BEFORE THE PUBLIC UTILITIES COMMISSION

OF THE STATE OF HAWAII

----In the Matter of----	)	
	)	
PUBLIC UTILITIES COMMISSION	)	DOCKET NO. 2008-0249
	)	
Instituting a Proceeding to Investigate the Issues and Requirements of Adopting or Establishing Standards for Solar Water Heater Systems as Mandated by Act 204, Session Laws of Hawaii (2008).	)	

DECISION AND ORDER

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DECISION AND ORDER

By this decision and order, the commission affirms, with two exceptions, the Decision and Order filed on July 1, 2009 ("Decision and Order") establishing standards for solar water heater systems ("SWHS"), pursuant to Act 204, Session Laws of Hawaii (2008) ("Act 204"), Section 3, codified as Hawaii Revised Statutes ("HRS") § 269-44. The revised SWHS standards are attached to this decision and order as Exhibit I.

I.

Background

A.

Act 204

Act 204 requires "the installation of solar water heater systems, comparable renewable energy systems, or demand gas water heaters in all new residential development projects constructed after January 1, 2010" and restricts "the solar

thermal energy system tax credit available for single-family residential properties to those properties for which building permits were issued prior to January 1, 2010."[1] The stated purposes of Act 204 are "to increase the use of renewable energy to protect our environment, reduce pollution, make housing more affordable, and enhance Hawaii's local economy[.]"[2]

Section 3 of Act 204, codified as HRS § 269-44, directs the commission to "adopt or establish by rule, tariff, or order, standards for solar water heater systems to include, but not be limited to, specifications for the performance, materials, components, durability, longevity, proper sizing, installation, and quality to promote the objectives of [HRS] section 269-124."[3] Under HRS § 269-44, the commission was required to comply with this mandate by July 1, 2009, or as soon as reasonably practicable.

B.

Procedural History

The commission instituted this proceeding on September 26, 2008, to examine the issues and requirements of adopting or establishing standards for SWHS as mandated by

[1] See Act 204, Section 1.

[2] Id.

[3] Id. at Section 3.

HRS § 269-44.[4] The parties to this proceeding are: HAWAIIAN ELECTRIC COMPANY, INC. ("HECO"); HAWAII ELECTRIC LIGHT COMPANY, INC. ("HELCO"); MAUI ELECTRIC COMPANY, LIMITED ("MECO")[5]; KAUAI ISLAND UTILITY COOPERATIVE ("KIUC"); the DEPARTMENT OF COMMERCE AND CONSUMER AFFAIRS, DIVISION OF CONSUMER ADVOCACY ("Consumer Advocate")[6]; and the HAWAII SOLAR ENERGY ASSOCIATION ("HSEA")[7]. HONEYWELL INTERNATIONAL INC. ("Honeywell") is a participant[8] to this proceeding.[9]

On April 28, 2009, the Parties and Participant submitted their Stipulation in Lieu of Final Statements of

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[4]The investigation was initiated pursuant to Act 204, HRS §§ 269-6 and 269-7, and Hawaii Administrative Rules ("HAR") § 6-61-71. See Order Initiating Investigation to Adopt or Establish Standards for Solar Water Heater Systems ("Initiating Order"), filed on September 26, 2008.

[5]HECO, HELCO and MECO are hereafter collectively referred to as the "HECO Companies."

[6]The Consumer Advocate is statutorily mandated to represent, protect, and advance the interests of all consumers of utility service and is an ex officio party to any proceeding before the commission. See HRS § 269-51 and HAR § 6-61-62. In its Initiating Order, the commission, sua sponte, designated the HECO Companies, KIUC, and the Consumer Advocate as parties to this proceeding.

[7]HSEA filed a Motion to Intervene and Become a Party to this proceeding on October 14, 2008, which the commission granted. See Order Granting Intervention and Participation, filed on December 19, 2008.

[8]On October 16, 2008, Honeywell filed a Motion to Participate without Intervention, which the commission granted. See Order Granting Intervention and Participation, filed on December 19, 2008.

[9]The HECO Companies, KIUC, the Consumer Advocate, and HSEA are collectively referred to as the "Parties" and Honeywell is referred to as the "Participant."

Position, Hearing and Briefs ("Stipulation") and accompanying exhibits (i.e., Exhibits A-D).[10]

On July 1, 2009, the commission issued the Decision and Order establishing standards for SWHS, pursuant to HRS § 269-44, in which the commission adopted the Residential Solar Water Heating System ("RSWHS") standards[11] and specifications ("Standards"), with modifications ("SWHS Standards"), which were attached as Exhibit I to the Decision and Order. In doing so, the commission approved in part, and rejected in part, the Parties and Participant's Stipulation.

In the Decision and Order, the commission invited any interested persons to provide comments regarding the SWHS Standards by July 31, 2009. On July 13, 2009, the Consumer Advocate filed a Motion for Clarification of the Commission's Decision and Order ("Consumer Advocate's Motion"). On July 30, 2009, comments were filed by: (1) Harpiris Energy, LLC ("Harpiris") and SunEnergy Hawaii, Inc. ("SunEnergy) jointly ("Joint Comments"); and (2) FAFCO, Inc. ("FAFCO"). On July 31, 2009, comments were also submitted by: (1) Stanford Carr

[10]To facilitate review of the Stipulation, the commission issued information requests on May 15, 2009, to which the Parties and Participant provided responses on May 29, 2009. Further, on June 1, 2009, the Parties and Participant submitted their Stipulation Setting Forth Proposed Alternatives to the Third-Party Administrator ("Alternatives Stipulation") in response to a commission letter dated May 8, 2009.

[11]The "RSWHS Standards" is the September 19, 2007 version of the HECO Companies' standards for their Residential Efficient Water Heating ("REWH") Program, which was attached to the Initiating Order as PUC Exhibit II.

Development, LLC ("Stanford Carr"); (2) RMA Sales ("RMA"); (3) The Solaray Corporation ("Solaray"), dba Inter-Island Solar Supply; and (4) the HSEA.[12] By letter dated August 5, 2009, the commission forwarded copies of the comments received on July 30 and 31, 2009, to the Parties and Participant for their responses.

By letter filed on August 31, 2009, the Parties and Participant filed joint response to the comments ("Joint Response"). On the same day, HSEA also filed a separate response entitled "Responses to Comments by SRCC OG-300 Advocates on the Public Utilities Commission's Decision and Order in Docket No. 2008-0249" ("HSEA's Additional Response").[13]

C.

Consumer Advocate's Motion[14]

The Consumer Advocate filed its Motion on July 13, 2009, seeking clarification as to: (1) what the commission envisions the process by which the RSWHS Standards will be

[12]On July 31, 2009, the American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. ("ASHRAE"), requested an extension of time to submit comments. By letter dated August 7, 2009, the commission granted ASHRAE's request for an extension of time to submit its comments; however, the commission required ASHRAE to file its comments by August 14, 2009. ASHRAE, however, failed to submit any comments within the extension of time allotted by the commission.

[13]The "OG-300" is a nationally recognized standard for solar water heating systems set forth in the Solar Rating and Certification Corporation's ("SRCC") Document OG-300 "Operating Guidelines and Minimum Standards for Certifying Solar Water Heating Systems." The June 2008 version of the OG-300 was attached to the Initiating Order as PUC Exhibit I.

[14]While submitted as a motion for clarification, the Consumer Advocate's Motion "merely" sought clarification with respect to specific concerns and, thus, the motion will be treated as such.

administered and enforced; and (2) what the commission envisions the process by which the HECO Solar Water Heating Systems Accepted Products List ("Products List") will be made current and posted for up-to-date use by the solar water heater industry.

With respect to administration and enforcement, while the Consumer Advocate recognizes the commission's decision not to establish an administrator for the standards, it requests that the commission clarify what the process will be to administer and enforce the RSWHS Standards for mandated systems. The Consumer Advocate states that contrary to the commission's finding that an administrator is unnecessary, it "believes that an administrator is essential not only to answer questions by solar water heater contractors and residential customers in implementing the RS[WH]S[15] Standards, but as discussed in the Alternatives Stipulation, to perform such functions as site verification of each system."[16] In addition, the Consumer Advocate states that:

> By its recommendation in the Alternatives Stipulation, the Consumer Advocate believed that references to "Administrator" could be deleted in the RS[WH]S Standards to allow the Commission to address the immediate deadline set forth in Act 204 for establishing the RS[WH]S Standards with the intent that the administration and/or enforcement could be addressed at a later time potentially through additional legislative action or clarification. It was not the intention of the Consumer Advocate to imply that an administrator is unnecessary.[17]

[15]In some portions of its motion, the Consumer Advocate incorrectly refers to the RSWHS as the "RSHWS." See Consumer Advocate's Motion at 2 and 5.

[16]Id. at 5.

[17]Id.

Further, the Consumer Advocate states that a question remains concerning who will administer the provisions of the RSWHS Standards not under the purview of the respective county building departments. According to the Consumer Advocate, HECO currently provides approval of system designs that exceed the county building codes but meets HECO's RSWHS Standards.

With respect to the Products List, the Consumer Advocate contends that a dynamic process is needed to update and maintain the Products List and that posting an obsolete Products List on the commission's website without further direction on what the most up-to-date acceptable products are will lead to confusion. The Consumer Advocate states that without such a process, there may be confusion for interested stakeholders with respect to the acceptable products that can be used to meet the RSWHS Standards, and that installation of products that do not meet the standards would result in systems that do not meet or comply with the performance requirements set forth in the standards. In addition, a dynamic process, according to the Consumer Advocate, will also be needed for the Solar Collector BTU/Day Output by Hawaii Sunshine Zone ("Output Tables") which were incorporated into the RSWHS Standards. Thus, the Consumer Advocate requests that the commission provide clarification on what process should be used to disseminate information on a timely basis to interested stakeholders regarding acceptable products that are expected to change "rapidly."

D.

Joint Comments

Harpiris manufactures the SunCache SWHS, a passive polymer ICS system, which "is the lowest-priced residential-scale renewable energy system certified in the U.S."[18] In Hawaii, the SunCache system is distributed by SunEnergy. Harpiris and SunEnergy represent that their SunCache system received SRCC OG-300 and Florida Solar Energy Center certifications.[19]

In the Joint Comments, Harpiris and SunEnergy contend that the decision to adopt the RSWHS Standards instead of the SRCC OG-300 standards will have a detrimental effect on the long-term sustainability of the solar water heating industry in Hawaii. According to Harpiris and SunEnergy, solely using the RSWHS Standards to qualify for the mandate for new construction will: (1) limit consumer choice, (2) stifle technological innovation, (3) put Hawaii out of sync with the rest of the nation and the world, and (4) increase the costs of SWHS for Hawaii consumers. Accordingly, Harpiris and SunEnergy request that the commission modify the eligibility requirements adopted by the commission to allow SRCC OG-300 certification to be used along with the RSWHS Standards to qualify for the new construction mandate.

Specifically, Harpiris and SunEnergy contend that the RSWHS Standards will significantly limit the number of SWHS

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[18]See Joint Comments at 8.

[19]Harpiris was formed in June 2008 and began shipping the SunCache units to Hawaii in late 2008, "after the deadline to become a party to this proceeding." Id.

technologies that qualify for the mandate, and that of the six most common technologies, only two meet the 90% minimum solar fraction requirement of the RSWHS Standards. In addition, Harpiris and SunEnergy state that the 90% solar fraction requirement of the RSWHS Standards is "excessively high" and that 75% solar fraction is considered to be high-performance on the continental U.S. They contend that only direct open-loop active SWHS are sold with regularity in Hawaii, and that other types of systems have been shut out of the market due to the 90% minimum solar fraction requirement. According to Harpiris and SunEnergy, the passive polymer ICS systems are more cost-effective and reliable, and require less maintenance than the direct open-loop systems. Among other things, Harpiris and SunEnergy further state that "[a]cceptance of lower-cost SWH technologies would increase competitive pressures on hardware manufacturers and distributors" and since the "alternative systems are easier to install than direct open-loop systems, the barrier to entry for installers would be reduced and competition would increase amongst installers, benefiting both the retrofit and new construction markets."[20]

E.

FAFCO's Comments

In its comments, FAFCO asserts that it supports the comments provided by Harpiris and SunEnergy. FAFCO states that it agrees that expanding the solar water heating mandate for new

[20] See Joint Comments at 4.

residential construction to include all SRCC OG-300 certified systems will benefit consumers and citizens by:

- Increasing consumer choice by including new and innovative SWH systems, as well as technologies proven to work for decades around the world[;]
- Introducing new and retrofit customers to SWH systems that are easier, faster, and more reliable to install[;]
- Increasing competition amongst manufacturers, distributors, and installers[; and]
- Reducing systems cost for both new construction and retrofit customers[.][21]

In addition, FAFCO states that the best solution is to allow SWHS to qualify for the new construction mandate if they have met the RSWHS Standards or have SRCC OG-300 certification.

F.

Stanford Carr's Comments

In its comments, Stanford Carr requests that the commission include the SRCC OG-300 standards. Stanford Carr states that including the OG-300 standards in the mandate would: (1) provide an opportunity to have more affordable SWHS available to homeowners; and (2) lower the cost to homebuilders and homeowners. Specifically, he states that the OG-300 standards "will provide homeowners with lower priced, cost effective and energy efficient solar water heating system[s] to meet their energy needs and budgets" and that "[s]avings in the OG-300 system is realized in both the purchase price of the unit as well as in maintenance cost when compared to systems under the current

[21] See FAFCO's Comments.

RSWHS Standards."[22] According to Stanford Carr, systems under the RSWHS Standards are projected to "add $4,000 - $10,000" to the cost of a new home, and that homeowners will be burdened with annual maintenance costs for the systems. In addition, he contends that "[i]ncluding the OG-300 system into the RSWHS Standards will result in more Hawaii homes with SWH systems that will reduce our dependence on fossil fuels and aid in achieving the State's intent on clean energy."[23]

G.

RMA's Comments

The comments provided by RMA mirror those provided by Stanford Carr, word-for-word.

H.

Solaray's Comments

Solaray, incorporated in 1975, states that it was a founding member of the HSEA in 1977 and served as a "trade ally" during HECO's administration of its REWH and residential new construction ("RNC") programs from 1995-2009. Solaray represents that it currently supports SAIC/Honeywell in its capacity as an active Hawaii market participant and wholesale distributor of renewable energy systems and components.

According to Solaray, the commission's Decision and Order does not guarantee the stated purpose of Act 204 of

[22]See Stanford Carr's Comments at 1 (emphasis in original omitted).

[23]Id. at 2.

reducing pollution and making housing more affordable. It contends that the adopted standards do not adequately include specifications for performance, materials, components, durability, longevity, proper sizing, installation and quality, or "provide for the maintenance of essential aspects of the status quo nor allow for simple changes to documents that must remain dynamic to be coherent, effective, and enforceable."[24] Solaray states that the "HECO REWH and RNC program documents, protocols, and thorough third-party post installation system inspections were woven tightly together in a continuous and interconnected quality assurance chain . . . [and] that [t]he legislative goals of reducing pollution and making housing more affordable are out the window without field inspections and verification that the standards and specifications are being enforced."[25] In addition, Solaray asserts that the success of the program going forward requires active administration and enforcement of the standards.

Solaray further asserts that it "believes that SAIC/Honeywell have the necessary expertise and experience to administer the standards and specifications, make timely updates to the Output Tables, and conduct cost effective field inspections and verification."[26] Solaray contends that these tasks are outside of the scope and budgets of the county departments and that "SAIC/Honeywell already administer these

[24] See Solaray's Comments at 2.

[25] Id.

[26] Id. at 2-3.

program documents and protocols for the residential retrofit market."[27] According to Solaray, the incremental cost for SAIC/Honeywell to maintain and update the new construction documents and protocols will be minimal.

Specifically, Solaray contends that the Output Tables for HECO, MECO, and HELCO contain errors and dated materials that must be corrected prior to final acceptance. It contends that HSEA prepared and submitted corrected Output Tables for the review of the "parties and interveners [sic]" and that the July 13, 2008 Output Tables[28] filed by the utilities do not include HSEA's corrections and updates.

In addition, Solaray states that the commission's decision not to include a Products List is inconsistent with thirteen years of real world program experience and "makes no sense." According to Solaray, the types of products that can be used are already defined by the program documents since the "standards and specifications make specific judgments about the products that can and cannot be used and the Commission has ruled in this docket that these judgments and requirements are not too stringent."[29] Solaray contends that it is unaware "of a single product ever having been rejected by the HECO companies that met the minimum program requirements and was represented by a local

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[27] Id.

[28] Solaray incorrectly refers to the tables being filed on July 13, 2008, as opposed to July 13, 2009. See Solaray's Comments at 3.

[29] Id. at 4.

stocking distributor, contractor, dealer or retailer."[30] According to Solaray, the maintenance of the Products List protects consumers from false and inaccurate claims and is consistent with the public interest.

Finally, Solaray contends that current, accurate, and timely updates of the Output Tables are necessary for proper design, sizing, and performance of approved systems. According to Solaray, SAIC/Honeywell will be updating the Output Tables for the retrofit program and that the same collector ratings should be "used and harmonized" for the mandated systems. Thus, it suggests that "[i]t therefore seems prudent and reasonable to also require SAIC/Honeywell keep these documents current for the new construction market."[31]

I.

HSEA's Comments

In its comments, HSEA states that it concurs with the commission's decision on some issues but disagrees with others. In particular, HSEA states that it disagrees with, among other things, the commission's decision to: (1) not designate an administrator; (2) delete the Products List; (3) not provide a dynamic process to update the Output Tables; and (4) not provide for system inspections. According to HSEA, these decisions "ha[ve] compromised the RSWHS Standards to the point that

[30] Id.

[31] Id. at 4-5.

measurement and evaluation of impacts become[] guesswork at best."[32]

With respect to an administrator, HSEA states that its position is that an administrator is essential to comply with the intent and objectives of HRS §§ 269-44 and 269-124. Specifically, by deciding not to designate an administrator, the commission, according to HSEA, "failed to provide a means for ensuring the performance, materials, components, durability, longevity, proper sizing, installation, and quality to promote the objectives of HRS § 269-44."[33] While it agrees with the commission that the building departments of the respective counties have oversight over portions of the installation of SWHS, HSEA contends that the commission failed to identify which provisions of the RSWHS Standards fall under the duties and obligations of the building departments and how provisions of the standards that do not fall under the building departments should be treated. According to HSEA, the functions of an administrator "include, but are not limited to, maintenance of those aspects of the RSWHS Standards that require timely updates, to answer questions about the RSWHS Standards from affected parties, and to verify compliance with the RSWHS Standards" -- functions that will not be met without an administrator.[34]

HSEA states that the Output Tables and Products List are integral to the RSWHS Standards and are dynamic, requiring

[32]See HSEA's Comments at 6.

[33]Id. at 3 (internal quotes omitted).

[34]Id. at 3.

more frequent and timely updates than the core portions of the standards. It contends that requiring that a docket be opened every time the Output Tables need to be updated would "create an unnecessary burden on the affected parties, hinder innovation, and detract from the effectiveness of the RSWHS Standards."[35]

HSEA recommends that the commission designate an administrator for the RSWHS Standards and states that the most logical choice for the "Administrator" is the Third Party Administrator ("TPA"). According to HSEA, the "TPA already administers the RSWHS Standards for SWHS on new (until January 1, 2010) and existing homes [and] . . . uses the same RSWHS Standards proposed by the" Parties and Participant in their Stipulation.[36] It contends that the TPA already inspects SWHS installed under the standards and is already contracted with the commission to administer the RSWHS Standards. Thus, HSEA contends that the TPA can provide similar tasks regarding the SWHS mandate for new construction homes for a "minor incremental cost" increase to its existing contract.

In addition, HSEA states that the commission should not adopt the Output Tables submitted by the electric utilities on July 13, 2009, since those tables contain errors and are based on outdated SRCC OG-100 collector ratings. HSEA contends that the SRCC recently changed its OG-100 collector rating methods from rounding collector output to the thousands of BTU per panel per day to hundreds of BTU per panel per day. Due to the above,

[35] Id. at 6.

[36] Id. at 7.

HSEA recommends that the commission adopt the tables it prepared (Attachment 2 of the HSEA's Comments) "so that the most current collector output ratings are incorporated into the RSWHS Standards."[37]

Furthermore, HSEA states that the TPA currently updates the Products List for SWHS eligible for ratepayer-funded rebates for new and existing residential homes. Stating that the same Products List can and should be maintained and updated by the TPA for mandated SWHS, HSEA recommends that the commission re-instate the Products List and designate the TPA to maintain and update the list for mandated SWHS. HSEA also asserts that "[w]ithout the Products List and without a means to maintain and update the list, the performance, longevity, and quality of mandated SWHS may be jeopardized."[38]

Finally, HSEA recommends that the commission provide for system inspections of mandated SWHS. HSEA contends that the purpose of system inspections are to verify compliance with the RSWHS Standards and, are in addition to, and not in lieu, of those provided by county building departments. HSEA states that inspections are provided on rebate SWHS and are "essential to insure the economic and environmental benefits accruing to homebuyers and the state are preserved in the same way they are for rebated SWHS."[39]

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[37] Id. at 8.

[38] Id. at 8-9.

[39] Id. at 9.

J.

Parties and Participant's Responses

1.

Joint Response

On August 31, 2009, the Parties and Participant filed their Joint Response to the comments on the SWHS Standards adopted by the commission. In their Joint Response, the Parties and Participant state that: (1) they continue to believe that adoption of the RSWHS Standards, consistent with their Stipulation and Alternatives Stipulation (collectively, "Stipulations"), is more appropriate and reasonable for the installation of SWHS in Hawaii than the SRCC OG-300 standards; and (2) the RSWHS Standards were developed specifically for Hawaii's climate and "have successfully guided the installation of over 50,000 SWHS in Hawaii over the last thirteen years."[40] They note that while certain persons or entities have suggested that adoption of the OG-300 standards is preferable over the RSWHS Standards for various reasons including increasing customer choice and reducing costs, "albeit at some degradation in system performance," the RSWHS Standards are the right choice for Hawaii.[41] According to the Parties and Participant, "[w]ith its superior solar resource, relatively constant and benign climate and lack of freezing temperatures, Hawaii is one of the few

[40] See Joint Response at 1.

[41] Id.

locations in the United States where a 90 percent solar fraction is possible."[42]

In addition, the Parties and Participant state that there is insufficient information at this time to determine the impacts of adopting the OG-300 standards on the current program. They state that information is needed to review certain pertinent issues such as the following:

> (1) Determine and analyze the advantages and disadvantages of allowing the installation of solar water healing systems with varying solar fraction (i.e., less than 90%) to the consumer and the State. Such advantages asserted by the various persons' and entities' comments include greater selection of systems and lower prices. However, these must be measured against the fact that allowing lower solar fraction systems would result in lost opportunities for energy efficiencies and savings as homeowners would be hesitant to replace their installed systems (e.g, a solar water heater system with a 60% solar faction to achieve a 90% solar fraction).
>
> (2) Determine and analyze the processes that may be necessary to educate consumers that solar water heating systems with varying solar fractions and estimated savings will be in place in new construction.
>
> (3) Determine and analyze the changes that will need to be implemented by the solar water heating system industry to adopt the OG-300 Standards.[43]

Furthermore, the Parties and Participant advise that technological advancements and periodic retesting of the outputs of SWH panels under SRCC OG-100 standards incorporated into the

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[42] Id. at 2 (footnote omitted).

[43] Id.

RSWHS Standards require updates to various sections of the standards, including the Output Tables.[44] Thus, the Parties and Participant state that they "continue to believe that it is essential for an administrator of these standards or a process to update these standards, in a timely manner, be established by the Commission consistent with their Stipulations."[45]

2.

HSEA's Response to OG-300 Advocates

In addition to being a signatory to the Parties and Participant's Joint Comments, the HSEA submitted an additional response on August 31, 2009, focused on comments provided by advocates for the inclusion of OG-300 certification.[46] HSEA summarized the comments expressed by the OG-300 Advocates in a table entitled "Table 1. Submitted Commentary Tabulation", which is set forth on page 5 of its response.

HSEA questions the assertions of OG-300 Advocates: (1) that allowing SRCC OG-300 certified SWHS will reduce costs; and (2) that the RSWHS Standards limits customer choice and stifles innovation. With respect to cost, HSEA disputes

[44]The Parties and Participant referred to the Output Tables as "Table 6" which is inaccurate. In its adoption of the RSWHS Standards, the commission relabeled the tables as "Attachment A." See RSWHS Standards (effective July 1, 2009) at 4.

[45]See Joint Response at 3.

[46]In their comments, Harpiris, SunEnergy, FAFCO, Stanford Carr and RMA advocated that the commission allow OG-300 certification to be used along with the RSWHS Standards to qualify for the SWHS mandate for newly constructed single-family homes. Thus, Harpiris, SunEnergy, FAFCO, Stanford Carr and RMA are collectively referred to as the "OG-300 Advocates."

Harpiris' statement that its SunCache system can be installed for $3,600 with a 60% solar fraction by stating that based on its calculations, "a very expensive $7,000+ two collector (unit) system will meet less than half the RSWHS Standard 90% contribution."[47] In addition, according to HSEA, the average cost under the HECO standards for new construction in 2008 for a family of four, with a 90% solar fraction, was "4,240 tax included" as opposed to $7,300 and up to $10,000 cited by some of the OG-300 Advocates.[48] Thus, it contends that costs for systems installed in compliance with the RSWHS Standards for new homes are "grossly overstated."

On the assertion that both RSWHS Standards and the OG-300 standard should be allowed to satisfy the mandate, HSEA contends that the OG-300 standard has no minimum energy savings requirement while the RSWHS Standards do, and that lowering the standards will not result in more systems since all new single-family homes will be built with mandated SHWS, beginning January 1, 2010. HSEA contends that allowing OG-300 certified systems to qualify for the mandate will "only result in less energy savings and more oil used to generate electricity to heat water."[49]

With respect to the assertion that adoption of the RSWHS Standards limits choice, HSEA contends that under the RSWHS Standards new home builders are limited only to those systems

[47] See HSEA's Additional Response at 5.

[48] Id. at 6.

[49] Id. at 7.

that can demonstrate a solar contribution of at least 90% of the average annual water heating load. According to HSEA, under these constraints, builders have "substantial choice." Among other things, HSEA contends that collector manufacturers that represent 83% of the U.S. market are active in the Hawaii market and that there are over 70 participating contractors in the State who know and install systems in accordance with the RSWHS Standards. In addition, with respect to the RSWHS Standards stifling innovation, HSEA states that it "supports innovation and system cost reductions but not at the expense of system efficiency, performance, longevity, and the persistence of energy savings."[50]

In summary, HSEA states that the "OG-300 Advocates admit that their systems cannot save as much energy as systems that conform to the RSWHS Standards."[51] In addition, HSEA states that it has "been shown that there is no cost savings resulting from the systems offered by the OG-300 Advocates, and that builder choice (78 manufacturers offering 375 products) and competition (over 70 contractors) exist within the RSWHS Standards arena."[52] Thus, the HSEA contends that the commission "should not lower the state solar standards to accommodate the commercial interests of companies whose products have no cost advantages and save less energy."[53]

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[50] Id. at 8.

[51] Id. at 10.

[52] Id.

[53] Id.

II.

Discussion

A.

Allowing Both OG-300 and RSWHS Standards

The OG-300 Advocates argue that SRCC OG-300 certification should be used along with RSWHS Standards to qualify for the SWHS mandate under HRS § 269-44. In general, the OG-300 Advocates contend that allowing OG-300 certification along with the RSWHS Standards would increase customer choice and competition in the SWHS market while reducing costs. They also state that their OG-300 certified systems would be "easier, faster, and more reliable to install[,]"[54] more cost-effective, and require less maintenance. In response, the Parties and Participant argue that there is insufficient information to determine the impacts of adopting OG-300 standards on the current program. Specifically, the Parties and Participant state that there must, among other things, be a determination and analysis of the "advantages and disadvantages of allowing the installation of solar water heating systems with varying solar fraction (i.e., less than 90%) to the consumer and the State."[55] They also state that while the advantages noted by OG-300 Advocates include greater selection of systems and lower prices, these advantages "must be measured against the fact that allowing lower solar

[54]See FAFCO's Comments.

[55]See Joint Response at 2.

fraction systems would result in lost opportunities for energy efficiencies and savings[.]"[56]

Even if the commission were to agree with the assertions of the OG-300 Advocates,[57] it is indisputable that the purposes of Act 204 are "to increase the use of renewable energy to protect our environment, reduce pollution, make housing more affordable, and enhance Hawaii's local economy[.]"[58] To allow SWHS with lower solar fractions would result in less energy savings and will not provide the homeowner with the full benefits that the homeowner should receive as a result of the Act 204 mandate. Based on the above, the commission affirms its decision to adopt the RSWHS Standards, with modifications, as set forth in the Decision and Order. The commission notes, however, that if the OG-300 Advocates (or any other entities) wish to amend the standards in any manner, they may file an application to do so in accordance with Section 6.01 of the RSWHS Standards, adopted by the commission.

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[56] Id.

[57] The commission also notes that HSEA disputes many of the assertions made by the OG-300 Advocates.

[58] See Joint Response at 2.

B.

Administrator, Products List, and Output Tables

The Parties and Participant and Solaray, in their various filings,[59] suggest that the commission should appoint an administrator, reinstate the Products List, and establish a "dynamic" process to update the Output Tables (and Products List). HSEA also recommends that the commission reject the Output Tables filed by the electric utilities on July 13, 2009, and instead adopt the tables it attached as "Attachment 2" to its comments.[60]

With respect to an administrator, the Parties and Participant and Solaray state that an administrator is essential to the RSWHS Standards. In particular, the Consumer Advocate requests guidance on how the RSWHS Standards would be "administered and enforced" and who would administer provisions of the standards not under the purview of the county building departments (when designs exceed county codes but meet the RSWHS Standards). The commission believes that provisions beyond the county codes would fall under Section 2.03 of the RSWHS Standards which state "[w]here discrepancies, if any, exist between local codes in effect at that time and these Standards and

[59]These filings include the Consumer Advocate's Motion, Solaray's Comments, HSEA's Comments, the Joint Response, and HSEA's Additional Response.

[60]Solaray also recommends that the commission adopt the Output Tables proposed by HSEA in its comments. See Solaray's Comments at 3.

Specifications, local codes shall govern."[61] Thus, it does not appear that an administrator is as essential as articulated by the proponents.

Furthermore, the commission disagrees that the "Administrator" for the RSWHS Standards should be the TPA. The TPA administers the residential efficiency programs of the HECO Companies (operating on the islands of Oahu, Maui, Molokai, Lanai, and the Big Island). HRS § 269-44 is a statewide mandate and the TPA does not have duties to administer programs on the island of Kauai. In addition, while proffering that the TPA should assume the responsibilities of the "Administrator" for mandated SWHS for a "minor incremental cost," they fail to identify how this cost would be met since no funding was provided by the Legislature, and ratepayers should not be required to fund a State mandate without specific direction from the Legislature, which is also lacking.

With respect to the Products List, the commission disagrees that there is a necessity for such a document. While having such a list may provide ease to stakeholders, to a certain extent, the commission still believes that "inclusion of a product list could result in negative consequences such as, but not limited to unnecessarily restricting the type of products that can be utilized for the installation of SWHS in Hawaii for compliance with these standards, which could unreasonably

[61]This section was not amended from the original document. See Stipulation, Exhibit A, Section 2.03 (Systems).

increase the costs to homeowners."[62] Any product that meets the standards can and should be used at the option of the homebuilder. As HSEA states, "[u]nder the RSWHS Standards the builder is limited only to those systems that can demonstrate a solar contribution of at least 90% of the average annual water heating load."[63] The commission agrees with HSEA, and believes that this statement should be applicable with respect to all products and components of SWHS installed under the commission's RSWHS Standards. Further, the commission finds that not restricting homebuilders to an "approved" Products List would allow for more choices in the industry and, ultimately, reduce costs to homeowners. Given the above, the Consumer Advocate's request for clarification on what process should be used to disseminate information on the Products List is unnecessary. The static Products List on the commission's website is for informational purposes and will only be accessible for a few years, while industry stakeholders become more familiar with the new standards. The accessibility of the list should not lead to confusion as articulated by the Consumer Advocate since it is clear that the list is for informational purposes only.

Finally, with respect to the Output Tables, HSEA, the Consumer Advocate, and Solaray contend that a process is needed to update the tables "expeditiously." Specifically, HSEA argues that "[r]equiring a docket to be opened every time the Output Table[s] needs updating would create an unnecessary burden on the

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[62] See Decision and Order at 22.

