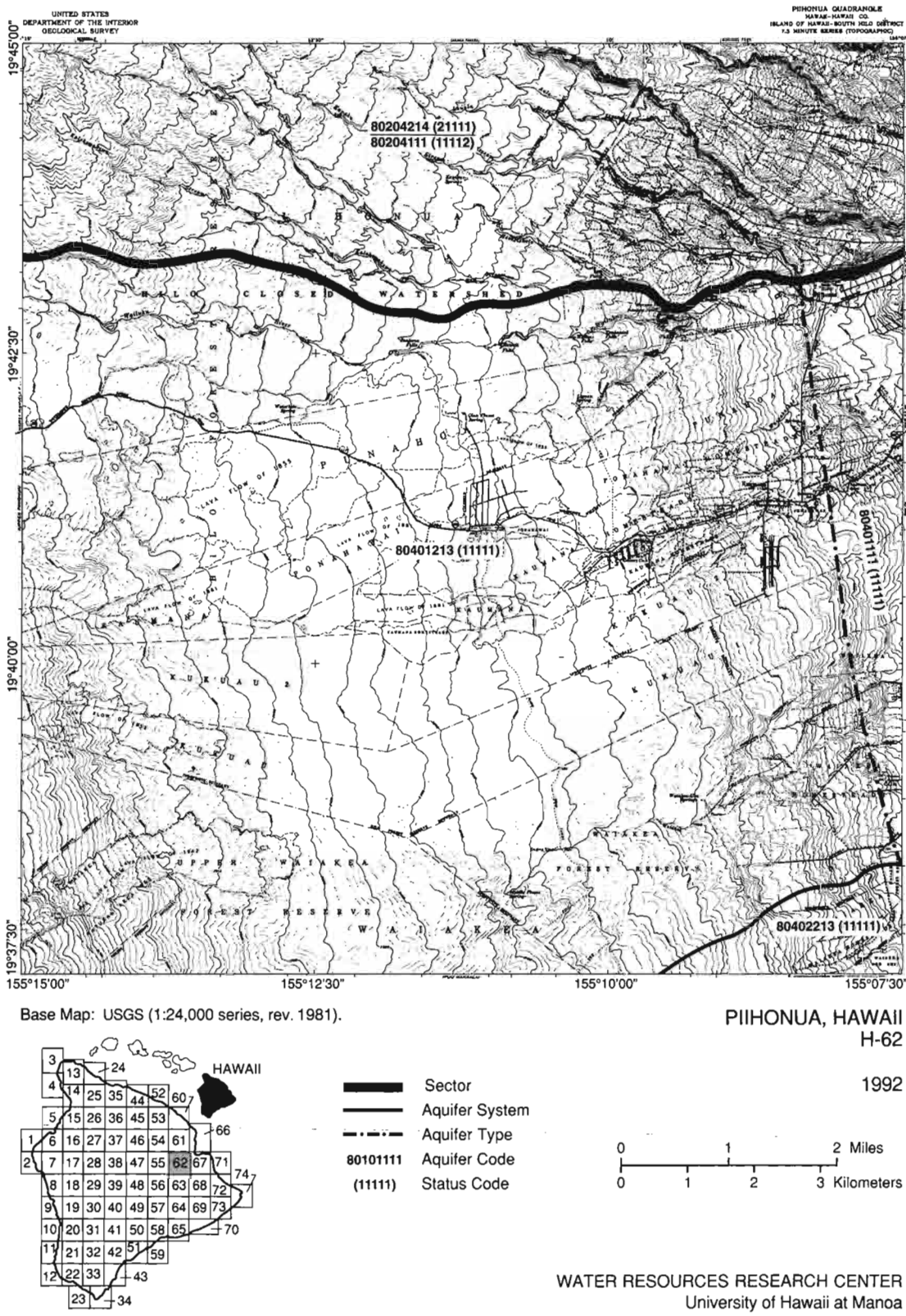
Appendix Figure A.1.59. Aquifer classification map, Naliikakani Point, Hawai'i



Appendix Figure A.1.60. Aquifer classification map, Papaaloa, Hawai'i



Appendix Figure A.1.61. Aquifer classification map, Akaka Falls, Hawai'i



Base Map: USGS (1:24,000 series, rev. 1981).

PIIHONUA, HAWAII
H-62

1992

Sector
Aquifer System
Aquifer Type
80101111 Aquifer Code
(11111) Status Code

0 1 2 Miles
0 1 2 3 Kilometers

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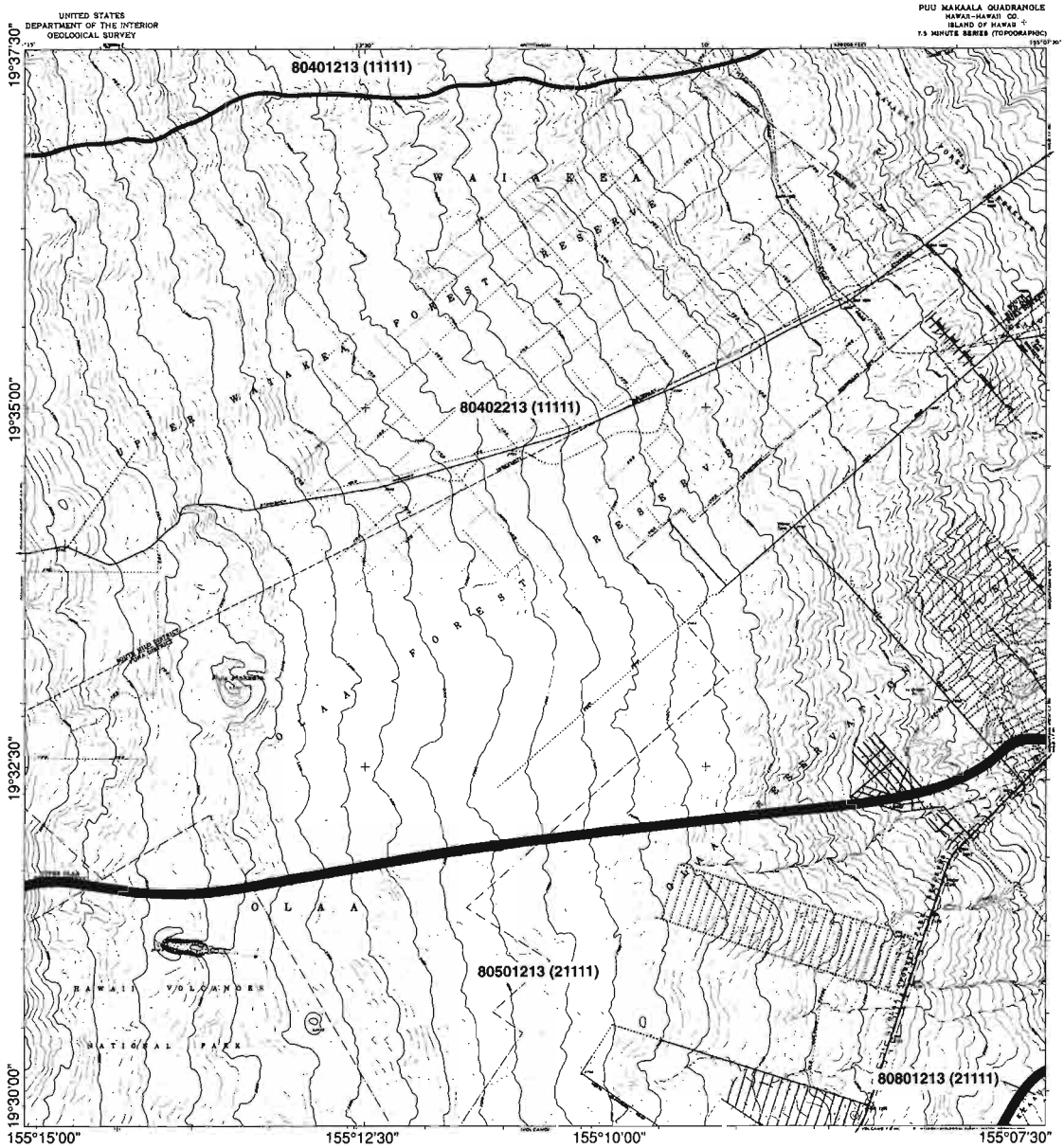
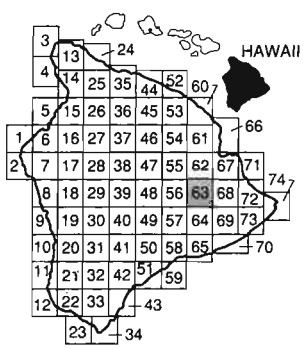
Appendix Figure A.1.62. Aquifer classification map, Piihonua, Hawai'i



