542
9/15/78

44.518

SAN/1327-5

**TOTAL ENERGY RECOVERY SYSTEM FOR
AGRIBUSINESS: LAKE COUNTY STUDY**

Final Report

**By
Sam F. Fogleman
Leonard A. Fisher
Allan R. Black**

**April 1978
Date Published**

Work Performed Under Contract No. EY-76-C-03-1327

**International Engineering Company, Inc.
San Francisco, California**

MASTER

**U. S. DEPARTMENT OF ENERGY
Geothermal Energy**

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Department of Energy, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

This report has been reproduced directly from the best available copy.

Available from the National Technical Information Service, U. S. Department of Commerce, Springfield, Virginia 22161.

Price: Paper Copy \$6.00
Microfiche \$3.00

**TOTAL ENERGY RECOVERY SYSTEM
FOR AGRIBUSINESS:
LAKE COUNTY STUDY**

FINAL REPORT

**Sam F. Fogleman
Leonard A. Fisher
Allan R. Black**

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Department of Energy, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

**INTERNATIONAL ENGINEERING COMPANY, INC.
220 MONTGOMERY STREET
SAN FRANCISCO, CALIFORNIA 94104**

Date Published -- April 1978

MASTER

**PREPARED FOR THE
DEPARTMENT OF ENERGY
DIVISION OF GEOTHERMAL ENERGY
UNDER CONTRACT EY-76-C-03-1327**

TABLE OF CONTENTS

	<u>PAGE</u>
1. INTRODUCTION	1
1.1 GENERAL	
1.2 BACKGROUND	
1.3 OBJECTIVES	
1.4 ORGANIZATION OF THE REPORT	
2. THE "ORIGINAL" TERSA	3
2.1 INTRODUCTION	
2.2 SYSTEM DESCRIPTION	
2.3 SYSTEM SITE PLAN	
2.4 OPERATION AND MAINTENANCE	
2.5 SYSTEM ECONOMICS	
2.6 ECONOMIC SCENARIOS	
3. LAKE COUNTY, CALIFORNIA	15
3.1 INTRODUCTION	
3.2 ECONOMY AND EMPLOYMENT	
3.3 AGRICULTURE	
3.4 A LIMITED HISTORY OF GEOTHERMAL DEVELOPMENT IN LAKE COUNTY	
3.5 ECONOMIC AND EMPLOYMENT IMPACTS OF GEOTHERMAL DEVELOPMENT	
3.6 MARKETING CONSIDERATIONS	
4. SITE AREAS STUDIED	22
4.1 SELECTION CONSIDERATIONS	
4.2 AREA DELINEATION	
4.3 LAND USE AND CLASSIFICATION MAPS	
4.4 PROSPECTIVE SITE AREA IDENTIFICATION	
4.5 SITE AREA DESCRIPTION SOURCES	
4.6 MT. KONOCTI - THURSTON LAKE	
4.7 COBB MOUNTAIN	
4.8 BORAX LAKE - SULPHUR BANK	
5. SITE IMPLEMENTATION EVALUATION	35
5.1 FACTORS	
5.2 SITE IMPLEMENTATION EVALUATION MATRIX	
5.3 MATRIX EVALUATION	
5.4 MT. KONOCTI-THURSTON LAKE SELECTED SITE	
5.5 COMMENTS ON THE EVALUATION	
6. THE "NEW" TERSA	42
6.1 PHASING	
6.2 HYDROPONIC GREENHOUSING	
6.3 OTHER TERSA SUBSYSTEM CONSIDERATIONS	
6.4 SYSTEM ECONOMICS	

	<u>PAGE</u>
7. CONCLUSIONS AND RECOMMENDATIONS	48
7.1 INTRODUCTION	
7.2 IMPLEMENTATION	
7.3 MODIFICATIONS FOR IMPLEMENTATION	
7.4 CLOSING	
REFERENCES AND APPENDIX	51

1. INTRODUCTION

1.1 GENERAL

International Engineering Company, Inc., (IECO) under contract with the new United States Department of Energy (DOE), formerly the Energy Research and Development Administration (ERDA), has reviewed, modified, adapted, and updated the conceptual design of its earlier report on the Total Energy Recovery System for Agribusiness (TERSA) to be suitable for a specific site or area in Lake County, California.

1.2 BACKGROUND

The objective of the initial study was "to evaluate the costs and viability of combined thermodynamic and biologic cycles in a system known as the Total Energy Recovery System for Agribusiness (TERSA)." This conceptual system involved the combined geothermally assisted activities of greenhouse crop and mushroom growing, fish farming, and biogas generation in an integrated biologic system such that the waste or by-products of each subsystem cycle were recovered to service input needs of companion cycles.

The results of this initial study provide the bases for this report and are an integral part thereof. A minimum of the initial results are repeated here; the TERSA subsystems and the methodology of system integration are explained in the initial report, "Total Energy Recovery System for Agribusiness," by Sam F. Fogleman, Leonard A. Fisher, Allan R. Black, and Dev P. Singh. Copies may be obtained from the National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia 22161. Cost of domestic paper copies is four dollars and fifty cents each.

1.3 OBJECTIVE

The objective of the present report is to present an updated (April 1978) direct use geothermal system based on TERSA that is viable for implementation in Lake County. Particular consideration is given to: location of geothermal resources, availability of land and irrigation quality water, compatibility of the specific direct use geothermal activities with adjacent and local uses, private interest and opposition, and institutional factors as identified.

1.4 ORGANIZATION OF THE REPORT

Following a description of the TERSA system from our prior report, the specific county of study is introduced, factors relevant to local TERSA implementation are discussed, followed by sites consid-

ered, selection criteria, site selection, and the modified system resulting. Particular attention is paid to attempt to make clear the process followed in applying this conceptual design to the specific task of realistic local implementation in hope that others might be able to make use of some of the steps involved. Previous publications on geothermal energy and Lake County are referenced where specific details outside the scope of this study may be found.

2. THE "ORIGINAL" TERSA

2.1 INTRODUCTION

The design of the "original" Total Energy Recovery System for Agribusiness is presented in schematic diagram as finally evolved in Figure 2-1.

2.2 SYSTEM DESCRIPTION

As depicted in Figure 2-1, the hydrothermal fluid passes through the heat exchangers under pressure and is reinjected with most of its original chemical content intact. A pumped hot water heating system of the type commonly utilized in institutional applications is piped to the clean water side of TERSA's heat exchanger loop.

The highest temperature clean water (200°F) is used in the absorption refrigeration system for product storage. High temperature hot water is also used for space heating of the greenhouses, mushroom houses, and the laboratory/office. Following these applications, the water is used for prawn pond heating, followed by biomass digester heating and, finally, the water is recirculated through the heat exchanger.

Figure 2-1 also indicates the flow of biogas and the accompanying production of fertilizer and compost. As can be seen from the TERSA Nutrient Cycle (Figure 2-2), the biomass digestion process is central to nutrient recycling. The process provides fertilizer/compost inputs to all other agribusiness aspects of the Total Energy Recovery System for Agribusiness.

The inputs to the biogas units (as shown in Figure 2-2) are: water hyacinths from the prawn ponds; entrails and other remainders from the prawn and scavenger fish harvesting operations that are not re-used directly as prawn nutrient; organic surplus from the greenhouse and mushroom crops; spent mushroom growing media; and any organic refuse which may occur or be accumulated at the TERSA site.

These inputs are decomposed in the biomass digesters under heat and pressure and the resulting biogas is burned in engine-generator sets to produce electricity for use as required by subsystem components. The organic compost that remains from this processing is utilized as planting mulch and fertilizer for agricultural activities and as a fertilizer to promote best growing conditions for the prawn ponds. It is possible that the portion of the biomass compost that is not recycled may be sold commercially; however, this economic benefit is not included in the TERSA economic analysis.

It should be noted that the waste heat from the biogas powered engine-generator sets may be used for heating the circulating TERSA clean water.

LEGEND

- HEATING WATER SUPPLY
- - - HEATING WATER RETURN
- G- BIOGAS
- III- COMPOST
- O- BIOMASS SLURRY
- M MOTOR

NOT TO SCALE

UNITED STATES ERDA

TERSA SCHEMATIC DIAGRAM

INTERNATIONAL ENGINEERING COMPANY, INC.

DESIGNED <i>IECO</i>	CHECKED <i>ML</i>	APPROVED <i>[Signature]</i>
DRAWN <i>ML</i>	INSPECT <i>[Signature]</i>	RECOMMENDED <i>[Signature]</i>

IECO
220 MONTGOMERY STREET
SAN FRANCISCO CALIFORNIA 94104

DATE MAY 1977
DRAWING NO
Figure 2-1

INTERNATIONAL ENGINEERING COMPANY, INC.			
DESIGNED <u>IECO</u>	CHECKED <u>MS</u>	APPROVED <u>[Signature]</u>	
DRAWN <u>HPL</u>	INSPECT <u>MS</u>	RECOMMENDED <u>[Signature]</u>	
IECO		DATE <u>MAY 1977</u>	
220 MONTGOMERY STREET SAN FRANCISCO CALIFORNIA 94104		DRAWN BY <u>[Signature]</u>	

Figure 2-2

Figure 2-2. TERSA Nutrient Cycle

The uniqueness of the Total Energy Recovery System for Agribusiness lies in its combination of cycles such that they use their waste products and geothermal energy to serve each other's needs. Furthermore, the accelerated growing rates of each cycle would promote accelerated cycling of energy so that all cycles tend toward very intensive production, both per unit area and per energy unit of input, although conservative production and energy requirement figures have been used to reflect minimum expectations.

2.3 SYSTEM SITE PLAN

A TERSA family sized module occupies a little over six acres in the manner shown in Figure 2-3 and as sized for average conditions.