[63] See HSEA's Additional Response at 7.

affected parties, hinder innovation, and detract from the effectiveness of the RSWHS Standards."[64] The commission generally disagrees. While the Output Tables may require more frequent updates as opposed to the core portions of the RSWHS Standards, the process established for updating the standards should be equally and nondiscriminatory applied to ensure that the changes proposed (including those regarding the Output Tables) are reasonable and in the public interest, given the statewide impact and mandatory nature of the standards. In addition, given the commission's decision not to designate an administrator as requested by the Parties and Participant in the Stipulation, the commission's options are limited. Moreover, the commission notes that the duration of a proceeding before the commission is often dependent on the structure and completeness of the filed application. For instance, those proposing changes to the Output Tables or any portions of the RSWHS Standards could include the endorsement of or a stipulation amongst affected stakeholders (including the Parties and Participant) with regards to the proposed changes, which could assist in the timely review and assessment of the proposed change. In addition, the Parties and Participant could opt to jointly submit proposed changes to the adopted RSWHS Standards.

Furthermore, the commission finds HSEA's recommendation that the commission adopt the tables it submitted as "Attachment 2" to its comments rather than those submitted by the electric utilities on July 13, 2009, to be inappropriate. HSEA

[64] See HSEA's Comments at 6.

represents that the tables submitted on July 13, 2009, contain errors and are based on outdated SRCC OG-100 collector output ratings, and proposed revised output tables (attached as "Attachment 2" to its comments) for adoption by the commission. It appears, however, that the tables proposed by HSEA are not endorsed nor fully vetted by the other Parties or the Participant to this proceeding. The Joint Response filed by the Parties and Participant have no reference to or any mention of the tables proposed by HSEA. In addition, Solaray in endorsing HSEA's proposed Output Tables state that "HSEA prepared and submitted correct Output Tables for Oahu, Maui, and the Big Island to the parties and interveners for review."[65] Thus, while they may have been submitted for review, it does not appear that the Parties or Participant have approved or endorsed HSEA's proposed Output Tables. The record with respect to HSEA's proposed revised Output Tables appears, at this time, to be incomplete. In addition, the submittal of HSEA's proposed Output Tables is not in compliance with Section 6.01 of the adopted RSWHS Standards. Thus, the commission concludes that adoption of HSEA's proposed revised Output Tables is unreasonable and not in the public interest.

However, given the current state of this proceeding, and the representation by HSEA that the July 13, 2009 Output Tables contain errors,[66] the commission will allow the Parties and Participant to file revised Output Tables through a stipulation.

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[65] See Solaray's Comments at 3.

[66] See HSEA's Comments at 7.

The revised Output Tables should correct any errors and may also reflect updated SRCC OG-100 collector output ratings, as applicable; however, any revisions to the tables must be filed within thirty days of this decision and order. Upon filing of the stipulation, the revised Output Tables will be deemed to replace the July 13, 2009 tables submitted by the electric utilities (which have been incorporated as Attachment A to the revised standards, attached hereto as Exhibit I). All further revisions to the Output Tables must be conducted through the process set forth in Section 6.01 of the RSWHS Standards adopted by the commission.

C.

System Inspections

The Parties and Participant argue that an administrator is needed to conduct system inspections to verify compliance with the RSWHS Standards. According to HSEA, "[i]nspections are essential to insure the economic and environmental benefits accruing to homebuyers and the state are preserved in the same way they are for rebated SWHS."[67] Thus, HSEA recommends that the commission provide for system inspections of mandated SWHS.

Although the commission is not persuaded that it is necessary to designate an administrator for the RSWHS in general, the commission does recognize that system inspections can be beneficial to verify compliance with RSWHS Standards and confirm cost savings to homebuyers achieved through use of SWHS.

[67] See HSEA's Comments at 9.

Although the commission is also concerned that requiring system inspections for all mandated SWHS could add to the cost of home purchases, it may be a necessary expense for this program.

Thus, the commission believes that homebuilders should be required to arrange or contract for system inspections on mandated SWHS to confirm that installations have been completed pursuant to the commission's RSWHS Standards, at the homebuilders expense. Such system inspections, however, must be done by an independent and qualified third-party (i.e., not by the contractor that installed the system, or any entity affiliated with the contractor). Accordingly, the RSWHS Standards adopted by the commission in the Decision and Order is amended to include a new section under "Part II - General" to read as follows:

> **2.04. SYSTEM INSPECTIONS.** System inspections confirming that solar water heating systems were installed according to these Standards and Specifications are required and must be conducted at the cost of the homebuilder, and each contractor that installs solar water heater systems pursuant to these Standards and Specifications shall inform homebuilders, in writing, of this system inspection requirement. Any such inspections must be provided by an independent and qualified third-party (i.e., not by the contractor that installed the system, or any entity affiliated with the contractor).

The revised RSWHS Standards, incorporating the amendment set forth above, are attached as Exhibit I to this decision and order.

III.

Orders

THE COMMISSION ORDERS:

1. The commission's decision to establish standards for SWHS, as required under Act 204 (codified as HRS § 269-44), by adopting the RSWHS Standards, with modifications (set forth in Exhibit I of the Decision and Order issued on July 1, 2009) is affirmed, with the revisions set forth in Exhibit I to this decision and order, and described below.

2. Within thirty days of this decision and order, the Parties and Participant shall file revised Output Tables through a stipulation, pursuant to Section II.B, above. Upon filing of the stipulation, the revised Output Tables shall be deemed to replace the July 13, 2009 tables submitted by the electric utilities (which have been incorporated as Attachment A to the revised standards, attached hereto as Exhibit I). All further revisions to the Output Tables must comply with the process set forth in Section 6.01 of the RSWHS Standard adopted by the commission, set forth as Exhibit I to the Decision and Order (and attached hereto as Exhibit I, as revised).

3. The RSWHS Standards adopted by the commission, set forth as Exhibit I to the Decision and Order, is amended to

include a new section under "Part II - General" to read as follows:

> **2.04. SYSTEM INSPECTIONS.** System inspections confirming that solar water heating systems were installed according to these Standards and Specifications are required and must be conducted at the cost of the homebuilder, and each contractor that installs solar water heater systems pursuant to these Standards and Specifications shall inform homebuilders, in writing, of this system inspection requirement. Any such inspections must be provided by an independent and qualified third-party (i.e., not by the contractor that installed the system, or any entity affiliated with the contractor).

The revised RSWHS Standards, incorporating the amendment set forth above, is attached as Exhibit I to this decision and order.

DONE at Honolulu, Hawaii OCT 29 2009.

PUBLIC UTILITIES COMMISSION
OF THE STATE OF HAWAII

By: _____
Carlito P. Caliboso, Chairman

By: _____
John E. Cole, Commissioner

By: _____
Leslie H. Kondo, Commissioner

APPROVED AS TO FORM:

_____
Ji Sook Kim
Commission Counsel

2008-0249.SWH Standards.

RESIDENTIAL SOLAR WATER HEATING SYSTEM STANDARDS AND SPECIFICATIONS

Effective as of October 29, 2009

PART I – DEFINITIONS.

"Commission" means the Public Utilities Commission of the State of Hawaii.

"HAR" means the Hawaii Administrative Rules, as amended.

"HRS" means the Hawaii Revised Statutes, as amended.

"RSWHS" means Residential Solar Water Heating System.

"Solar Collector BTU/Day Output by Hawaii Sunshine Zone" means the listing of accepted collectors and their output ratings for each sunshine zone as described in Section 4.02 of these Standards and Specifications.

"Standards and Specifications" or "RSWHS Standards and Specifications" means this Residential Solar Water Heating System Standards and Specifications.

The following abbreviations used, and their meanings, shall be as follows:

"BTU" means British Thermal Unit.
"PSI" means Pounds per Square Inch.
"F" means Fahrenheit.

PART II – GENERAL.

2.01. APPLICATION AND USE OF RSWHS STANDARDS AND SPECIFICATIONS. HRS § 196-6.5 mandates that on or after January 1, 2010, no building permits shall be issued for a new single-family dwelling that does not include a solar water heater system that meets the standards established under HRS § 269-44, unless a variance is approved by the energy resource coordinator.[1] HRS § 269-44[2] provides that the

[1]HRS § 196-6.5 was established by Section 2, Act 204 of the 2008 Session Laws of Hawaii ("Act 204"), and amended pursuant to Section 14, Act 155 of the 2009 Session Laws of Hawaii.

[2]As established by Section 3, Act 204.

Commission, not later than July 1, 2009 or as soon as reasonably practicable, shall adopt or establish by rule, tariff, or order, standards for solar water heater systems to include, but not be limited to, specifications for the performance, materials, components, durability, longevity, proper sizing, installation, and quality to promote the objectives of HRS § 269-124.

2.02. OTHER DOCUMENTS. Values, forms, tables, charts, approvals, and Policies and Procedures referred to herein are hereby incorporated into these RSWHS Standards and Specifications.

2.03. SYSTEMS. Solar systems installed shall conform to applicable local building, plumbing and electrical codes, these Standards and Specifications, and other requirements described in this document. Where discrepancies, if any, exist between local codes in effect at that time and these Standards and Specifications, local codes shall govern.

2.04. SYSTEM INSPECTIONS. System inspections confirming that solar water heating systems were installed according to these Standards and Specifications are required and must be conducted at the cost of the homebuilder, and each contractor that installs solar water heater systems pursuant to these Standards and Specifications shall inform homebuilders, in writing, of this system inspection requirement. Any such inspections must be provided by an independent and qualified third-party (i.e., not by the contractor that installed the system, or any entity affiliated with the contractor).

PART III – SYSTEM REQUIREMENTS.

3.01. SYSTEM DESIGN. Systems shall be designed specifically for residential water heating. Systems shall be of forced circulation or thermosiphon design which contains potable water. Systems may consist of single or multiple tanks and/or collectors. Multiple tank systems shall have the tanks connected in series. Multiple collector systems shall have the collectors connected in parallel. Single and multiple collectors shall be plumbed in a reverse return (i.e., opposite-end) method to achieve balanced flow through collectors. The solar return collector connection shall be at the highest point on each collector. Systems shall be designed to prevent back-siphoning. Acceptable system designs for forced circulation systems are bottom-return, side-return and top-return. Side-return and top-return system designs shall incorporate check valves and heat loops. Multiple tank bottom-return system designs shall incorporate swing check valves. Forced circulation system component sequence shall conform to Figure 1 for bottom-return systems; to Figure 2 for side-return systems; to Figure 3 for top-return systems; or which conform with applicable county building codes and are approved by the respective county building department. Thermosiphon system designs shall conform to the manufacturer's recommendations. System mounting method shall conform to the mounting method as set forth in the manufacturer's recommendations

and applicable county building codes and approved by the respective county building department. Systems installed in areas which experience freezing conditions shall incorporate appropriate freeze protection measures.

3.02. SYSTEM PERFORMANCE. Systems shall be designed to provide a minimum of 90% of the annual average water heating load, except as provided for in Section 3.03.4 of these Standards and Specifications; to provide consistency of performance over the life of the system; and to achieve a minimum 15 year useful life.

3.03. SYSTEM SIZING. Systems shall be sized to yield an acceptable solar fraction. Solar fraction, expressed as a percentage, is the contribution by the solar system to the average daily water heating requirements. Solar fraction is a function of the actual system hot water storage, design finish tank temperature, daily BTU requirement to achieve design finish tank temperature, and daily collector output as determined by collector tilt, orientation and sunshine zone.

3.03.1. Water Storage. The minimum water storage for the combined capacity of the primary and any additional tanks in systems for new single-family residential construction shall be based on the number of bedrooms as listed in Table 1.

3.03.2. Tank Temperature. The design finish tank temperature shall be 130 degrees F.

3.03.3. Daily BTU Requirement. The daily BTU requirement for the actual system storage shall be determined from Table 2 for the island on which the system is installed.

3.03.4. Solar Fraction. The system design solar fraction shall be not less than 90% and not more than 110% of the total actual system storage BTU requirement. The solar fraction shall be determined by dividing the total adjusted collector BTU output per day by the total actual system storage BTU requirement per day as provided on Form 1.

3.04. COLLECTOR TILT. Collectors shall be tilted not less than 14 degrees and no more than 60 degrees from the horizontal. Forced circulation system collectors mounted on roofs whose pitch is less than 14 degrees shall be tilted to no less than 20 degrees and no more than 30 degrees. Thermosiphon system collectors mounted on roofs whose pitch is less than 14 degrees shall be tilted to no less than 20 degrees and no more than 30 degrees. Collectors mounted on roofs whose tilt is above 35 degrees shall have their output rating derated by percentages listed in Table 3. Collector tilt factors shall be determined by rounding collector tilt to the nearest 5 degrees.

3.05. COLLECTOR ORIENTATION. Collectors shall be oriented between South of due East and South of due West. Collectors oriented East of 135 degrees true or West of 225 degrees true shall have their output rating derated by the percentages shown on Chart 1, Orientation Factors for Solar Installations (Compass Rose Diagram). Chart 1 shows allowable collector orientations and orientation factors corrected for magnetic deviation.

3.06. COLLECTOR SHADING. Collectors shall not be shaded by any permanent obstacle at any portion of the time after 9:00 a.m. or before 3:00 p.m. on December 21 or any other day of the year.

PART IV – PRODUCTS.

4.01. GENERAL. All products used for system installations must conform to these Standards and Specifications.

4.02. COLLECTOR RATINGS. Collectors shall be of the liquid type and shall have a current Solar Rating & Certification Corporation OG-100 rating and certification. Collector output ratings shall be based on OG-100 Category C data for clear sky, mildly cloudy, and cloudy sky conditions and shall be correlated to the applicable sunshine map and the "Solar Collector BTU/Day Output by Hawaii Sunshine Zone" table for the island on which the system is installed.

The sunshine maps reflect the solar energy in terms of calories per square centimeters per day on each island and are attached to these Standards and Specification as Attachment B.

A listing of accepted collectors and their output ratings for each sunshine zone, "Solar Collector BTU/Day Output by Hawaii Sunshine Zone" are attached to these Standards and Specifications as Attachment A. The sunshine zone closest to the collector installation site shall be used to determine collector output. Sites equidistant between two zones may be considered to be in either zone. Sites in the 300 zone shall be considered to be in a 350 zone for system sizing purposes.

4.03. COLLECTOR MATERIALS. For flat plate collectors, collector frame material shall be aluminum, stainless steel or copper. Collector glazing shall be low-iron tempered solar glass. Collector waterways shall be of Type M minimum copper tube.

4.04. COLLECTOR/SYSTEM MOUNTING BRACKETS. Collector/system mounting brackets which secure the collector/system to the support structure or directly to the roof structural member shall be designed specifically for the equipment to be bracketed and shall be fabricated by an established manufacturer.

4.05. COLLECTOR/SYSTEM LEG SETS. Collector/system leg sets which secure the collector/system to the support structure or directly to the roof structural member shall be designed specifically for the equipment to be supported and shall be fabricated by an established manufacturer.

4.06. COLLECTOR/SYSTEM SUPPORT STRUCTURE. Collector/system support structure shall be of structurally sound material. The material shall be of non-corrosive metal channel or similar sections of approved material and finish which are compatible with the collector, collector mounting brackets, collector leg supports and leg set cross braces. Acceptable support structure materials are extruded aluminum solar strut, channel and double T, isolated galvanized steel and UV resistant plastic. Unless otherwise consistent with applicable building codes and approved by the respective county building department, solar strut shall be 1 5/8" x 1 5/8" x 1/8" in size, channel and double T shall be 3" x 1" x 1/8" in size, and angle aluminum shall be 2" x 2" x 3/16" in size. Wood or wood products are not acceptable.

4.07. TANKS. Tanks shall be designed specifically as residential water heaters or water storage tanks. The manufacturer shall provide a warranty over new tanks for at least 5 years. The new tank shall be listed in the most current Air-Conditioning, Heating and Refrigeration Institute's Consumers' Directory of Certified Efficiency Ratings for Heating and Water Heating Equipment. In single tank systems, the tank shall be equipped with an internal thermostat and heating element rated at not more than 4500 Watts. In single tank systems, the lower element, if any, shall be disabled at the upper element. In multiple tank systems, the tank which directly supplies the hot water load shall have an internal thermostat and heating element of an approved rating and the lower element, if any, shall not be disabled.

4.08. PUMP. Pumps shall be of a circulating type. The pump shall be designed to attain the manufacturer's recommended collector flow rate for the total number of system collectors and the total developed head of the solar lines. AC powered pumps shall be compatible with the pump controller. DC powered pumps shall be compatible with the photovoltaic module. Pump isoflanges are not acceptable in lieu of ball valves.

4.09. CONTROLLER. Controller shall automatically control the operation of the circulating pump so that optimum system performance is attained. The controller shall be compatible with the circulating pump. Controller sensors shall be thermisters, which conform to the manufacturer's specifications for the controller.

4.10. PHOTOVOLTAIC MODULE. Photovoltaic modules used to power DC pumps shall be compatible with the pump's performance rating and power requirements.

4.11. TIME SWITCHES. All systems shall have time switches, which control the operation of the auxiliary heating system. Acceptable time switches are electric, electronic and spring-loaded mechanical switches. Electric and electronic time switches shall have a manual override feature.

4.12. ELECTRICAL CONDUCTOR. Electrical conductors exposed to direct sunlight shall have sunlight resistant insulation. Conductors interconnecting the photovoltaic module and DC circulating pump shall not have more than a 3% voltage drop over the one way distance between the pump and module. Refer to Table 5 for conductor sizes based on one way distances.

4.13. PIPING. Piping shall be copper tubing Type M minimum. Solar supply and return pipe shall be sized to attain the manufacturer's recommended collector flow rate for the total number of system collectors and pump size. The pipe size for forced circulation systems with not over 120 square feet of collector area and not over 120 feet total round trip distance shall be 1/2-inch minimum. The pipe size for forced circulation systems with collector area over 120 square feet and/or over 120 feet total round trip distance shall conform to applicable county building codes and be approved by the respective county building department. The pipe size for water heater/storage tank supply, distribution, multiple tank interconnections and overflow lines shall be 3/4-inch minimum. The hot and cold supply lines to a thermosiphon system shall have a pipe size of 3/4-inch minimum. Water heater flex connectors are not acceptable.

4.14. FITTINGS. Fittings shall be bronze, brass, or wrought copper approved for potable water distribution. Factory installed galvanized tank nipples are acceptable.

4.15. PIPE SUPPORTS, BLOCKS AND SPACERS. Pipe supports shall be copper, stainless steel or other approved material. Rooftop piping support blocks or spacers, when used, shall be 2" x 4" painted wolmanized wood blocks, UV resistant non-metallic spacers, solar strut or equal.

4.16. VALVES. Valves shall be bronze or brass.

4.16.1. Ball Valves. Ball valves shall be provided to isolate major system components such as tanks, collectors and circulating pumps. Factory supplied pump isolation flanges are not acceptable to isolate the pump in lieu of ball valves. A ball valve or pump isolation flange is not required between the tank and pump as long as the pump remains above the top of the tank.

4.16.2. Check Valves. Check valves shall be provided with side-return, top-return and multiple tank, bottom-return forced circulation systems or where back siphoning may occur. Check valves shall be of the swing check type.

4.16.3. Flush Out Valves. Flush out valves shall be provided to allow for storage tank and collector draining and periodic flushing. Acceptable valves are hose bibs and boiler drains.

4.16.4. Pressure Relief Valve. A pressure relief valve shall be provided at the collector(s). The pressure setting shall be non-adjustable and rated at 125 or 150 PSI. The valve lever shall be stainless steel and the valve pin shall be brass.

4.16.5. Temperature & Pressure Relief Valve. A temperature & pressure relief valve shall be provided for single or multiple pressurized water storage tank systems provided that the location complies with local code requirements. The temperature and pressure relief settings shall be non-adjustable and rated at 210 degrees F and 150 PSI, respectfully.

4.17. UNIONS. Unions shall be bronze or brass. Unions shall be used to connect dissimilar piping materials. Dielectric unions connecting corrosion causing dissimilar metals are acceptable.

4.18. TEMPERATURE MEASURING DEVICE. A temperature-measuring device shall be provided to measure the temperature of the storage tank, which directly supplies the hot water load. Acceptable temperature measuring devices are temperature gauges and electronic temperature devices.

4.19. FASTENING HARDWARE. All fastening hardware, including, but not limited to, strut-nut sets, through-bolt sets, lag-bolt sets, and hanger-bolt sets, shall be stainless steel Series 300 minimum or other approved material.

4.19.1. Strut-Nut Sets. Strut-nut sets shall consist of one strut nut, bolt, and flat or lock washer each. The size, length and quantity of strut-nut sets shall be that recommended by the manufacturer or one strut-nut set per collector mounting bracket with a minimum bolt diameter and length of 5/16" by 3/4", whichever is greater.

4.19.2. Through-Bolt Sets. Through-bolt sets shall consist of one bolt, nut, flat or fender washer and lock washer each. The size, length and quantity of through-bolt sets shall be that recommended by the manufacturer or one through-bolt set per collector mounting bracket with a minimum bolt diameter and length of 5/16" by 3/4", whichever is greater.

4.19.3. Lag-Bolt Sets. Lag-bolt sets shall consist of one lag bolt and one flat or fender washer. Lag bolt diameter shall be that recommended by the manufacturer or 5/16-inch minimum, whichever is greater. Lag bolts shall be of sufficient length to penetrate a minimum of 1-3/4 inches into the roof structural

member. The number of anchoring lag bolts shall be that recommended by the manufacturer or that listed in Table 4, whichever is greater.

4.19.4. Hanger-Bolt Sets. Hanger-bolt sets shall consist of one hanger bolt and lock washer each and two nuts and flat or fender washer each. Hanger bolt diameter shall be that recommended by the manufacturer or 3/8-inch minimum, whichever is greater. Hanger bolts shall be of sufficient length to penetrate a minimum of 1-3/4 inches into the roof structural member. The number of anchoring hanger bolts shall be that recommended by the manufacturer or that listed in Table 4, whichever is greater.

4.20. INSULATION. Piping insulation shall be flexible and elastomeric with a minimum wall thickness of 1/2 inch and a minimum design temperature of 220 degrees F.

4.21. SOLDER. Solder shall be lead free.

4.22. FLASHING. Flashing, when used, shall be designed to positively seal roof penetrations resulting from the solar system installation. Acceptable flashing materials are lead, copper, aluminum or other approved material. Lead shall not be used where water supplying a catchment system contacts the flashing.

4.23. OTHER PRODUCTS. Neoprene, EPDM spacers or other approved material shall separate corrosion causing dissimilar metals. Minor component products not otherwise listed in these Standards and Specifications may be used provided that their use does not detract from overall system performance.

4.24. PRODUCT WARRANTIES. Manufacturer warranties shall apply to all products. Contractors and/or vendors who unilaterally extend manufacturer product warranties shall provide the solar system purchaser with a written statement that the extension is not guaranteed by any other party.

4.25. ASBESTOS PROHIBITION. No materials containing asbestos shall be used in any product.

PART V – EXECUTION.

5.01. GENERAL. Solar system installations shall result in fully operational systems. Solar systems shall be installed by properly licensed contractors. All required governmental permits shall be issued prior to system installation. Installations shall be in accordance with applicable governmental codes and these RSWHS Standards and Specifications or manufacturer's recommendations where they meet or exceed these Standards and Specifications.

References to the approval of respective county building department in these Standards and Specifications are not intended to obligate the county departments to extend or broaden their purview in any manner. However, to the extent that the county building departments already have inspection and oversight functions over the installation of various portions of solar water heater systems through county building codes, their approval will concurrently satisfy relevant portions of these Standards and Specifications.

5.02. COLLECTORS/SYSTEMS. Solar collectors/systems, mounting brackets, leg sets, support structure and support structure anchoring fasteners shall be attached to form a secure mechanical bond between adjoining components and the roof structural members.

5.02.1. Collectors/Systems. In multiple collector systems, collectors shall be installed with the same tilt and orientation. Solar collectors/systems shall be mounted in a stand-off method with a minimum of 1-1/2 inches between the roof and the bottom edge of the collectors/system, except where the collectors are integrated into the roof.

5.02.2. Mounting Brackets. Mounting brackets shall secure flush mounted collectors directly to the collector support structure or the roof structural members. Unless otherwise provided by the collector manufacturer, a minimum of four brackets per collector shall secure each flush mounted collector. For mounting brackets which require penetration of the collector box, the number of fasteners attaching each bracket to the collector shall equal the number of holes in the bracket, unless otherwise provided by the collector manufacturer. Collector box penetrations by mounting bracket fasteners shall be positively sealed to prevent moisture infiltration. Brackets attached directly to roof structural members shall be secured with a minimum required diameter anchoring fastener. Brackets attached to support structures shall be secured with lock-nut sets on "solar strut" and with through-bolt sets on channel.

5.02.3. Mounting Flanges. Fastening of collectors with mounting flanges directly to the support structure through the mounting flange is acceptable provided that this is consistent with the collector manufacturer's recommendations. When collectors with mounting flanges are fastened directly to the support structure through the mounting flange, collectors shall be secured with strut-nut sets or through-bolt sets. These bolt-sets shall be through-bolted to the support structure in accordance with the collector manufacturer's recommendations, or secured with a minimum of four bolt-sets of the size and length described for mounting brackets per collector, whichever is greater.

5.02.4. Leg Sets. Leg sets shall secure tilted collectors directly to the collector support structure or the roof structural members. The type, number, location and installation method of leg sets shall be in accordance with the collector manufacturer's recommendations. Unless otherwise provided by the collector manufacturer, each tilted collector shall be supported by a minimum of two leg sets. For leg set brackets which require penetration of the collector box, the number of fasteners attaching the collector leg sets to the collector shall equal the number of holes in the leg set bracket, unless otherwise provided by the collector manufacturer. Collector box penetrations by leg set bracket fasteners shall be positively sealed to prevent moisture infiltration. Leg sets shall be secured to the support structure with strut-nut sets on "solar strut" and with through-bolt sets on channel. Leg sets which are 4 feet or longer in length shall be cross-braced diagonally. Cross braces shall be through bolted to the leg sets.

5.02.5. Support Structure. Collector/system support structures shall be anchored by fasteners firmly secured to the roof structural members. Support structure runners, when used, shall be located no farther in than 24 inches from the shorter ends of the collector(s). Anchor fasteners along each runner shall be located no farther from the edge of outer most collector than one-half the collector width and no farther than 4 feet apart. Collector/system support structure anchoring fasteners shall not be exposed on the interior side of roof structural members. Support structures installed parallel to the roof ridge shall provide sufficient clearance from the roof covering to allow for adequate water and debris shed.

5.03. TANKS. Water heaters and/or storage tanks shall be plumbed so that the attached equipment, cover plates and warning labels are visible and accessible. Attached equipment shall be defined as pump, controller, time switch, piping and any other components attached or connected to the tank. All pressurized tanks shall be equipped with a securely attached temperature and pressure relief valve. Piping connections to the tank shall be made with brass or bronze fittings. The tank combination temperature and pressure relief valve drain line shall be securely attached to the temperature and pressure relief valve and shall terminate no more than 2 feet nor less than 6 inches above the ground and pointing downward. Adjustable auxiliary heating thermostats shall be set at 120 degrees F.

5.03.1. Ground Mounted Tanks. Vertical and horizontal ground mounted tanks shall be set level on concrete or other approved base extending not less than 3 inches above the adjoining ground level. Cement bricks placed between the tank and the supporting base shall support tanks. Cement bricks shall be whole and of a nominal minimum size of 2 inches high, 3 inches wide and 7 inches long. A minimum of three bricks evenly spaced shall be used to support vertical tanks. Bricks are not required for tanks with non-metallic bottoms. Horizontal tanks shall be supported in accordance with the tank manufacturer's

recommendations. Acceptable leveling devices are manufactured plastic shims, or other approved material. In side-return, top-return single and multiple tank systems, the solar return line shall be plumbed with a heat loop which extends to within 12 inches of the bottom of the tank. Required swing check valves shall be installed horizontally on the solar return line at the bottom of the heat loop. In bottom-return multiple tank systems, the required swing check valve shall be installed horizontally at the solar return line connection to the tank drain port. Nipples replacing manufacturer supplied tank drain valve shall be of sufficient length to allow adequate access to tank sensor. All contractor installed flush out valves shall have thread caps with hose washer securely attached to the valve.

5.03.2. Roof Mounted Tanks. Roof mounted thermosiphon system tanks shall be supported by the number of tank supports, support fasteners and tank mounting brackets recommended by the manufacturer or those which correspond to the tank length ranges shown on Table 6 for Minimum Thermosiphon System Tank Supports, Support Anchoring Fasteners and Tank Mounting Brackets, whichever is greater. The number of supports and fasteners are based on roof structural member spacing of 24 inches on center or less. The length of tank supports shall be not less than the tank diameter or width and shall conform to Section 4.06. Collector/System Support Structure of these Standards and Specifications. Each tank support shall be installed parallel to and directly over a roof structural member. Each tank support shall be securely attached to the roof structural member with a minimum of 2 anchoring fasteners per support, which shall be located no farther than 4 inches from the ends of each support. Tank mounting brackets shall be located on and secured to opposite sides of each tank support. Tank mounting brackets shall be secured to the tank supports with strut nut sets on "solar strut", with through-bolt sets on channel, and with lag bolt-sets on approved plastic lumber.

5.04. CONTROLLERS. Pump controllers shall be installed in accordance with manufacturer's recommendations. The top of the controller shall not be higher than 6 feet. 7 inches above the floor/ground level and shall not be located behind the tank. Controller sensors shall be attached at the hottest and coldest points in the solar piping loop by stainless steel clamps. Collector sensors shall be attached no farther than 6 inches from the collector header connection to the solar return line. Tank sensors shall be attached no farther than 12 inches from the coldest point at the tank on the solar supply line. Attachment of the tank sensor to factory provided tank sensor stud is permitted. Controller sensor attachment shall form a positive mechanical bond between the sensor and the sensing point to optimize heat transfer to the sensor. The sensor shall be clamped on its flanged end. Clamping of sensors over the sensor "barrel" end is unacceptable. Sensors shall be connected to sensor wire with all plastic wire nuts. Wire nuts shall be sealed with silicon and wrapped with electrician's tape. Sensor wiring shall be secured in a workmanlike manner.

5.05. TIME SWITCHES. Time switches shall be installed in accordance with manufacturer's recommendations. The top of the time switch shall not be higher than 6 feet 7 inches above the floor/ground level and shall not be located behind the tank. Time switches shall be set so that tank thermostats are not energized during the solar day (i.e., between 9:00 a.m. and 3:00 p.m.). Recommended automatic time switch settings are 4 p.m. "on", 5 p.m. "off". Multiple automatic time switch settings, exclusive of the solar day, are acceptable. At a minimum, electric time switches shall have at least one "off" tab securely affixed to the face of the timing mechanism and electronic time switches shall be programmed to turn off within 24 hours of being turned on. Time switch wiring shall be secured in a workmanlike manner.

5.06. PHOTOVOLTAIC MODULES. Photovoltaic modules shall be securely installed with approved support structure materials in the same tilt and orientation as the system collectors. Module location shall conform to Section 3.06 Collector Shading. Wire nuts used to interconnect module and pump shall be all plastic and shall be sealed with silicon and wrapped with electrician's tape.

5.07. PIPING, FITTINGS AND VALVES. Solder joints shall be sanded, fluxed and soldered with approved solder. Threaded fittings and valves shall be wrapped with Teflon or equal tape and/or joint sealant. Piping shall be plumb and level where practical. Vertical piping shall be supported at each story or at maximum intervals of 10 feet. Horizontal piping shall be supported at approximately 6-foot intervals. Pipe supports shall not penetrate piping insulation. Rooftop piping shall be raised off the roof by blocks or spacers. Blocks/spacers shall be placed at approximately 6-foot intervals on straight runs and not more than 2 feet of each side of an angular joint. Piping shall be attached to blocks/spacers with acceptable pipe supports. Blocks/spacers shall be adhered to the roof. Roof penetration shall not be made to attach blocks/spacers to the roof. Valves, including hose bibs and boiler drains, shall be installed in the sequence shown on the accepted system schematic.

5.08. PIPING INSULATION. Insulation shall be installed on all new hot water piping, including solar supply and return lines and on accessible existing hot and cold water supply pipe for a minimum of 6 feet leading to the system. Insulation is not required on the cold water supply line to thermosiphon systems. The tank temperature and pressure relief overflow line and collector pressure relief overflow line, where present, shall be insulated to within the 12 inches of the end of exposed pipe. Insulation butt joints shall be sealed in accordance with manufacturer's recommendations. Packing of insulation butt joints in attics and within walls, in lieu of sealing, is acceptable. Abutment of valves, unions and tees with pipe insulation is acceptable. Insulation shall in no way restrict the operation of any valve. Collector headers and interconnections shall be insulated. Collector headers and interconnections insulation may be slit and ny-tied without sealing. The entire circumference of rooftop exposed insulation shall be UV protected. Acceptable UV protection is latex based paint. UV protection of insulation on exterior vertical piping is acceptable.