Base Map: USGS (1:24,000 series, rev. 1981).

PUU MAKAALA, HAWAII
H-63

1992



Sector
Aquifer System
Aquifer Type
80101111 Aquifer Code
(11111) Status Code

0 1 2 Miles
0 1 2 3 Kilometers

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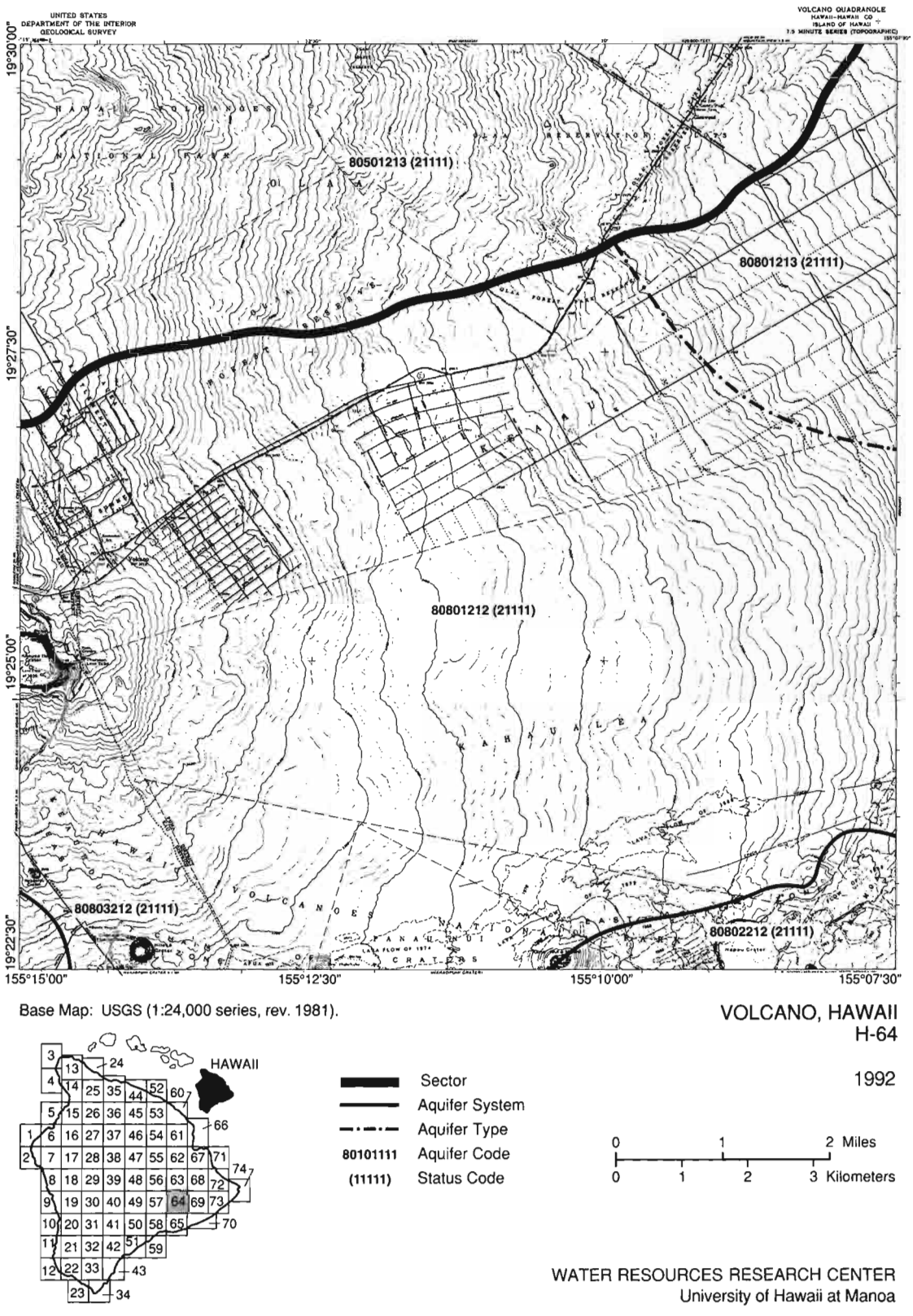
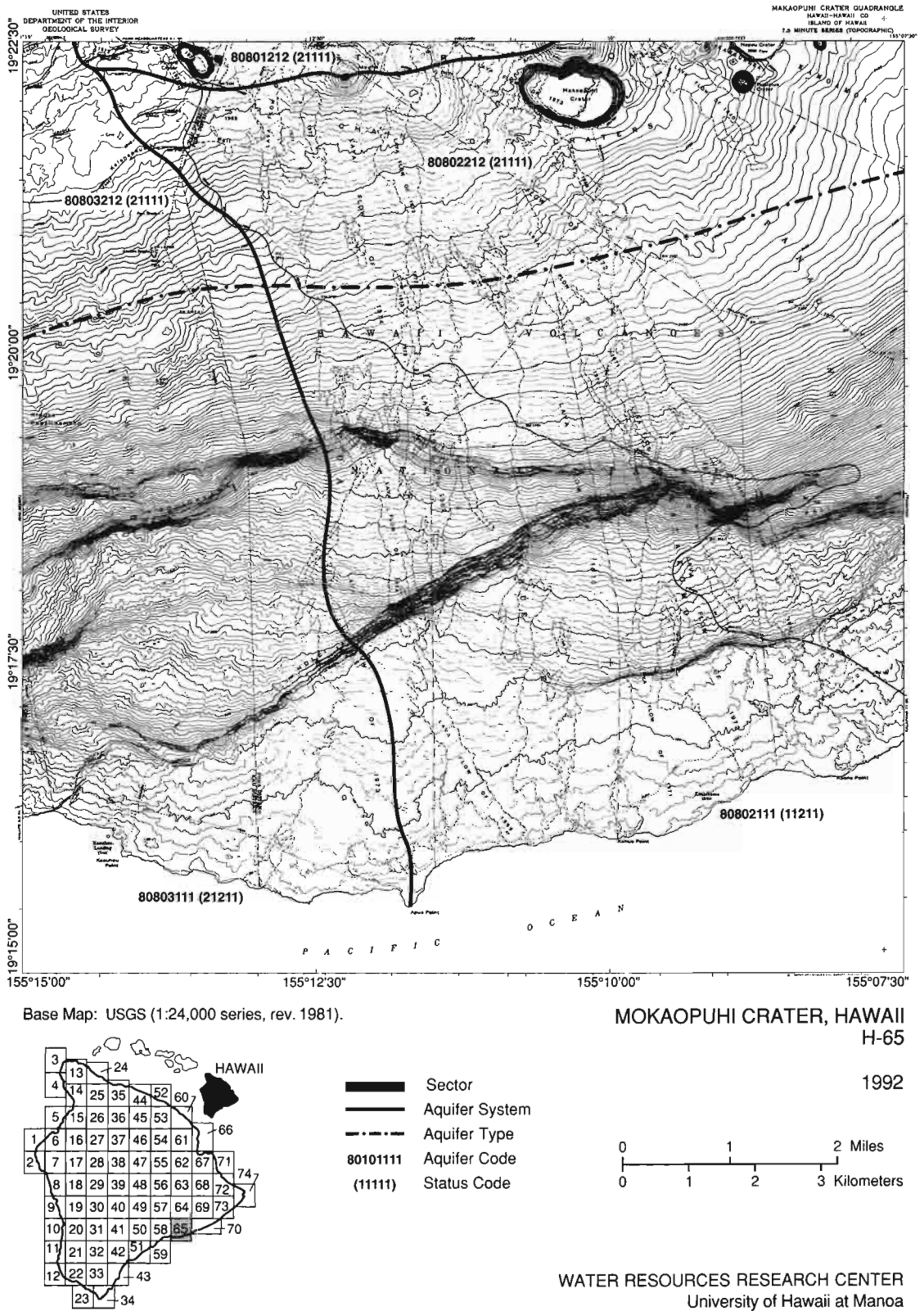
University of Hawaii at Manoa