Features are:

- a hydrothermal source providing 500 gpm at 250°F
- three greenhouses of 3000 square feet floor area each
- three mushroom houses, each with 4000 square feet of bed space
- six prawn ponds of one-half acre each
- six biogas units, each of 2500 cubic feet daily biogas production capacity
- two heat exchangers of six million British thermal units per hour (Btuh) capacity each
- two ten horsepower engine-generator sets to be fueled by biogas
- refrigerated storage area capable of holding 1000 pounds of prawns at 40°F, 2500 of tomatoes or cucumbers at 50-55°F, and 3000 pounds of mushrooms at 40°F
- a combination laboratory and office occupying 900 square feet
- circulating pumps and various appurtenant facilities.

Figure 2-3 also shows the major site piping arrangements and indicates pipe sizes and subsystem heat requirements.

2.4 OPERATION AND MAINTENANCE

Subsystem operational requirements are summarized following. More detailed discussion may be found in the initial TERSA report previously referenced.

Tomato crop labor consists of: growth media preparation; planting; stringing; pruning and training; pollination; fertilization and irrigation; pest control; harvesting; packing and storage; and post-harvest plant removal. Labor is conservatively estimated to require 2100 hours for the single annual TERSA tomato crop. (Ref. 74, 77).

LEGEND

— HEATING WATER SUPPLY
 - - - HEATING WATER RETURN
 — CW — COOL IRRIGATION WATER
 — G — BIOGAS

UNITED STATES ERDA

TERSA SITE PLAN

INTERNATIONAL ENGINEERING COMPANY, INC.

DESIGNED: IECO CHECKED: DATE: MAY 1977

DRAWN: IECO SCALE: 1" = 50'

128 MONTGOMERY STREET, SAN FRANCISCO, CALIFORNIA 94104

Fig. 2-3

Cucumber crop labor involves the same activities as for the tomatoes except for pollination and is conservatively estimated to require 1700 hours for the single annual TERSA cucumber crop. (Ref. 73, 77).

Labor for mushroom culture includes: compost preparation; bed filling; casing soil preparation; spawn planting; casing; irrigation; pest control; harvesting; packing and storage; and house cleaning. These activities are conservatively estimated to require 6000 hours for the two and one-half annual crops from this component of the Total Energy Recovery System for Agribusiness. (Ref. 16, 80, 87).

Prawn pond labor requirements are conservatively estimated to be 2500 hours per year for TERSA's three acres of ponds and consist of: pond preparation; introduction of juveniles; feeding; weeding; silt and pest control; harvesting; packing and storage; and postharvest pond treatment. (Ref. 48, 115).

Other required labor includes: hyacinth harvesting; biomass preparation for digestion; distribution of digested biomass; heat exchanger maintenance; material handling equipment maintenance; general office work; and miscellaneous other activities. This labor requirement is estimated to consume 1100 hours per year for biomass handling and 800 hours for other activities.

Table 2-1 summarizes annual labor requirements for TERSA.

TABLE 2-1
ANNUAL TERSA LABOR REQUIREMENTS

<u>Subsystem</u>	<u>Labor Hours</u>
Greenhouse Tomatoes	2,100
Greenhouse Cucumbers	1,700
Mushroom Culture	6,000
Prawn Ponds	2,500
Biomass Handling	1,100
Other Activities	800
Subtotal	14,200
+20% contingency	2,840
TOTAL, say	<u>17,000</u>

Costs for supplies used in the agribusiness subsystems include: growing media; chemicals; plants, spawn, and juvenile prawns; support strings and clips for the greenhouse operations; water, electricity; and packing. Table 2-2 summarizes lumped operation and maintenance costs for TERSA based on published data updated to 1977. (Ref. 16, 73, 74, 77, 80, 87, 115).

TABLE 2-2
ANNUAL TERSA OPERATION AND MAINTENANCE REQUIREMENTS

<u>Subsystem</u>	<u>Cost</u>
Greenhouse Tomatoes	\$ 1,100
Greenhouse Cucumbers	1,300
Mushroom Culture	5,000
Prawn Ponds	11,000
Subtotal	18,400
+20% contingency	3,680
say	\$22,100
Less: replacement value of electricity produced by biogas at \$0.04/kWhr	\$ 5,200
TOTAL	<u>\$16,900</u>

2.5 SYSTEM ECONOMICS

Capital costs for the Total Energy Recovery System for Agribusiness are based on most recent published data updated to 1977 and on 1977 budget quotations from suppliers. Table 2-3 summarizes estimated TERSA installed capital costs and their bases.

TABLE 2-3
TERSA CAPITAL COST SUMMARY

<u>Item</u>	<u>Basis</u>	<u>Total Cost</u>
Greenhouses and Equipment	\$4.80/sq. ft	\$ 43,200
Greenhouse Site Preparation	\$2.00/sq. ft	18,000
Mushroom Houses and Site	\$7.50/sq. ft of floor	30,000
Ponds	\$4,200/acre	12,600
Biogas Units	\$6,400/unit	38,400
Heat Exchangers	\$20,000/unit	40,000
Refrigeration	\$24,000/unit	24,000
Piping	\$92,500 lump sum	92,500
Lab/Office	\$20.00/sq. ft	18,000
Pumps and Motors	\$2,000/unit	4,000
Engine-Generator Sets	\$2,000/unit	4,000
Material Handling Equipment	\$23,500 lump sum	23,500
Miscellaneous Capital Costs	\$10,000 lump sum	10,000
Subtotal		<u>\$358,200</u>
+20% contingency		<u>71,600</u>
TOTAL		<u>\$429,800</u>

The figures in Tables 2-1 through 2-3 and sales figures discussed in the original report provide the bases for summary of system economics for the Total Energy Recovery System for Agribusiness as expressed in Table 2-4 following. TERSA economics based on other yields and pricing are discussed in the next section.

TABLE 2-4
TERSA ECONOMIC SUMMARY

Total Product Gross Sales	\$151,200
Less: Labor at \$3.00/hour	\$ 51,000
Less: Operation and Maintenance Costs	\$ 16,900
	<hr/>
YIELDS: Net Operating Profit	\$ 83,300
Discounted Cash Flow Present Value of \$83,300 Flow Annually for 17 years at 7 percent	\$813,200
Less: Capital Costs	\$429,800
	<hr/>
YIELDS: Capital available for site, well, and return on investment	<u>\$383,400</u>

Due to the generalized nature of this original non-site specific study, it is impractical to reasonably estimate land acquisition and well costs and, consequently, the rate of return on investment is calculated without these costs. Assuming that the yearly net operating profit remains constant as annual cash flow, the rate of return on the non-site capital investment for seventeen years amounts to slightly over eighteen percent. (Ref. 56, 61). This presumed seventeen year useful life for a typical TERSA module is based on average estimates for minimum depreciation periods for pumps, piping systems, engines, and similar equipment as recommended by the American Society of Heating, Refrigerating, and Air Conditioning Engineers. (Ref. 3). It remains for a site specific TERSA design for determination of the expected rate of return for the total investment.

Based on an average TERSA demand of six million Btuh and seventeen year system life, TERSA can afford to pay \$383,400 total or an average of \$0.43 per million Btu for well and land and still break even on capital investment. This energy cost is within a published nonelectric application range (Ref. 64) of \$0.37 to \$5.22 per million Btu, with values around \$1.00 per million Btu being most common. Finally, for purposes of energy comparison, the reader should note that the use of geothermal heat in the Total Energy Recovery System for Agribusiness replaces over 480,000 gallons of oil that would be required for the same amount of heating.

2.6 ECONOMIC SCENARIOS

Table 2-5 summarizes alternative economic scenarios for the Total Energy Recovery System for Agribusiness based on yield and price ranges discussed in the subsystem portions of the original report.

TABLE 2-5
TERSA ECONOMIC SCENARIOS

<u>Activity</u>	<u>High</u>	<u>Yields*</u>	
		<u>Selected</u>	<u>Low</u>
Tomatoes	45,000	40,500	36,000
Cucumbers	40,500	36,000	28,800
Mushrooms	81,000	81,000	81,000
Prawns	24,000	13,500	13,500

<u>Activity</u>	<u>High</u>	<u>Prices**</u>	
		<u>Selected</u>	<u>Low</u>
Tomatoes	\$0.63	\$0.50	\$0.45
Cucumbers	\$0.52	\$0.45	\$0.45
Mushrooms	\$0.85	\$0.75	\$0.75
Prawns	\$4.00	\$4.00	\$3.00

<u>Activity</u>	<u>High</u>	<u>Incomes</u>	
		<u>Selected</u>	<u>Low</u>
Tomatoes	\$ 28,350	\$ 20,250	\$ 16,200
Cucumbers	21,060	16,200	12,960
Mushrooms	68,850	60,750	60,750
Prawns	96,000	54,000	40,500
TOTALS	<u>\$214,260</u>	<u>\$151,200</u>	<u>\$130,410</u>

* In pounds.

** In dollars per pound.

Based on the above incomes and expenses of \$67,900 annually, the rates of return to the nearest percent on the nonsite capital investment for seventeen years for the three cases are: thirty-four percent for the case of high yields and prices; eighteen percent for the case selected for the original report; and thirteen percent for the case of low yields and prices.

These scenarios permit calculation of the amount that can be paid in dollars per million Btu for well and land for TERSA to break even on capital investment. This amount is also a function of the rate of interest used in calculating the discounted cash flow present value of net income and is summarized in Table 2-6 for seventeen years and varying interest rates.

TABLE 2-6
TERSА BREAKEVEN COST OF ENERGY
(Dollars per Million Btu)

<u>Interest Rate</u>	<u>High</u>	<u>Selected</u>	<u>Low</u>
7%	\$1.12	\$0.43	\$0.20
8%	\$1.02	\$0.37	\$0.16
10%	\$0.83	\$0.27	\$0.08
12%	\$0.69	\$0.18	\$0.02

3. LAKE COUNTY, CALIFORNIA

3.1 INTRODUCTION

Lake County, with an estimated population of about 25,000, is located in Northern California, approximately 120 miles north of San Francisco. The county's rural nature is supported by an economy based chiefly upon agriculture, tourism, and retirement living. The reader is referred to the reports by Vollintine, Kunin, and Sathaye (Ref. 184) and Geonomics (Ref. 157) for detailed socioeconomic descriptions of Lake County.