5.09. ROOF/WALL/CEILING PENETRATIONS. Roof penetrations shall be detailed on system mounting detail drawings and shall be positively sealed in accordance with standard roofing practices. Flashing installed on metal roofs shall be compatible with the roofing material. Exterior/interior wall penetrations shall be made watertight. Ceiling penetrations shall be sealed.

5.10. TEMPERATURE MEASURING DEVICE. In forced circulation systems, the temperature-measuring device shall be installed at the hot water outlet port on the tank, which directly supplies the domestic hot water load. In thermosiphon systems, the temperature-measuring device shall be installed only on an accessible hot water supply after the storage tank and before any hot water fixture; the device shall not be required on inaccessible hot water supply lines.

5.11. OTHER PRODUCTS. Minor component products not otherwise listed in these Standards and Specifications shall be installed in a professional, workmanlike manner in accordance with manufacturer's recommendations.

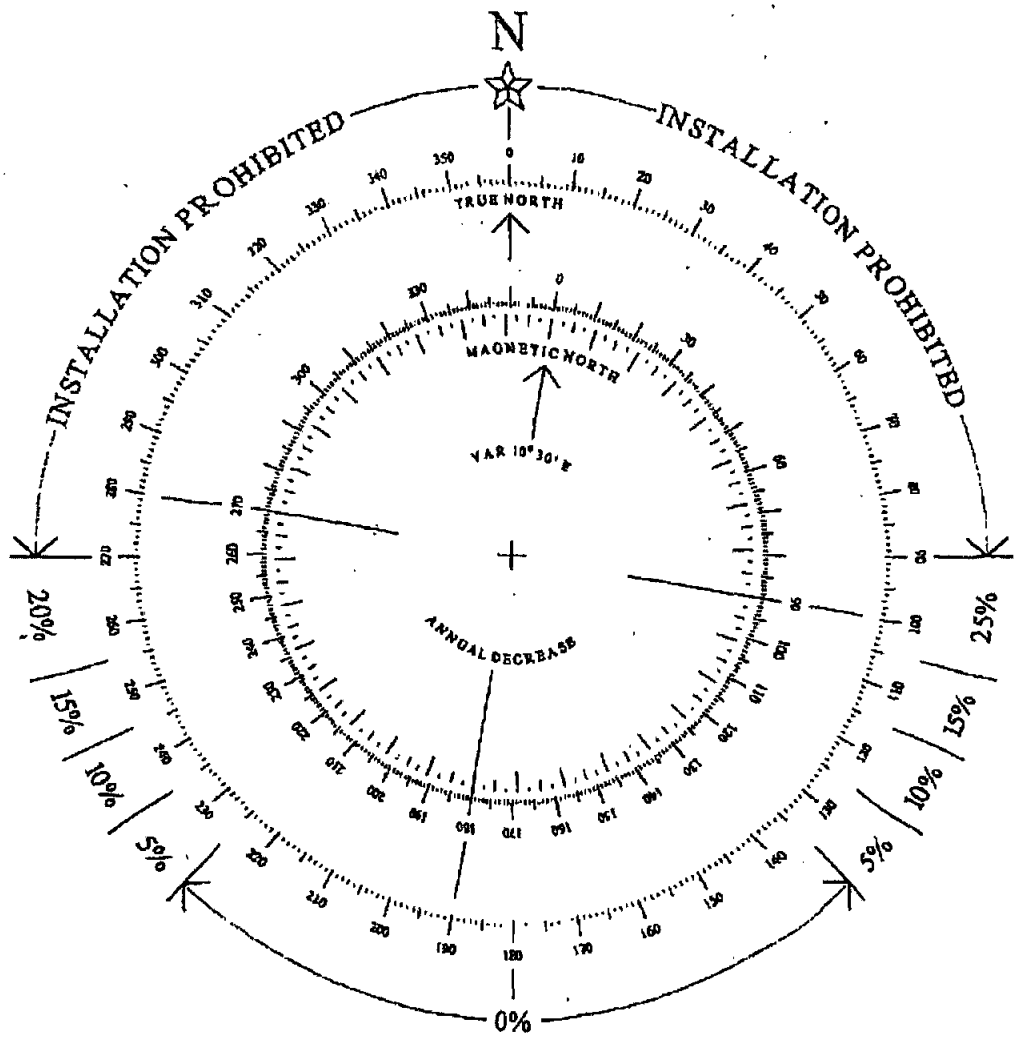
5.12. SYSTEM WARRANTY. Contractors shall provide full labor warranty for one (1) year from the date each system is installed. Contractors and/or vendors who unilaterally extend manufacturer product warranties shall provide the solar system purchaser with a written statement that the extension is not guaranteed by any other party.

PART VI – AMENDMENTS AND MODIFICATIONS TO THESE STANDARDS AND SPECIFICATIONS.

6.01. Unless otherwise provided for by the Commission, any amendments or modifications to these Standards and Specifications (including the Solar Collector BTU/Day Output by Hawaii Sunshine Zone Table and the sunshine maps for each island, i.e., Attachments A and B, respectively) will be initiated through a filing of an application with the Commission as set forth in and compliance with HAR Chapter 6-61, and require express Commission approval.

RESIDENTIAL SOLAR WATER HEATING SYSTEM
STANDARDS AND SPECIFICATIONS

Chart 1. Orientation Factors for Solar Installations



This compass rose diagram is to be used in conjunction with Table 4 and Form 1.

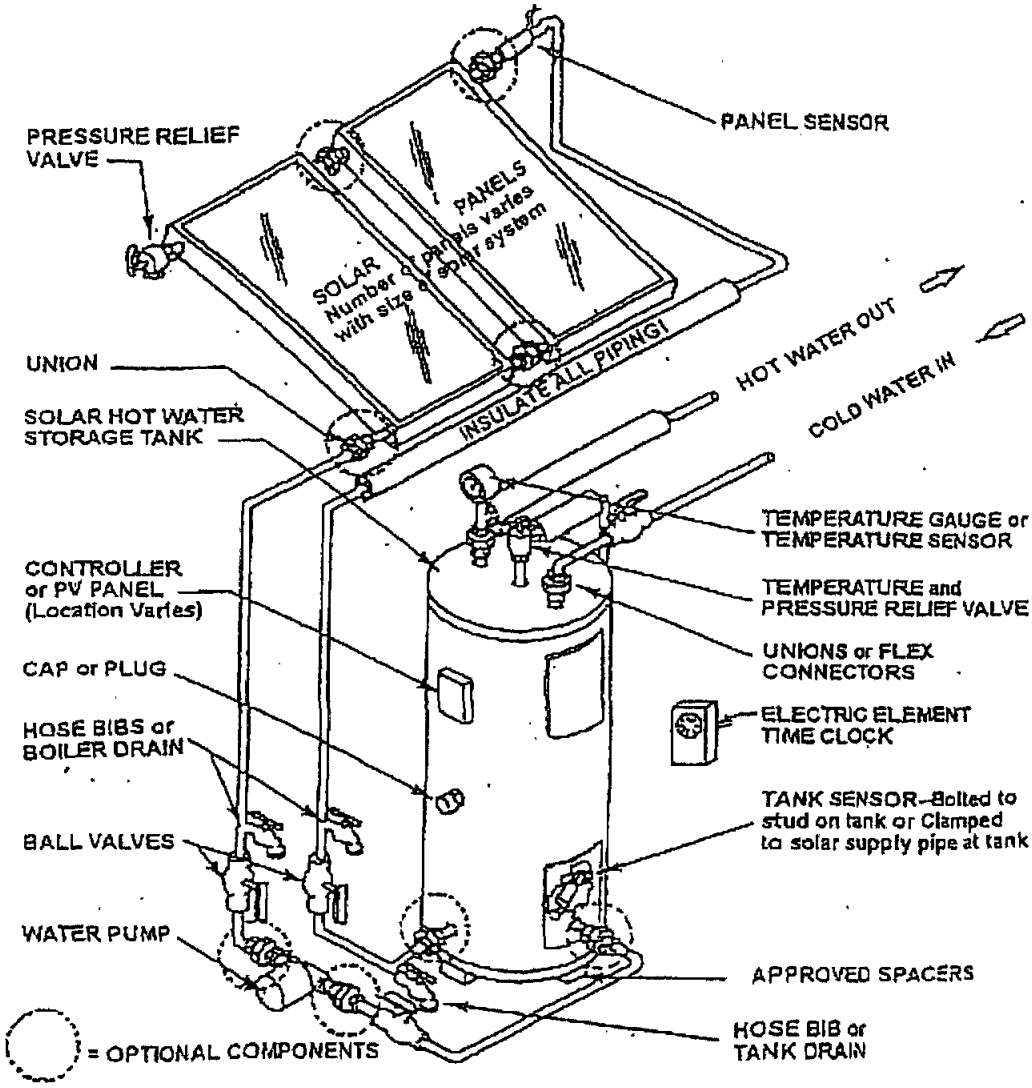
Steps to determine True direction of solar collector panels using the compass rose:

1. With a Magnetic compass, determine the Magnetic bearing (direction) that the long axis of the panels will sit at when installed. This bearing must be between 080° and 260° Magnetic, (090° and 270° True).
2. On the compass rose, lay a straightedge along the X at the center of the compass rose and, using the inner circle, through the Magnetic bearing (determined in step 1).
3. Read the True bearing from the outer circle. This is the True bearing which is used to determine the orientation factor, if any, which must be used on Form 1.

True compass direction can also be found on the Island of Hawaii by adding 10° to the Magnetic compass bearing. (The current magnetic variation in Hawaii is 10° East).

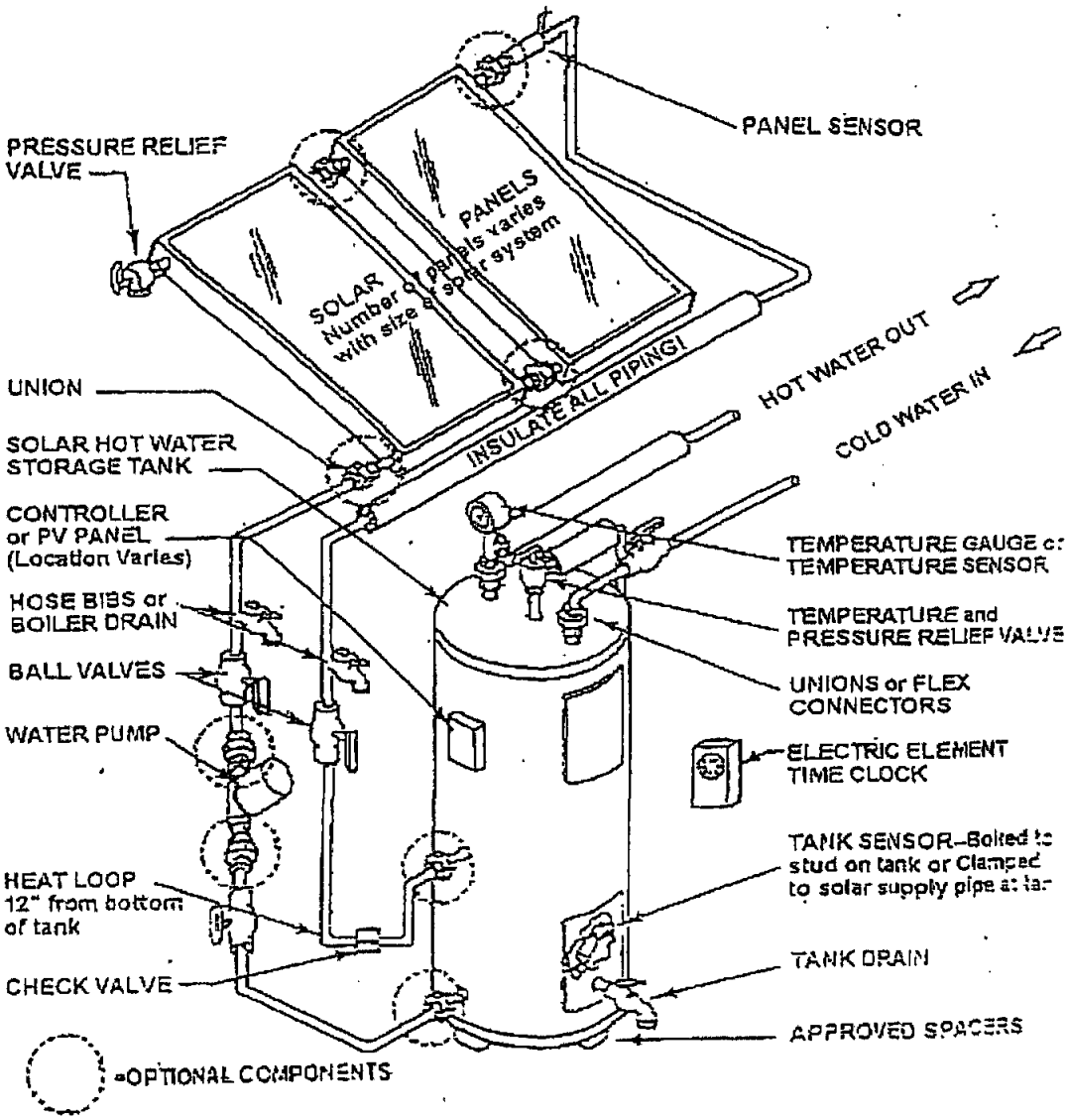
Compass Rose Diagram courtesy of Hawaii Electric Light Company

FIGURE 1.
BOTTOM-RETURN RESIDENTIAL FORCED CIRCULTATION SYSTEM DESIGN



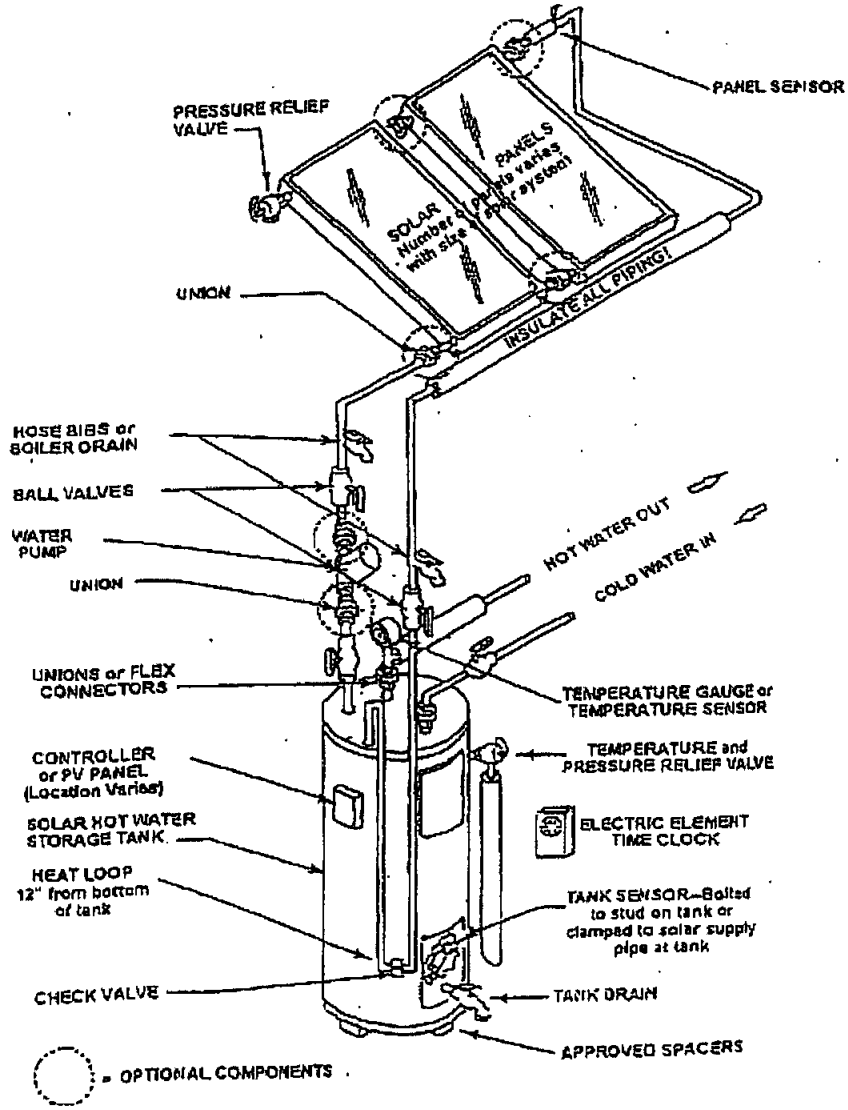
Reference: HECO Residential Solar Water Heating System Standards and Specifications Section 1.04. System Design

FIGURE 2.
SIDE-REUTRN RESIDENTIAL FORCED CIRCULATION SYSTEM DESIGN



Reference: HECO Residential Solar Water Heating System Standards and Specifications Section 1.04. System Design

FIGURE 3.
TOP-REUTRN RESIDENTIAL FORCED CIRCULATION SYSTEM DESIGN



Reference: HECO Residential Solar Water Heating System Standards and Specifications Section 1.04. System Design

Form 1. Residential Solar Water Heating System Sizing Tool

SYSTEM DATA

1	System Type	Active/Passive
2	Sunshine Zone	300 350 400 450 500
3	Collector Manufacturer	
4	Collector Model Number	
5	Collector Size	
6	Absorber Coating	Chrome / Paint
7	Collector Orientation	Degrees
8	Collector Orientation Factor	%
9	Collector Mounting Method	Flush / side tilt / end tilt
10	Collector Tilt	Degrees
11	Collector Tilt Factor	%
12	Actual Hot Water Storage	Gallons
13	Back-Up Heating Type	Electric / Gas / Heat Pump
14	Pump Type	AC / DC / None
15	System Solar Fraction	%

HOT WATER STORAGE SIZING

		gal/day	Line
1. Hot Water Use: Number of Bedrooms ___		_____	1
2. Total Number of Additional Showers / Day (___ x 10 gal.)		_____	2
3. Tub Bath Hot Water Use (No. of Tub Baths Taken/Week ___ x 20 ÷ 7 days)		_____	3
4. Clothes Washing Hot or Warm Water Use (No. Loads/Week ___ x 18 ÷ 7 days)		_____	4
5. Required Storage (add Lines 1, 2, 3, 4) or Table 1 minimum which ever is greater)		_____	5
6. Actual System Storage from Table 2)	gals	BTU's/day	6
7. Tank #1	_____	_____	7
8. Tank #2	_____	_____	8
9. Tank #3	_____	_____	9
10. Total Actual System Storage/BTU's/Day (add Lines 7,8,9)	_____	_____	10

COLLECTOR OUTPUT SIZING

11. Collector Rated BTU Output/Panel/Day/Sky Condition (from Attachment A)	_____	11
12. Number of Collector	_____	12
13. Total Collector BTU Output/Day (Multiply Lines 11 and 12)	_____	13
14. Off-Orientation BTU's Required/Day (Multiply Chart 1 Factor & Line 13)	_____	14
15. Off-Tilt BTU's Required/Day (Multiply Table 3 Factor & Line 13)	_____	15
16. Total Adjusted Collector BTU Output/Day (Subtract Lines 14 &15 from Line 13)	_____	16

SOLAR FRACTION

17. Percent Solar Fraction (Divide Line 16 by Line 10 BTU/day value)	_____ %	17

Tables 1-6. RESIDENTIAL SOLAR WATER HEATING SYSTEM STANDARDS AND SPECIFICATIONS

Table 1. Minimum Water Storage for New Construction

No. of Bedrooms	Storage
1-3	80 gal.
4-5	120 gal.
Over 5	120 gal. plus 20 gal. per additional room

Table 2. Daily BTU Requirements for Common Nominal Size Residential Heaters and Storage Tanks at 55 Deg. Rise to Tank Temperature of 130 Deg.

Nominal Storage Capacity	Daily BTU Requirement	Nominal Storage Capacity	Daily BTU Requirement
30 gals.	13,745	70 gals.	32,071
40 gals.	18,326	80 gals.	36,652
50 gals.	22,908	90 gals.	41,234
52 gals.	23,824	100 gals.	45,815
60 gals.	27,489	115 gals.	52,687
66 gals.	30,238	120 gals.	54,978

Table 3. Tilt Factors

Tilt (in deg.)	Add'l Collector BTU	Tilt (in deg.)	Add'l Collector BTU
14	0%	50	15%
35	0%	55	20%
40	5%	60	25%
45	10%		

Table 4. Minimum Support Structure Anchors*

No. of Collectors	Collector Size	No. of Anchors
1	Any size	4
2	3' x 7' or 3' x 8'	4
2	1 @ 3' x 8' or 1 @ 4' x 8'	4
2	4' x 6' or 4' x 8' or 4' x 10'	6
3	3' x 7' or 3' x 8'	6
3	2 @ 3' x 8' or 1 @ 4' x 8'	6
3	1 @ 3' x 8' or 2 @ 4' x 8'	6
3	4' x 6' or 4' x 8' or 4' x 8'	8
4	3' x 7' or 3' x 8'	8
4	2 @ 3' x 8' and 2 @ 4' x 8'	8
4	4' x 6' or 4' x 8' or 4' x 10'	10

* Applies to extruded aluminum sizes: 1 5/8" x 1 5/8" x 1/8" solar strut, 3" x 1" x 1/8" channel & double T, 2" x 2" x 3/16" angle aluminum.

Table 5. Minimum Conductor Size for PV Powered Pumps (One Distance)

Module Output	18 AWG	16 AWG	14 AWG	12 AWG	10 AWG	8 AWG
5 W	54 ft	109 ft	219 ft	327 ft	545 ft	>1000 ft
10 W	26 ft	52 ft	104 ft	156 ft	269 ft	429 ft
20 W	n/a	26 ft	52 ft	78 ft	130 ft	208 ft
43 W	n/a	n/a	24 ft	36 ft	60 ft	96 ft

Table 6. Minimum Thermosiphon System
Tank Support Anchoring Fasteners & Tank Mounting Brackets

Tank Length	No. of Tank Supports[1]	No. of Support Fasteners[2]	No. of Tank Mount Brackets[3]
48" – 56"	2	4	4
69" – 75"	3	6	6
91" – 108"	4	8	8
120" – 130"	5	10	10
160"	6	12	12

[1] Based on typical rafter/joise spacing of 24" on center or less. For rafter/joist spacing greater than 24" on center refer to Section 3.03.2
[2] Minimum of 2 support fasteners per support of 5/16" diameter for direct mount method. Fasteners of sufficient length to penetrate a minimum of 1 ¾" into the roof structural member.
[3] Tank mounting brackets shall be located on and secured to opposite sides of each tank support.

OG-100 Protocol Format		(BTU/sq ft day)	1845	1661	1476	1292	1107
Hawaii Sunshine Zone		(Cal/sq cm/day)	500	450	400	350	300
Nom. Size	Coating	Model					
3' x 7'	Paint	AE-21E	17,528	14,707	11,808	9,299	9,299
		EP-20	17,528	15,182	12,792	10,332	10,332
		EP-21	19,373	16,605	13,776	11,365	11,365
		EPI-308CU (3' X 7')	18,450	15,656	12,792	9,815	9,815
		EPI-308SS (3' X 7')	18,450	15,656	12,792	9,815	9,815
		J Collector	20,295	17,079	13,776	10,849	10,849
		L Collector	13,838	11,861	9,840	7,232	7,232
		MSC-21E	17,528	15,182	12,792	9,815	9,815
		SSP-21	18,450	16,131	13,776	10,849	10,849
		ST-21E	17,528	15,182	12,792	9,815	9,815
		SunPro 21	18,450	15,656	12,792	9,815	9,815
3' x 7'	Selective	AE-21	19,373	16,605	13,776	11,365	11,365
		Apricus AP-10	11,070	9,489	7,872	6,716	6,716
		Bt	21,218	18,503	15,744	12,398	12,398
		EC-20	18,450	16,131	13,776	11,365	11,365
		EC-21	20,295	17,554	14,760	12,398	12,398
		K Collector	21,218	18,503	15,744	12,915	12,915
		M Collector	17,528	15,182	12,792	9,815	9,815
		MSC-21	19,373	17,079	14,760	11,882	11,882
		SS-21	19,373	16,605	13,776	11,365	11,365
		SSC-21	20,295	17,554	14,760	12,398	12,398
3' x 8'	Paint	AE-24E	19,373	16,605	13,776	10,849	10,849
		EP-24	22,140	19,452	16,728	13,432	13,432
		EPI-308CU (3' x 8')	20,295	17,554	14,760	11,365	11,365
		EPI-308SS (3' x 8')	20,295	17,554	14,760	11,365	11,365
		IP-24	22,140	19,452	16,728	13,432	13,432
		MSC-24E	20,295	17,554	14,760	11,365	11,365
		SP-24	22,140	19,452	16,728	13,432	13,432
		SSP-24	21,218	18,503	15,744	12,915	12,915
		SunPro24	21,218	18,028	14,760	11,365	11,365
		308P-HP	21,218	18,028	14,760	11,882	11,882
3' x 8'	Selective	308C-HP	23,985	20,875	17,712	14,465	14,465
		AE-24	22,140	18,977	15,744	12,915	12,915
		EC-24	23,985	20,875	17,712	14,465	14,465
		IC-24	23,985	20,875	17,712	14,465	14,465
		MSC-24	22,140	19,452	16,728	13,432	13,432
		SC-24	23,985	20,875	17,712	14,465	14,465
		SS-24	22,140	18,977	15,744	12,915	12,915
		SSC-24	23,985	20,875	17,712	14,465	14,465
4' x 6'	Paint	AE-26E	21,218	18,028	14,760	11,882	11,882
		MSC-26E	21,218	18,028	14,760	11,882	11,882
4' x 6'	Selective	AE-26	23,063	19,926	16,728	13,432	13,432
		MSC-26	23,985	20,875	17,712	14,465	14,465
		SLCO-30	24,908	21,349	17,712	14,465	14,465
		SS-26	23,063	19,926	16,728	13,432	13,432
4' x 7'	Paint	AE-28E	23,063	19,926	16,728	12,915	12,915
		Gobi 406 002	0	0	0	0	0
		MSC-28E	23,985	20,400	16,728	12,915	12,915
4' x 7'	Selective	AE-28	25,830	22,298	18,696	14,981	14,981
		Gobi 336 013	23,985	20,875	17,712	14,465	14,465
		Gobi 406 001	25,830	22,773	19,680	16,015	16,015
		MSC-28	26,753	23,247	19,680	16,015	16,015
		SS-28	25,830	22,298	18,696	14,981	14,981

OG-100 Protocol Format		(BTU/sq ft day)	1845	1661	1476	1292	1107
Hawaii Sunshine Zone		(Cal/sq cm/day)	500	450	400	350	300
Nom. Size	Coating	Model					
4' x 8'	Paint	408P-HP	27,675	23,721	19,680	14,981	14,981
		AE-32E	26,753	22,773	18,696	14,465	14,465
		EP-32	29,520	25,619	21,648	17,564	17,564
		EPI-308CU (4' x 8')	27,675	23,721	19,750	15,498	15,498
		EPI-308SS (4' x 8')	27,675	23,721	19,750	15,498	15,498
		Gobi 408 002	29,520	25,145	19,750	16,015	16,015
		IP-32	30,443	26,094	19,750	17,564	17,564
		MSC-32E	26,753	22,773	18,696	14,981	14,981
		SLCO-32P	24,908	20,875	16,728	12,915	12,915
		SP-32	29,520	25,619	21,648	17,564	17,564
		SSP-32	28,598	24,670	20,664	17,048	17,048
		SunPro 32	27,675	23,721	19,750	15,498	15,498
4' x 8'	Selective	408C-HP	33,210	28,940	24,600	19,631	19,631
		AE-32	29,520	25,619	21,648	17,564	17,564
		EC-32	32,288	28,466	24,600	20,147	20,147
		Gobi 408 001	31,365	27,517	23,616	19,114	19,114
		Gobi 408 013	29,520	25,145	20,664	16,531	16,531
		IC-32	32,288	28,466	24,600	20,147	20,147
		MSC-32	29,520	25,619	21,648	17,564	17,564
		SC-32	32,288	28,466	24,600	20,147	20,147
		SLCR-30	30,443	26,568	22,632	19,114	19,114
		SLCO-32	32,288	27,991	23,616	19,114	19,114
		SLCR-32	32,288	28,466	24,600	20,147	20,147
		SSC-32	32,288	28,466	24,600	20,147	20,147
		SS-32	29,520	25,619	21,648	17,564	17,564
4' x 10'	Paint	410P-HP	35,055	29,889	24,600	18,598	18,598
		AE-40E	33,210	28,466	23,616	18,598	18,598
		EP-40	36,900	32,261	27,552	22,214	22,214
		Gobi 410 002	36,900	31,787	26,568	20,664	20,664
		IP-40	37,823	32,736	27,552	22,214	22,214
		MSC-40E	33,210	28,466	23,616	18,598	18,598
		SLCO-40P	29,520	25,145	20,664	16,015	16,015
		SP-40	36,900	32,261	27,552	22,214	22,214
		SSP-40	35,978	31,312	26,568	21,697	21,697
		ST-40E	32,288	27,517	22,632	17,564	17,564
		SunPro 40	35,055	29,889	24,600	19,114	19,114
4' x 10'	Selective	410C-HP	41,513	35,582	29,520	23,764	23,764
		AE-40	36,900	31,787	26,568	21,697	21,697
		EC-40	40,590	35,582	30,504	24,797	24,797
		Gobi 410 001	39,668	34,633	29,520	24,280	24,280
		Gobi 410 013	36,900	31,787	26,568	21,181	21,181
		IC-40	40,590	35,582	30,504	24,797	24,797
		MSC-40	38,745	33,684	28,536	23,247	23,247
		SC-40	40,590	35,582	30,504	24,797	24,797
		SLCO-40	38,745	33,684	28,536	22,730	22,730
		SLCR-40	40,590	35,582	30,504	25,313	25,313
		SSC-40	40,590	35,582	30,504	24,797	24,797
		SS-40	36,900	31,787	26,568	21,697	21,697
4' x 12'	Paint	412P-HP	42,435	35,582	28,536	21,697	21,697
4' x 12'	Selective	412C-HP	49,815	43,173	36,408	29,446	29,446
5' X 7'	Selective	Apricus AP-20	21,218	18,977	16,728	14,465	14,465
		Apricus AP-22	23,985	21,349	18,696	16,015	16,015
7' x 7'	Selective	Apricus AP-30	32,288	28,466	24,600	21,181	21,181
Notes:							
1. Values for the 350 and 450 Sunshine Zones are interpolated assuming a linear relationship.							
2. Values for the 300 Sunshine Zone equals the 350 Sunshine Zone per Section 2.02.							