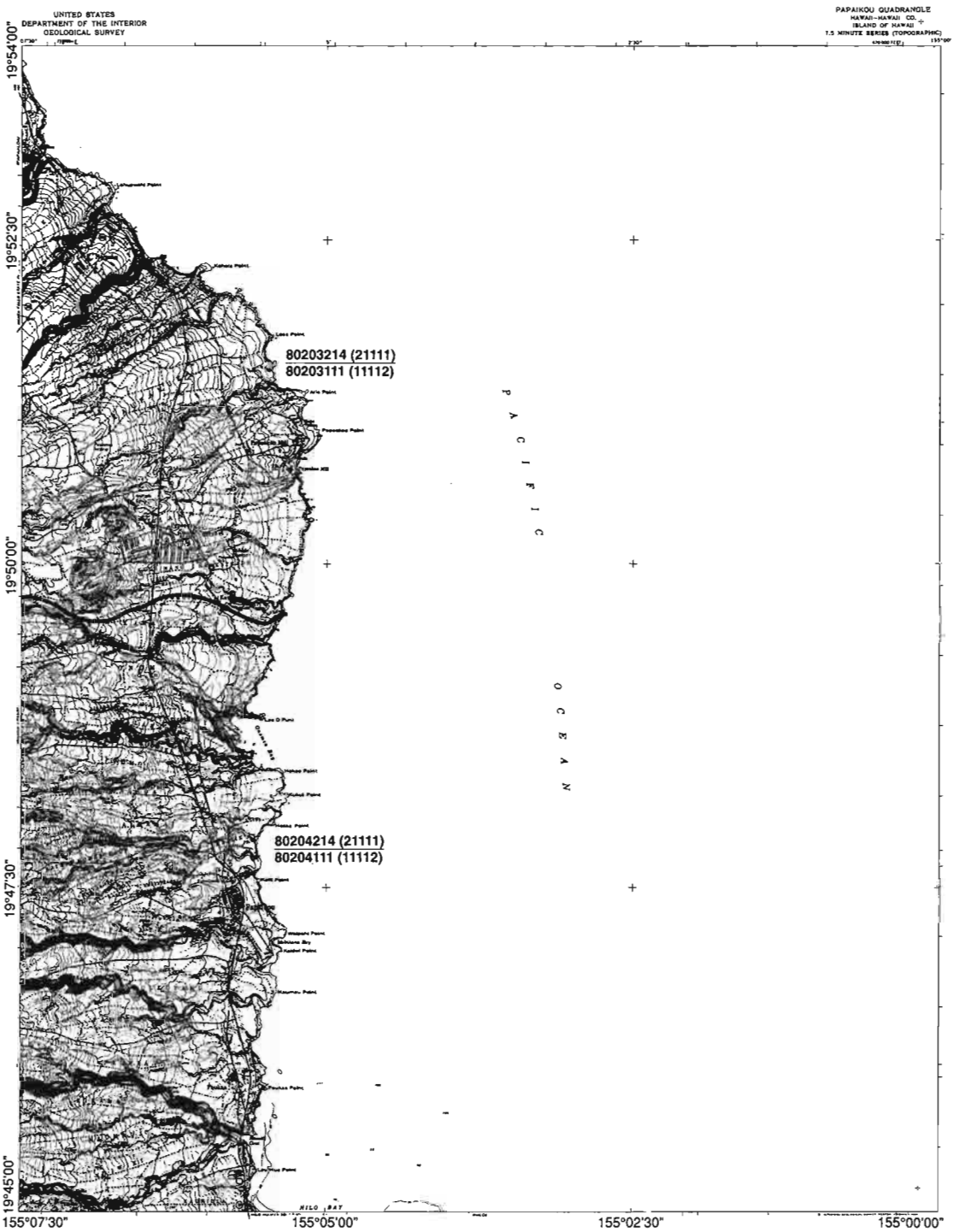
Appendix Figure A.1.63. Aquifer classification map, Puu Makaala, Hawai'i



Appendix Figure A.1.64. Aquifer classification map, Volcano, Hawai'i



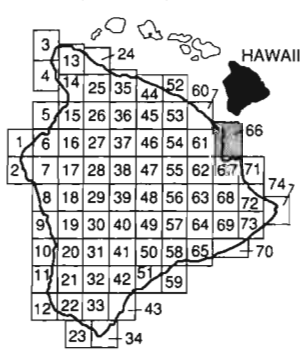
Appendix Figure A.1.65. Aquifer classification map, Mokaopuhi Crater, Hawai'i



Base Map: USGS (1:24,000 series, rev. 1981).