3.2 ECONOMY AND EMPLOYMENT

In recent years retirement and recreational service activities have comprised the major portion of the Lake County economy. Nearly three-quarters of the total county wage earners are employed in retail trade, services, and government. (Ref. 184).

Employment and the economy show seasonal fluctuations. Unemployment typically peaks around the first of a year and "seems to result from two independent sources with similar cyclical effects": both agricultural and recreational activities peak during late summer harvest time. (Ref. 184). Combined with the emigration of summer-only residents, unemployment fluctuates vigorously. Figure 3-1 following depicts variation in employment in Lake County. (Ref. 157, California Employment Development Department.)

3.3 AGRICULTURE

Farming in Lake County has long been an important portion part of its economic and employment picture. Traditionally, Lake County is famous for its Bartlett pear production; in 1976 there were 7,920 acres of bearing pears, most of which were of the Bartlett variety. Next in agricultural importance is the newly introduced varietal grape industry: Lake County Cabernet Sauvignon grapes, the predominant variety, have been awarded outstanding ratings in State competition. As of the last Agricultural Commissioner's Crop Report (Ref. 156), there were 1,715 bearing acres of varietal grapes and many new plantings.

According to this report there were also 9,300 acres of English walnuts, both irrigated and dry farmed. Irrigated pastures accounted for 4,750 acres. Other crops included 229 acres of almonds and 145 acres of prunes.

Figure 3-1. LAKE COUNTY UNEMPLOYMENT

There is much land in the county for expansion of agriculture. Intensifying the present agriculture and clearing suitable brush land for new agricultural activities are both possibilities to accelerate agricultural development in the area. The California Department of Water Resources projects 35,700 irrigated acres in the year 2020 with reasonably priced water. (pers. comm.)*.

3.4 A LIMITED HISTORY OF GEOTHERMAL DEVELOPMENT IN LAKE COUNTY

The bulk of the land classified as a Known Geothermal Resource Area (KGRA) in Lake County is part of the field known as "The Geysers". Other Lake County areas in this classification are Knoxville, Little Horse Mountain, and Witter Springs. (Ref. 165). Figure 3-2 indicates these KGRAs.

The present geothermal activity in Lake County follows long-term development of The Geysers field in adjacent Sonoma County where the Pacific Gas and Electric Company operates the world's largest geothermal power plant complex. Exploratory drilling projects since 1960 have expanded the proven resources area of The Geysers into Lake County, although no power plant in the county has yet become operable.

It should be noted that the bulk of The Geysers KGRA lies in southern Lake County; most of this Lake County area has not yet been explored for steam. Direct applications of geothermal energy in Lake County are presently limited to recreational uses.

3.5 ECONOMIC AND EMPLOYMENT IMPACTS OF GEOTHERMAL DEVELOPMENT

Figures for 1977 (Ref. 184) indicate that geothermal development produced roughly three percent of county tax revenues. Tax revenue from geothermal power generation is relatively small as this industry is effectively a newcomer to this county.

At present the employment impact of geothermal development has been limited to the establishment of residence by some employees of drilling companies and their households.

No figures are available regarding the impact of privately run hot springs in Lake County, although this impact is clearly minimal at this time.

* pers. comm. indicates personal communication (see Appendix).

Figure 3-2

3.6 MARKETING CONSIDERATIONS

Greenhouse Tomatoes and Cucumbers

Marketing of the greenhouse grown tomatoes and cucumbers would normally utilize the services of a produce broker (sales agent). It is anticipated that sales will take place outside Lake County as this area already has an established local supplier.

The produce broker could typically be based in the Los Angeles area. Although the San Francisco/Sacramento/Reno produce market areas are much closer to the Lake County site, Los Angeles was selected for brokering for these reasons: as the second largest produce market in the United States, Los Angeles could more realistically absorb a growing new source of premium hydroponic vegetables - in fact, Los Angeles acts as a clearinghouse for other regional produce markets; the freight differential is mitigated by services offered; brokers in this area are aggressive in seeking new produce sources; and figures from this market area were confirmed by several independent sources. (pers. comm.). For a fixed percentage of the gross sales price of the produce, the broker will: pick up the produce at the site; be responsible for trucking, handling, and refrigeration in transit; sell all produce; bill purchasers; make collections; and remit the proceeds (less fee) to the grower.

The produce would likely be marketed to supermarket chains, hotel and motel chains, caterers, and produce jobbers (for resale in smaller units). Interviews with those knowledgeable in this field (pers. comm.) indicate excellent demand and prices for the premium quality greenhouse products; demand quantity is at present limited only by the available supply.

A private investigation (pers. comm.), Federal-State Market New Service records (a service provided cooperatively by the U.S. Department of Agriculture and the State of California Department of Food and Agriculture), and information from jobbers was utilized in arriving at produce prices. For the purpose of comparative economics, unit prices were reduced to a conservative "freight-on-board" (FOB) grower's price by deducting ten percent for brokerage and boxing supplies (conservative) and an additional three cents per pound for freight to Los Angeles (again conservative). On this basis the grower's FOB price for greenhouse tomatoes will be \$0.50 per pound initially and, for greenhouse European type cucumbers, will be \$0.38 per pound.

Giant Prawns

Prawn marketing considerations have been extended since the initial TERSA report:

- Wholesale prices shell and head on: 16-20 prawns per pound sell for \$4.10 per pound, and under 15 prawns per pound sell for \$4.75 per pound.
- TERSA yields may be reasonably increased to 4,500 pounds/acre/year for established production.
- The goal of Dr. Bill Johnson, Oregon Institute of Technology, Klamath Falls, is to raise 6 to 7 prawns per pound and get two equivalent crops per year. A wholesale price of \$5.00 per pound for these large premium prawns is reasonable.
- The most important thing in marketing of such a fish product is being able to insure a continuing supply of good quality; the best way to lose a market is to run out of fish.
- Competition in prawn marketing will be from Asian and Central American grown products.
- As an indication of sales price per pound and volume of sales, the commercial landings of Macrobrachium in Mexico is shown as Table 3-1 below. It should be noted that the Macrobrachium fishing in Mexico is based on wild stocks only, is seasonal, and consists of four species not including the Macrobrachium rosenbergii proposed in this report. (Ref. 163).

TABLE 3-1
MACROBRACHIUM LANDINGS IN MEXICO

	<u>1970</u>	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>	<u>1975</u>	<u>1976</u>
Total landings in metric tons ^a	200	300	400	700	697	___b	___b
Total value in millions of dollars	1.60	2.88	4.16	7.84	8.36	___b	___b
Market price/Kg ^c in U.S. dollars	8.00	9.60	10.40	11.20	12.00	12.80	14.00
Market price/lb ^c in U.S. dollars	3.64	4.36	4.73	5.09	5.46	5.82	6.36

^aSource: FAO Yearbook of Fishery Statistics, Vol. 38, 1974.

^bData not available.

^cMexico City market price of whole animal, any size.

- Although primarily a big city market item, in Klamath Falls, Oregon, alone, 450 pounds of imported Malaysia-Bangladesh prawns are sold each week for five to six dollars per pound wholesale frozen and seven dollars per pound retail. (Ref. 172).
- A market already exists in Lake County; giant prawns are available in a local restaurant as supplied from Bangladesh.
- Allowance is made for the developing commercial status of this industry in the modification of the TERSA module described following.

Mushrooms

Mushroom production can be integrated functionally with the biological and heat cycles in a full scale TERSA, but is not essential for the initial small scale operation of the TERSA system and, although mushroom culture has compatible external heat requirements for portions of the production process, it is not as heat dependent as are the other biological systems in TERSA. Therefore, it is proposed that in the initial stages of Lake County TERSA implementation it be omitted for simplification of the development process. Space will be reserved, and process heat allowance made, for mushroom houses at the site and when the aquacultural, greenhousing, and biogas generation units are fully operational a decision may be made as to the desirability of including mushroom culture.

Economics remain as discussed in the previous TERSA report.

4. SITE AREAS STUDIED

4.1 SELECTION CONSIDERATIONS

It was contractually arranged that this study would evaluate a maximum of three potential site areas for application of the Total Energy Recovery System for Agribusiness. The major considerations used in the selection of prospective site areas in Lake County were:

- reasonable evidence of the availability of geothermal fluids
- compatibility of land use
- land available for potential expansion of the project
- fresh water supplies
- accessibility
- interest of land owners, geothermal developers, and power companies, among others
- environmental concerns in a very general sense
- governmental agencies concerned
- early commercial implementation possibility.

4.2 AREA DELINEATION

General areas were blocked out chiefly by section line; other major features such as roads, watershed breaks or subdivision boundaries were occasionally used as area demarcations. These areas are generally ones where geothermal leases have nearly full property coverage and where there is current or soon to be initiated drilling activity. Usually there are existing sources of nearly suitable geothermal fluids or wells that could very likely be deepened to obtain the necessary fluid temperature.

As these delineations are not the result of strictly physical features, descriptions of the selected areas may in the future be extended to similar adjacent areas.

4.3 LAND USE AND CLASSIFICATION MAPS

This study has made extensive use of two types of maps prepared by the California Department of Water Resources (DWR): land use and land classification maps. These maps are of the familiar 7-1/2 minute quadrangle size utilized by the United States Geologic Survey (USGS) [1:24,000 scale]. Their primary purpose is to assist in estimating present and future water requirements; they have also been put to several secondary uses here.