OG-100 Protocol Format		(BTU/sq ft day)	2030	1,845	1,661	1,476	1,292
Hawaii Sunshine Zone		(Cal/sq cm/day)	550	500	450	400	350
Nom. Size	Coating	Model					
3' x 7'	Paint	AE-21E	19,280	17,528	14,707	11,808	9,299
		EP-20	19,280	17,528	15,182	12,792	10,332
		EP-21	21,310	19,373	16,605	13,776	11,365
		EPI-308CU (3' X 7')	20,295	18,450	15,656	12,792	9,815
		EPI-308SS (3' X 7')	20,295	18,450	15,656	12,792	9,815
		J Collector	22,325	20,295	17,079	13,776	10,849
		L Collector	15,221	13,838	11,861	9,840	7,232
		MSC-21E	19,280	17,528	15,182	12,792	9,815
		SSP-21	20,295	18,450	16,131	13,776	10,849
		ST-21E	19,280	17,528	15,182	12,792	9,815
		SunPro21	20,295	18,450	15,656	12,792	9,815
3' x 7'	Selective	AE-21	21,310	19,373	16,605	13,776	11,365
		Aprius AP-10	12,177	11,070	9,489	7,872	6,716
		EC-21	22,325	20,295	17,554	14,760	12,398
		K Collector	23,339	21,218	18,503	15,744	12,915
		M Collector	19,280	17,528	15,182	12,792	9,815
		MSC-21	21,310	19,373	17,079	14,760	11,882
		BT	23,339	21,218	18,503	15,744	12,398
		SS-21	21,310	19,373	16,605	13,776	11,365
3' x 8'	Paint	AE-24E	21,310	19,373	16,605	13,776	10,849
		EP-24	24,354	22,140	19,452	16,728	13,432
		EPI-308CU (3' x 8')	22,325	20,295	17,554	14,760	11,365
		EPI-308SS (3' x 8')	22,325	20,295	17,554	14,760	11,365
		MSC-24E	22,325	20,295	17,554	14,760	11,365
		SP-24	24,354	22,140	19,452	16,728	13,432
		SSP-24	23,339	21,218	18,503	15,744	12,915
		SunPro24	23,339	21,218	18,028	14,760	11,365
		308P-HP	23,339	21,218	18,028	14,760	11,882
3' x 8'	Selective	AE-24	24,354	22,140	18,977	15,744	12,915
		EC-24	26,384	23,985	20,875	17,712	14,465
		MSC-24	24,354	22,140	19,452	16,728	13,432
		SSC-24	24,354	22,140	19,452	16,728	13,432
		308C-HP	26,384	23,985	20,875	17,712	14,465
		SS-24	24,354	22,140	18,977	15,744	12,915
4' x 6'	Paint	AE-26E	23,339	21,218	18,028	14,760	11,882
		MSC-26E	23,339	21,218	18,028	14,760	11,882
4' x 6'	Selective	AE-26	25,369	23,063	19,926	16,728	13,432
		MSC-26	26,384	23,985	20,875	17,712	14,465
		SLCO-30	27,398	24,908	21,349	17,712	14,465
		SSP-32	31,457	28,598	24,670	20,664	17,048
		SS-26	25,369	23,063	19,926	16,728	13,432
4' x 7'	Paint	AE-28E	25,369	23,063	19,926	16,728	12,915
		Gobi 406 002	26,384	23,985	20,400	16,728	12,915
		MSC-28E	26,384	23,985	20,400	16,728	12,915
4' x 7'	Selective	AE-28	28,413	25,830	22,298	18,696	14,981
		Gobi 336 013	26,384	23,985	20,875	17,712	14,465
		MSC-28	29,428	26,753	23,247	19,680	16,015
		Gobi 406 001	28,413	25,830	22,773	19,680	16,015
		SS-28	28,413	25,830	22,298	18,696	14,981
Notes:							
1. Values for the 350 and 450 Sunshine Zones are interpolated assuming a linear relationship.							

OG-100 Protocol Format		(BTU/sq ft day)	2030	1,845	1,661	1,476	1,292
Hawaii Sunshine Zone		(Cal/sq cm/day)	550	500	450	400	350
Nom. Size	Coating	Model					
4' x 8'	Paint	AE-32E	29,428	26,753	22,773	18,696	14,465
		EP-32	32,472	29,520	25,619	21,648	17,564
		EPI-308CU (4' x 8')	30,443	27,675	23,721	19,750	15,498
		EPI-308SS (4' x 8')	30,443	27,675	23,721	19,750	15,498
		MSC-32E	29,428	26,753	22,773	18,696	14,981
		SP-32	32,472	29,520	25,619	21,648	17,564
		SSP-32	31,457	28,598	24,670	20,664	17,048
		SunPro32	30,443	27,675	23,721	19,750	15,498
		408P-HP	30,443	27,675	23,721	19,680	14,981
		SLCO-32P	27,398	24,908	20,875	16,728	12,915
		Gobi 408 002	32,472	29,520	25,145	20,664	16,015
4' x 8'	Selective	AE-32	32,472	29,520	25,619	21,648	17,564
		EC-32	35,516	32,288	28,466	24,600	20,147
		IC-32	35,516	32,288	28,466	24,600	20,147
		MSC-32	32,472	29,520	25,619	21,648	17,564
		SLCR-30	33,487	30,443	26,568	22,632	19,114
		SLCO-32	35,516	32,288	27,991	23,616	19,114
		SLCR-32	35,516	32,288	28,466	24,600	20,147
		408C-HP	36,531	33,210	28,940	24,600	19,631
		Gobi 408 001	34,502	31,365	27,517	23,616	19,114
		Gobi 408 013	32,472	29,520	25,145	20,664	16,531
		SS-32	32,472	29,520	25,619	21,648	17,564
4' x 10'	Paint	AE-40E	36,531	33,210	28,466	23,616	18,598
		EP-40	40,590	36,900	32,261	27,552	22,214
		MSC-40E	36,531	33,210	28,466	23,616	18,598
		SP-40	40,590	36,900	32,261	27,552	22,214
		SSP-40	39,575	35,978	31,312	26,568	21,697
		ST-40E	35,516	32,288	27,517	22,632	17,564
		SunPro40	38,561	35,055	29,889	24,600	19,114
		410P-HP	38,561	35,055	29,889	24,600	18,598
		SLCO-40P	32,472	29,520	25,145	20,664	16,015
		Gobi 410 002	40,590	36,900	31,787	26,568	20,664
		IP-40	41,605	37,823	32,736	27,552	22,214
4' x 10'	Selective	AE-40	40,590	36,900	31,787	26,568	21,697
		EC-40	44,649	40,590	35,582	30,504	24,797
		410C-HP	45,664	41,513	35,582	29,520	23,764
		MSC-40	42,620	38,745	33,684	28,536	23,247
		SLCO-40	42,619	38,745	33,684	28,536	22,730
		SLCR-40	44,649	40,590	35,582	30,504	25,313
		Gobi 410 001	43,634	39,668	64,633	29,520	24,280
		Gobi 410 013	40,590	36,900	31,787	26,568	21,181
		IC-40	44,649	40,590	35,582	30,504	24,797
		SS-40	40,590	36,900	31,787	26,568	21,697
4' x 12'	Paint	412P-HP	46,679	42,435	35,582	28,536	21,697
4' x 12'	Selective	412C-HP	54,797	49,815	43,173	36,408	29,446
5' x 7'	Selective	Aprius AP-20	23,339	21,218	18,977	16,728	14,465
		Aprius AP-22	26,384	23,985	21,349	18,696	16,015
7' x 7'	Selective	Aprius AP-30	35,516	32,288	28,466	24,600	21,181
Notes:							
1. Values for the 350, 450 and 550 Sunshine Zones are interpolated assuming a linear relationship.							

OG-100 Protocol Format		BTU/sq ft day	1,845	1,771	1,661	1,587	1,476	1,292	1,107
Hawaii Sunshine Zone		Solar Zone	500	480	450	430	400	350	300
Nom. Size	Coating	Model							
3' x 7'	Paint	AE-21E	17,528	16,826	14,707	13,548	11,808	9,299	9,299
		EP-20	17,528	16,826	15,182	14,226	12,792	10,332	10,332
		EP-21	19,373	18,598	16,605	15,473	13,776	11,365	11,365
		EPI-308CU (3' X 7')	18,450	17,712	15,656	14,510	12,792	9,815	9,815
		EPI-308SS (3' X 7')	18,450	17,712	15,656	14,510	12,792	9,815	9,815
		J Collector	20,295	19,483	17,079	15,758	13,776	10,849	10,849
		L Collector	13,838	13,284	11,861	11,052	9,840	7,232	7,232
		MSC-21E	17,528	16,826	15,182	14,226	12,792	9,815	9,815
		SSP-21	18,450	17,712	16,131	15,189	13,776	10,849	10,849
		ST-21E	17,528	16,826	15,182	14,226	12,792	9,815	9,815
		SunPro21	18,450	17,712	15,656	14,510	12,792	9,815	9,815
3' x 7'	Selective	AE-21	19,373	18,598	16,605	15,473	13,776	11,365	11,365
		Apricus AP-10	11,070	10,627	9,489	8,842	7,872	6,716	6,716
		BT Collector	21,218	20,369	18,503	17,399	15,744	12,398	12,398
		EC-20	18,450	17,712	16,131	15,189	13,776	11,365	11,365
		EC-21	20,295	19,483	17,554	16,436	14,760	12,398	12,398
		K Collector	21,218	20,369	18,503	17,399	15,744	12,915	12,915
		M Collector	17,528	16,826	15,182	14,226	12,792	9,815	9,815
		MSC-21	19,373	18,598	16,605	15,867	14,760	11,882	11,882
		SS-21	19,373	21,000	16,605	15,473	13,776	14,000	14,000
		SSC-21	19,373	18,598	16,605	15,473	13,776	11,365	11,365
3' x 8'	Paint	AE-24E	19,373	18,598	16,605	15,473	13,776	10,849	10,849
		EP-24	22,140	21,254	19,452	18,362	16,728	13,432	13,432
		EPI-308CU (3' x 8')	20,295	19,483	17,554	16,436	14,760	11,365	11,365
		EPI-308SS (3' x 8')	20,295	19,483	17,554	16,436	14,760	11,365	11,365
		IP-24	22,140	21,254	19,452	18,362	16,728	13,432	13,432
		MSC-24E	20,295	19,483	17,554	16,436	14,760	11,365	11,365
		SP-24	22,140	21,254	19,452	18,362	16,728	13,432	13,432
		SSP-24	21,218	20,369	18,503	17,399	15,744	12,915	12,915
		SunPro24	21,218	20,369	18,028	16,721	14,760	11,365	11,365
		308P-HP	21,218	20,369	18,028	16,721	14,760	11,882	11,882
3' x 8'	Selective	AE-24	22,140	21,254	18,977	17,684	15,744	12,915	12,915
		EC-24	23,985	23,026	20,875	19,610	17,712	14,465	14,465
		IC-24	23,985	23,026	20,875	19,610	17,712	14,465	14,465
		MSC-24	22,140	21,254	19,452	18,362	16,728	13,432	13,432
		SC-24	23,985	23,026	20,875	19,610	17,712	14,465	14,465
		SS-24	22,140	24,000	18,977	17,684	15,744	16,000	16,000
		SSC-24	22,140	21,254	19,452	18,362	16,728	13,432	13,432
		308C-HP	23,985	23,026	20,875	19,610	17,712	14,465	14,465
4' x 6'	Paint	AE-26E	21,218	20,369	18,028	16,721	14,760	11,882	11,882
		MSC-26E	21,218	20,369	18,028	16,721	14,760	11,882	11,882
4' x 6'	Selective	AE-26	23,063	22,140	19,926	18,647	16,728	13,432	13,432
		MSC-26	23,985	23,026	20,875	19,610	17,712	14,465	14,465
		SLCO-30	24,908	23,911	21,349	19,894	17,712	14,465	14,465
		SS-26	23,063	25,000	19,926	18,647	16,728	17,000	17,000
4' x 7'	Paint	AE-28E	23,063	22,140	19,926	18,647	16,728	12,915	12,915
		Gobi 406 002	23,985	23,026	20,400	18,931	16,728	12,915	12,915
		MSC-28E	23,985	23,026	20,400	18,931	16,728	12,915	12,915

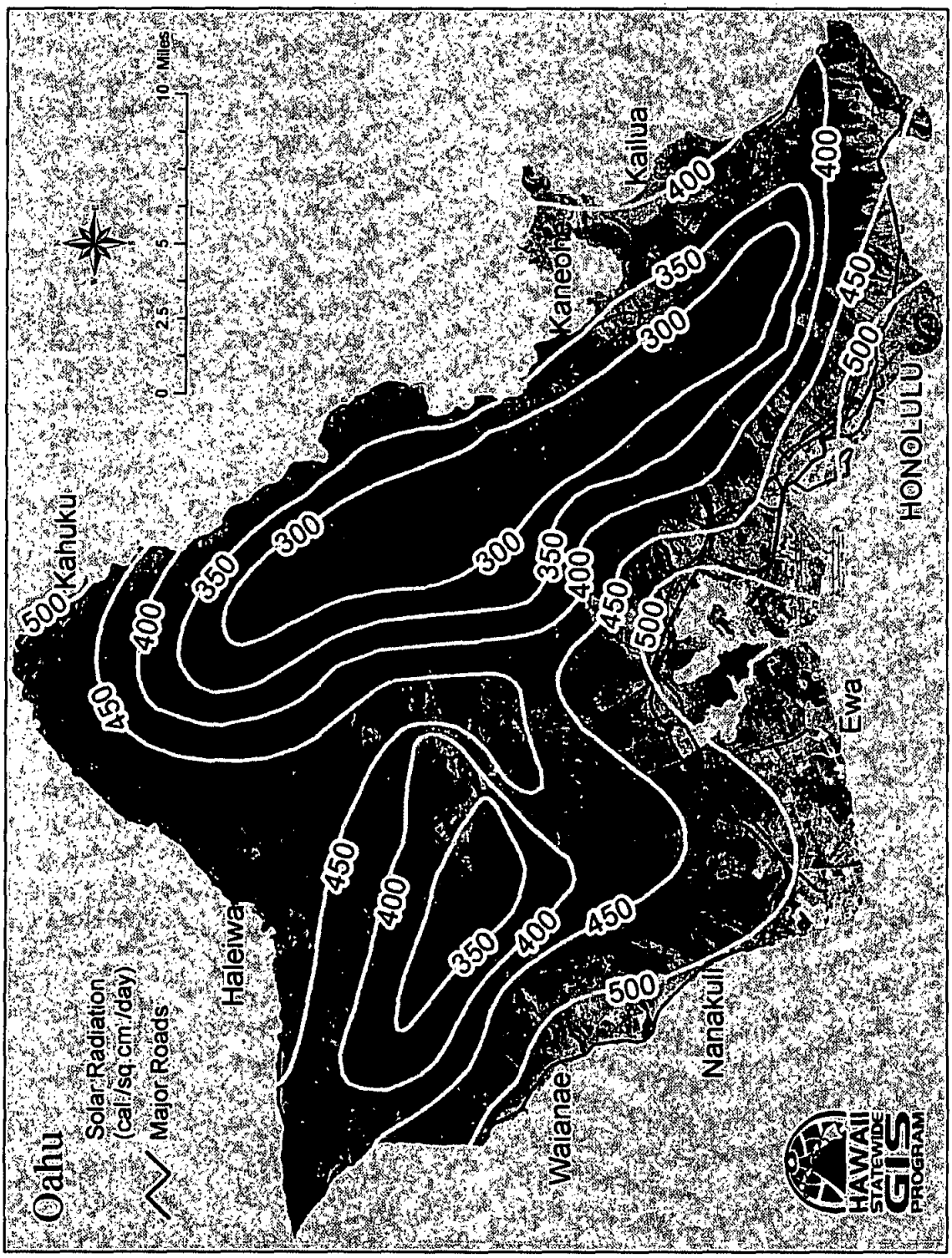
OG-100 Protocol Format		BTU/sq ft day	1,845	1,771	1,661	1,587	1,476	1,292	1,107
Hawaii Sunshine Zone		Solar Zone	500	480	450	430	400	350	300
Nom. Size	Coating	Model							
4' x 7'	Selective	AE-28	25,830	24,797	22,298	20,857	18,696	14,981	14,981
		Gobi 3366	27,675	26,568	24,196	22,783	20,664	17,048	17,048
		Gobi 336 013	23,985	23,026	20,875	19,610	17,712	14,465	14,465
		Gobi 406 001	25,830	24,797	22,773	21,536	19,680	16,015	16,015
		MSC-28	26,753	25,682	23,247	21,820	19,680	16,015	16,015
		SLCR-30	30,443	29,225	26,568	24,994	22,632	19,114	19,114
		SS-28	25,830	28,000	22,298	20,857	18,696	19,000	19,000
4' x 8'	Paint	AE-32E	26,753	25,682	22,773	21,142	18,696	14,465	14,465
		EP-32	29,520	28,339	25,619	24,031	21,648	17,564	17,564
		EPI-308CU (4' x 8')	27,675	26,568	23,721	22,105	19,680	15,498	15,498
		EPI-308SS (4' x 8')	27,675	26,568	23,721	22,105	19,680	15,498	15,498
		Gobi 408 002	29,520	28,339	25,145	23,352	20,664	16,015	16,015
		IP-32	30,443	29,225	26,094	24,315	21,648	17,564	17,564
		MSC-32E	26,753	25,682	22,773	21,142	18,696	14,981	14,981
		SLCO-32P	24,908	23,911	20,875	19,216	16,728	12,915	12,915
		SP-32	29,520	28,339	25,619	24,031	21,648	17,564	17,564
		SSP-32	28,598	27,454	24,670	23,068	20,664	17,048	17,048
		SunPro32	27,675	26,568	23,721	22,105	19,680	15,498	15,498
		408P-HP	28,598	27,454	24,196	22,390	19,680	14,981	14,981
4' x 8'	Selective	AE-32	29,520	28,339	25,619	24,031	21,648	17,564	17,564
		EC-32	32,288	30,996	28,466	26,919	24,600	20,147	20,147
		Gobi 408	34,133	32,767	29,415	27,489	24,600	20,147	20,147
		Gobi 408 001	31,365	30,110	27,517	25,957	23,616	19,114	19,114
		Gobi 408 013	29,520	28,339	25,145	23,352	20,664	16,531	16,531
		IC-32	32,288	30,996	28,466	26,919	24,600	20,147	20,147
		MSC-32	29,520	28,339	25,619	24,031	21,648	17,564	17,564
		SC-32	31,365	30,110	27,517	25,957	23,616	19,114	19,114
		SSC-32	30,443	29,225	26,568	24,994	22,632	18,598	18,598
		408C-HP	33,210	31,882	28,940	27,204	24,600	19,631	19,631
		SLCO-32	32,288	30,996	27,991	26,241	23,616	19,114	19,114
		SLCR-32	32,288	30,996	28,466	26,919	24,600	20,147	20,147
		SS-32	29,520	32,000	25,619	24,031	21,648	22,000	22,000
4' x 10'	Paint	AE-40E	33,210	31,882	28,466	26,526	23,616	18,598	18,598
		EP-40	36,900	35,424	32,261	30,377	27,552	22,214	22,214
		Gobi 410 002	36,900	35,424	31,787	29,699	26,568	20,664	20,664
		IP-40	37,823	36,310	32,736	30,662	27,552	22,214	22,214
		MSC-40E	33,210	31,882	28,466	26,526	23,616	18,598	18,598
		SLCO-40P	29,520	28,339	25,145	23,352	20,664	16,015	16,015
		SP-40	36,900	35,424	32,261	30,377	27,552	22,214	22,214
		SSP-40	35,978	34,538	31,312	29,415	26,568	21,697	21,697
		ST-40E	32,288	30,996	27,517	25,563	22,632	17,564	17,564
		SunPro40	35,055	33,653	29,889	27,773	24,600	19,114	19,114
		410P-HP	35,055	33,653	29,889	27,773	24,600	18,598	18,598

OG-100 Protocol Format		BTU/sq ft day	1,845	1,771	1,661	1,587	1,476	1,292	1,107
Hawaii Sunshine Zone		Solar Zone	500	480	450	430	400	350	300
Nom. Size	Coating	Model							
4' x 10'	Selective	AE-40	36,900	35,424	31,787	29,699	26,568	21,697	21,697
		EC-40	40,590	38,966	35,582	33,551	30,504	24,797	24,797
		Gobi 410	42,435	40,738	36,531	34,120	30,504	25,313	25,313
		Gobi 410 001	39,668	38,081	34,633	32,588	29,520	24,280	24,280
		Gobi 410 013	36,900	35,424	31,787	29,699	26,568	21,181	21,181
		IC-40	40,590	38,966	35,582	33,551	30,504	24,797	24,797
		MSC-40	38,745	37,195	33,684	31,625	28,536	23,247	23,247
		MSC-40-H	38,745	37,195	33,684	31,625	28,536	23,247	23,247
		SC-40	38,745	37,195	33,684	31,625	28,536	23,247	23,247
		SSC-40	37,823	36,310	32,736	30,662	27,552	22,730	22,730
4' x 10'	Selective	410C-HP	41,513	39,852	35,582	33,157	29,520	23,764	23,764
		SLCO-40	38,745	37,195	33,684	31,625	28,536	22,730	22,730
		SLCR-40	40,590	38,966	35,582	33,551	30,504	25,313	25,313
		SS-40	36,900	40,000	31,787	29,699	26,568	27,000	27,000
4' x 12'	Paint	412P-HP	42,435	40,738	35,582	32,764	28,536	21,697	21,697
4' x 12'	Selective	412C-HP	49,815	47,822	43,173	40,467	36,408	29,446	29,446
5' x 7'	Selective	Apricus AP-20	21,218	20,369	18,977	18,077	16,728	14,465	14,465
		Apricus AP-22	23,985	23,026	21,349	20,288	18,696	16,015	16,015
7' x 7'	Selective	Apricus AP-30	32,288	30,996	28,466	26,919	24,600	21,181	21,181
Notes:									
1. Values for the 350, 430, 450, & 480 Sunshine Zones are interpolated assuming a linear relationship.									
2. Values for the 300 Sunshine Zone equals the 350 Sunshine Zone per Section 2.02.									

Attachment B

SUNSHINE MAPS FOR THE HAWAIIAN ISLANDS


Kauai
Solar Radiation
(Cal/sq.cm./day)
Major Roads
Hanalei
Kapaa
Lihue
Poipu
Hanapepe
Waimea
250
300
350
400
450
500
0 1.5 3 6 Miles
HAWAII
STATEWIDE
GIS
PROGRAM


Oahu
Solar Radiation
(cal./sq.cm./day)
Major Roads
0 2.5 5 10 Miles
Kahuku
Haleiwa
Waianae
Nanakuli
Kaneohe
Kailua
Ewa
HONOLULU
500
450
400
350
300
HAWAII
STATEWIDE
GIS
PROGRAM

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The Ready Mapbook

of

EAST HAWAII

SOLAR ZONES EDITION

2005

Odyssey Publishing, LLC

Field verifications were made using a Garmin 12 Global Positioning Instrument (12 satellites). Over 95 % of the passenger car roads were driven with a 1997 Dodge Intrepid. The report of the condition of these roads is based on the capabilities of this car and personal perception. Even so, we cannot guarantee 100% accuracy. Not intended for legal descriptions. Any corrections, criticisms, or additions are gratefully accepted.

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NEW!! Marini Map, Hawaii (folding)

"We are pleased to promote the commerce of Hawaii with the publication of accurate and comprehensive maps."

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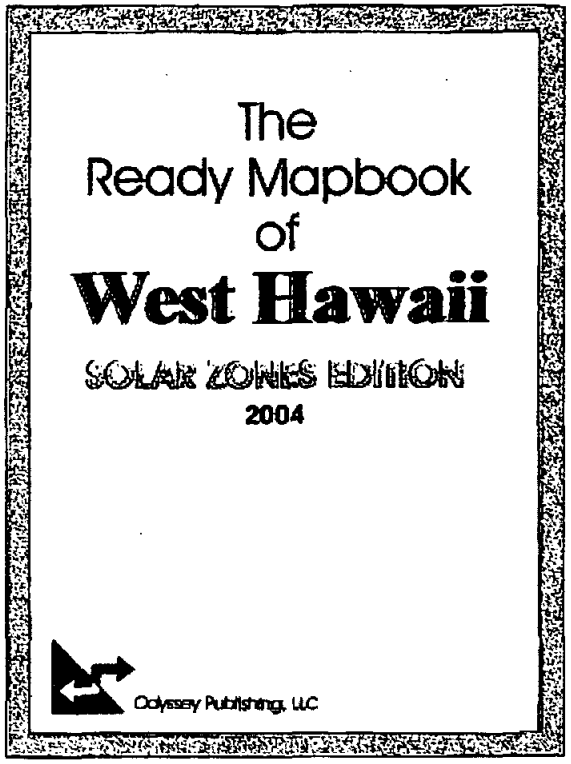

Field verifications were made using a Garmin 12, Global Positioning Instrument (12 satellites). Over 98 % of the passenger car roads were driven with a 1997 Dodge Intrepid. The report of the condition of these roads is based on the capabilities of the car and personal perception. Even so, we cannot guarantee 100% accuracy. Not intended for legal descriptions. Any corrections, criticisms, or additions are gratefully accepted.

The solar lines represented in this book have been modified from the State of Hawaii Department of Business, Economic Development and Tourism maps for HELCO's Residential Efficient Water Heating program use. HELCO reserves the right to change the REWH program solar lines without notice. HELCO should be contacted to verify whether any changes have been made since the time of the printing of this book.

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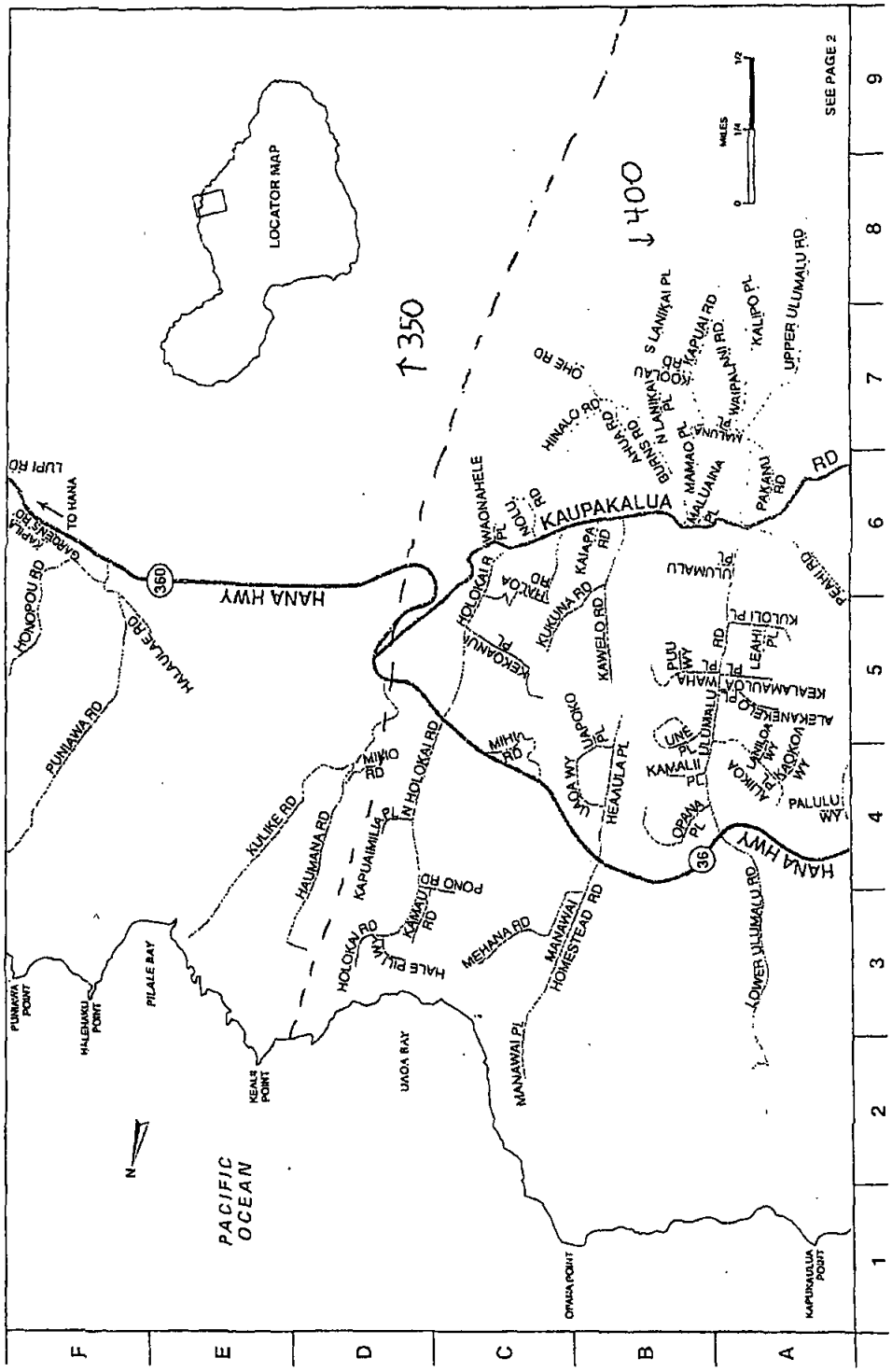
Attachment B
Page 4