PAPAIKOU, HAWAII
H-66

1992



Sector
Aquifer System
Aquifer Type
80101111 Aquifer Code
(11111) Status Code

0 1 2 Miles
0 1 2 3 Kilometers

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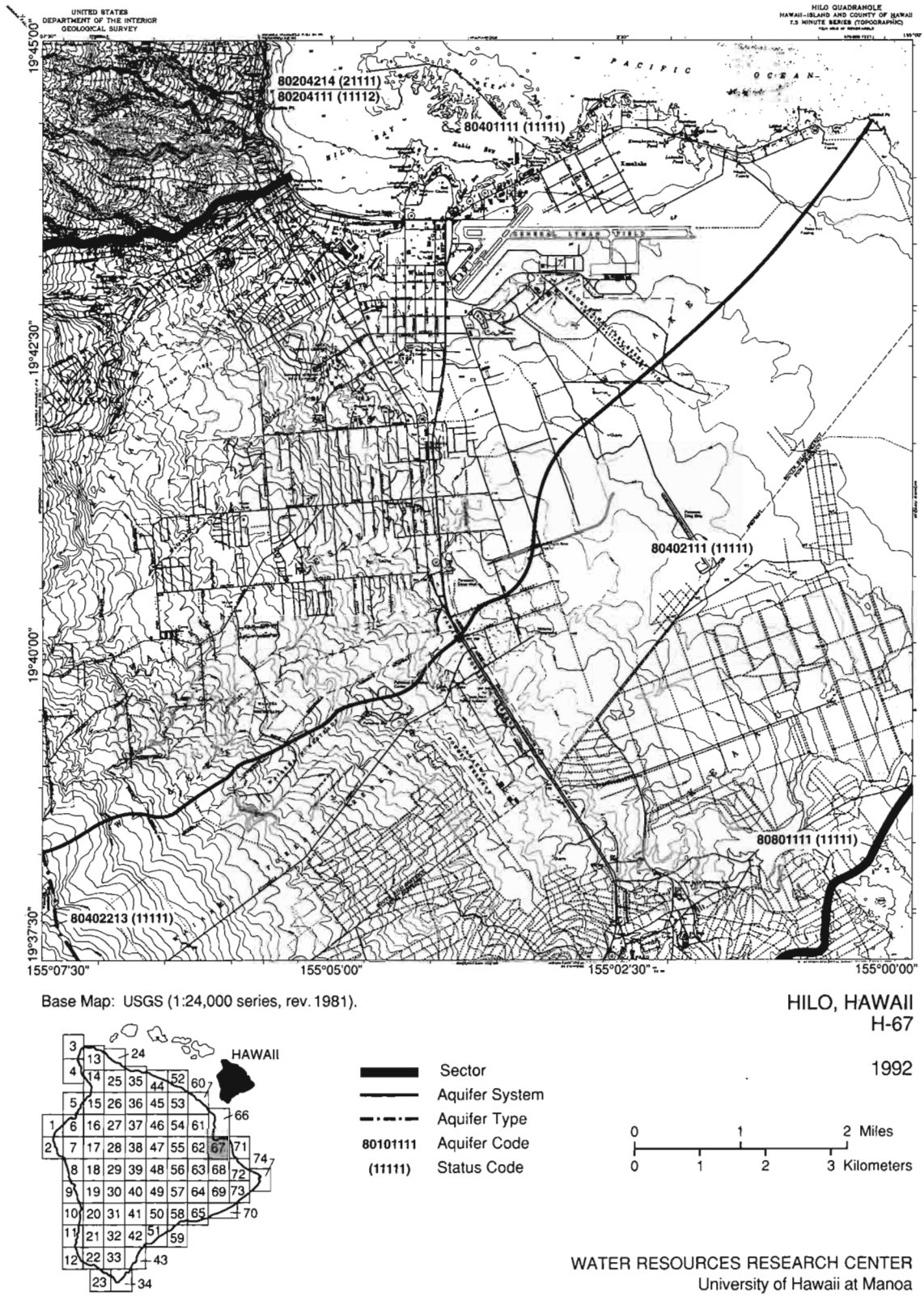
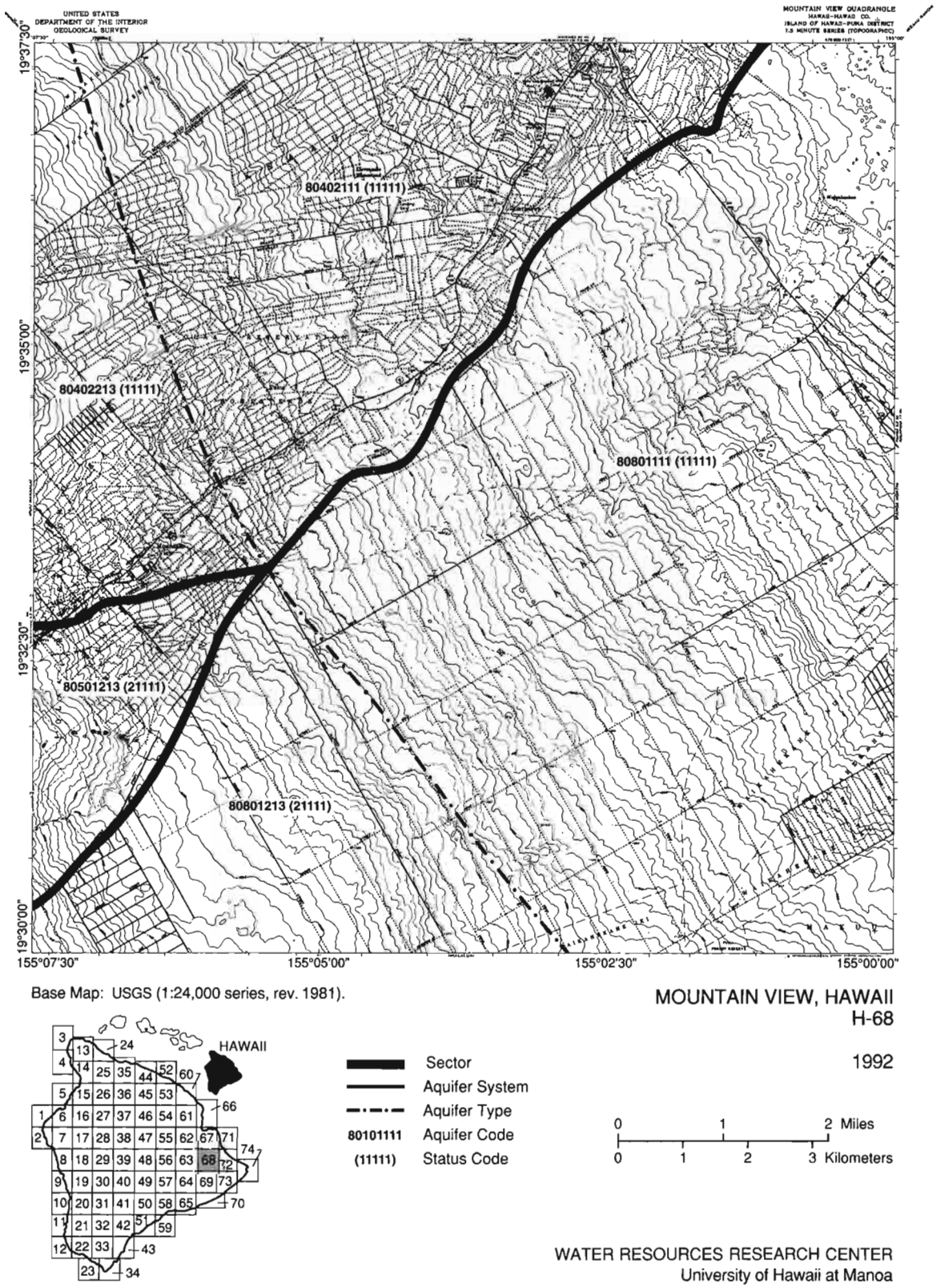
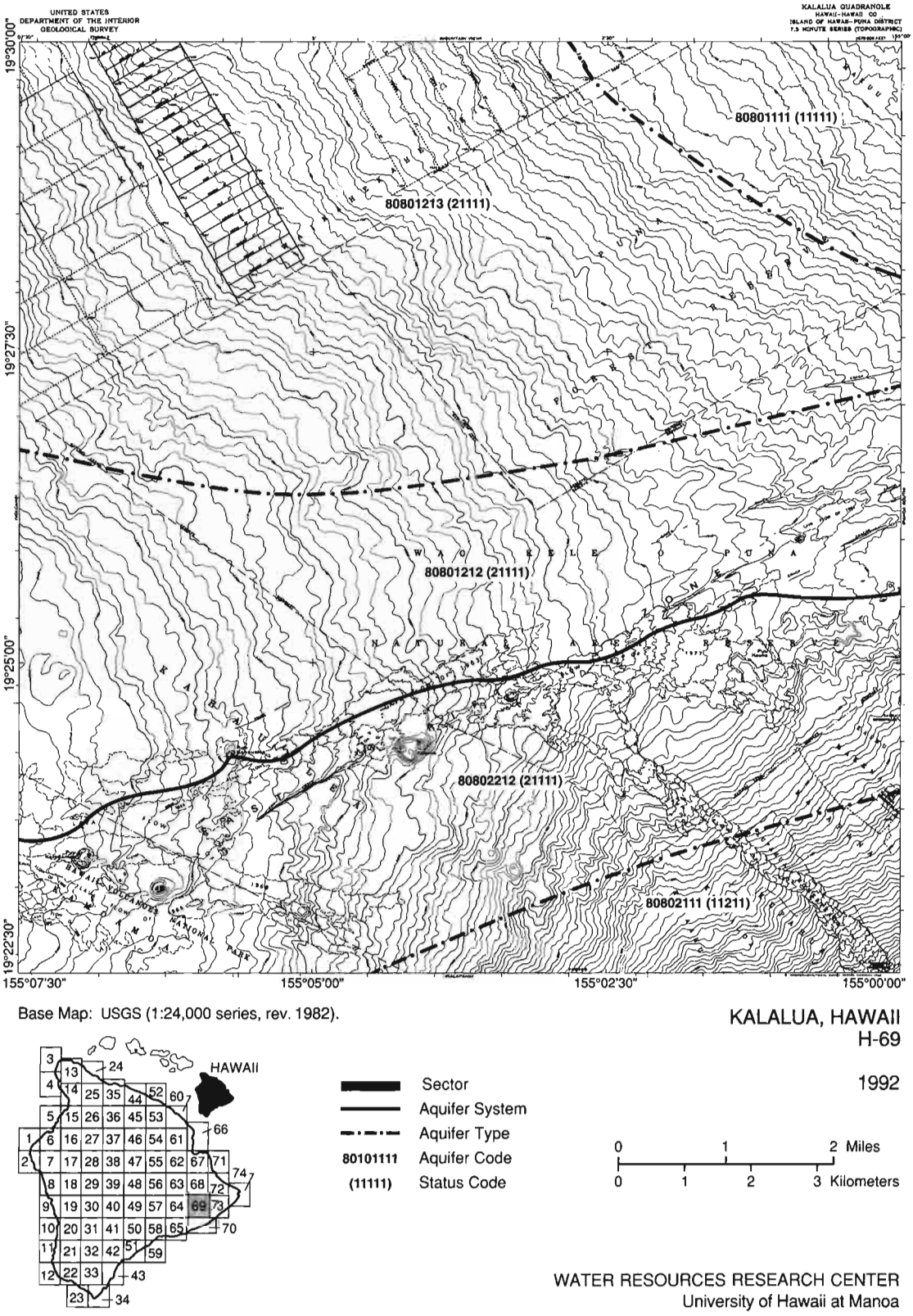
Appendix Figure A.1.66. Aquifer classification map, Papaikou, Hawai'i