Land use maps of Lake County showing the cultural development for 1975 are available and were used for this study. Delineations have been made of industrial, commercial, recreational and residential uses as well as for irrigated and dry farmed crops, such as walnuts, pears, almonds, pasture, alfalfa and vineyards.

Available land classification maps for Lake County were of key importance. These maps are land capability maps and take into consideration all the soils information available at the time this classification was performed in the field in 1961. Basic information provided includes: slope group (0-5% slope, 5-15% slope, 15-30% slope, and those slopes in excess of 30%); rockiness; soil depth; texture; micro-relief; brush and tree cover; as well as marsh and wet meadow areas. An attempt was made to place a holding capacity or density on lands identified as having summer home potential.

These two sets of maps, the land use and the land classification, are valuable tools for identifying both present and potential uses. Land classification is especially helpful in isolating the developable valleys and rolling lands found in Lake County and in identifying those lands too steep for reasonable development (over 30% slope). This characterization of the land allows identification of several intermountain valleys or rolling lands and their extent relative to the existing or expected location of geothermal fluids.

4.4 PROSPECTIVE SITE AREA IDENTIFICATION

The three prospective site areas selected from preliminary investigations were named "Mt. Konocti-Thurston Lake", "Cobb Mountain", and "Borax Lake-Sulphur Bank"; they are shown in Figure 4-1.

Agricultural usage dominates the area identified as Mt. Konocti-Thurston Lake; both irrigated and dry farmed walnuts are found growing, as well as irrigated pasture and an ample supply of rolling brush land of potential agricultural use. Most of this area is leased for geothermal power development.

The Cobb Mountain prospective site area consists, in the overview, of high intermountain valleys adjacent to developed resort areas. It is the area most proximate to the present development of The Geysers and has been the area of most of the geothermal development to date in Lake County. It also is the focal area for the most polarized citizen interest regarding geothermal development (Ref. 183).

Borax Lake-Sulphur Bank really consists of two closely located, but physically very differentiated, areas. The Sulphur Bank portion is a sloping terrace that has been mined for mercury and sulfur; there are large pits, spoil areas and remnants of industrial activity.

Borax Lake, according to experts, is likely to prove to have a water dominated geothermal resource; the area is largely unused, contains gently sloping areas between steep mountains and a lake saturated with borax (once the principal source of supply for U.S. Borax), and is next to Clearlake Park, a retirement and resort area on Clear Lake.

4.5 SITE AREA DESCRIPTION SOURCES

Descriptions following cover existing categorized features. These descriptions are based primarily on site field investigations, topographical, land use and land classification maps, local interviews, and the literature.

Excellent detailed overall descriptions related to these identified areas may be found in the Ecoview portion of the study "Direct Heat Applications of Geothermal Energy in the Geysers/Clear Lake Region" (Ref. 157). Also highly informational were Environmental Impact Reports for electrical power projects at these sites: Borax Lake (for Phillips Petroleum by Ecoview), Francisco (for McCulloch Geothermal Corporation and Geothermal Kinetic Systems by Ecoview), Thurston Lake (for Union Oil Drilling by VTN), Watson (for Magma Energy by Jones and Stokes Associates), and Cobb Valley (for Northern California Power Agency/Resource Funding Limited by Sociotechnical Systems, Inc.). (Ref. 152, 151, 185, 167, 174).

Throughout the course of this study the citizens of Lake County have been most open, helpful, and generous of their time. Some key descriptions used in this report and information relative to site evaluation have been provided by personal communication with those who are most directly aware of local causes and effects - the citizens of Lake County in unofficial and official capacities. Their participation is, to say the least, appreciated.

4.6 MT. KONOCTI-THURSTON LAKE

General

The Mt. Konocti - Thurston Lake prospective area is a more or less rectangular area adjacent to the south end of Clear Lake roughly nine miles from east to west and four miles from south to north. The area touches Clear Lake at Clear Lake's southermost reach. The major subdivided areas of Clear Lake Riviera and the area north of Point Lakeview Road from Clear Lake Riviera to Brown's Landing are excluded. The gross area of this unit is thirty square miles.

The area is composed of many intermountain valleys and rolling lands from 1400 to 2400 feet elevation and generally consists of brush

covered red volcanic soils. There are several large plantings of English Walnuts, most of which are dry farmed.

Land Use

Land use is shown on Figure 4-2. (The Appendix contains a complete list of DWR symbols utilized.) Along State Highway 29 there are extensive plantings of walnuts, most of which are dry farmed (nD13). A few walnut orchards receive supplemental irrigation (iD13) near the Red Hill Road turnoff and east of Round Top Mountain. The young plantings of walnuts (iD13y and nD13y) are now matured and no significant new plantings have been made. There are some improved irrigated pastures at the S-Bar-S Ranch on Highway 29 and along Highway 175.

Adjacent to Clear Lake and the prospective site area, but excluded from it, is the major urbanized area, Clear Lake Riviera. At present in this developing subdivision there are about 300 homes, a restaurant, a fire station, commercial offices, swimming pools and a golf course. The lots are generally sixty feet by one hundred twenty feet and are all sold; at full development there will be several thousand houses and possibly 10,000 people residing in this area. The narrow strip along Lake View Road to Clear Lake itself is a mixture of summer homes, mobile parks, permanent residences and resorts. The predominant land use is native vegetation (NV) in the form of brush, scattered oaks and some pine trees at the highest elevations.

Land Classification

Figure 4-3 depicts the land classification of Mt. Konocti-Thurston Lake as overlaid to indicate TERSA suitability. A legend of the DWR standards for symbols of land classification is presented in the Appendix. The shadings and delineations overlaid for this study reflect the following classification of land within the heavy site area border relative to TERSA implementation:

- usable areas are those of less than fifteen percent slope
- marginal areas exhibit slopes of fifteen to thirty percent
- not usable refers to those areas classified as excluded for agribusiness
- BLM areas are those in which mineral rights are held by the U.S. Bureau of Land Management and recent court interpretation has classified the geothermal resource in certain of these areas as "mineral".

The largest flat area ("V" lands) are around Sugarloaf Mountain (just west of Soda Bay Road). Other V lands (less than five percent slope) are near the headwaters of Thurston Creek, Manning Flat, Shoul Valley, on Highway 175 between Mt. Olive and Glenview, and on the western shore of Thurston Lake. In addition, there are a number of ten to forty acre intermountain valleys of flat land dispersed throughout the area.

UNITED STATES DOE			
TERSA MT. KONOCTI-THURSTON LAKE LAND USE			
INTERNATIONAL ENGINEERING COMPANY, INC.			
DESIGNED BY	CHECKED BY	APPROVED BY	DATE
DATE	DATE	DATE	APRIL 1978
Figure 4-2

About seventy percent of the land is less than thirty percent slope and usable for agriculture or other development.

About twenty percent of the developable land is flat ("V" slopes) and the rest is evenly split between hilly ("H" slopes of five to fifteen percent) and mountainous slopes ("M" slopes of fifteen to thirty percent). Some of these surfaces are less than thirty inches deep and are indicated by a "p" (profile restriction) symbol such as Hp. A rocky soil will have a "r" symbol such as Hpr. Brush covered land will have a "-(L)" symbol such as Hpr-(L). Lands with heavy brush and some trees will be identified with a "-(M)" symbol. A "V-2" symbol means the land is essentially flat, but has micro relief features such as undulations or channeling. A symbol such as "RR2/M" means that the land had a fifteen to thirty percent slope and due to view, present summer homes in area or other attractive features, in the judgment of the field surveyor at the time of the survey it was felt to be better suited to recreational residential (RR) with an overall density of two houses per acre.

Geothermal Activity

Union Oil has recently finished its first deep well at Thurston Lake called "Jorgensen Number One". Initial testing of this well indicated a hot water system with lower temperatures than anticipated and less than commercial flows. Costs of drilling this well exceeded one million dollars. Well fluid temperature and flows and other testing results were held confidential. (Ref. 161, 166).

Union Oil has permits to drill two more exploratory wells in this leasehold. Further evaluation will be made of this well, its logs and earlier reports and data before proceeding with any further drilling.

Republic Geothermal is another active exploration company in this area.

Some short-term geothermal leases are scheduled to begin to expire in 1979. As these lease contracts approach expiration, the development companies will have to decide whether to: expedite exploration (which in many cases automatically extends the contract); to renegotiate the contract with more benefits to the geothermal right holder; or to let the leases expire.

Many of the earlier leases were for under five dollars per acre per year and for ten percent royalty. Present lease contracts are for fifty dollars per acre per year and twelve percent royalty. It is conceivable that a new lease may be one hundred dollars per acre per year, short term (say 5 years), and for a royalty of say, fifteen percent. Of course the location of the land relative to proven wells could make new leases even more favorable to the owner of the geothermal right. (pers. comm.). The land owner may choose a modified lease with specific provisions for direct heat use.

Increased geothermal exploration activity will benefit the direct application user in several ways. If commercial steam or hot water is found, there are several possibilities for direct use: 1) interim development from bleed lines from drilled wells prior to power plant construction with possible later adaption to excess heat from the power plant; 2) possible use of abandoned power wells. The primary objective of the development companies is to sell geothermal fluids to utility companies. Any activity that accelerates the power development will benefit secondary uses of the heat.

4.7 COBB MOUNTAIN

General

The Cobb Mountain prospective site area is an "L" shaped area of about eighteen square miles. This area includes Boggs Lake, Glenbrook, Seigler Mountain and Mt. Hannah.

This Cobb Mountain area includes several intermountain valleys of about 2400 to 2700 feet elevation. This area is just south of and adjacent to the Mt. Konocti-Thurston Lake Area; it is of somewhat higher elevation with the areas between valleys more rugged in comparison. This area is northwest of the Clear Lake resort areas of Loch Lomond, Hobergs, Pine Grove, Forest Lake and Wispering Pines.