LOCATOR MAP
SEE PAGE 2
MILES
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↑350
↓400
KAUPAKALUA
HANA HWY
TO HANA
LUPI RD
HONOPOU RD
PUNIAWA RD
HALAULE RD
KULIKE RD
HAUMANA RD
KAPUAIMILIA
HOLOKAI RD
N HOLOKAI RD
MIKIO RD
PONO RD
KAIMAU RD
HALE PUU
MEHANA RD
MANAWAI HOMESTEAD RD
MANAWAI PL
HEAMULA PL
UAPOKO PL
KAWELO RD
KUKUNA RD
KAIAPA RD
HOLOKAI PL
WAONAHELE
KEKOANUI PL
HINALO RD
AHUA RD
BURNS RD
N LANIKAI PL
S LANIKAI PL
KAPUAI RD
WAIPALANI RD
KALIPO PL
UPPER ULUMALU RD
LOWER ULUMALU RD
PAKANU RD
PEAHI RD
KULOLI PL
LEAHI PL
KEALAMAULOA PL
ALEKANEKEO PL
KAWALI PL
OPANA PL
PALULU WY
PUNAWAI POINT
HALEHAKU POINT
PILALE BAY
KEALE POINT
UAOA BAY
OPANA POINT
KAPUKAULUA POINT
PACIFIC OCEAN
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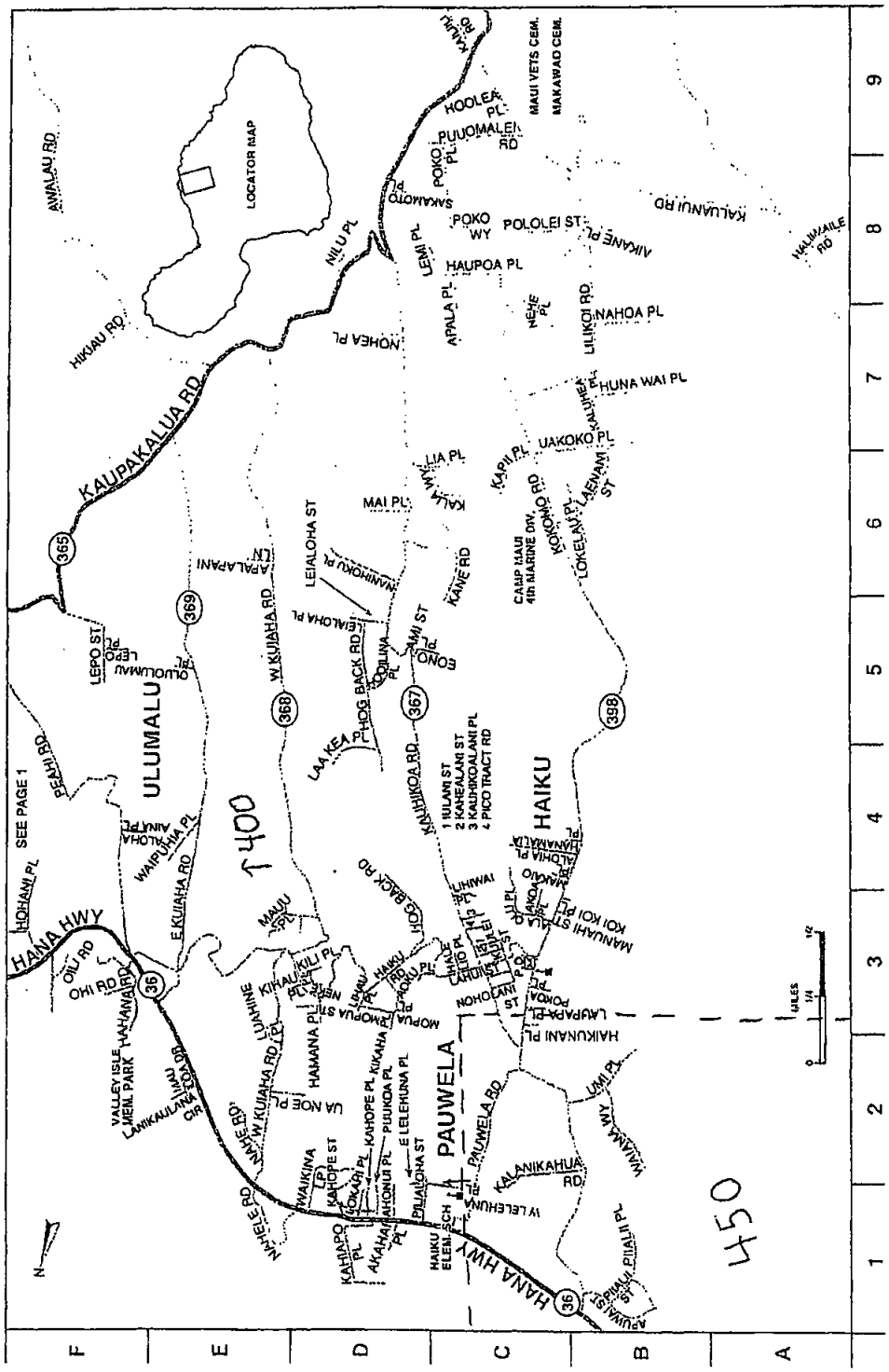
HAIKU
ULUMALU
PAUWELA
KAUPAKALUA RD
HANA HWY
SEE PAGE 1
LOCATOR MAP
MAUI VETS CEM.
MAKAWAO CEM.
HOOLEA PL
PUUOMALEI RD
POKO PL
POKO WY
POLOLEI ST
HAUPOA PL
NAHOA PL
HUNA WAI PL
UAKOKO PL
KOKOMO RD
CAMP MAUI 4th MARINE DIV.
MAI PL
LEIALOHA ST
W KUIAHA RD
E KUIAHA RD
HOG BACK RD
LAA KEA PL
KAUHIKOA RD
1 IULANI ST
2 KAHEALANI ST
3 KAUHIKOALANI PL
4 PICO TRACT RD
PAUWELA RD
KALANIKAHUA RD
HAIKUNANI PL
LAUPAPAPA PL
MANUHI ST
KOI KOI PL
HAIKU ELEM. SCH
VALLEY ISLE MEM. PARK
HOHANI PL
PEAHI RD
LEPO ST
OLUOLUMAU PL
WAIPUHA PL
ALOHA AINA PL
HAHANA RD
OHI RD
OLI RD
LUAHINE
KIHAU ST
HAMANA PL
MOPUA ST
KAHOPE PL
KUKAHA PL
PUUKOA PL
E LELEHUNA PL
PUUALOHA ST
W LELEHUNA
UMI PL
WAIMANA HWY
KAPUWAI ST
PIIALII PL
NAHELE RD
UA NOE PL
WAIKINA LP
KAHOPE ST
KAHAPO PL
AKAHANUI PL
AKAHONUI PL
NOHEA PL
NILU PL
LEMI PL
APALA PL
NENE PL
LILIKOI RD
KALUANUUI RD
HALIMAILE RD
AIKANE PL
SAKAMOTO PL
AWALAU RD
HIKIAU RD
KAPII PL
LAENAM ST
LOKELANI PL
KAUHEA
KAIWI PL
KAVE RD
EONO PL
AMI ST
KOLUNA PL
EIALOHA PL
NAMIHOKU PL
APALAPANI LN
BACK RD
MANU PL
IKU PL
HAIKU RD
LUHIWAI PL
CHAR PL
KAUIST
KAULEI ST
KAKO PL
KOHOLANI ST
PONOA PL
MAUI PL
LIA PL
KALA WY
365
369
368
367
398
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450
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MILES
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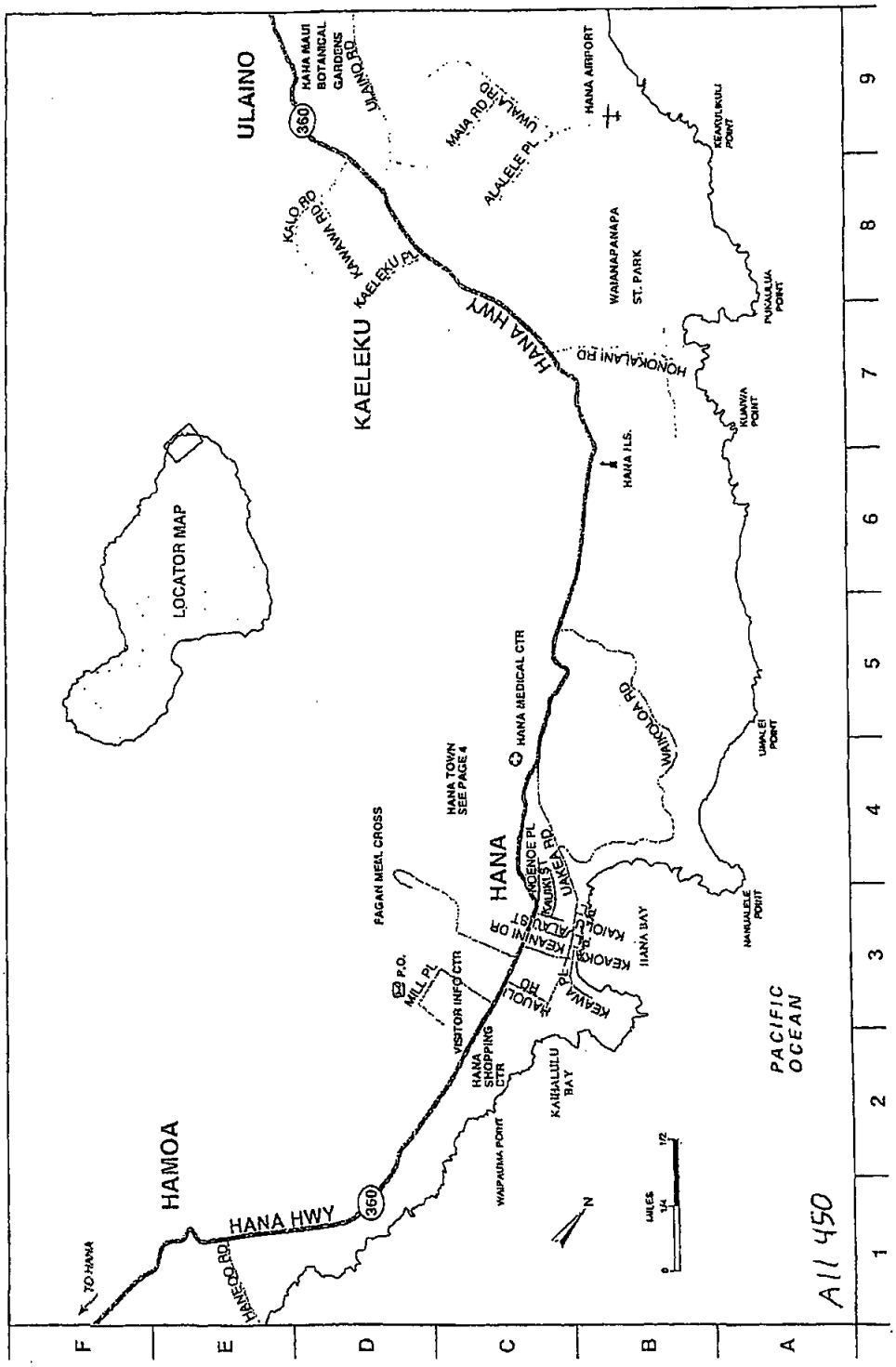
ULAINO
HANA MAUI BOTANICAL GARDENS
UAINO RD.
360
MAIA RD.
UWALAHO RD.
ALALELE PL.
HANA AIRPORT
KEAHOLKULI POINT
KALO RD.
KAWAWA RD.
KAELEKU PL.
KAELEKU
HANA HWY
WAIANAPANAPA ST. PARK
PUHALULU POINT
HONOKALANI RD.
KUAWA POINT
HANA ILS.
LOCATOR MAP
HANA MEDICAL CTR
WAIKOLOA RD.
UAKEA RD.
HANA TOWN SEE PAGE 4
HANA
KOENOE PL.
KAUMI ST.
KEANINI DR.
KAIOLU PL.
KAUMAKU ST.
KEAOKA PL.
KEAWA PL.
HAUOLI RD.
FAGAN MEM. CROSS
P.O.
MILL PL.
VISITOR INFO CTR
HANA SHOPPING CTR
KAHALULU BAY
HANA BAY
UMALEI POINT
NAHUALELE POINT
PACIFIC OCEAN
HAMOA
HANA HWY
HANEOO RD.
TO HANA
WAIPAUMA POINT
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MILES
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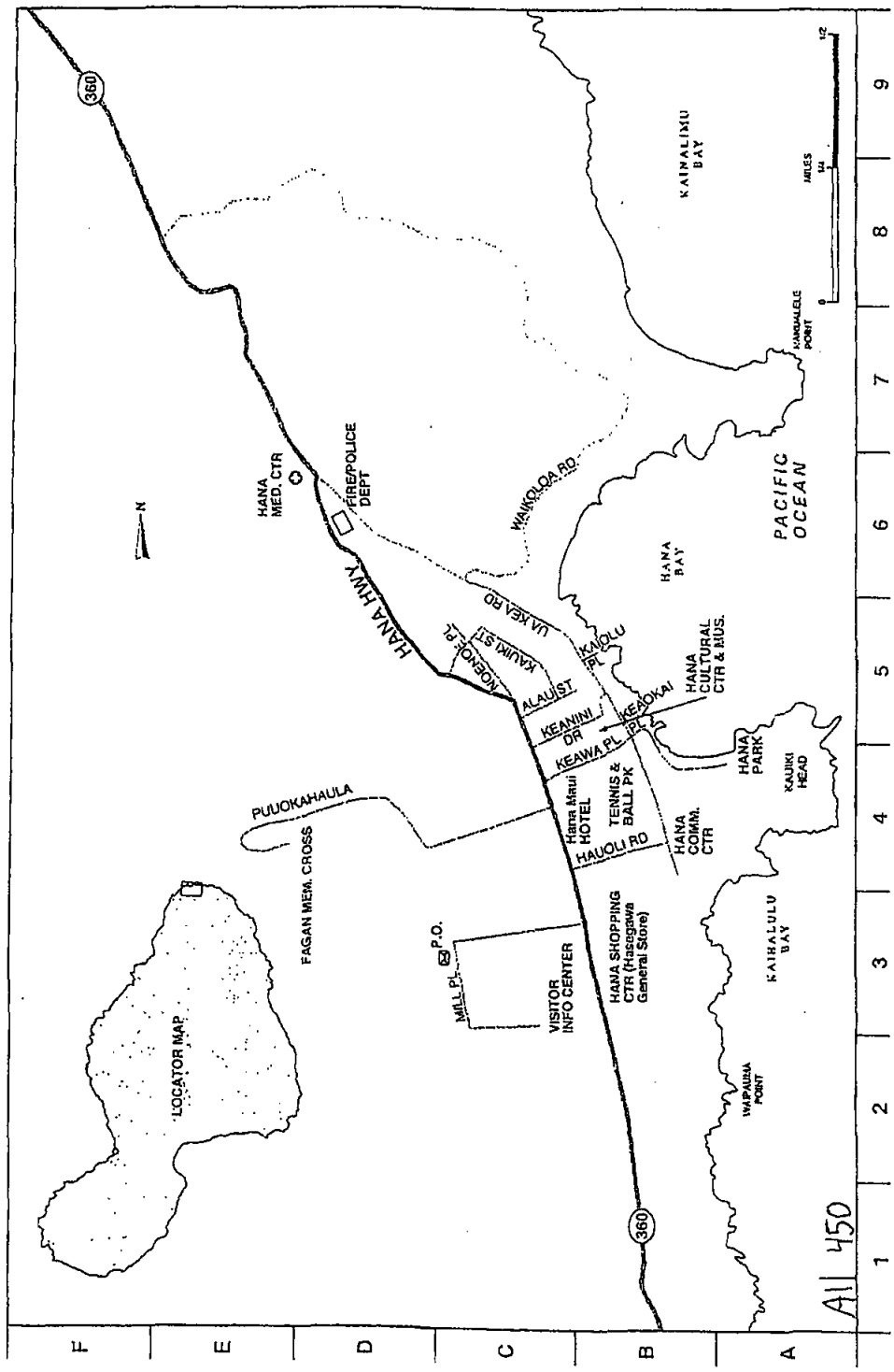
All 450


HANA
LOCATOR MAP
FAGAN MEM. CROSS
PUUOKAHAULA
MILL PL.
P.O.
VISITOR INFO CENTER
HANA SHOPPING CTR (Hasegawa General Store)
HAUOLI RD
Hana Maui HOTEL
TENNIS & BALL PK
HANA COMM. CTR
KEAWA PL.
KEANINI DR
ALAU ST.
NOENOE PL.
KAUIKI ST.
UA KEA RD
HANA HWY
KAOLU PL.
KEAOKAI PL.
HANA CULTURAL CTR & MUS.
HANA PARK
KAUIKI HEAD
HANA BAY
PACIFIC OCEAN
KAIMALIKU BAY
KAIHALULU BAY
WAIPAUNA POINT
HANAMALELE POINT
WAIKOLOA RD.
FIRE/POLICE DEPT
HANA MED. CTR
360
N
MILES
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1/4
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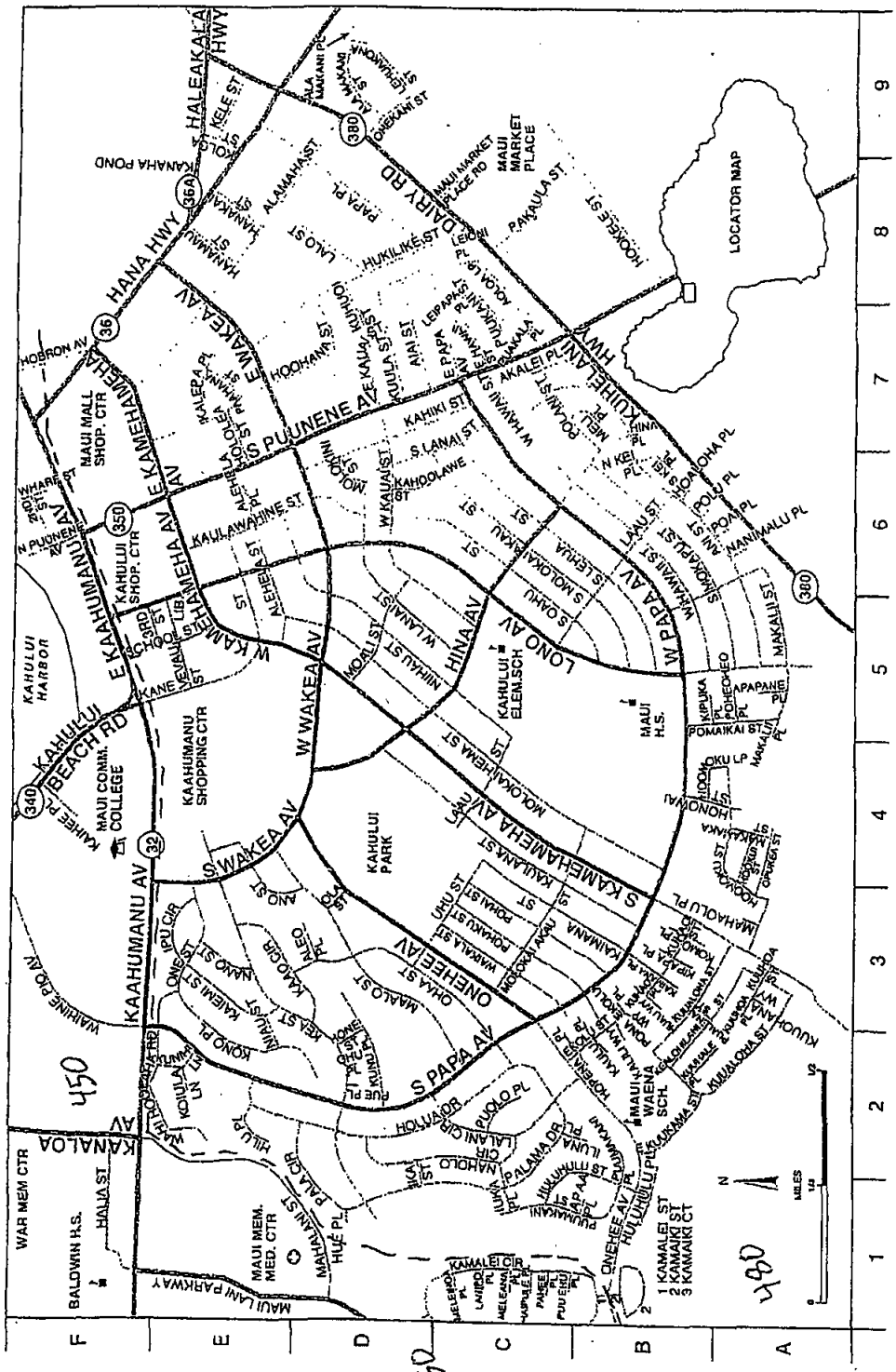
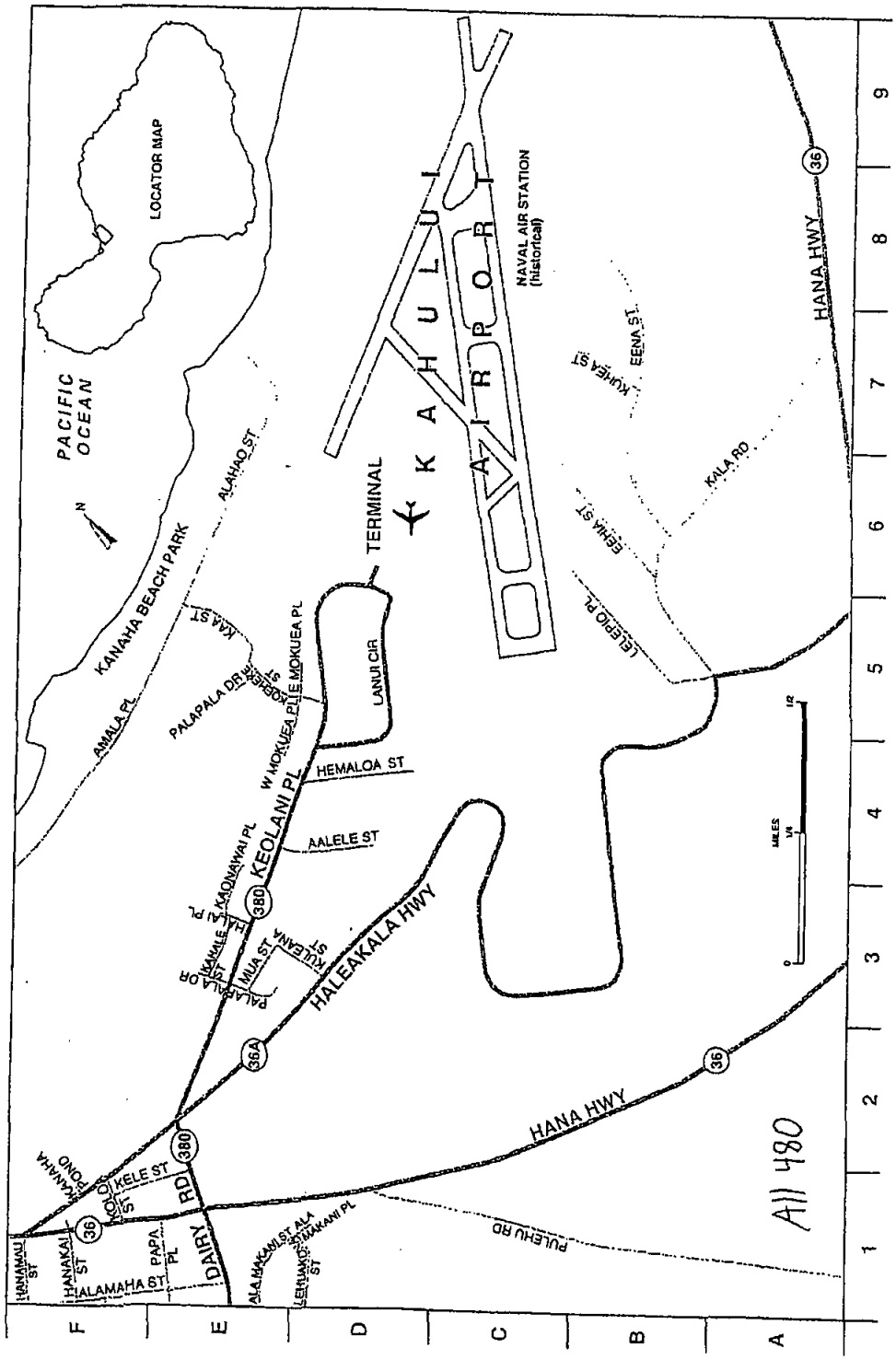
All 450


LOCATOR MAP
HALEAKALA HWY
HANA HWY
DAIRY RD
KUIHELANI HWY
W PUUNENE AV
E KAMEHAMEHA AV
W KAMEHAMEHA AV
E KAAHUMANU AV
KAHULUI BEACH RD
W KAAHUMANU AV
KAHULUI HARBOR
MAUI COMM. COLLEGE
KAAHUMANU SHOPPING CTR
KAHULUI SHOP. CTR
MAUI MALL SHOP. CTR
W WAKEA AV
S WAKEA AV
KAHULUI PARK
KAHULUI ELEM.SCH
MAUI H.S.
LONO AV
HINA AV
W PAPA AV
S KAMEHAMEHA AV
ONEHEE AV
S PAPA AV
KANALOA AV
WAR MEM CTR
BALDWIN H.S.
MAUI MEM. MED. CTR
MAUI LANI PARKWAY
MAUI MARKET PLACE
MAUI WAENA SCH.
KANAHA POND
1 KAMALEI ST
2 KAMAKI ST
3 KAMAKI CT
450
450
450


LOCATOR MAP
PACIFIC OCEAN
N
KANAHA BEACH PARK
ALAHAO ST
AMALA PL
KAA ST
PALAPALA DR
W MOKUEA PL
E MOKUEA PL
LANUI CIR
TERMINAL
KAHULUI AIRPORT
NAVAL AIR STATION (historical)
KUHEA ST
EENA ST
EEHIA ST
LELEPIO PL
KALA RD
HANA HWY
HEMALOA ST
AALELE ST
KEOLANI PL
KAONAWAI PL
HALEAKALA HWY
MUA ST
PULEHU RD
HANAMAU ST
HANAKAI ST
HALAMAHA ST
PAPA PL
DAIRY RD
KOLO ST
KELE ST
ALA MAKANI ST
LEHUAKONA ST
ALA WAKANI PL
380
36
36A
MILES
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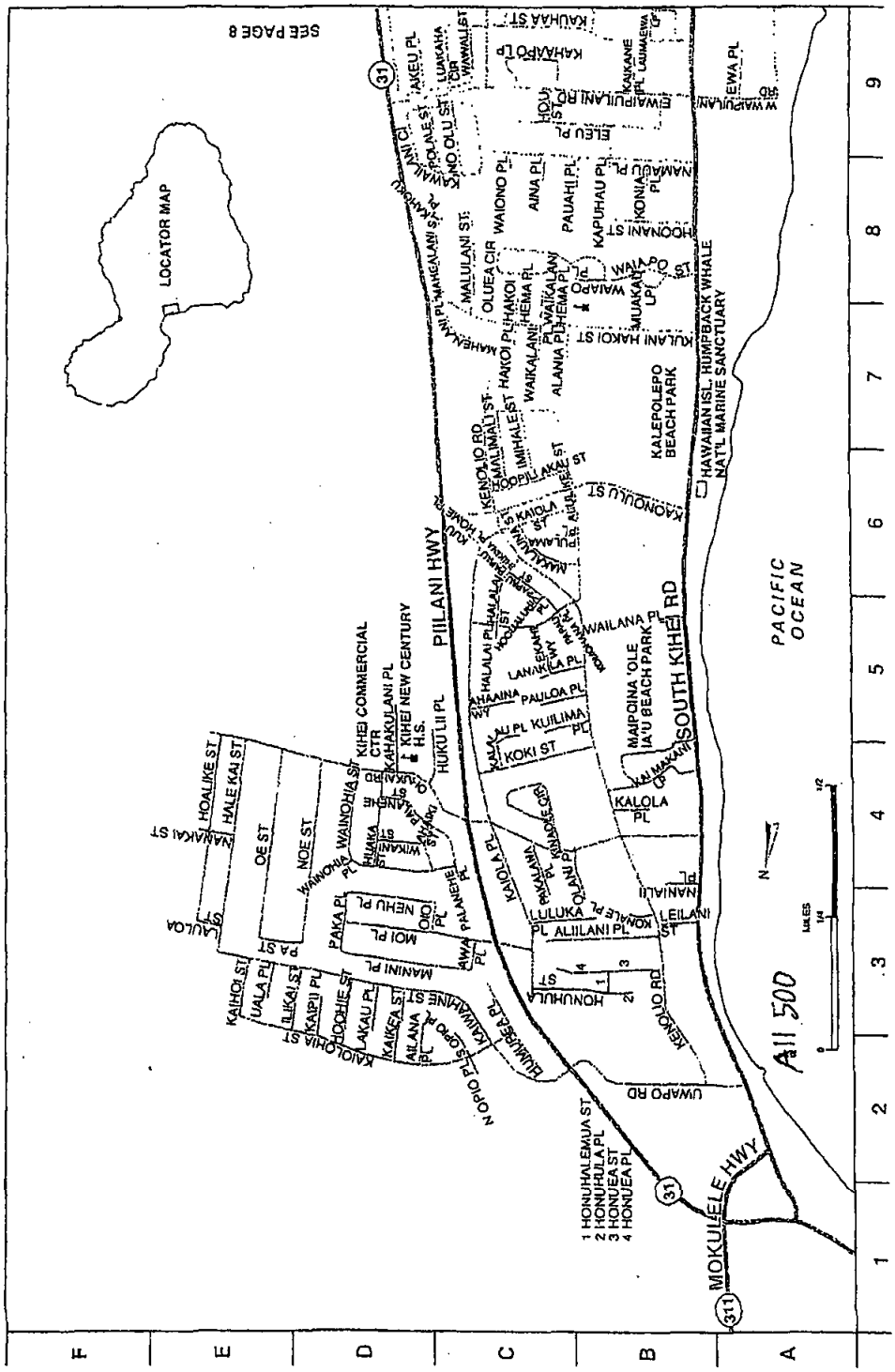
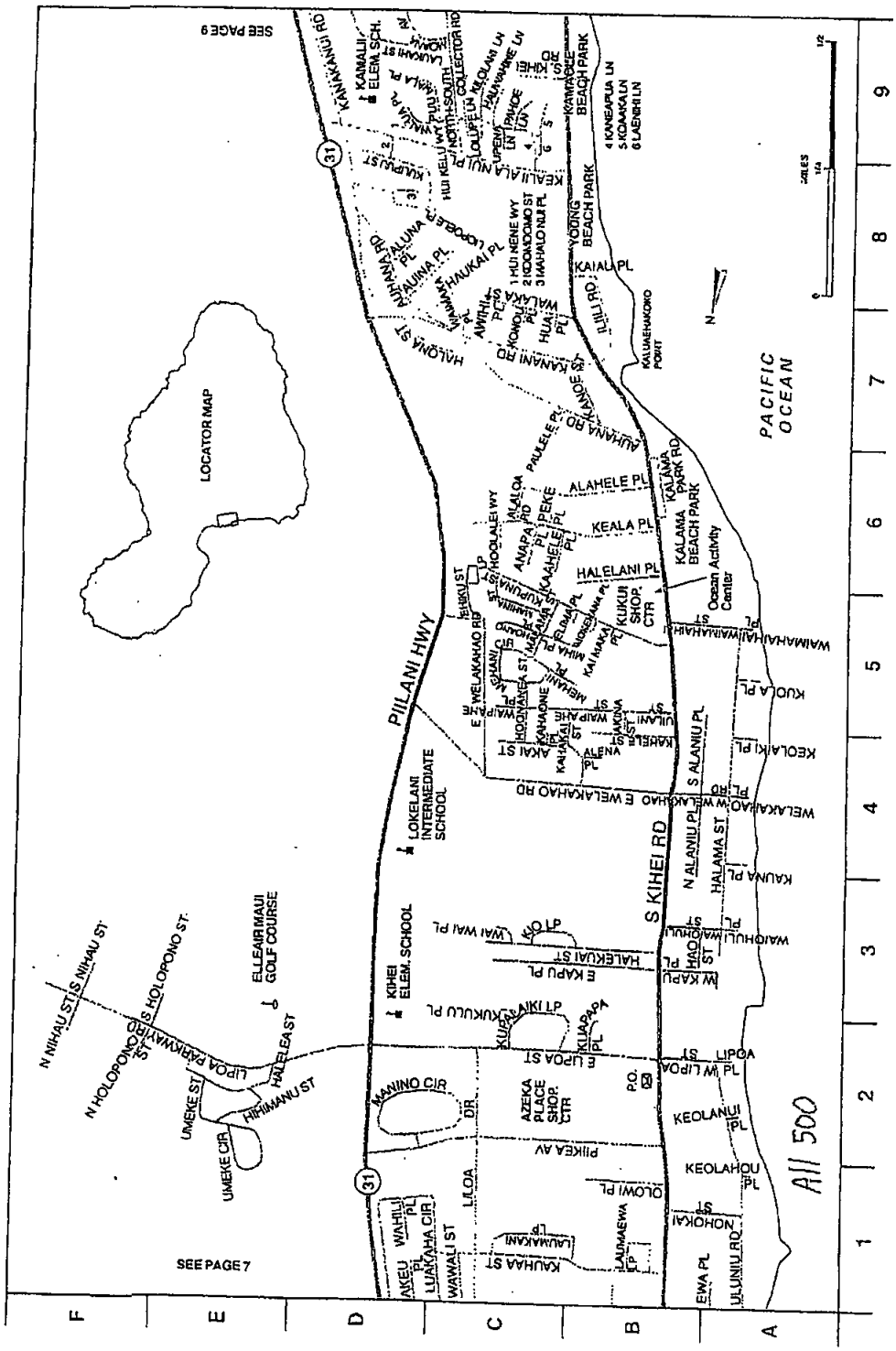
All 480


LOCATOR MAP
SEE PAGE 8
PIILANI HWY
SOUTH KIHEI RD
MOKULELE HWY
PACIFIC OCEAN
KIHEI COMMERCIAL CTR
KIHEI NEW CENTURY H.S.
KALEPOLEPO BEACH PARK
HAWAIIAN ISL. HUMPBACK WHALE NAT'L MARINE SANCTUARY
MAIPOINA 'OLE IA'U BEACH PARK
All 500