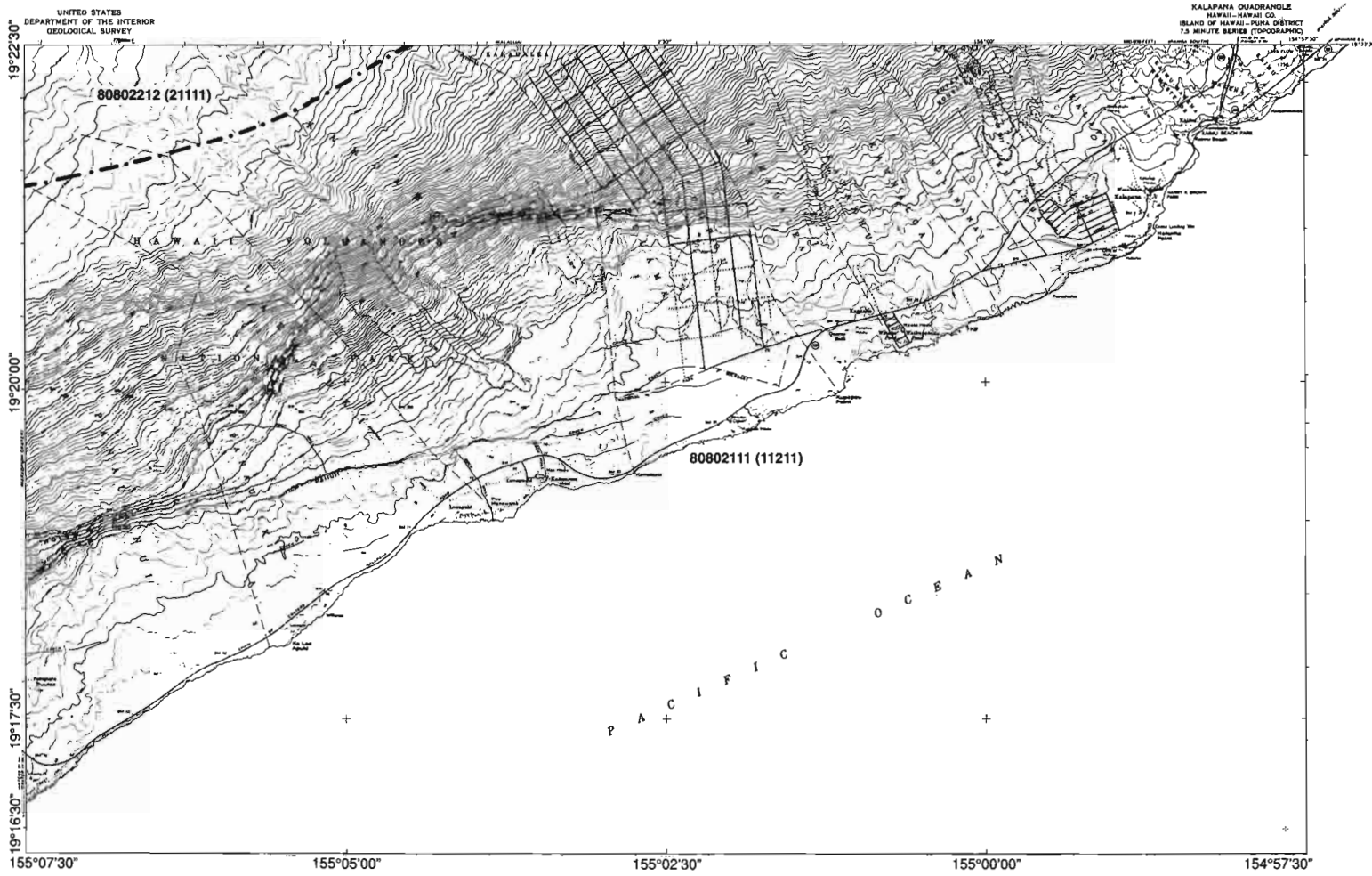
Appendix Figure A.1.67. Aquifer classification map, Hilo, Hawai'i



Appendix Figure A.1.68. Aquifer classification map, Mountain View, Hawai'i



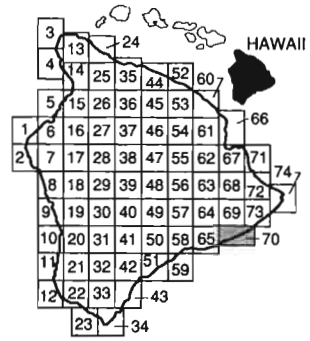
Appendix Figure A.1.69. Aquifer classification map, Kalalua, Hawai'i



Base Map: USGS (1:24,000 series, rev. 1981).