Land Use

There is very little development in the Cobb Mountain prospective site area (Figure 4-4a): the major cultural feature identified in this area is "RR" or recreational residences near Mt. Hannah Lodge, Salminas Resort, north of the Harrington Flat landing strip and south of Glenbrook. There are a few dry farmed walnuts on Bottle Rock Road and at Sunrise Vista. There is also some recreational commercial use at Sunrise Vista and some irrigated pasture in the north portion of Cobb Valley.

Land Classification

Figure 4-5a shows the California Department of Water Resources 1961 Land Classification Survey for the Cobb Mountain prospective site area. Over sixty percent of the area is composed of rough land with complex slopes over thirty percent. The valley lands are found near High Valley Creek (next to McCulloch's Francisco One and Two steam wells), in the North Cobb Valley area, Salminas Valley, and in and around Glenbrook.

The hilly land is found from the Boggs Lake area to the Harrington Flat landing strip, as well as north of Salminas Valley. These hilly slopes are usually adjacent to steeper or mountainous slopes of fifteen to thirty percent. There are also "H" lands adjacent to the valley lands along High Valley Creek, Glenbrook and Cobb Valley.

Some wet meadow lands (Vw) are found on Kelsey Creek in the North Cobb Valley area, as well as in the lowest part of Salminas Valley.

Geothermal Activity

There are many electricity oriented wells in this area. (Ref. 157). The most promising site in this area for nonelectric development is proximate to McCulloch Geothermal Corporation wells known as Francisco One and Two. Plans have been announced for DWR to construct a power plant utilizing this resource (Ref. 150); both of these organizations have indicated receptivity toward nonelectric utilization of a portion of power plant heat. McCulloch has also indicated the possibility of interim well usage prior to power plant completion. (pers. comm.).

4.8 BORAX LAKE - SULPHUR BANK

General

The Borax Lake-Sulphur Bank prospective site area consists of two adjacent areas, one a valley of gentle to moderate slopes containing a shallow lake saturated with boron and the other, to the north, a terrace sloping from steep mountainous watershed to the shore of Clear Lake. The two subareas together consist of about four square miles and are situated between the lake fronting resort areas of Clearlake Park and Clearlake Oaks.

Land Use

The land use in 1975 for the Borax Lake-Sulphur Bank prospective site area is shown on Figure 4-4b. There are a few acres of dry farmed walnuts near the southeast end of Borax Lake. Sulphur Bank mine (U12) is over one hundred acres in extent and consists of spoil areas and pits from earlier sulfur and cinnibar (mercury) mining. An Indian settlement, Sulphur Bank Rancheria, is between Sulphur Bank Mine and Clear Lake. There is a planting of almonds (nD12) just north of the mine area at the boundary of the prospective site. Outside, but adjacent to the prospective site area to the south, is Clearlake Park (U), urbanized but not as yet built upon land (UV1), and urban residential (UR). Along the shore of Clear Lake there are recreational residential (RR) areas along with commercial recreational areas (designated as RC). Most of the site is designated as NV for native vegetation.

Land Classification

As shown in Figure 4.5b, this prospective site area is generally "H" lands or lands of five to fifteen percent slope with the lands adjacent being very abrupt and steep (NT). Borax Lake is a closed

basin type lake with a fluctuating water level. A wet meadow-like area (VW) is at the southwest edge of the lake due to poor drainage. The Sulphur Bank area is designated as NT due to the cut up nature of the terrain: pits and piles of spoil from former mining activities. There is a marsh (VM) at the northwestern edge of the prospective site.

As mentioned in the land classification description of the Mt. Konocti-Thurston Lake Area, the California Department of Water Resources in 1961 evaluated the potential for summer homes or recreational residential development for the purpose of forecasting water requirements. Therefore, such symbols as RR-1/H appear in the area which mean the land is from five to fifteen percent slope and an overall recreational residential density of one house per acre was estimated for the area.

Geothermal Activity

Phillips Oil Company has the geothermal leases around Borax Lake and has set up a pad to drill for geothermal fluids. While other wells have been drilled in the past, there is no other geothermal activity in this area at this time.

5. SITE IMPLEMENTATION EVALUATION

5.1 FACTORS

The close geographic proximity of the three site areas was such that marketing factors (excluding access) could be considered effectively equal for all. Those factors contributing to evaluation of potential sites for implementation were classified as follows:

- hot water resource: temperature, flow rate, quality, well requirements, pumping requirements (depth and distance), and cost of supply and effluent systems
- irrigation water resource: availability, flow rate, quality, well requirements, pumping requirements (depth and distance), and cost of supply and effluent systems
- land: availability, slope, climate, soil, development status, use compatibility, location for demonstration, area for expansion, and cost
- access: adjacent road type, distance to major road, distance to highway, access improvements required, and distance cost differential
- environmental: aesthetic, air and water pollution, endangered species, archaeology, landslides, flooding, unique features, recreational impact, fire hazard, vistas/views, noise, and health/safety
- institutional: ownership, political, social, and legal/governmental. These institutional factors are further described following.

Ownership

The lands in the prospective sites are generally in private ownership. Parcel sizes range from a few acres to over one thousand acres with the average holding being about one hundred acres. Many of the land holdings are owned by people living outside of Lake County.

Most of the lands are under lease for geothermal exploration and, for all but a few parcels, the mineral rights belong to the surface owners; exceptions are those lands acquired originally through the Federal 1916 Stockraising Homestead Act and those lands originally designed for State School Development (usually the sixteenth and thirty-second Sections). A recent decision by the Ninth Circuit Court of Appeals stated that ownership of the geothermal rights where the Federal Government retains a mineral reservation is said

to be with the Federal Government. These mineral reservations are being administered by the Federal Bureau of Land Management and are indicated on Figures 4-3 and 4-5.

Political

The local political forces involved in geothermal development in Lake County are largely centered in two groups: the Geothermal Association for Lake County and the Lake County Energy Council. (Ref. 157, pers. comm.).

Social

In that Lake County is traditionally a farming and fishing area, the people identify with these activities. The response from people interviewed in the county was very encouraging toward geothermally assisted agricultural development. The intensifying and coupling of these traditional activities with the newly discovered geothermal fluids could be very well received. Those geothermal activities which will receive the support of the people in Lake County are those which produce physically perceived benefits.

Legal/Governmental

Governmental impacts, in particular, stand out. "No less than 16 state agencies, 9 federal agencies, and at least three local agencies (in each county) have an interest or role in the administrative process associated with the total geothermal resource development." (Ref. 165).

In the permitting process for a geothermal project such as the proposed Total Energy Recovery System for Agribusiness, possible involvement of governmental agencies is indicated in Table 5-1 following.

In addition to the indicated local agencies, Lake County is part of a four county agency called GRIPS (Geothermal Resources Impact Projection Study), intended to provide tools for interim and long range planning and management of geothermal development. GRIPS has very recently (February 1978) become a joint power commission with legal and political status. (pers. comm.).

5.2 SITE IMPLEMENTATION EVALUATION MATRIX

The factors listed and described previously were arranged as rows in a matrix format with the three prospective site areas arranged as columns. The resulting site implementation evaluation matrix was utilized by classifying each intersection of evaluation factor and site on a relative basis as one of: "advantageous for TERSA implementation," "neutral for TERSA implementation," "disadvantageous

TABLE 5-1
PUBLIC AGENCIES INVOLVED IN THE GEOTHERMAL RESOURCE DEVELOPMENT PROCESS

Primary Area of Agency Interest	California	Federal	Regional or Local
Land use	State Land Commission	Department of the Interior/ Bureau of Land Management	County Planning Department
Operations requirements; enforcement	Division of Oil and Gas	Department of the Interior/ U.S. Geological Survey	
Air quality standards; enforcement	Air Resources Board		Local Air Pollution Control District
Water protection; discharge requirements	State Water Resources Control Board		Regional Water Quality Control Board
Fish and wildlife protection	Department of Fish and Game	Department of the Interior/ U.S. Fish and Wildlife Service	
Solid waste disposal	Solid Waste Management Board		
Water resources development	Department of Water Resources		
Forest watershed protection	Division of Forestry	Department of Agriculture/ Forest Service	
Intra-governmental coordina- tion	Geothermal Resources Board	Geothermal Environmental Advisory Panel	
Pollution control		Environmental Protection Agency	Local Air Pollution Control District
Energy research and devel- opment; conservation of resources	State Energy Resources Conservation and Development Commission	Department of Energy	
Siting approval of power plants; rate regulating	California Public Utilities Commission, CERCDC	Federal Power Commission	
Clearinghouse for environ- mental impact reports	Governor's Office of Planning and Research		
Occupational health and safety standards; enforcement	Department of Industrial Relations	Occupational Safety and Health Administration	
Radioactive waste disposal control	Department of Health		
Public securities - issuance and trading regulation	Corporations Commission	Securities and Exchange Commission	
Property tax assessment (Based on Ref. 165)	State Board of Equalization		Local Assessor

for TERSA implementation," or "unknown impact on implementation." Evaluations were based on: field and literature investigations; interviews with locally knowledgeable individuals; discussions with local, state, and federal government agencies which would be involved in implementation; and engineering/economic tradeoffs. Any such evaluation contains subjective as well as objective considerations. Where such considerations require verbal ramification, the attempt is made to describe the basis of the decision making process.

5.3 MATRIX EVALUATION

The matrix evaluation, shown as Figure 5-1 following, clearly indicated that the Mt. Konocti-Thurston Lake prospective site area was the most advantageous location for first implementation of the Total Energy Recovery System for Agribusiness.