SEE PAGE 9
SEE PAGE 7
LOCATOR MAP
PACIFIC OCEAN
PIILANI HWY
S KIHEI RD
KAMAOLE BEACH PARK
KAMAOLE BEACH PARK
YOUNG BEACH PARK
KALAMA BEACH PARK
Ocean Activity Center
KALAMA PARK RD
KALUAHAKONI POINT
KUKUI SHOP. CTR
LOKELANI INTERMEDIATE SCHOOL
KIHEI ELEM. SCHOOL
KAMALII ELEM SCH.
ELLEAIR MAUI GOLF COURSE
AZEKA PLACE SHOP. CTR
P.O.
N NIHAU ST
S NIHAU ST
N HOLOPONO ST
S HOLOPONO ST
LIPOA PARKWAY
HALELEA ST
HIHIMANU ST
UMEKE CIR
MANINO CIR
LIPOA ST
W LIPOA ST
E LIPOA ST
PIIKEA AV
OLOWI PL
LILOA
KAUHAA ST
WAWALI ST
LUAKAHA CIR
AKEU PL
WAHILI PL
KEOLANUI PL
KEOLAHOU PL
NOHOKAI ST
EWA PL
ULUNIU RD
KAUNA PL
HALAMA ST
N ALANIU PL
S ALANIU PL
WELAKAHAO RD
E WELAKAHAO RD
W WELAKAHAO PL
KUOLA PL
KEOLAIKI PL
WAIMAHALI PL
WAIOHULI PL
W KAPU PL
E KAPU PL
HALEKUAI ST
KUKULU PL
AIKI LP
KUPAPA PL
WAI WAI PL
KIO LP
AKAI ST
ALENA PL
KAHAONE ST
WAIPAHE ST
HOONANA ST
KAHAKAI ST
KAIAKOA ST
ULANI ST
KAHELE ST
E WELAKAHAO RD
KAIAKAI PL
MIHA PL
MEHANI ST
KUPUNA ST
HOOLALEI WY
ANAPA PL
KAAHELE PL
PEKE PL
HALOA PL
HALELANI PL
KEALA PL
ALAHELE PL
PAULELE PL
AUHANA RD
KAIAU PL
KANANI RD
KAMANE ST
HALONA ST
ALUNA PL
HAUKAI PL
AWHILI PL
KONOKI PL
WALANA PL
HUA PL
ILILI RD
KEALI'I ALA NUI PL
KULIPOLI ST
HUI KELU WY
HUI NENE WY
HOOKOMO ST
HAHALO NUI PL
LOUPE LN
KEOLANI LN
HAUWAHINE LN
LUPENA LN
PANOE LN
KANAKOLE RD
KANAKANUI RD
KAMAOLE RD
KAMAOLE RD
LUMAHAI ST
NOMA ST
COLLECTOR RD
NORTH-SOUTH
KAMAOLE RD
KIHEI
4 KANEAPUA LN
5 KOAKAKA LN
6 LAENI HI LN
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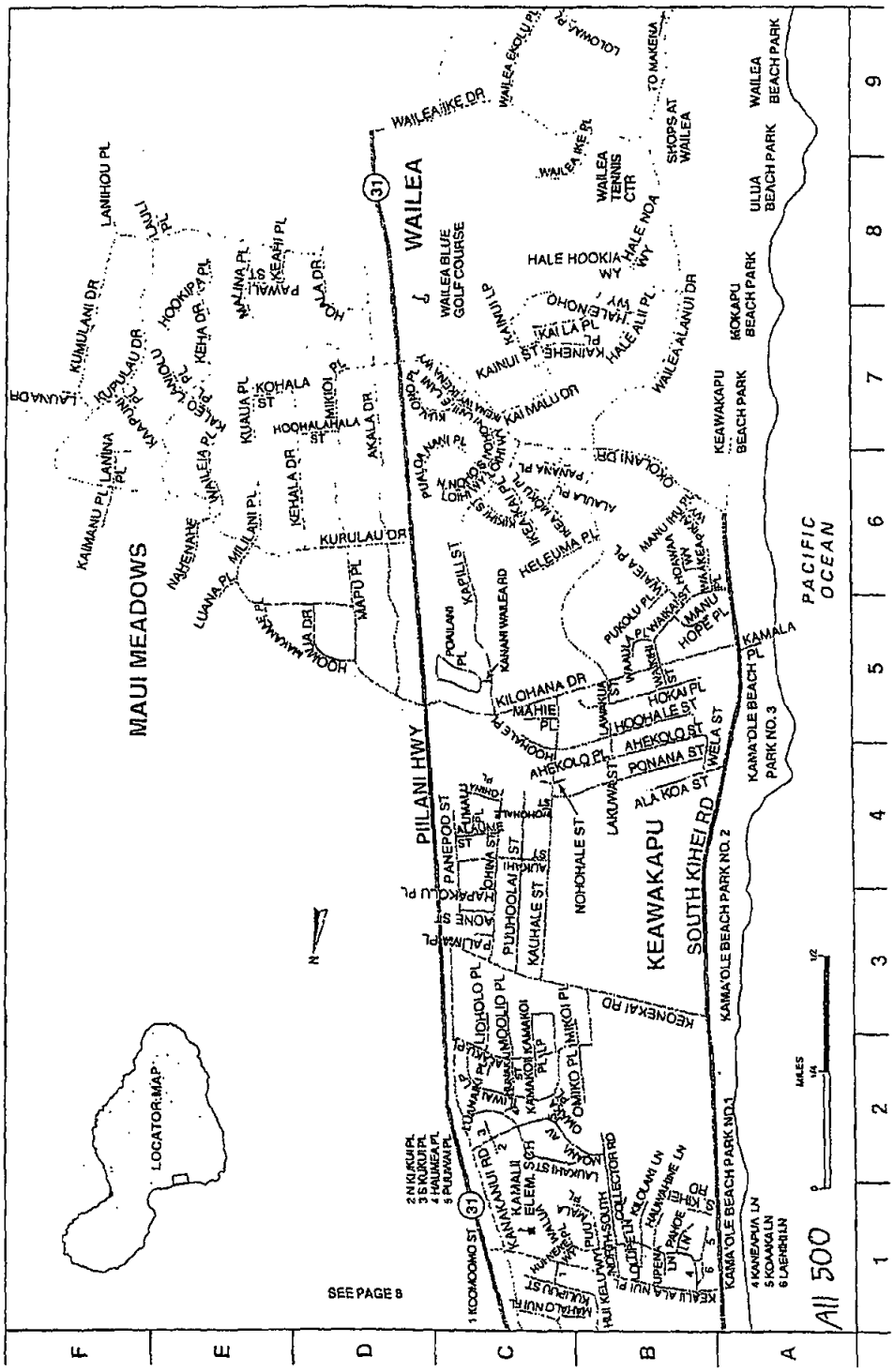
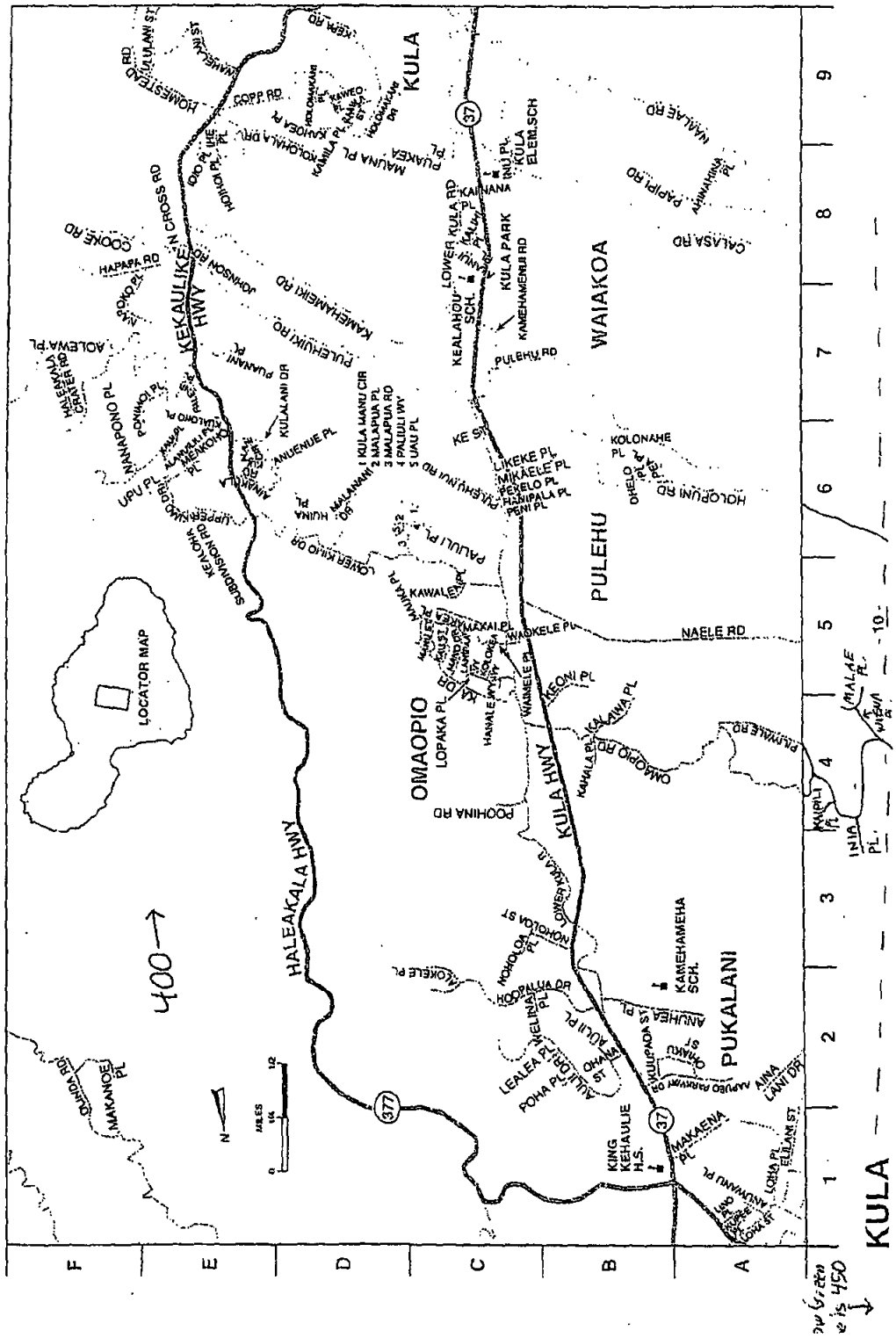
KIHEI


MAUI MEADOWS
WAILEA
KEAWAKAPU
SOUTH KIHEI RD
PILANI HWY
PACIFIC OCEAN
WAILEA BLUE GOLF COURSE
WAILEA TENNIS CTR
SHOPS AT WAILEA
WAILEA BEACH PARK
ULUA BEACH PARK
MOKAPU BEACH PARK
KEAWAKAPU BEACH PARK
KAMA'OLE BEACH PARK NO. 1
KAMA'OLE BEACH PARK NO. 2
KAMA'OLE BEACH PARK NO. 3
LOCATOR MAP
SEE PAGE 8
All 500


KULA
WAIAKOA
PULEHU
OMAOPIO
PUKALANI
KEKAULIKE HWY
KULA HWY
HALEAKALA HWY
400
LOCATOR MAP
KULA ELEM.SCH
KULA PARK
KAMEHAMEHA SCH.
KING KEHAULIE H.S.
LOWER KULA RD
PULEHU RD
NAELE RD
POOHINA RD
OMAOPIO RD
KAWALEI PL
KAMAKA PL
KAMEHAMEHA RD
KULALANI DR
MAKAENA PL
MAKANOE PL
N CROSS RD
JOHNSON RD
COPP RD
HOMESTEAD RD
COOKE RD
CALASA RD
PAPIPI RD
MALAE RD
HOLOPUNI RD
KOLONAHE PL
NANAPONO PL
UPU PL
ALEWA PL
HALEAKALA CRATER RD
KEALAHOU SCH.
LIKEKE PL
MIKAELE PL
FEKELO PL
HANIPALA PL
PENI PL
WAIOKELE PL
KAWALEI PL
KAMAKAI PL
KAMALA PL
KAMEONI PL
WAIMELE PL
LOPAKA PL
HANALEAWAI PL
NOHOLOA ST
HOOPALUA DR
LEALEA PL
POHA PL
ALULI PL
ANUHEA ST
OHAWU ST
KUUPAOA ST
AINA LANI DR
LOHA PL
ELILANI ST
ANUWANU PL
KAPILI PL
INIA PL
MALAE PL
WAIMA PL
SIBDONSON RD
LOWER KULA RD
PULEHUIKI RD
PUANANI PL
ANUENUE PL
MALANAI DR
1 KULA MANU CIR
2 MALAPUA PL
3 MALAPUA RD
4 PALILILI WY
5 UAU PL
PAULU PL
LOWER KULA RD
KAMAKA PL
KAWALEI PL
KAMAKAI PL
WAIOKELE PL
KAMEONI PL
WAIMELE PL
KAMALA PL
OMAOPIO RD
PUUMALE RD
NOHOLOA ST
HOOPALUA DR
ANUHEA ST
OHAWU ST
KUUPAOA ST
AINA LANI DR
LOHA PL
ELILANI ST
ANUWANU PL
MAKAENA PL
KAPILI PL
INIA PL
MALAE PL
WAIMA PL
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MILES
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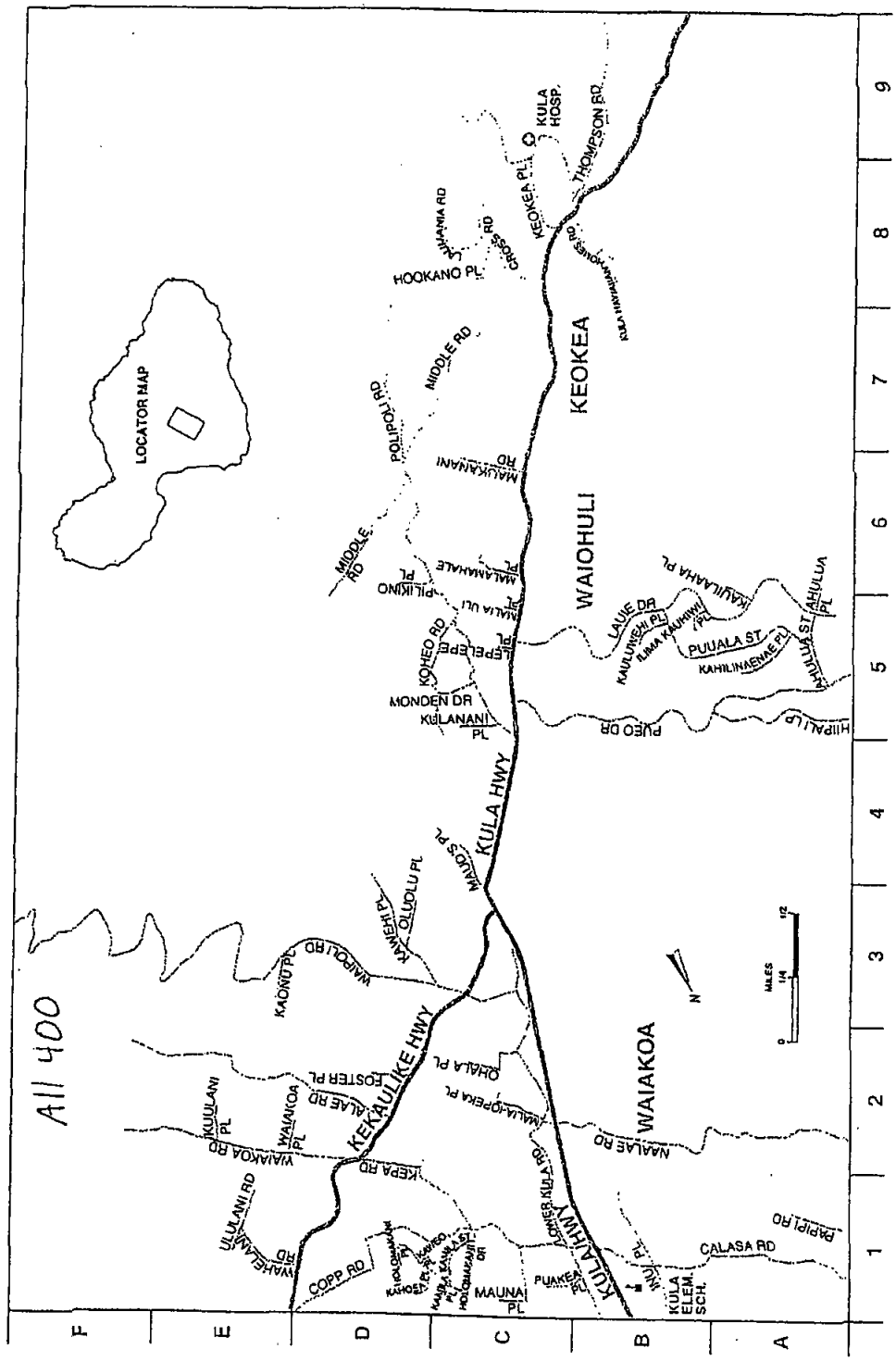
KULA


LOCATOR MAP
KEOKEA
WAIOHULI
WAIAKOA
KULA HWY
KEKAULIKE HWY
KULA HOSP.
THOMPSON RD
KEOKEA PL
HOOKANO PL
MIDDLE RD
POLIPOLI RD
MALAMANI RD
MALAMAHALE PL
PILIKINO PL
KOHEO RD
LEPELEPE PL
MONDEN DR
KULANANI PL
LAUIE DR
KAULUNWEHI PL
ILIMA KAUHIWI PL
PUUALA ST
KAHILINAENAE PL
KAULILAHA PL
AHULUA PL
PUEO DR
HIPALU PL
MAUDS PL
OLUOLU PL
KAONO PL
WAIPOLI RD
FOSTER PL
OHALA PL
MALA-OPEKA PL
NAALAE RD
KEPA RD
WAIAKOA RD
KUULANI PL
WAIAKOA PL
ULULANI RD
WAHELAMA RD
COPP RD
MAUNAI PL
PUAKEA PL
CALASA RD
PAPIPI RD
KULA ELEM. SCH.
All 400
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MILES
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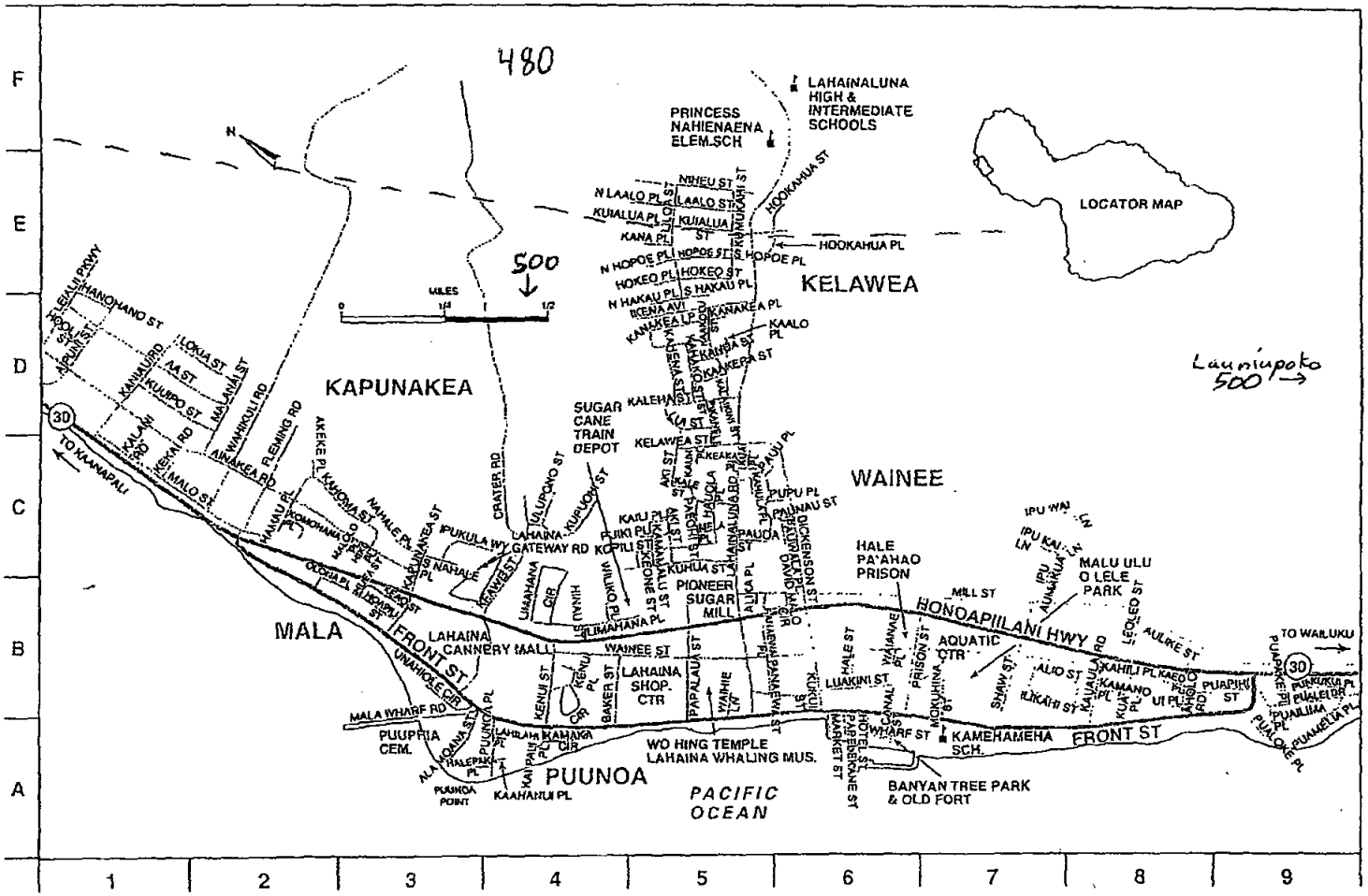
KULA


480
500
LAHAINALUNA HIGH & INTERMEDIATE SCHOOLS
PRINCESS NAHIENAENA ELEM.SCH
LOCATOR MAP
KELAWEA
KAPUNAKEA
WAINEE
MALA
PUUNOA
PACIFIC OCEAN
SUGAR CANE TRAIN DEPOT
PIONEER SUGAR MILL
HALE PA'AHAO PRISON
MALU ULU O LELE PARK
HONOAPIILANI HWY
FRONT ST
LAHAINA CANNERY MALL
LAHAINA SHOP. CTR
AQUATIC CTR
WO HING TEMPLE LAHAINA WHALING MUS.
BANYAN TREE PARK & OLD FORT
KAMEHAMEHA SCH.
PUUPIIA CEM.
LAHAINA GATEWAY RD
TO KAANAPALI
TO WAILUKU
Launiupoko 500
MILES
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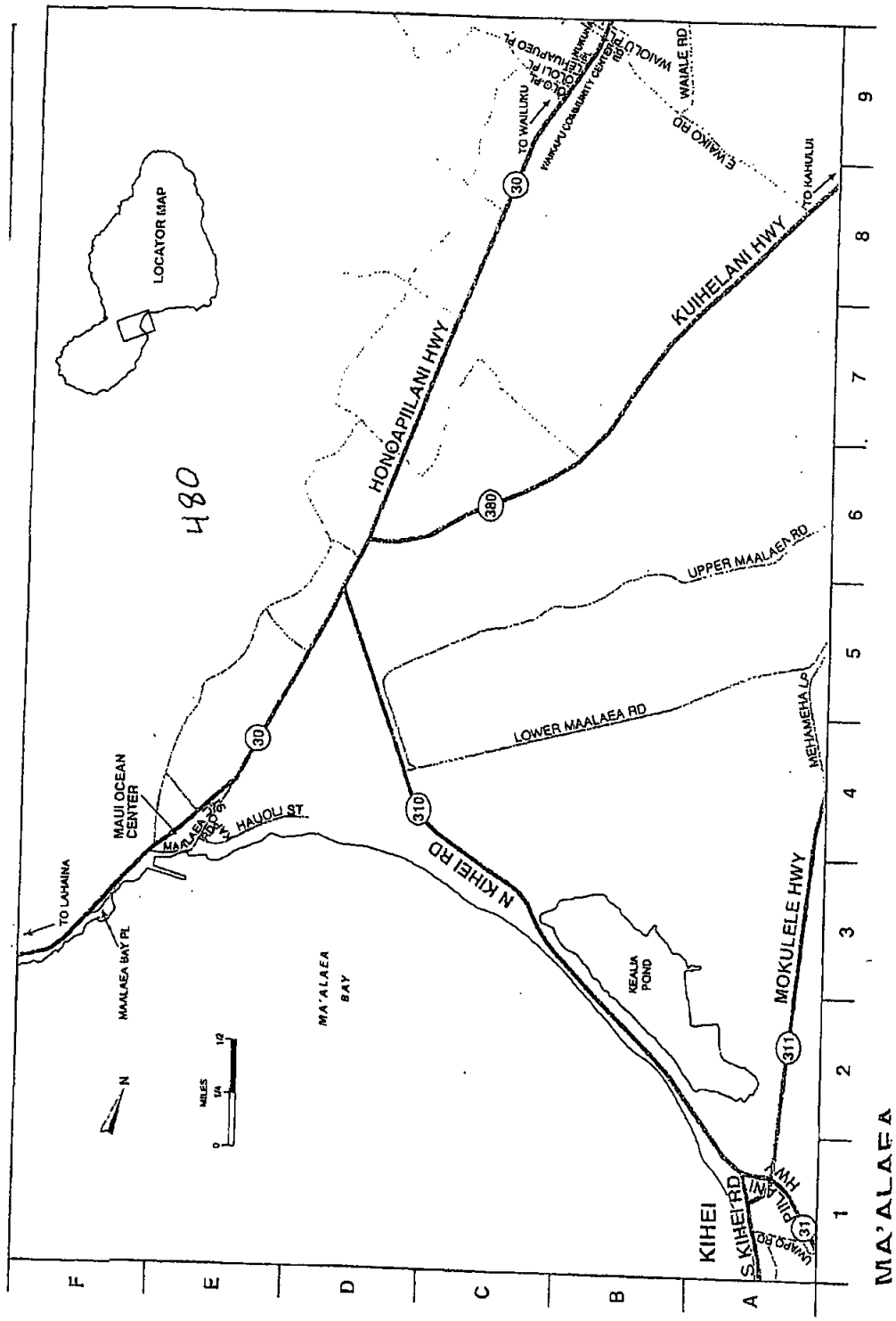
LAHAINA


LOCATOR MAP
480
HONOAPIILANI HWY
KUIHELANI HWY
TO WAILUKU
TO KAHULUI
WAIALE RD
E WAIKO RD
UPPER MAALAEA RD
LOWER MAALAEA RD
MEHAMEHA LP
MOKULELE HWY
N KIHEI RD
S KIHEI RD
PILI AINA HWY
UMPO RD
KEALIA POND
MA'ALAEA BAY
MAUI OCEAN CENTER
MAALAEA BOAT HARBOR
HAUOLI ST
MAALAEA BAY PL
TO LAHAINA
KIHEI
MA'ALAEA
N
MILES
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1/4
1/2
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380
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311
31
A
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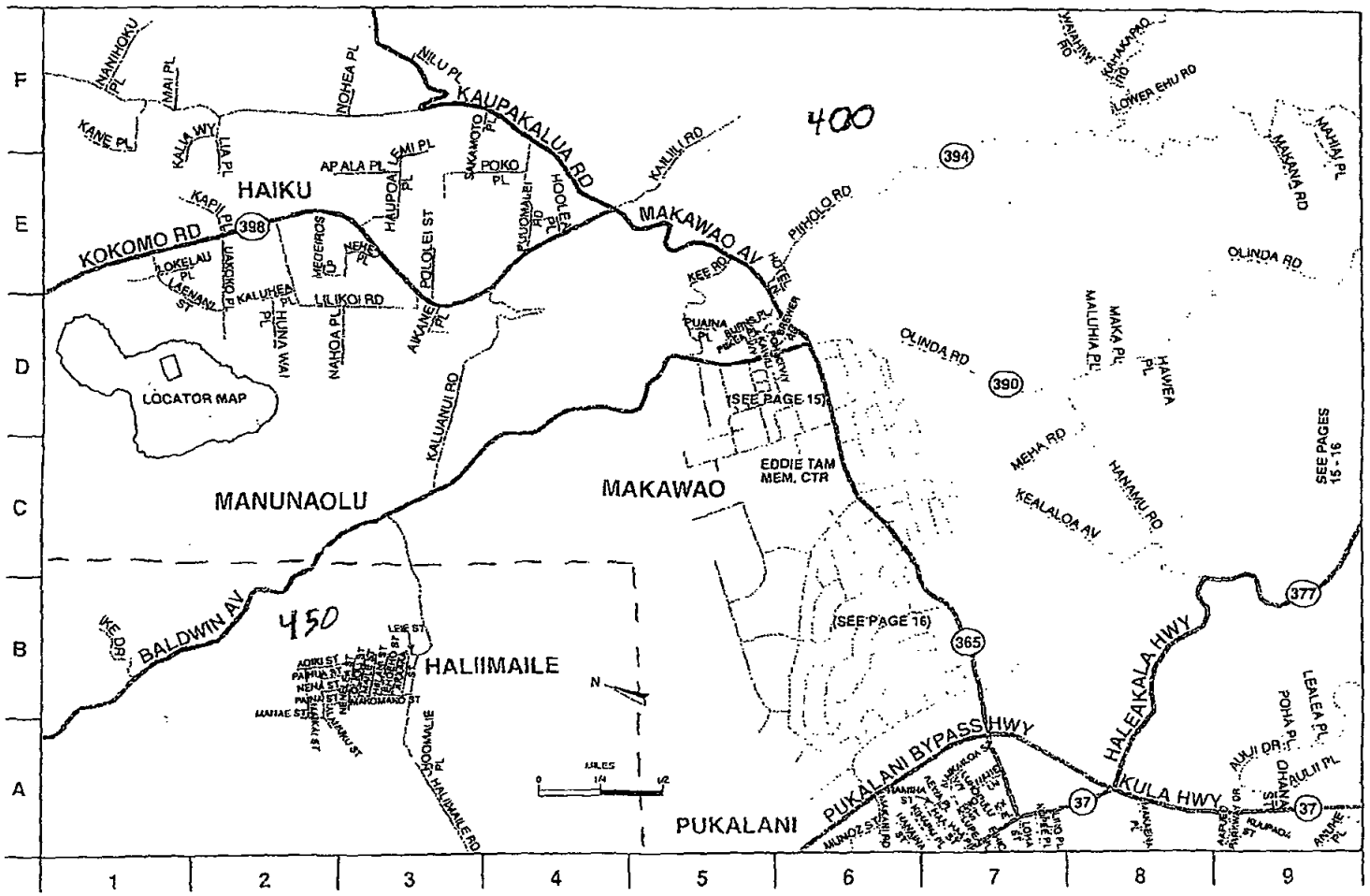
KAUPAKALUA RD
KOKOMO RD
HAIKU
MAKAWAO AV
KULA HWY
HALEAKALA HWY
PUKALANI BYPASS HWY
BALDWIN AV
MANUNAOLU
MAKAWAO
HALIIMAILE
PUKALANI
EDDIE TAM MEM. CTR
LOCATOR MAP
(SEE PAGE 15)
(SEE PAGE 16)
SEE PAGES 15 - 16
400
450
394
398
390
365
377
37
OLINDA RD
MEHA RD
KEALAOA AV
HANAMU RD
LOWER EHU RD
KALULI RD
PIIHOLO RD
KANIAHI RD
KALUANUI RD
POLOLEI ST
LILIKOI RD
HALIIMAILE RD
MILES
0
1/4
1/2
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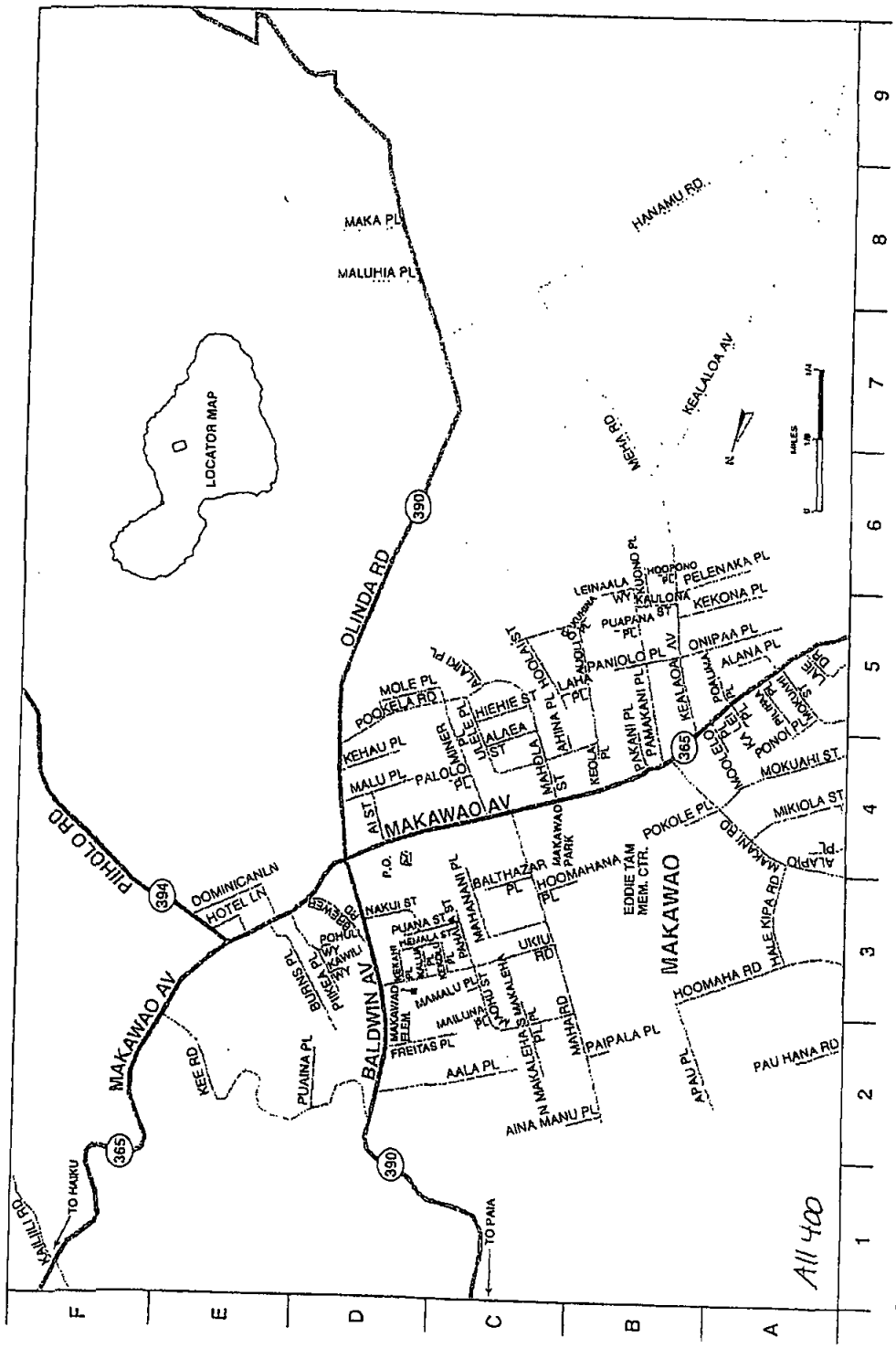
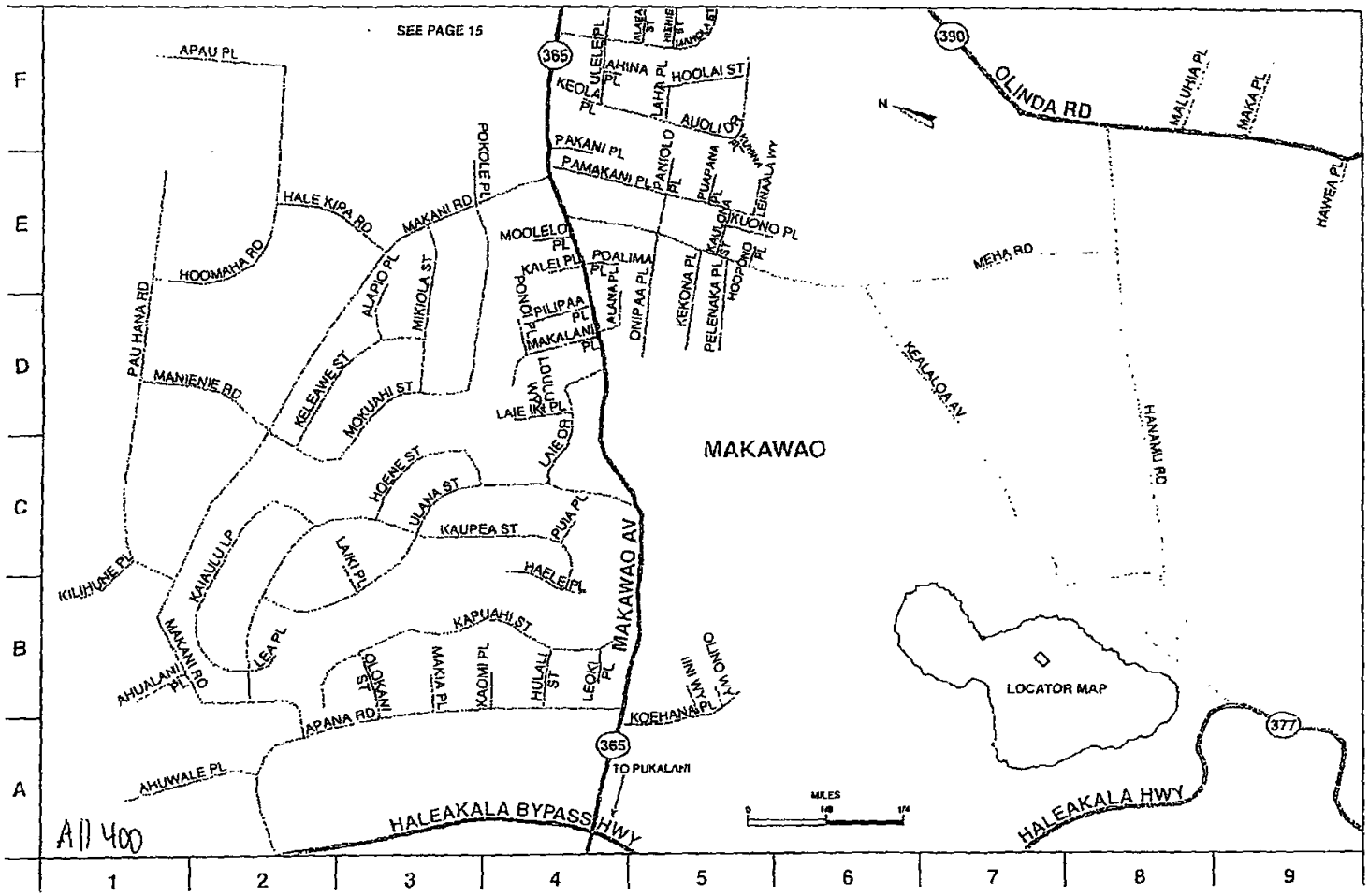
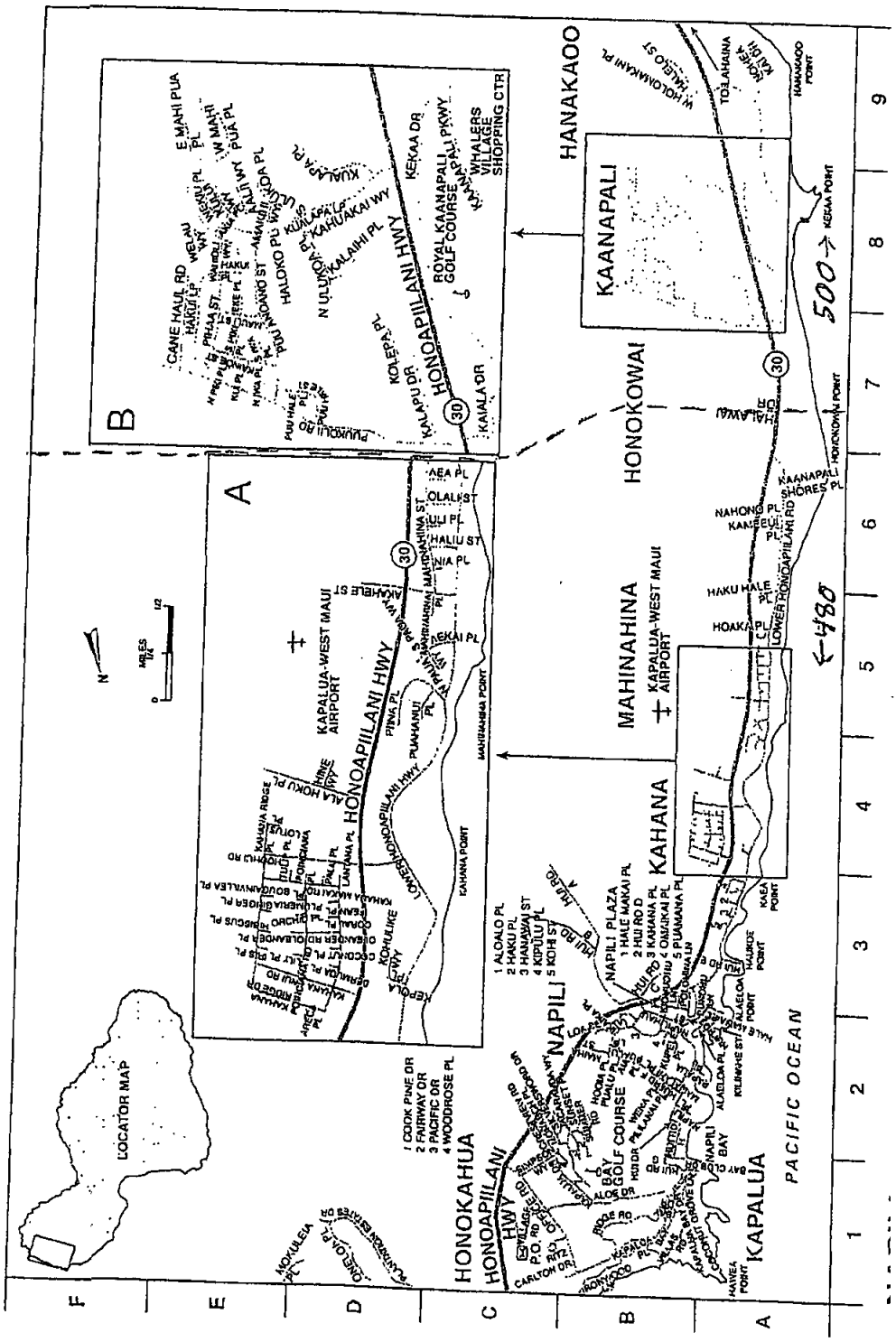
F