KALAPANA, HAWAII
H-70

1992



Sector
Aquifer System
Aquifer Type
80101111 Aquifer Code
(11111) Status Code

0 1 2 Miles
0 1 2 3 Kilometers

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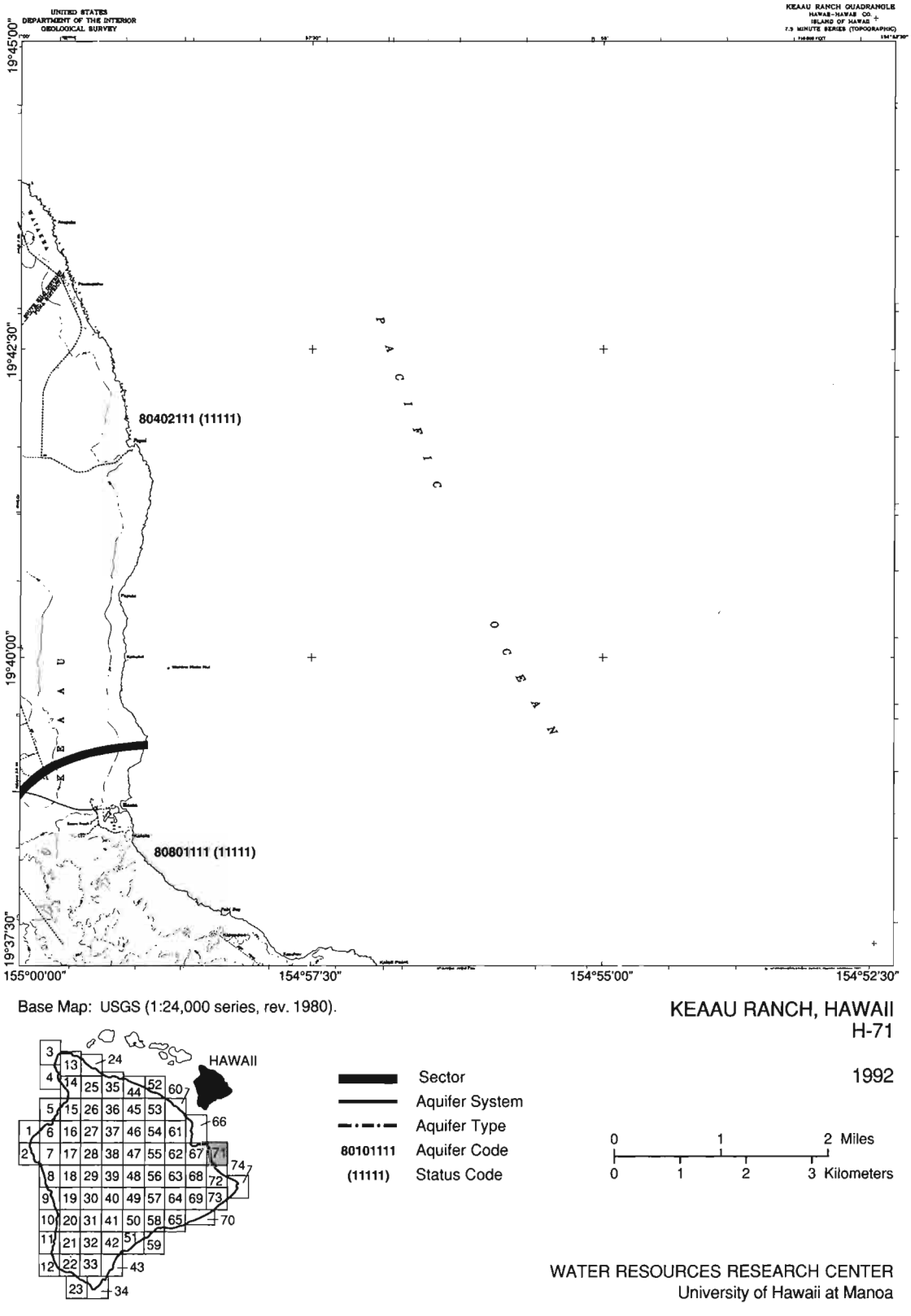
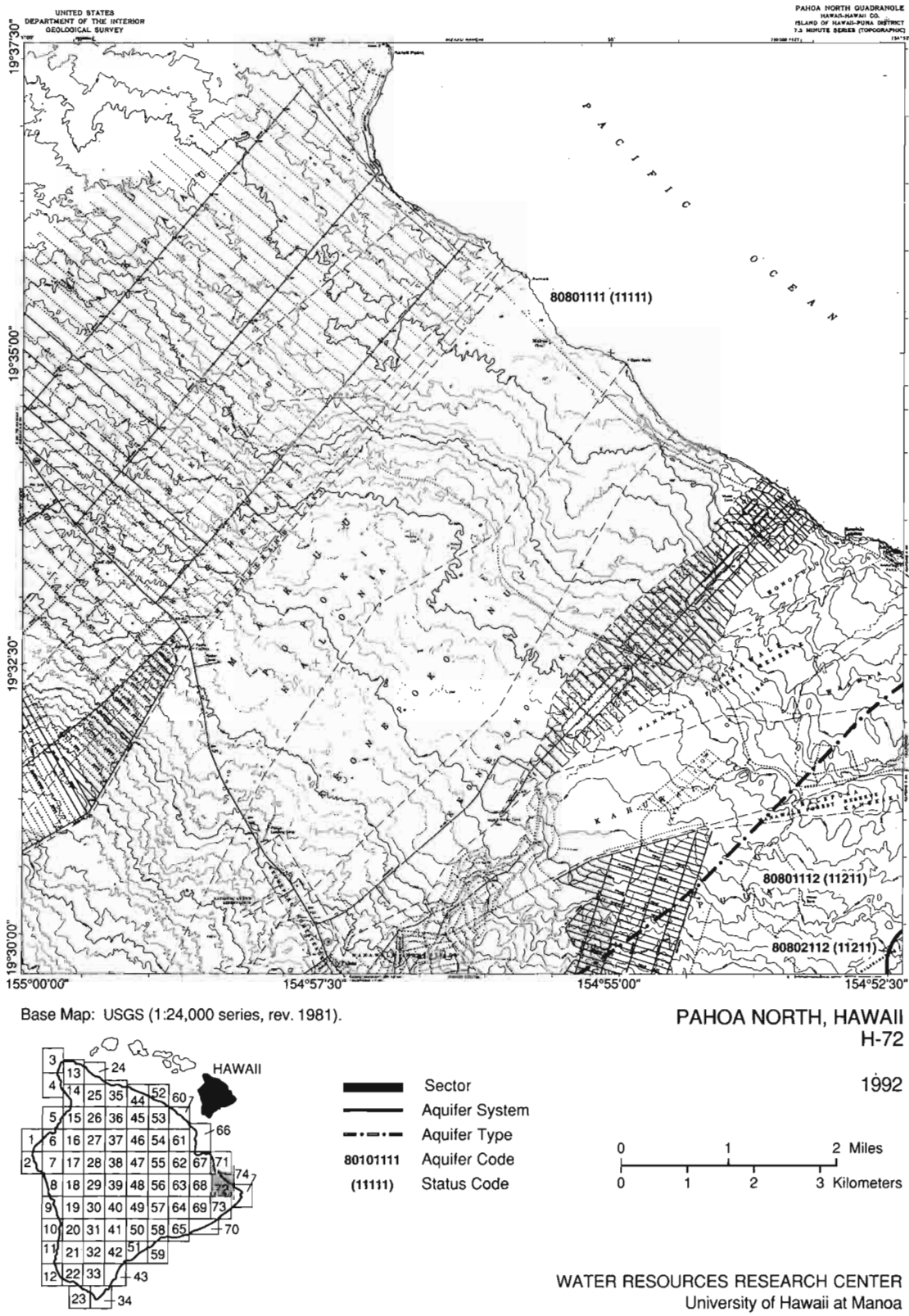
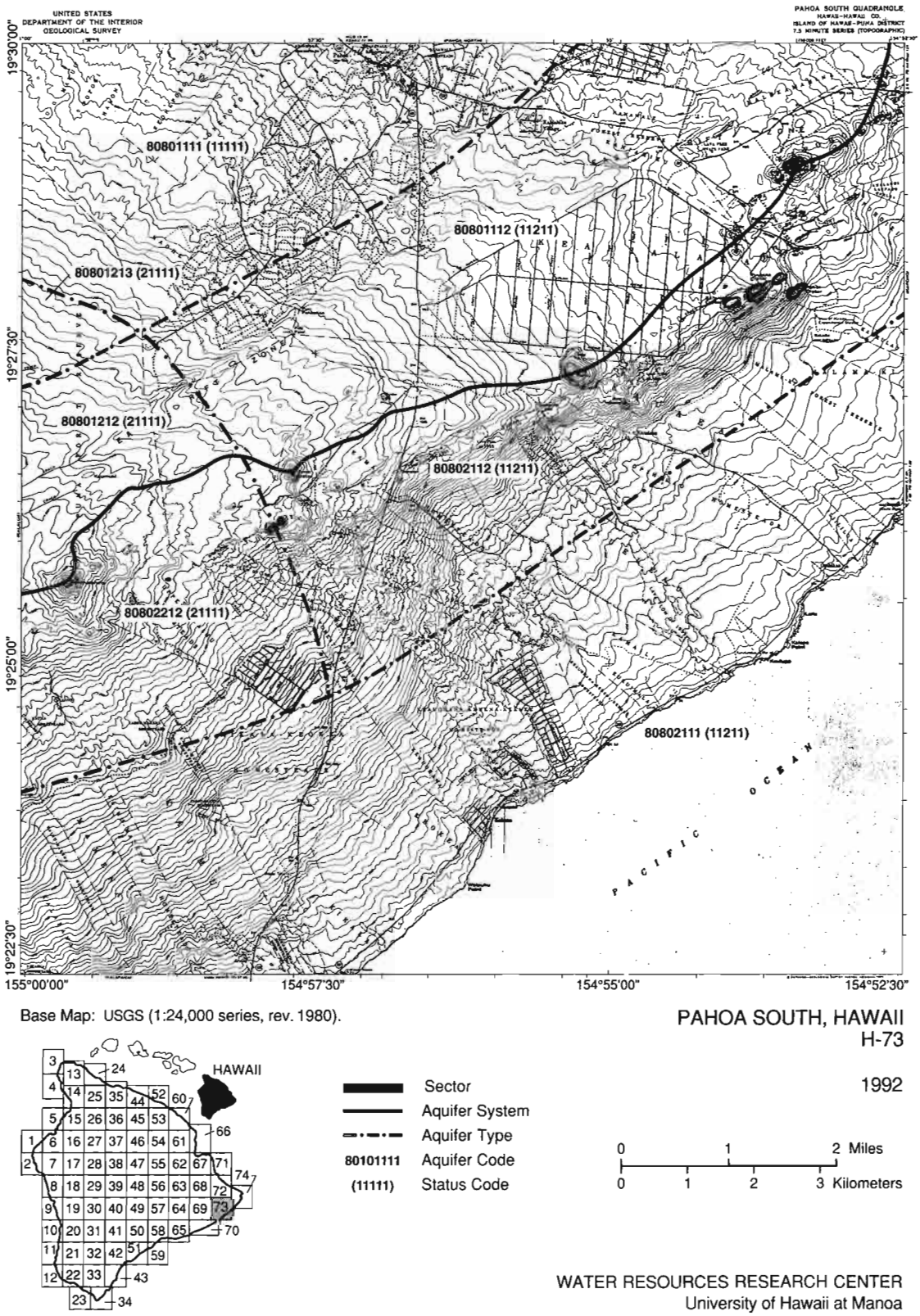
Appendix Figure A.1.70. Aquifer classification map, Kalapana, Hawai'i