5.4 MT. KONOCTI-THURSTON LAKE SELECTED SITE

Hot Water Resource

Within the Mt. Konocti-Thurston Lake site area, a number of 250-foot wells were drilled by geothermal development companies. Temperature measurements were made in the wells at that depth as an aid in evaluating the potential geothermal resource by computing temperature differential per unit depth. A limited amount of this information was obtained from the surface owners as the heat test results are mostly held to be confidential. At one location in the middle of the site area there was a pumped flow of 3000 gpm from four uncased temperature probe wells with temperatures of about 130°F at 200 feet. It was felt that comingling of geothermally heated waters with surface water due to the uncased nature of the well was responsible for lowering measured temperatures.

The Total Energy Recovery System for agribusiness requires temperatures of 200°-250°F as conceptually designed; well cost estimates presented later have been made utilizing published information on thermal gradients in the area and drilling and casing charges for the projected depth required.

Irrigation Water Resource

The Mt. Konocti-Thurston Lake prospective site area has several irrigation water possibilities depending upon the specific location within it. Water could be lifted from Thurston Lake or Clear Lake, could be pumped from the alluvium laid down by Thurston Creek, or winter runoff could be captured with a small holding dam.

SITE IMPLEMENTATION FACTORS		SITE 023
HOT WATER RESOURCE:		
TEMPERATURE		
FLOW RATE		?
QUALITY		?
WELL REQUIREMENTS		
PUMPING REQUIREMENTS - DEPTH		
- DISTANCE		?
SYSTEM COST		?
IRRIGATION WATER RESOURCE:		
AVAILABILITY		
FLOW RATE		
QUALITY		
WELL REQUIREMENTS		
PUMPING REQUIREMENTS - DEPTH		
- DISTANCE		
SYSTEM COST		
LAND:		
AVAILABILITY		
SLOPE		
CLIMATE		
SOIL		
DEVELOPMENT STATUS		
USE COMPATIBILITY		
LOCATION FOR DEMONSTRATION		
EXPANSION AREA		
COST		
ACCESS:		
ADJACENT ROAD TYPE		
DISTANCE TO MAJOR ROAD		
DISTANCE TO HIGHWAY		
IMPROVEMENTS REQUIRED		
COST DIFFERENTIAL		
ENVIRONMENTAL:		
AESTHETIC		
AIR POLLUTION		
WATER POLLUTION		
ENDANGERED SPECIES		
ARCHAEOLOGY		
LANDSLIDES		
FLOODING		
UNIQUE FEATURES		
RECREATION		
FIRE HAZARD		
VISTAS/VIEWS		
NOISE		
HEALTH/SAFETY		
INSTITUTIONAL:		
OWNERSHIP		
POLITICAL		
SOCIAL		
LEGAL/GOVERNMENTAL - USA		?
- CALIFORNIA		?
- LAKE COUNTY		?

SYMBOLS :

- ☒ ADVANTAGEOUS
- ☒ NEUTRAL
- ☐ DISADVANTAGEOUS
- ☐ UNKNOWN

SITES :

- ① MT. KONQCTI-THURSTON LAKE
- ② COBB MOUNTAIN
- ③ BORAX LAKE - SULPHUR BANK

UNITED STATES DOE		
TERSA		
SITE IMPLEMENTATION MATRIX EVALUATION		
INTERNATIONAL ENGINEERING COMPANY, INC.		
DESIGNED DRAWN <i>AKS</i>	CHECKED INSPECT <i>AKS</i>	APPROVED RECOMMENDED
IECO 220 MONTGOMERY STREET SAN FRANCISCO CALIFORNIA 94104		DATE APRIL 1978 DRAWING NO.

Figure 5-1

Land and Access

The Mt. Konocti-Thurston Lake prospective site area has several thousand acres suitable for agribusiness development as far as availability, suitable slopes, climate, soil and compatibility of use. This area would not displace intensive farming. Areas near Highway 29, Soda Bay Road, Point Lakeview Road, or Red Hill Road would be especially good to demonstrate direct geothermal uses as they are in view of the general public, farmers who might want to take up geothermal agribusiness, and potential investors from the San Francisco Bay area and elsewhere. Good all weather roads to truck out the produce as mentioned above are available. A truck stop is presently being proposed at the intersection of Soda Bay Road and Highway 29.

Environmental

The Environmental Impact Statements for the various sites very adequately cover the sensitiveness of the environment to power production. The direct uses can be looked upon, for the most part, as having a beneficial impact on the area. Fish farming, as licensed by the California Department of Fish and Game, and greenhousing are certainly compatible uses of the land and, in many cases, could be looked at as a beneficial trade off for power development and as a buffer zone between power and existing agriculture, urban developments or recreational developments.

Institutional

Institutional factors are similar in all three prospective site areas. Land ownership is mainly private and in medium size blocks. As yet there is no geothermal zoning and most geothermal leases are unclear regarding the permitted use of geothermal fluids for non-electric uses. Mineral right reservations have been previously discussed.

Political, social, and legal issues are not particularly site specific at this time, but may become so as particular projects and sites are proposed and required permits are requested.

5.5 COMMENTS ON THE EVALUATION

Some additional considerations on the tradeoffs between sites are as follows:

Mt. Konocti - Thurston Lake Area

This area has extensive agricultural land available for agribusiness expansion, excellent access and visibility for a demonstration, better growing season conditions than the higher mountain valleys

of the Cobb Mountain area, better fresh water availability, shallow hot water wells indicate deeper drilling would probably yield waters suitable to run TERSA, interest of several property owners to develop direct geothermal applications.

Cobb Mountain Area

This area has the advantage of existing deep steam wells (Francisco site). The California Department of Water Resources is likely to be a good potential cooperator, as is McCulloch Geothermal. Early implementation may be possible here, but the disadvantages of complexity of combined electric and nonelectric projects should be considered. Surface waters have high boron content, expansion area is limited, visibility is limited, access is not as good as other areas, and the growing season is more limited and the climate more harsh due to comparatively higher elevation.

Borax Lake - Sulphur Bank Area

This area has several advantages and disadvantages. The Sulphur Bank Mine area has mining spoil and pits that are very acid in nature due to the oxidized sulfur, and due to cinnibar mining, there may be mercury in the sediments and mixed in with the surface soils; these conditions would be prohibitive for earthen fish ponds. The Borax Lake area is limited in expansion area, especially if the high water mark of this closed basin lake is considered. The lake is extremely high in boron which is very toxic to both fish and plant growth; contamination from the lake to the biological systems is a major potential problem. On the positive side there is treated fresh water piped to the boundary of County Club Road and possibly available to this site. One organized group of people owns most of the land around Borax Lake and appears interested in the possibility of TERSA application in their area.

6. THE "NEW" TERSA

6.1 PHASING

Those subsystems of the Total Energy Recovery System for Agribusiness yielding the highest reliable return on investment are those most likely to appeal to commercial interests. It will be seen that the Lake County implementation of TERSA is recommended in a phased manner so as to promote a balance of financial return and demonstration value.

The Lake County TERSA site would begin with proven geothermal technology: greenhouses, heat source, and utilization system. More complex elements of the system such as polyculture fish farming, biogas digesters, producing the prawn larvae onsite, process heat application trials, adding mushroom block housing, and expansion of the operation would occur in phased stages. Process heat applications which might reasonably be tried in Lake County include: crop drying, particularly of pears; frost control for grapes; livestock husbandry; a small canning operation; sewage sludge digestion; and open field growing experiments.

The following simplified yearly phased five-year program is proposed as depicted in Figure 6-1.

- Year One: wells and supply system for the first three years (hot and irrigation water); trailer office; first block of ten greenhouses; appropriate site improvements.
- Year Two: second block of ten greenhouses; first group of two ponds - one for experimentation, one for standby; appropriate site improvements.
- Year Three: third block of ten greenhouses; supply system extensions; packing/refrigeration facilities; second group of two ponds - two in production; biogas experimental unit; consideration of process heat applications; relevant site improvements.
- Year Four: new supply wells and system expansion through the fifth year; fourth block of ten greenhouses; third group of two ponds, four in production; biogas units operational and recycling analysis initiated; process heat application trials begun; remainder of site improvements concluded.
- Year Five: fifth block of ten greenhouses; fourth group of two ponds, six to be operational at all times; biogas recycling system operational; process heat application trials continued.

Maximum TERSA sizing limitations have not been established. The approximate twenty-five acre unit defined here fits conveniently not only in the Mt. Konocti-Thurston Lake site area selected, but is

NOTES

- BOLD NUMBERS INDICATE THE YEAR OF FACILITY INSTALLATION (SEE TEXT).
- SEE FIGURE 2-3 FOR TYPICAL THERMALLY CASCADED PIPING PLAN.

SCALE 0 50 100 FEET

UNITED STATES DOE			
TERSIA SITE PLAN MT. KONOCTI-THURSTON LAKE			
INTERNATIONAL ENGINEERING COMPANY, INC.			
DESIGNED: <i>ME</i>	CHECKED: <i>CH</i>	APPROVED:	
PLANNED: <i>ME</i>	INSPECT: <i>CH</i>	RECOMMENDED:	
IECO 228 MONTGOMERY STREET SAN FRANCISCO CALIFORNIA 94104		DATE: APRIL 1978	DRAWING NO.: Figure 6-1

also roughly adaptable to available portions of the Cobb Mountain and Sulphur Bank-Borax Lake site areas. Expansion capability, particularly in regard to geographic continuity for efficient function, is best offered by the Mt. Konocti-Thurston Lake site selected.

6.2 HYDROPONIC GREENHOUSING

In the original TERSA study greenhouse growing took place in soil; for this study, hydroponic greenhouse growing techniques are utilized. Specific evaluation of soils at the selected site would permit a final decision to be made as to use of hydroponically or soil grown greenhouse facilities. As costs and yields are similar in both methods, TERSA offers good flexibility and transferability in this subsystem activity.

Hydroponics is the growing of plants in nutrient solutions with or without an inert medium to provide mechanical support to the plant and its root system. The nutrients are circulated to the plants in water solutions that are carefully controlled to provide the plants proper minerals at the right time.