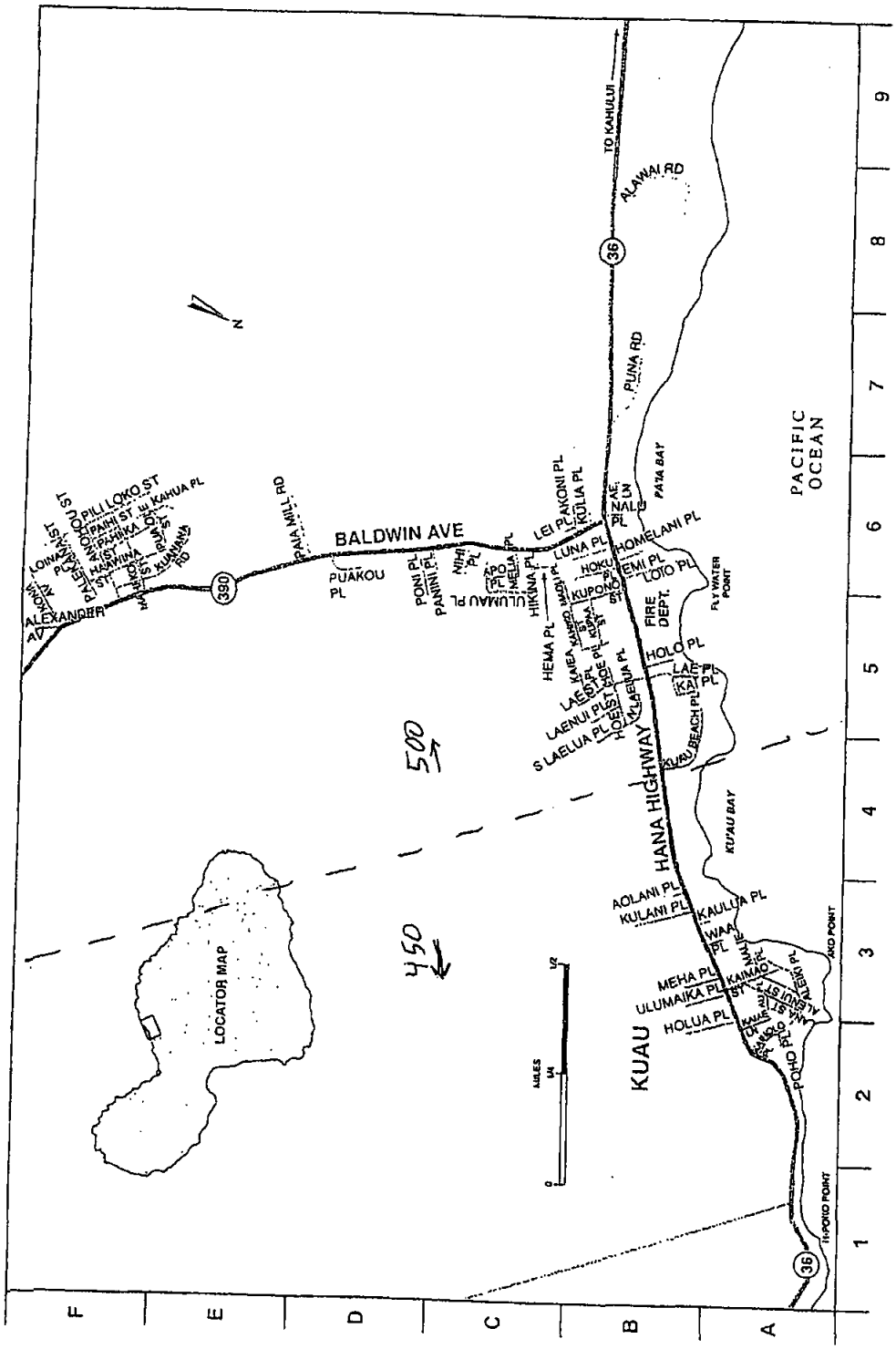
MAKAWAO

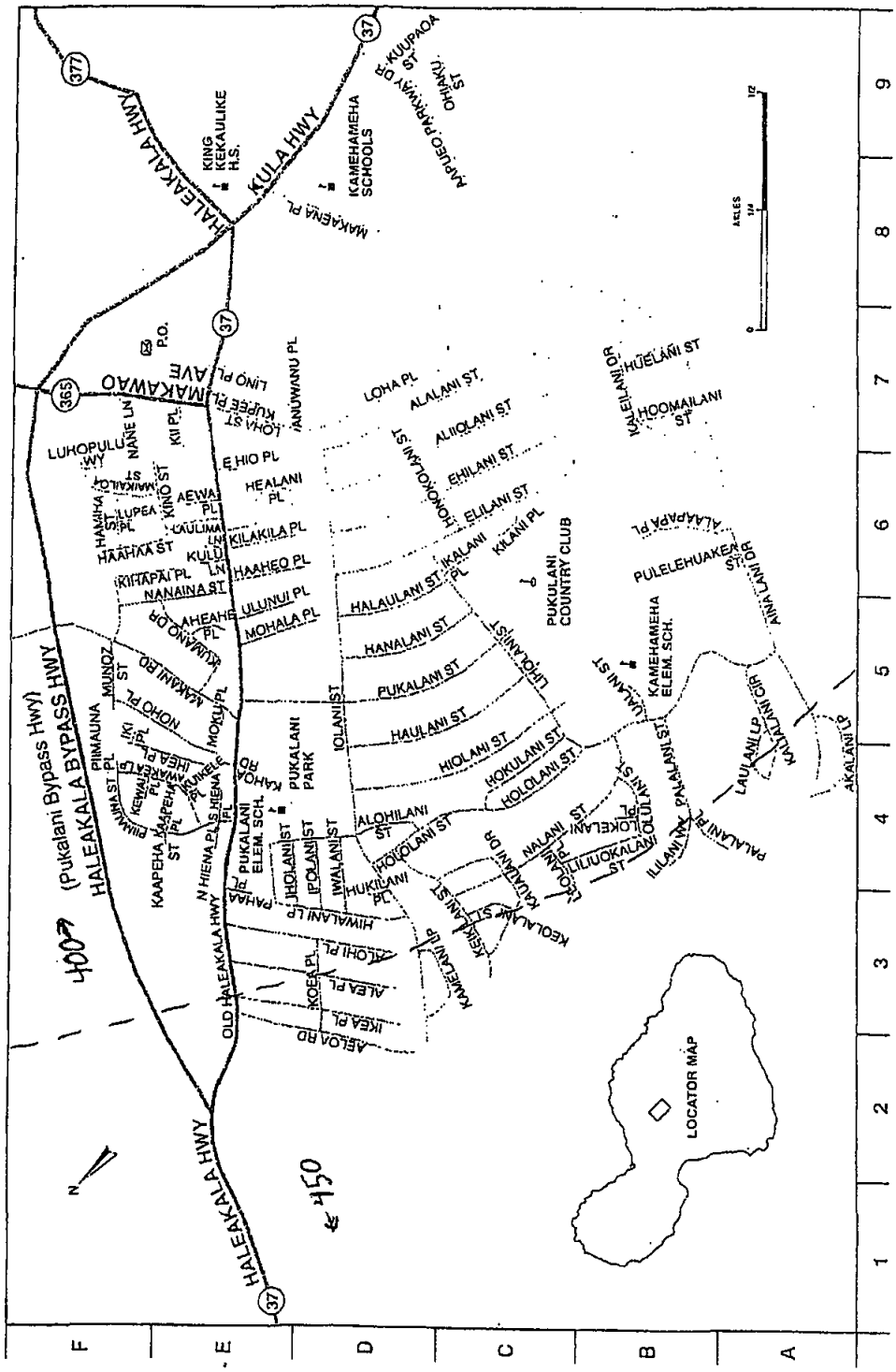

MAKA PL
MALUHIA PL
HANAMU RD
LOCATOR MAP
OLINDA RD
390
MEHA RD
KEALALOA AV
N
MILES
PILIKOA PL
LEINAALA WY
HOOPONO PL
PELENAKA PL
KAULONA WY
KEKONA PL
PUAPANA ST
ONIPAA PL
ALANA PL
PANIOLO PL
KEALAOA AV
MOLE PL
POOKELA RD
HIEHIE ST
ALAEA ST
LAHINA PL
KEOLA PL
PAKANI PL
PAMAKANI PL
KEHAU PL
MALU PL
PALOLO PL
MAHOLA ST
MAKAWAO AV
A1 ST
365
MOKUAHI ST
MIKIOLA ST
POKOLE PL
MAKANI RD
ALAPIO PL
PIIHOLO RD
394
DOMINICAN LN
HOTEL LN
NAKUI ST
BALTHAZAR PL
HOOMAHANA PL
MAKAWAO PARK
EDDIE TAM MEM. CTR.
MAKAWAO
HALE KIPA RD
BURNS PL
POHULI WY
PIIKEA WY
PUAINA ST
HEWALA ST
MAHAJANI PL
UKIU RD
HOOMAHA RD
MAKAWAO AV
KEE RD
BALDWIN AV
MAMALU PL
MAILUNA PL
MAKALEHA ST
MAHAIRD
PAIPALA PL
FREITAS PL
AALA PL
PUAINA PL
N MAKALEHA PL
AINA MANU PL
APAU PL
PAU HANA RD
TO HAIKU
KAILILI RD
TO PAIA
All 400


SEE PAGE 15
MAKAWAO
OLINDA RD
HALEAKALA BYPASS HWY
HALEAKALA HWY
MAKAWAO AV
TO PUKALANI
LOCATOR MAP
APAU PL
HALE KIPA RD
MAKANI RD
POKOLE PL
HOOMAHA RD
PAU HANA RD
MANIENIE RD
KELEAWE ST
MOKUAHI ST
ALAPIO PL
MIKIOLA ST
KILIHUNE PL
KAIAULU LP
MAKANI RD
AHUALANI PL
LEA PL
LAIKI PL
HOENE ST
ULANA ST
KAUPEA ST
HAELE PL
KAPUAHI ST
OLOKAN ST
MAKIA PL
KAOMI PL
HULALI ST
LEOKI PL
APANA RD
AHUWALE PL
KOEHANA PL
KEOLA PL
AHINA PL
HOOLAI ST
AUOLI ST
PAKANI PL
PAMAKANI PL
MOOLELO PL
KALEI PL
PUALIMA PL
PILIPAA PL
MAKALANI PL
LAJE IKI PL
LAJE OR
KEKONA PL
PELENAKA PL
HOOPONO PL
KUKUONO PL
MEHA RD
KEALAOA AV
HANAMU RD
MALUHIA PL
MAKA PL
HAWEA PL
N
MILES
A11 400

MAKAWAO


LOCATOR MAP
A
B
HONOAPIILANI HWY
KAPALUA-WEST MAUI AIRPORT
HONOKAHUA
NAPILI
KAHANA
MAHINAHINA
HONOKOWAI
HANAKAOO
KAANAPALI
KAPALUA
PACIFIC OCEAN
ROYAL KAANAPALI GOLF COURSE
WHALERS VILLAGE SHOPPING CTR
NAPILI BAY GOLF COURSE
NAPILI PLAZA
500
480


PAIA
KUAU
HANA HIGHWAY
BALDWIN AVE
PACIFIC OCEAN
LOCATOR MAP
TO KAHULUI
ALAWAI RD
PUNA RD
PAIA BAY
KU'AU BAY
PAIA MILL RD
PUAKOU PL
ALEXANDER AV
LOINAI ST
PIILANI ST
OPIILOKO ST
OPAIHI ST
OPIHIKA ST
KAWAINA ST
KUAWINA ST
KUAHUA PL
KUAHUA ST
KUAHUA RD
LEI PLAKONI PL
KOLIA PL
LUNA PL
HOMELANI PL
LOTO PL
KUPONO PL
HOKU PL
HIKINA PL
HEMA PL
LAENUI PL
S LAELUA PL
LAELUA PL
HOLO PL
LAEPI PL
KAULUA PL
AOLANI PL
KULANI PL
WAA PL
MEHA PL
ULUMAIKA PL
HOLUA PL
KAIMAO ST
POHO PL
FIRE DEPT.
FLY WATER POINT
AKO POINT
TI-POKO POINT
500
450
MILES
1/2
1
0
N
36
390


HALEAKALA HWY
(Pukalani Bypass Hwy)
HALEAKALA BYPASS HWY
KULA HWY
MAKAWAO AVE
KING KEKAULIKE H.S.
KAMEHAMEHA SCHOOLS
APPLEGO PARKWAY DR
KUUPAOA ST
OHAKU ST
MAKAENA PL
P.O.
LINO PL
KUPEE PL
LOHA ST
ANUWANU PL
LOHA PL
ALALANI ST
ALIIOLANI ST
EHILANI ST
ELILANI ST
HONOKOLANI ST
KALANI PL
KILANI PL
KALEILANI DR
HUELANI ST
HOOMAILANI ST
ALAAPAPA PL
PULELEHUAKEA ST
KINALANI DR
PUKULANI COUNTRY CLUB
KAMEHAMEHA ELEM. SCH.
LUALANI ST
LIHOKANI ST
HALAULANI ST
HANALANI ST
PUKALANI ST
HAULANI ST
HIOLANI ST
HOKULANI ST
HOLOLANI ST
LAULANI LP
KALALANI CIR
AKALANI LP
PALALANI PL
PALALANI ST
ILILANI PL
LILIUOKALANI ST
OLULANI ST
LOKELANI PL
NALANI ST
KEOLALANI ST
KAULANI DR
KEIKI LANI ST
KAMEALANI PL
ALOHILANI ST
HOLOLANI ST
HUKILANI PL
IWALANI ST
IPOLANI ST
IHOLANI ST
IOLANI ST
PUKALANI PARK
PUKALANI ELEM. SCH.
HIWALANI LP
ALOHI PL
ALEA PL
IKEA PL
ASLOA RD
OLD HALEAKALA HWY
N HIENA PL
S HIENA PL
PAHAA PL
KAAPEHA ST
KAAPEHA PL
KAUNEKE PL
KAHOA RD
MOKU PL
NOHO PL
KIKI PL
PIMAUNA ST
MUNOZ ST
KAMANO RD
KUMANO DR
AHEAHE PL
NANAINA ST
RITTAPAI PL
HAAHEO PL
ULUNUI PL
MOHALA PL
KILAKILA PL
KULU LN
HAAHKA ST
LUPEA PL
KIKO ST
AEWA PL
HEALANI PL
E HIO PL
NANE LN
KII PL
LUHOPULULU WY
HAMAHA PL
MAKALOA ST
LOCATOR MAP
N
AKLES
0
1/2
1/4
377
37
365
F
E
D
C
B
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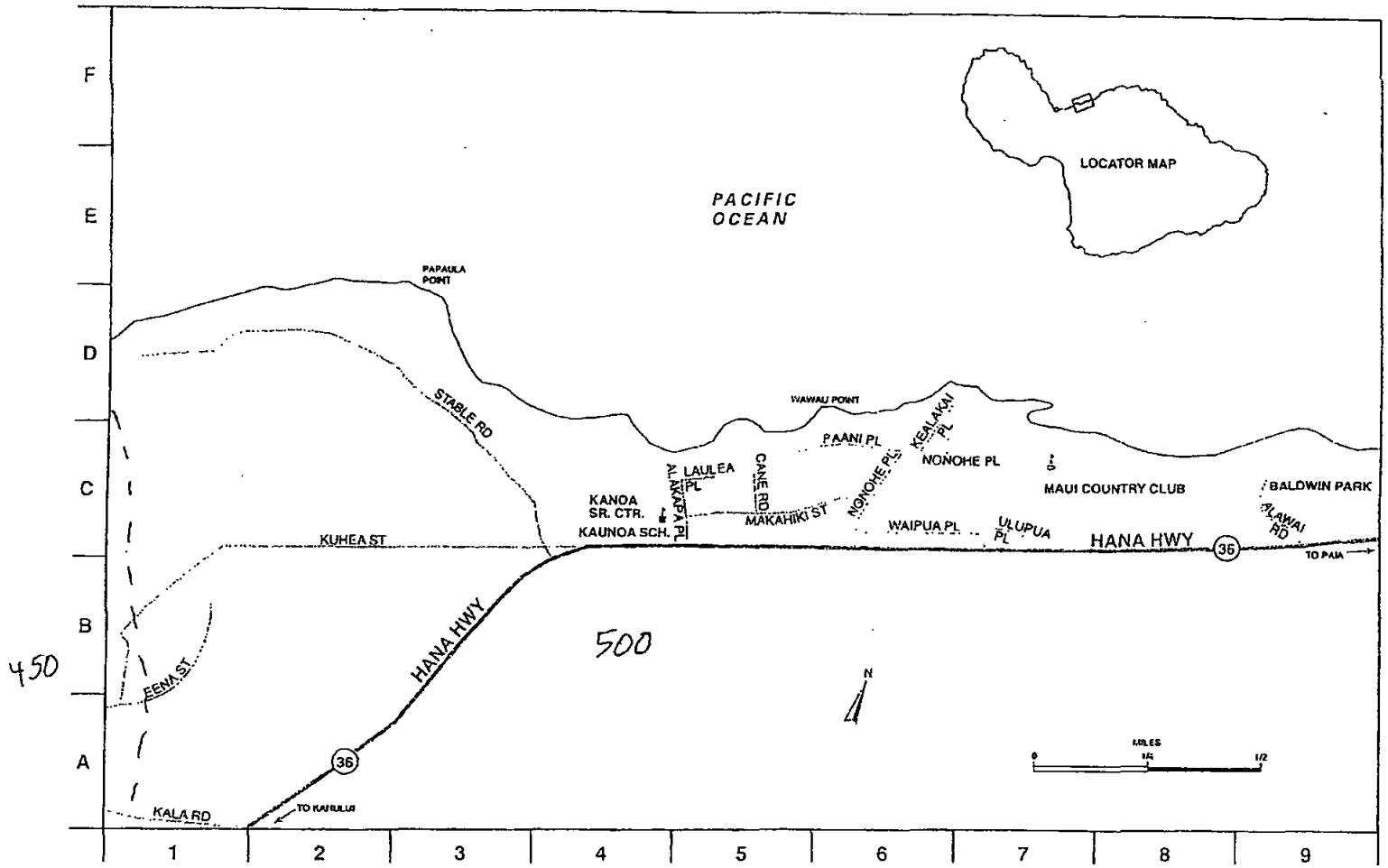
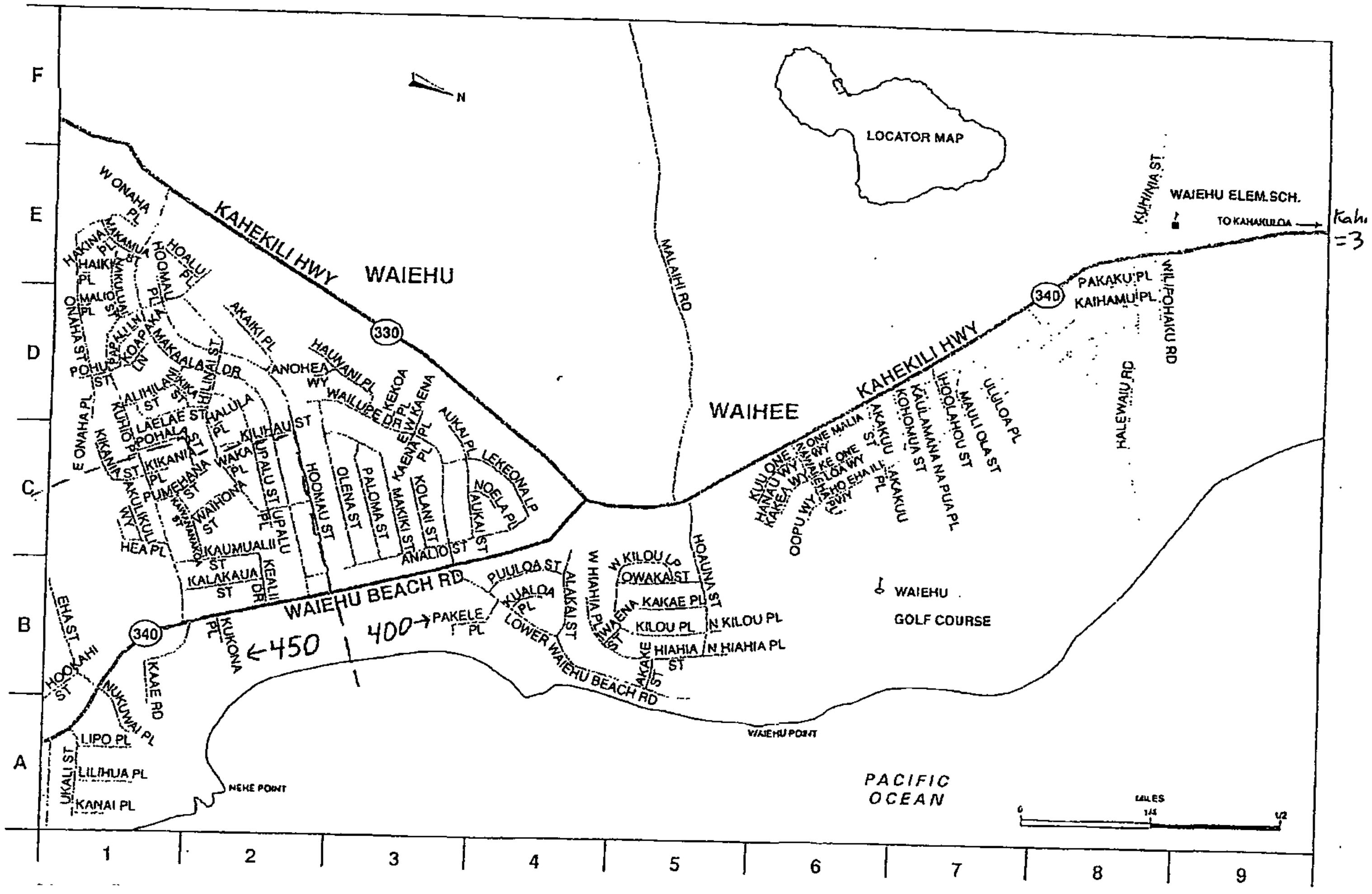