Appendix Figure A.1.71. Aquifer classification map, Keaau Ranch, Hawai'i



Appendix Figure A.1.72. Aquifer classification map, Pahoa North, Hawai'i



Base Map: USGS (1:24,000 series, rev. 1980).

PAHOA SOUTH, HAWAII
H-73

1992

Sector
Aquifer System
Aquifer Type
80101111 Aquifer Code
(11111) Status Code

0 1 2 Miles
0 1 2 3 Kilometers

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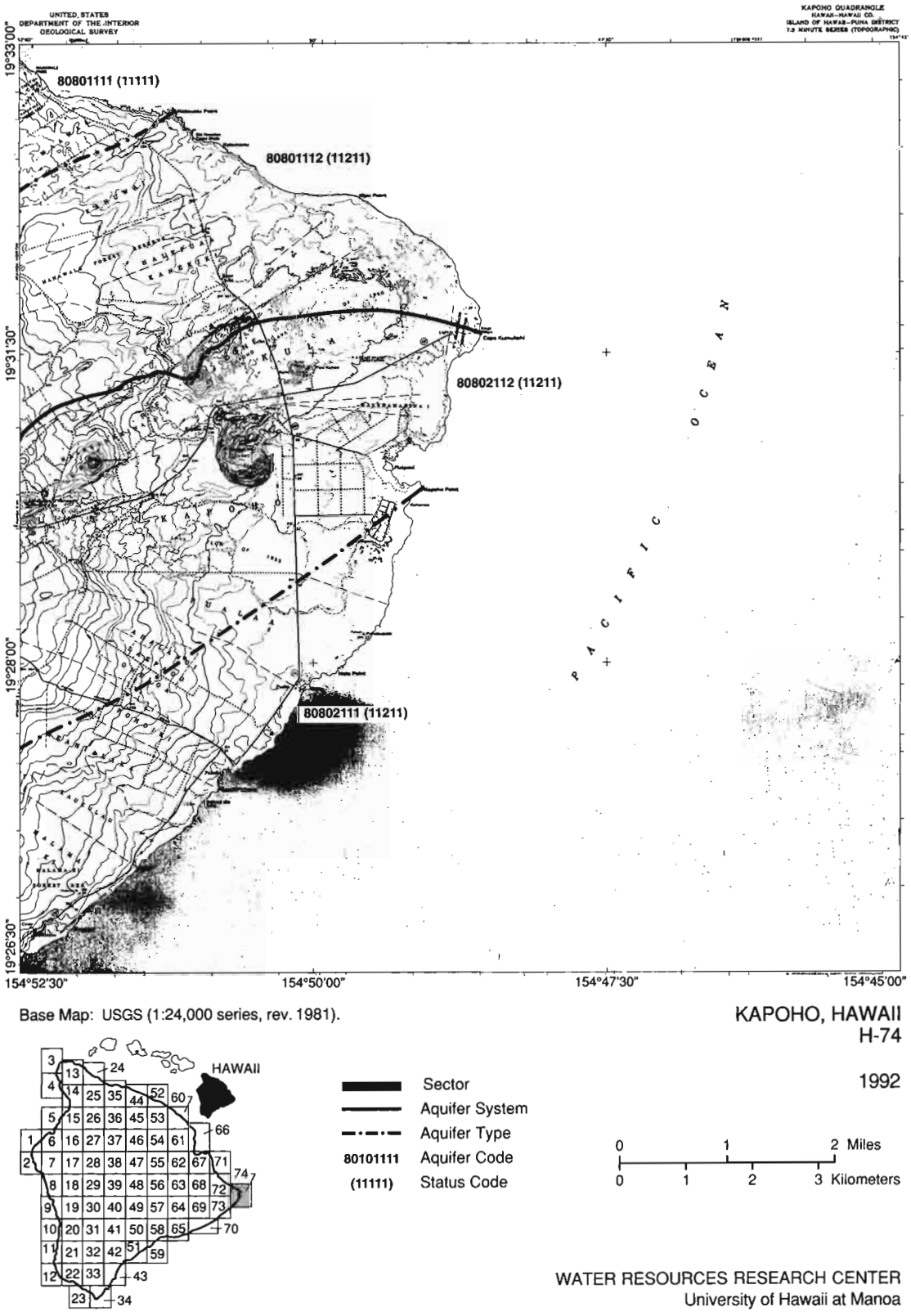
Appendix Figure A.1.73. Aquifer classification map, Pahoa South, Hawai'i



Appendix Figure A.1.74. Aquifer classification map, Kapoho, Hawai'i