Hydroponic growing is a sensitive operation that must be carefully controlled to be successful. Its chief advantages over soil grown greenhouse crops are: the production is unaffected by soil conditions; production is said to be more prolific; and disease, insects and physiological disorders can be better controlled.

Hydroponic vegetables supply a very small part of the California market. A survey made by the University of California at Riverside in 1974 showed that only seventy five acres were in hydroponic vegetable production in the state at that time. The high cost of fossil fuels and the question of their availability on an uninterrupted basis tend to limit the expansion of this industry. On the other hand, the availability of a substitute energy source such as geothermal energy might provide the impetus for a healthy expansion in the growing of hydroponic crops.

TERSA implementation of hydroponic greenhouse activities would be designed to use only "off-the-shelf" equipment and proven engineering principles to accomplish its objectives. No part of the system requires equipment that is not readily available and ready to use from the manufacturer. Calculations and costs for the greenhouses are based on a patented hydroponic system in operation in Lakeport, Lake County, and under construction for a geothermally heated greenhouse project near Honey Lake, California.

Each greenhouse is approximately 30 feet by 124 feet; this represents 3720 square feet. Although other designs are likely applicable to the sites in Lake County, the greenhouse design here is of the indi-

vidual quonset type. The cover is two layers of six mil copolymer, ultra violet light inhibited material designed to last at least two years. A small electric air blower continually inflates the area between the two layers and maintains an air space of about six inches; this provides insulation and retards condensation on the inside cover that could result in unwanted moisture dripping on the plants.

The heating system is comprised of two fan driven heaters supplied with hot water, a system of perforated polyethylene heating tubes, and a control system to monitor and regulate the heat and moisture content within the greenhouse. Heating tubes and run the length of the house at plant and ceiling level; the system is designed to provide near-uniform heating distribution throughout the growing area.

The cooling system within the greenhouse is provided by an evaporative system composed of twin exhaust fans mounted at one end of the house, evaporative cooling pads mounted horizontally in the rear end and a control system to monitor and regulate the cooling required.

A relatively pure water supply must be available to supply water for plant growth and for carrying the required nutrients. At maximum levels of summertime use, each greenhouse requires approximately 400 gallons of irrigation water per day. As an example, this system requires about four gallons of water per pound of tomatoes (field crop tomatoes require about 125 gallons per pound). (pers. comm.).

6.3 OTHER TERSA SUBSYSTEM CONSIDERATIONS

Giant Prawns

This system is essentially the same as described in the initial TERSA report:

- Although recent indications show closed raceway prawn culture to be economically competitive and thermally conservative, earthen grow out ponds are used in this system based on their proven success in Hawaii and elsewhere.
- Cultural operations such as growing, feeding and harvesting in the aquacultural portion remain the same as in the original TERSA report. Several new references have been added concerning *Macrobrachium* culture (Ref. 134, 163, 170, 171, 172, 177).
- Water hyacinth is currently being used in prawn grow out ponds and a similar operation is used in this study. The free floating variety used in TERSA may be moved to the pond side by floating booms when prawn harvesting takes place and is population density controlled by this harvesting. Hyacinth provides prawn food and shelter; controlled harvesting of water hyacinth for biogas will also assist in maintaining oxygen levels in grow out ponds.

Changes in pond design are as follows:

- The California Department of Fish and Game is concerned about the propagation of non-native species in waterways and adjacent lakes which might result if winter rains or nearby river flooding causes overtopping of banks in the grow out ponds. Consequently, the berm height has been increased to preclude this possibility.
- In the original TERSA study copper pipe was used to convey the hot water through the grow out ponds. Dr. Johnson of Oregon Institute of Technology (OIT) warned against the use of copper or zinc coated piping in grow out ponds as they are toxic to the prawns. He also suggested bioassaying all parts in contact with the grow out pond water before finalizing design. The University of California at Davis has facilities to do this by placing samples such as pipe and pump impellers in contact with live prawns in a small growing area. At OIT the prawn growout pond was first stocked with mosquito fish to test for toxic substances before stocking with prawns.
- Pond water circulation has been increased in order to increase oxygenation, particularly to compensate for nighttime respiration of aquatic species present.

Biogas

This system is as described in the initial TERSA report.

Water Hyacinth

The Lake County Agricultural Commissioner's Office has indicated that the only aquatic weeds on the State quarantine list or the list resulting from the Federal Noxious Weed Act of 1974 are alligator weed, hydrilla, and anchored water hyacinth, Eichornia azurea. Free floating water hyacinth, Eichornia crassipes, is not restricted in use and is the type used in both the initial TERSA study and the present study. The nonrestricted use status of free floating hyacinth was confirmed by the California Department of Food and Agriculture. (pers. comm.).

6.4 SYSTEM ECONOMICS

The Appendix contains tables detailing TERSA capital costs, operating bases, operating costs, and cash flow analysis. Discounted cash flow methods indicate an after tax return on investment of 21.3 percent for the selected Mt. Konocti-Thurston Lake site on an investment with present value of \$2,419,000 at 8 percent discount. (This present value is \$1,755,000 at 10 percent discount and \$1,244,000 at 12 percent.)

This indicated TERSA rate of return is reasonable for the level of risk inherent in such an investment and should prove to be attractive to potential investors. (pers. comm.).

As a comparison, removal of certain "demonstration" aspects of TERSA - biogas, process heat application trials, and the laboratory - result in a rate of return of 22.9 percent. The difference in present value capitalization resulting for this system is on the order of \$200,000 in this discount range rate, or roughly ten percent of the total discounted funding is required for these demonstration aspects to be "added" to a commercial venture of greenhouses and prawn ponds alone.

7. CONCLUSIONS AND RECOMMENDATIONS

7.1 INTRODUCTION

The Total Energy Recovery System for Agribusiness has evolved from its initial conceptual phase to a more specific design for a site in Lake County. The improvement in energy utilization (with concomitant resource conservation) offered via integrated agribusiness activities is preserved; it became clearly necessary to also provide a possible blueprint for the development of such a system within the simultaneous spheres of interest of both the private commercial sector and the Department of Energy.

Detailed design and progressive testing of integrated portions of TERSA will be required before such a system can actually be employed to maximum potential as a commercial enterprise.

7.2 IMPLEMENTATION

In the process of implementation of the Total Energy Recovery System for Agribusiness certain activities will need to be undertaken: permits, establishing a total capability team, and further studies.

Permits

Various permits would be required from involved governmental agencies noted previously in order to construct this Lake County modified Total Energy Recovery System for Agribusiness. Some representative examples are:

- A use permit would be required from the Lake County Planning Commission in order to construct TERSA.
- The operation of the aquacultural portion of TERSA would require obtaining a Domestic Fish Breeder's License for Lake County from Region 3 of the California Department of Fish and Game.
- In order to import prawn larvae from out of state (such as from the Anuenue Fisheries Research Center in Hawaii) arrangements for inspection must be made for disease control and verification of lawfully imported fish, typically at the airport. Arrangements may be made for an inspector from the California Fish and Game Fish Disease Laboratory in Sacramento to perform the inspection; all expenses of the inspector must be borne by the importer.
- Affairs related to the California Department of Water Resources in the project areas are handled by the Red Bluff office of this agency.

Total Capability Team

When actual implementation for a specific site is considered, it is necessary to establish a total capability team for purposes of running a commercial enterprise with identifiable demonstration aspects. This team would include: capital sources, land and resource owners, commercial agribusiness operator, engineer, demonstration experimenters and advisors, and marketing.

Likely sources for the demonstration aspects can be found in the academic community. The University of California at Davis (UCD), for example, offers staff expertise in greenhousing, prawn raising, aquatic plants and biogas systems - all key elements of TERSA. Arrangements could be made between the commercial venture and UCD along the lines of existing UCD contracts; Davis is close enough to the selected site in Lake County to permit commuter trips to the site for one day.

The commercial operator must be willing to work with the demonstration experimenters, the Department of Energy, and other involved governmental agencies to keep records needed to evaluate the system performance and must provide access to the public and interested potential users of the TERSA system or components of it, even though such individuals may be competitors of the operator in the future.

Further Studies

Further studies should be performed prior to and during operation of TERSA in these areas:

- economic sensitivity analyses to optimize relative subsystem sizes and overall system size
- identification of most promising process heat applications
- experimental studies of relevant aspects of the biological production systems involved
- interchange of nutrients between the agribusiness subsystems
- heated prawn culture methodologies
- heat exchanger requirements.

7.3 MODIFICATION FOR IMPLEMENTATION

Modification of certain institutional factors, in particular, could expedite implementation of TERSA or a similarly desirable thermally cascaded integrated biologic system:

- clarification of ownership of geothermal resource for surface use in direct applications
- modified geothermal rights lease forms permitting direct applications

- a mechanism for coordination of integrated program efforts within the Department of Energy: TERSA has program elements of the Division of Solar Energy (biomass) as well as its obvious major relevance to the Division of Geothermal Energy.
- possible modification of DOE funding programs for "reasonable support of demonstration aspects" of otherwise economically sound, geothermally dependent projects via subsidies for a portion of lost return on investment directly attributable to non-commercial demonstration portions of such projects. The economic results of the previous chapter of this report indicate the relatively small government expenditure inherent in such a proposed funding modification.

7.4 CLOSING

The use of geothermal energy instead of conventional energy in TERSA increases initial capital costs by approximately five percent; this is more than offset by reduced operating costs due to the elimination of fossil fuels for heating purposes. For purposes of energy comparison, the reader should note that the use of geothermal heat in the Total Energy Recovery System for Agribusiness replaces the equivalent heat value of 1,500,000 gallons of oil over the project life.

As can be seen from the complexity of factors involved, economic viability alone cannot guarantee the success of TERSA or other projects involving direct utilization of geothermal energy. However, as has been expressed repeatedly by local residents and officials at both state and local levels, suitably conceived DOE efforts such as TERSA can serve to provide the catalyst for widespread direct geothermal applications in Lake County and elsewhere.