SPRECKELSVILLE


LOCATOR MAP
N
WAIEHU ELEM.SCH.
TO KAHAKULOA →
Kahu
=3
KUHINIA ST
WILIPOHAKU RD
PAKAKU PL
KAIHAMU PL
HALEWAIU RD
340
KAHEKILI HWY
ULULOA PL
MAULI OLA ST
HOOLAHOU ST
KAULAMANA NA PUA PL
KOHOMUA ST
AKAKUU ST
AKAKUU PL
ONE MALIA
KUU ONE
HANAU WY
KAKEA WY
KE ONE
LOA WY
HO EHA ILI
OOPU WY
WAIEHU GOLF COURSE
WAIHEE
MALAIHI RD
HOAUNA ST
W KILOU LP
OWAKA ST
KAKAE PL
KILOU PL
N KILOU PL
HIAHIA ST
N HIAHIA PL
W HIAHIA PL
AKAKE ST
ALAKAI ST
PUULOA ST
KUALOA PL
PAKELE PL
LOWER WAIEHU BEACH RD
WAIEHU POINT
PACIFIC OCEAN
MILES
0
1/4
1/2
WAIEHU
KAHEKILI HWY
330
W ONAHA PL
HOALU PL
HOOMALU PL
AKAIKI PL
HAUWANI PL
ANOHEA WY
WAILUPE DR
KEKOA PL
E W KAENA
KAENA PL
AUKAI PL
LEKEONA LP
NOELA PL
AUKAI ST
ANALIO ST
KOLANI ST
MAKIKI ST
PALOMA ST
OLENA ST
HOOMAU ST
KILIHAU ST
UPALU ST
UPALU PL
KEALII DR
KAUMUALII ST
KALAKAUA ST
WAIHONA ST
WAKA PL
HALULA PL
PUMEHANA ST
KIKANIA PL
KIKANIA ST
AKULIKULI WY
HEA PL
POHALA ST
LAELAE ST
KUHIO PL
ALIHILANI ST
MAKAALA DR
HILINAI ST
KOAPAKA LN
PAPALUU WY
NAKULUAI ST
MALIO PL
HAIKI PL
HAKINA PL
MAKAMUA ST
POHU ST
ONAHA ST
E ONAHA PL
WAIEHU BEACH RD
400→
←450
KUKONA PL
KAAE RD
NUKUWAI PL
HOOKAHI ST
EHA ST
LIPO PL
LILIHUA PL
KANAI PL
UKALI ST
NEHE POINT
A
B
C
D
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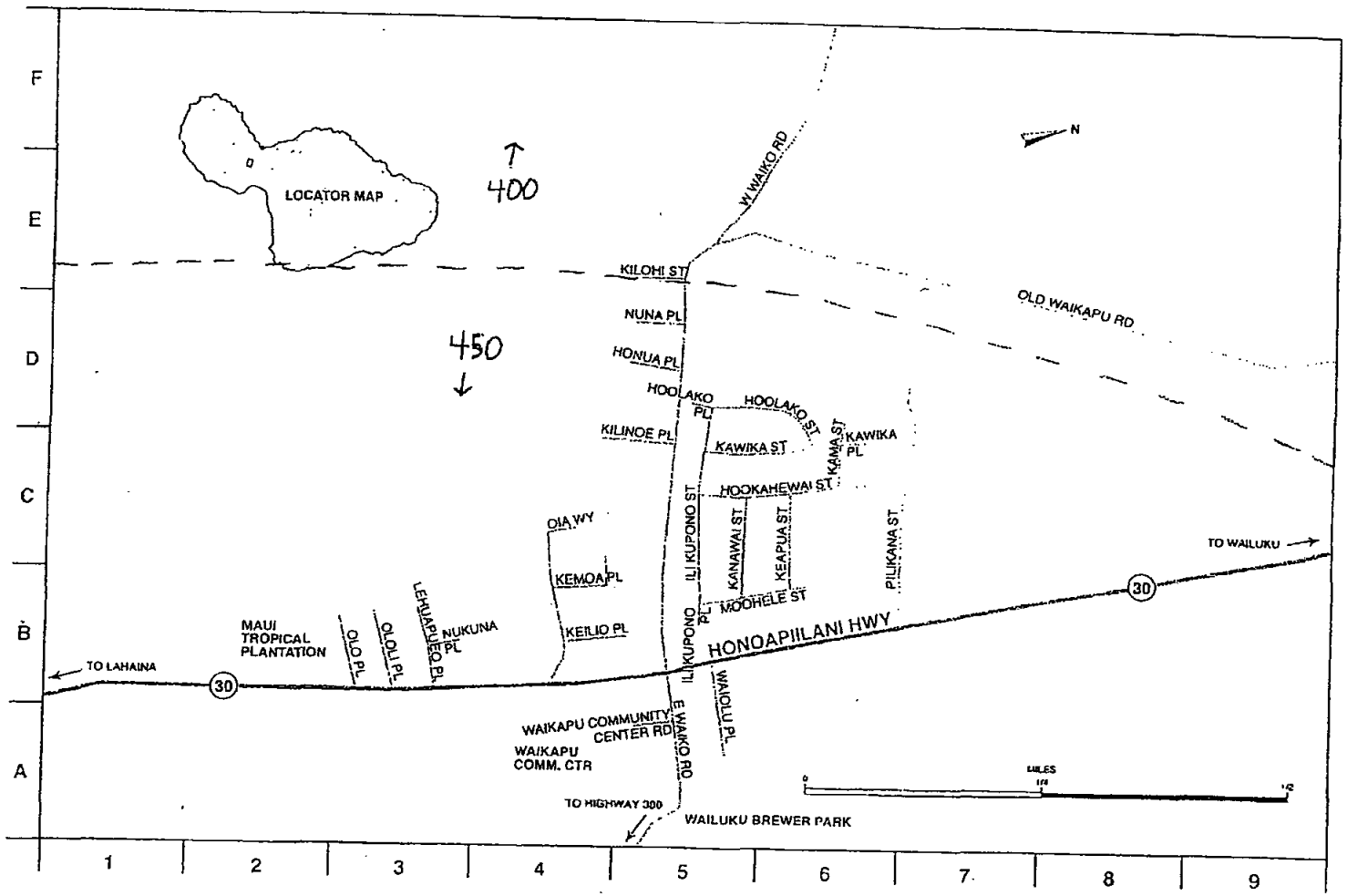
LOCATOR MAP
400
450
N
W WAIKO RD
KILOHI ST
NUNA PL
HONUA PL
HOOLAKO PL
HOOLAKO ST
KILINOE PL
KAWIKA ST
KAWIKA PL
KAMA ST
HOOKAHEWAI ST
OLD WAIKAPU RD
OIA WY
KEMOA PL
KEILIO PL
ILI KUPONO ST
ILI KUPONO PL
KANAWAI ST
KEAPUA ST
MOOHELE ST
PILIKANA ST
TO WAILUKU
30
HONOAPIILANI HWY
MAUI TROPICAL PLANTATION
OLO PL
OLOLI PL
LEHUAPUEO PL
NUKUNA PL
TO LAHAINA
WAIOLU PL
E WAIKO RD
WAIKAPU COMMUNITY CENTER RD
WAIKAPU COMM. CTR
TO HIGHWAY 300
WAILUKU BREWER PARK
MILES
F
E
D
C
B
A
1
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3
4
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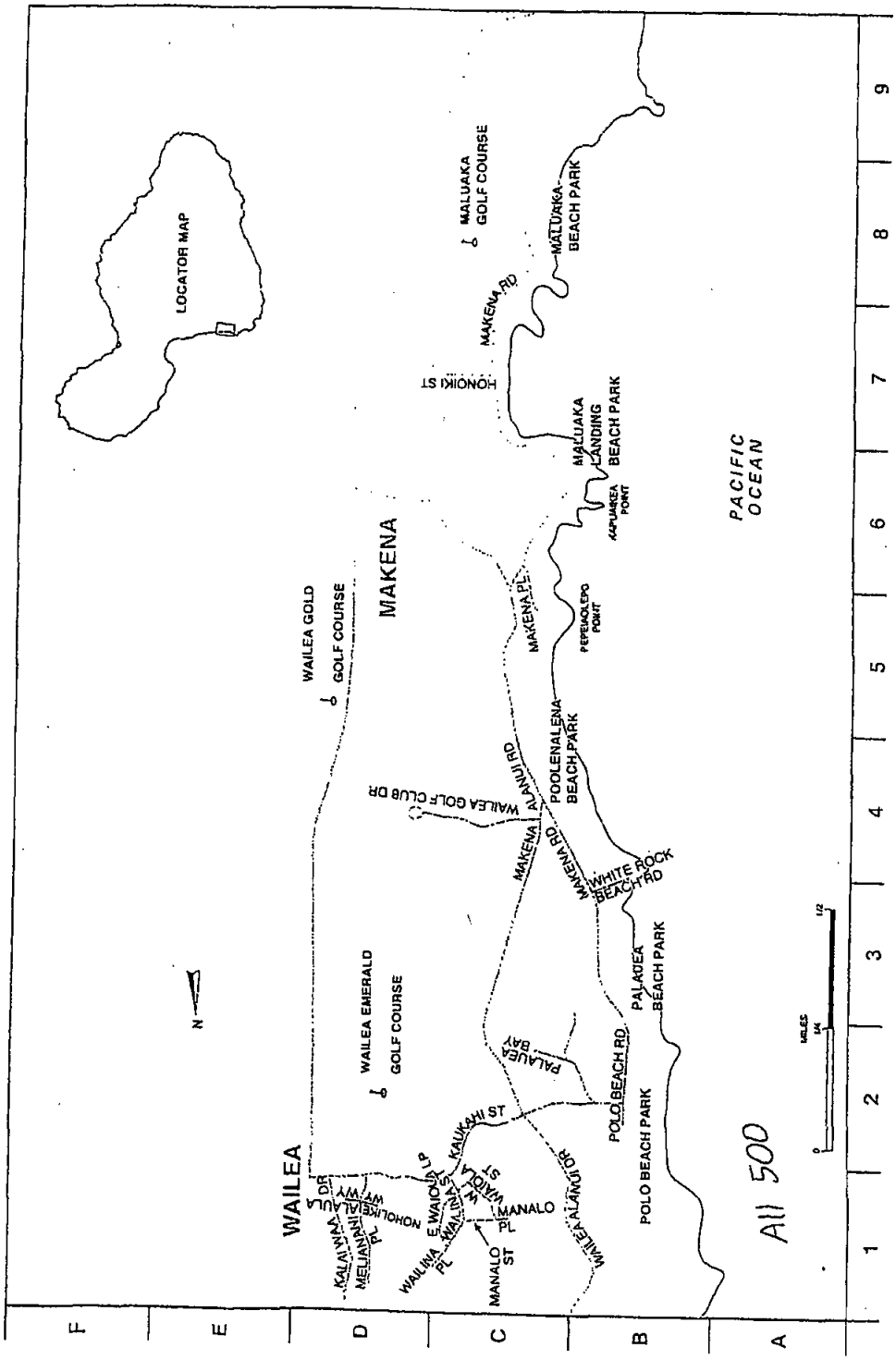
6
7
8
9

WAIKAPU


LOCATOR MAP
MALUAKA GOLF COURSE
MALUAKA-BEACH PARK
MAKENA RD
HONOIKI ST
MALUAKA LANDING BEACH PARK
KAPUAKEA POINT
PACIFIC OCEAN
MAKENA
WAILEA GOLD GOLF COURSE
MAKENA PL
PEPEUKOLEPO POINT
POOLENALENA BEACH PARK
WAILEA GOLF CLUB DR
MAKENA ALANUI RD
MAKENA RD
WHITE ROCK BEACH RD
PALAUEA BEACH PARK
WAILEA EMERALD GOLF COURSE
PALAUEA BAY
POLO BEACH RD
POLO BEACH PARK
KAUKAHI ST
WAILEA
KALAWAI DR
MELIANAHI PL
NOHOLIMEIALAULA WY
WAILINA PL
E WAIOLA ST
WAILINA ST
WAIOLA ST
MANALO PL
MANALO ST
WAILEA ALANUI DR
N
MILES
1/4
1/2
All 500
A
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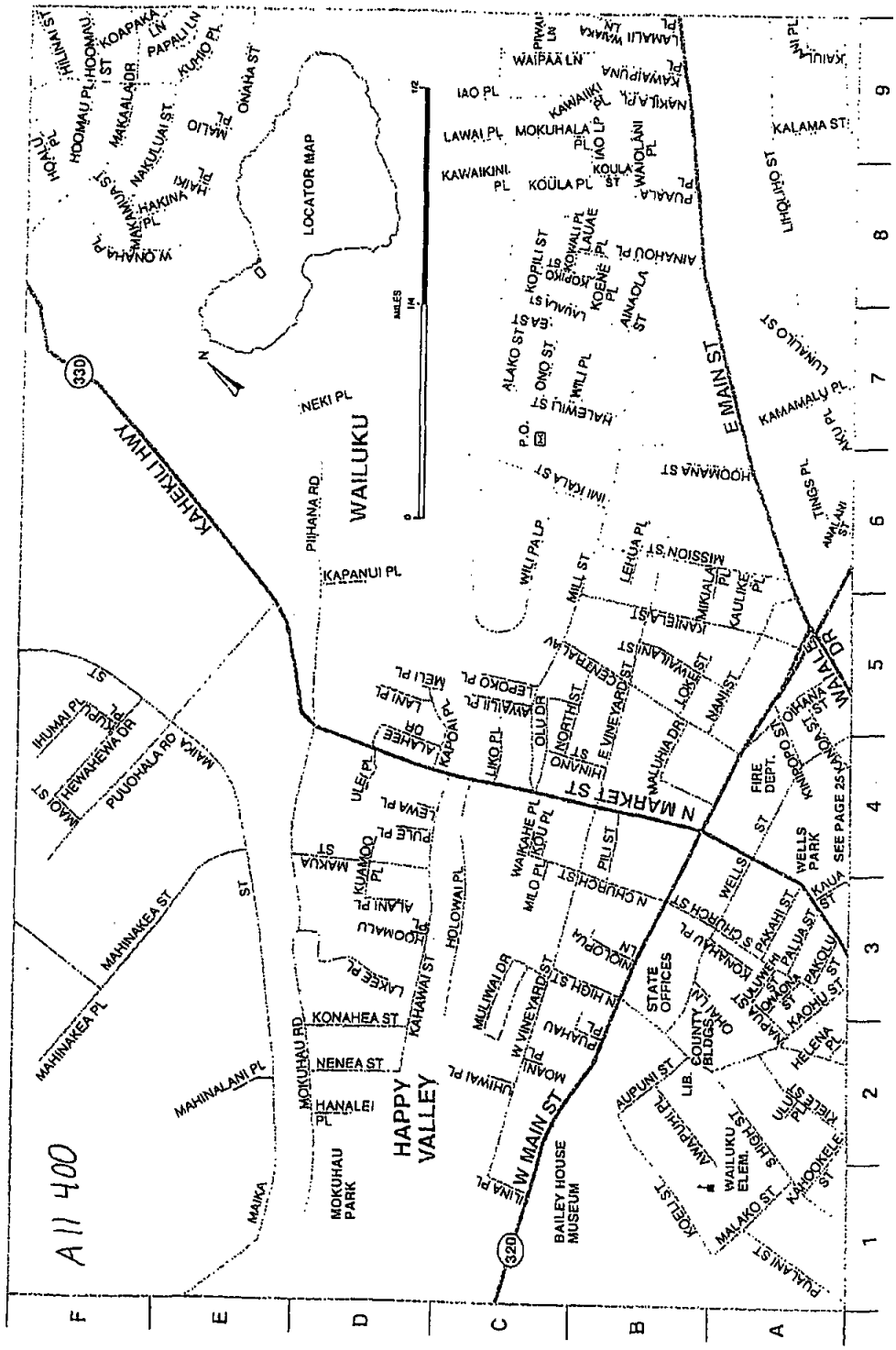
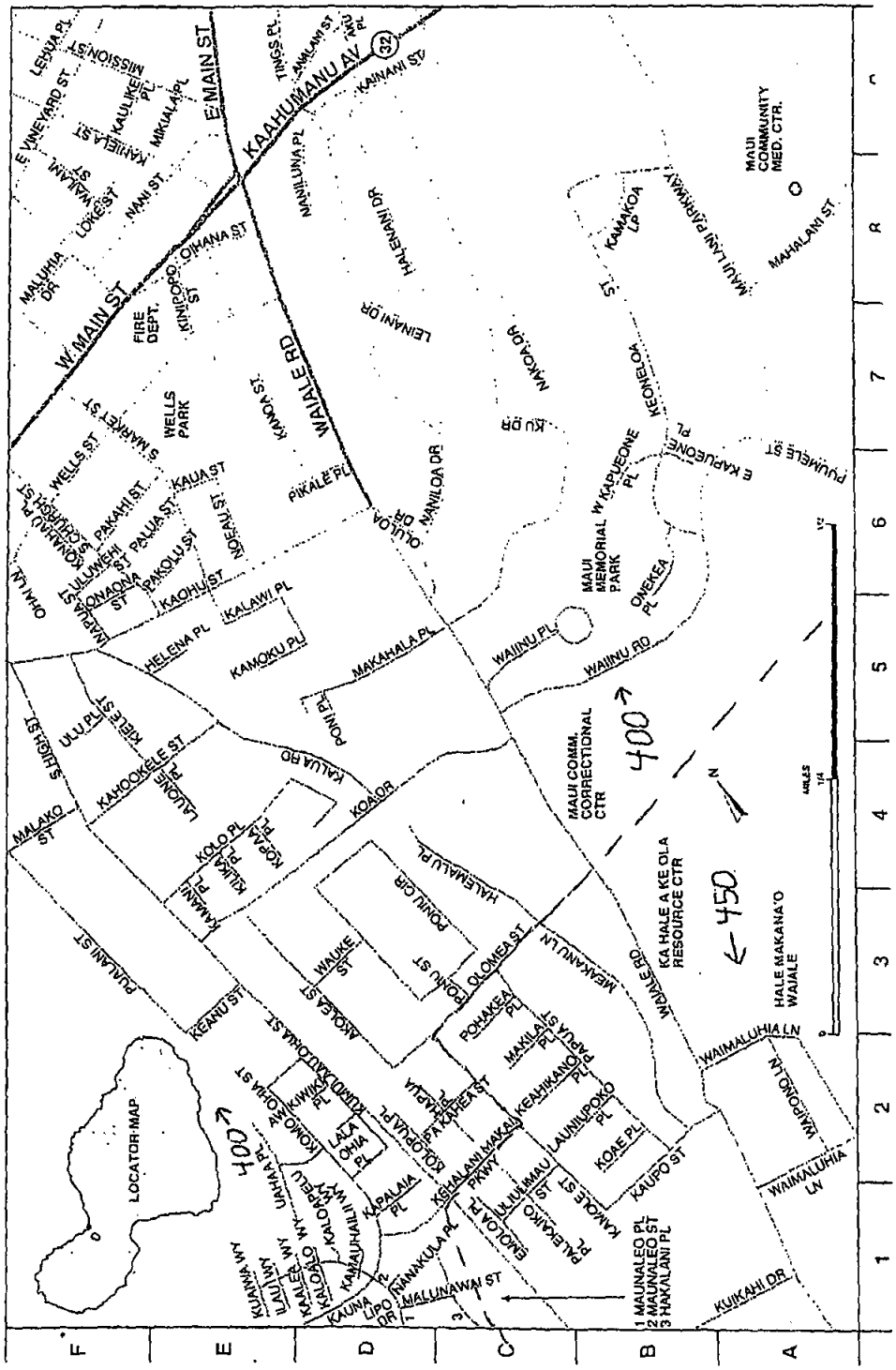
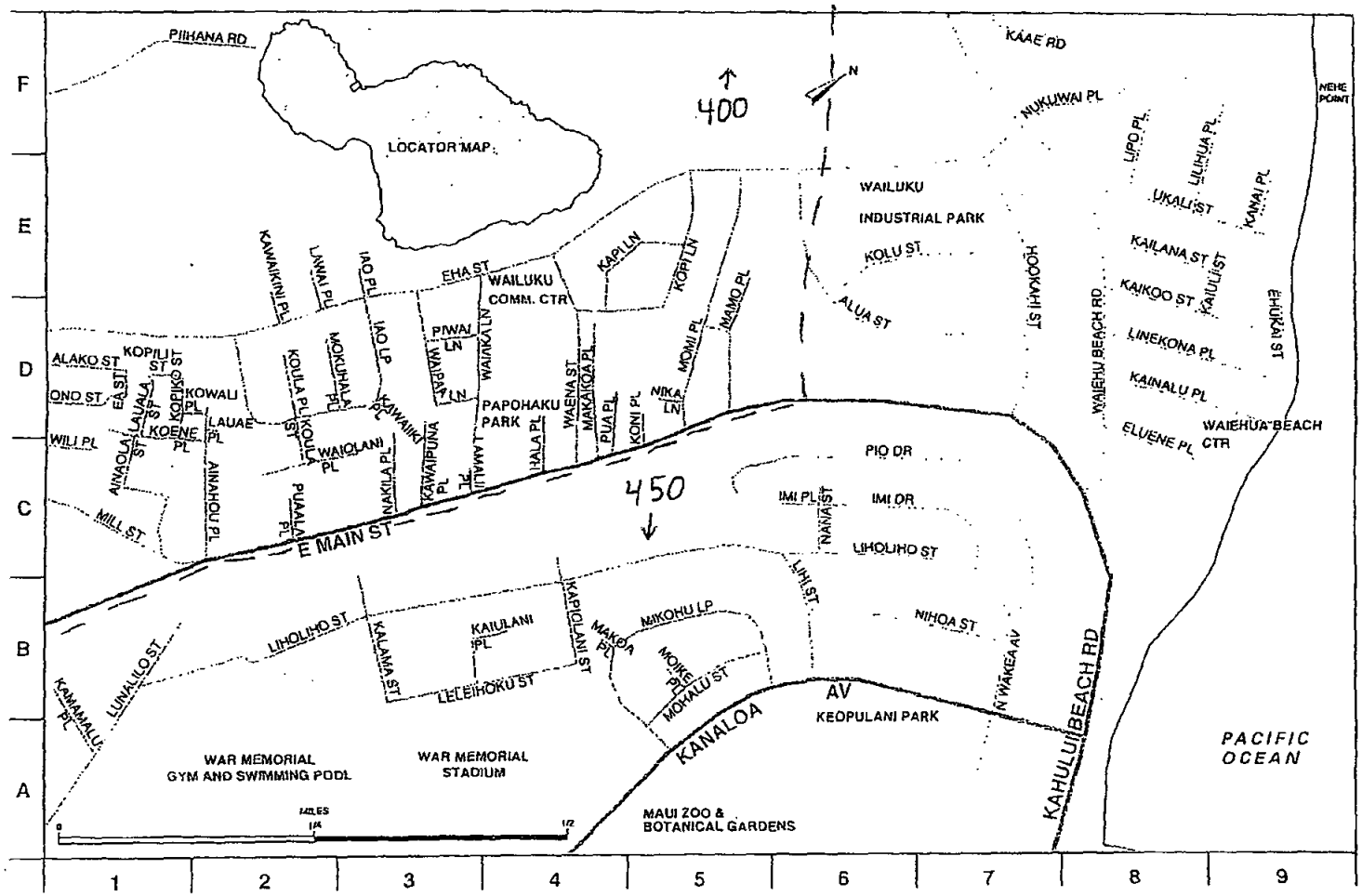

WAILUKU
KAHEKILI HWY
E MAIN ST
N MARKET ST
W MAIN ST
WAILUKU
HAPPY VALLEY
LOCATOR MAP
MOKUHAU PARK
BAILEY HOUSE MUSEUM
STATE OFFICES
COUNTY BLDGS
LIB.
WAILUKU ELEM.
FIRE DEPT.
WELLS PARK
SEE PAGE 25
A11 400


W. MAIN ST
E. MAIN ST
KAAHUMANU AV
WAILE RD
MAUI COMMUNITY MED. CTR.
MAUI MEMORIAL PARK
MAUI COMM. CORRECTIONAL CTR
KA HALE A KE OLA RESOURCE CTR
HALE MAKANA'O WAILE
WELLS PARK
FIRE DEPT.
LOCATOR MAP
400
450


PIIHANA RD
LOCATOR MAP
400
N
KAAE RD
NUKUIWAI PL
NEHE POINT
WAILUKU
INDUSTRIAL PARK
KOLU ST
ALUA ST
HOOKAHI ST
UPO PL
LILIHUA PL
UKALI ST
KANAI PL
KAILANA ST
KAIKOO ST
KAIULI ST
LINEKONA PL
KAINALU PL
ELUENE PL
WAIEHU BEACH RD
EHUKAI ST
WAIEHU BEACH CTR
KAWAIKINI PL
LANAI PL
IAO PL
EHA ST
WAILUKU COMM. CTR
KAPILN
KOPILN
MAMO PL
MOMI PL
NIKA LN
ALAKO ST
KOPILU ST
OND ST
EA ST
LAUALA ST
KOPIKO ST
KOWALI PL
LAUAE PL
KOENE PL
WILI PL
AINAOLA ST
AINAHOU PL
KOULA PL
KOULA ST
MOKUHALA PL
IAO LP
KAWAIKA PL
PIWAI LN
WAIKALN
PAPOHAKU PARK
WAENA ST
MAKAIOA PL
PUA PL
KONI PL
HALA PL
WAIOLANI PL
NAKILA PL
KAWAIPUNA PL
LAWALU PL
PUAALA PL
MILL ST
E MAIN ST
450
PIO DR
IMI PL
IMI DR
NANA ST
LIHOLIHO ST
LIHI ST
NIHOA ST
N WAKEA AV
KAHULUI BEACH RD
PACIFIC OCEAN
LIHOLIHO ST
KALAMA ST
KAIULANI PL
KAPIOLANI ST
MAKOA PL
MIKOHU LP
MOIKI PL
MOHALU ST
LELEIHOKU ST
LUNALILO ST
KAMAALU PL
KANALOA AV
KEOPULANI PARK
WAR MEMORIAL GYM AND SWIMMING POOL
WAR MEMORIAL STADIUM
MAUI ZOO & BOTANICAL GARDENS
MILES
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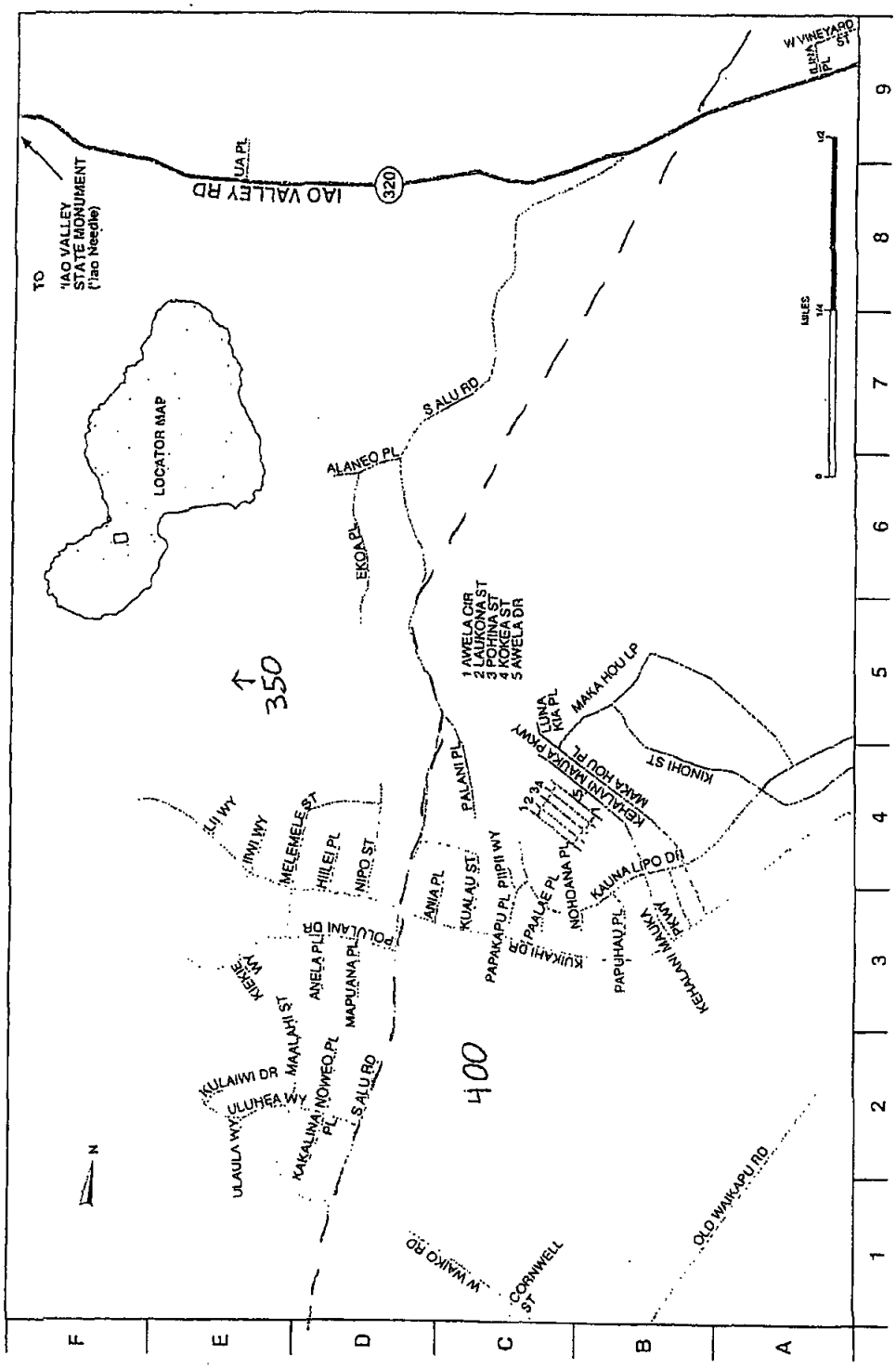
WAILUKU


TO
'IAO VALLEY STATE MONUMENT ('Iao Needle)
IAO VALLEY RD
320
UA PL
LOCATOR MAP
W VINEYARD ST
ALPINA PL
MILES
S ALU RD
ALANEO PL
EKOA PL
1 AWELA CIR
2 LAUKONA ST
3 POHINA ST
4 KOKEA ST
5 AWELA DR
350
MAKA HOU LP
LUNA KIA PL
KINOHI ST
MAKA HOU PL
KEHALANI MAUKA PKWY
PALANI PL
LUI WY
IWI WY
MELEMELE ST
HIILEI PL
NIPO ST
ANIA PL
KUALAU ST
PIIPII WY
NOHOANA PL
KAUNA LIPO DR
POLULANI DR
PAPAKAPU PL
KUIKAHI DR
PAPUHAU PL
KEHALANI MAUKA PKWY
KEKIE WY
ANELA PL
MAPUANA PL
MAALAHI ST
KULAIWI DR
ULUHEA WY
ULAULA WY
KAKALINA NOWEO PL
S ALU RD
400
N
W WAIKO RD
CORNWELL ST
OLD WAIKAPU RD
F
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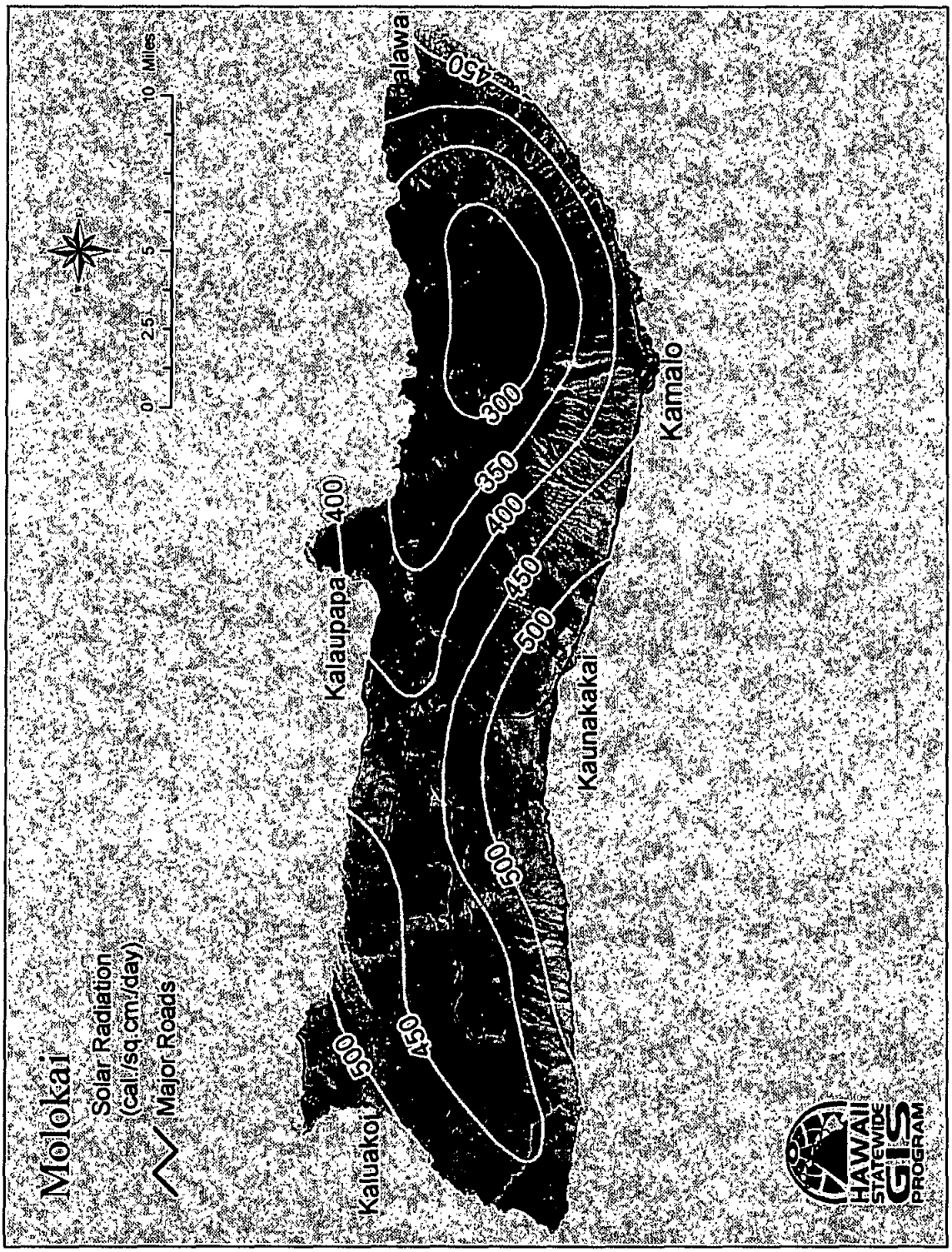
Molokai
Solar Radiation
(cal/sq cm/day)
Major Roads
0 2.5 5 10 Miles
Kalaupapa
Kaunakakai
Kamalo
Kaluakoi
Halawa
300
350
400
450
500
HAWAII
STATEWIDE
GIS
PROGRAM

Explanation of Moloka'i Sunshine Zones

Please note on the island of Moloka'i that the following applies:

1. From Kamalo to Waialua on the east end along the shoreline and makai (ocean side) of the highway is designated as a 450 sunshine zone.

2. Mauka (mountain side) of the highway between Kamalo and Waialua is designated as a 400 sunshine zone.

3. Maunaloa and Mo'olehua will be designated as 450 sunshine zones.

Explanation of Lāna'i Sunshine Zones

The island of Lāna'i shall be deemed a 400 sunshine zone with the exception of Manele. Manele on Lanai shall be considered a 500 sunshine zone.

CERTIFICATE OF SERVICE

The foregoing order was served on the date of filing by mail, postage prepaid, and properly addressed to the following parties:

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KRIS N. NAKAGAWA, ESQ.
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