REFERENCES AND APPENDIX

REFERENCES

References are presented in two lists:

- REFERENCE LIST 1 is from the original TERSA study. Some of these entries were utilized in this study as well.
- REFERENCE LIST 2 is composed of new written information sources utilized in the present study.

APPENDIX

The Appendix is divided in sections as follows:

- A. PERSONAL COMMUNICATION SOURCES
- B. CALIFORNIA DEPARTMENT OF WATER RESOURCES MAP SYMBOLS
 - B-1. LAND USE LEGEND
 - B-2. LAND CLASSIFICATION STANDARDS
- C. ECONOMIC TABLES
 - C-1. TERSA CAPITAL COST SUMMARIES
 - C-2. TERSA OPERATING BASES
 - C-3. TERSA OPERATING COSTS
 - C-4. TERSA ECONOMIC SUMMARY
- D. ACKNOWLEDGMENTS

REFERENCE LIST 1

1. Aerco International; Quotation; 1977.
2. American M.A.N. Corp.; Quotation; New York; 1977.
3. American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc.; ASHRAE Handbook and Product Directory: 1973 System; ASHRAE; New York; 1973.
4. American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc.; ASHRAE Handbook of Fundamentals; ASHRAE; New York; 1972.
5. Amertap Corp.; Quotation; Mineola, New York; 1977.
6. Ampco Metal; Ampco Application Data; Milwaukee; 1976.
7. Anonymous; "Building the Fact Bases and Methods for Sound Energy Decisions"; EPRI Journal; Vol. 2; No. 1; January/February 1977; pp. 44-45.
8. Anonymous; "Cattle Dung Offers Energy Relief for Rural India"; Energy International; April 1975; pp. 25-6.
9. Anonymous, "Coal: The R&D Pivot for New Energy Fuels, Cycles, and Storage"; EPRI Journal; Vol. 2; No. 1; January/February 1977; pp. 8-21.
10. Anonymous; "Greenhouse and Bedding Plant Issue"; American Vegetable Grower, Western Edition; Vol. 24, No. 11; November 1976.
11. Anonymous; Report to the Mushroom Industry Concerning Costs of Growing Mushrooms; The Department of Agricultural Economics and Rural Sociology of the Pennsylvania State University; 1974.
12. Anonymous; "Shellfish Research"; The Commercial Fish Farmer; July/August 1975; p. 25.
13. Anonymous; Vegetative Water Use in California, 1974; Bulletin No. 113-3; State of California, The Resources Agency, Department of Water Resources; April 1975.
14. Armstead, Christopher H., Editor; Geothermal Energy; UNESCO; Paris; 1973.
15. Atkins, Fred C.; Mushroom Growing To-Day; The MacMillan Company; New York; 1966.
16. Atlee, Charles B; 1959 Sample Inputs and Costs for Mushrooms, Santa Cruz County; University of California Extension; Santa Cruz; 1959.

17. Banta, Vern E.; "Continuous Cleaning Ups Chiller Performance"; Power; June 1974.
18. Bardack, John E., Ryther, John H., and McLarney, William O.; Aquaculture: The Farming and Husbandry of Freshwater and Marine Organisms; Wiley Interscience; New York; 1972.
19. Barmettler, Edmund R.; Geothermal Energy Utilization; University of Nevada; Reno.
20. Barnea, Joseph; "Economics of Multi-Purpose Use of Geothermal Resources"; Geothermal Energy Magazine; November 1974; pp. 29-34.
21. Baumeister, Theodore, Editor; Mark's Standard Handbook for Mechanical Engineers; Seventh Edition; McGraw-Hill Book Company; New York; 1967.
22. Beall, Sam E.; "Agro-Geothermal Production Facilities"; Geothermal Energy Magazine; October 1973; pp. 23-4.
23. Belteky, L.; "Problems Related to Operating Thermal Wells Subject to Scaling in Hungary"; Geothermics; Vol. 4; No. 1-4; 1975; pp. 57-65.
24. Berry, James W., and Miller, Herman, Jr.; A Demonstration of Thermal Water Utilization in Agriculture; EPA-660/2-70-01; Office of Research and Development, U.S. Environmental Protection Agency; Washington, D.C.; April 1974.
25. Besemer, Seward T.; Carnation Culture in San Diego County; University of California, Agricultural Extension Service; San Diego County; 1975.
26. Besemer, Seward T.; Economics of U.S. Carnation Industry; University of California, Agricultural Extension Service; San Diego County; 1967.
27. Besemer, Seward T., and Close, D.H.; Summary of Carnation Flower Production Study, San Diego County; University of California, Agricultural Extension Service; San Diego County; 1963.
28. Besemer, Seward T. and Phelps, Fisk H.; Growing Carnations in San Diego County; University of California, Agricultural Extension Service; San Diego County; 1958.
29. Bird, Kermit; "Some Economic Projections of the U.S. Mushroom Industry"; speech given to American Mushroom Institute Conference; Wilmington, Delaware; September 6, 1969.
30. Boldizsar, T.; "Geothermal Energy Use in Hungary"; Geothermal Energy Magazine; April 1975; pp. 5-13.

31. Bowen, R.G., and Peterson, N.V.; Thermal Springs and Wells in Oregon; State of Oregon; Portland; 1970.
32. Campbell, Glen; "Geothermal Hydroponics"; Geothermal Energy Magazine; August 1973; pp. 14-16.
33. Carrier Air Conditioning Company; Carrier System Design Manual - Water Conditioning; Syracuse, New York; 1963.
34. Carrier Air Conditioning Company; Quotation; San Francisco; 1977.
35. Chapman, Alan J.; Heat Transfer; The MacMillan Company; New York; 1960.
36. Copper Development Association, Inc.; Technical Report; New York; August 1973.
37. Corbin, John S.; Aquaculture in Hawaii, 1976; State of Hawaii, Department of Planning and Economic Development; January 1976.
38. Crane Company; Flow of Fluids; Technical Paper No. 410; New York; 1974.
39. Davidson, Jackson; A Greenhouse Grower's Checklist; 75-SP/3006; University of California; 1974.
40. Doucet, Lawrence G.; "Energy from Solid Waste: The Promise, The Potential"; Specifying Engineer; December 1976; pp. 110-11.
41. Eagleson, Peter S.; Dynamic Hydrology; McGraw-Hill Book Company; New York; 1970.
42. EG&G Idaho, Inc. and Idaho National Engineering Laboratory; Geothermal R&D Project Report for Period July 1, 1976 to September 30, 1976; TREE 1030; National Technical Information Service; Springfield, Virginia; 1976.
43. Engineers and Fabricators Company; Quotation; Houston, Texas; 1977.
44. Energy Research and Development Administration; Fuels from Biomass Program: Program and Project Status; Division of Solar Energy; Washington, D.C.; November 1976.
45. Energy Research and Development Administration; Geothermal Resources (A Bibliography); United States ERDA Technical Information Center; Oak Ridge, Tennessee; 1975.
46. Eriksen, I.F., and Fogleman, S.F.; Geothermal Plant Design Considerations; ASCE National Structural Engineering Meeting; San Francisco; April 9-13, 1973.

47. Farnham, Delbert S., and Parsons, Philip S.; Typical Costs of Developing Greenhouse Carnations, Monterey and Santa Cruz Counties; Agricultural Extension, University of California; Santa Cruz; 1972.
48. Fujimura, T.; Development of a Prawn Culture Industry in Hawaii, Job Completion Report; National Marine Fisheries Service; 1974.
49. Fujimura, T.; Notes on the Development of a Practical Mass Culturing Technique of the Giant Prawn Macrobrachium Rosenbergii; UNFAO; Indo-Pacific Fisheries Council; 1966.
50. Fujimura, T. and Okamoto, H; Notes on Progress Made in Developing a Mass Culturing Technique for Macrobrachium Rosenbergii in Hawaii; UNFAO; Indo-Pacific Fisheries Council; 1970.
51. Furuta, Tokuji; The Environment and Nursery Production, Nursery Management Handbook - Section IX; AXT-320; University of California, Agricultural Extension Service; Davis; 1970.
52. Genders, Roy; Mushroom Growing for Everyone; Faber and Faber; London; 1969.
53. Geothermal Resources Council; Proceedings of Second Workshop on Materials Problems Associated with the Development of Geothermal Energy Systems; Geothermal Resources Council; Davis, California; 1975.
54. Godfrey, Robert Sturgis, Editor-in-Chief; Means Building Construction Cost Data 1977; Robert S. Means Co., Inc.; Duxbury, Massachusetts; 1977.
55. Goodland, R. and Tillman, G; Guatemala National Energy Master Plan: Environmental Assessment; The Cary Arboretum; Millbrook, NY; December 1975.
56. Grant, Eugene L., and Ireson, W. Grant; Principles of Engineering Economy; Fifth Edition; The Ronald Press Company; New York; 1970.
57. Grist, D.H.; Rice; Tropical Agricultural Series; London; 1969.
58. Hall, Beverly A.; Materials Problems Associated with the Development of Geothermal Resources; Geothermal Resources Council; Davis, California; 1975.
59. Hannah, Judith L.; The Potential of Low Temperature Geothermal Resources in Northern California; 1975 Edition; Report TR13; Division of Oil and Gas, State of California; Sacramento; 1975.

60. Hasek, Raymond F; "Sources of Horticultural Information"; reprinted from The Florida Foliage Grower; Vol. 10; No. 3 and 4; 1973.
61. Hewlett-Packard Company; HP-25 Applications Programs; 1975.
62. Hickling, C.F.; Fish Culture; Faber and Faber; London; 1962.
63. Hickling, C.F.; The Farming of Fish; Pergamon; New York; 1968.
64. Howard, J.H., Editor; Present Status and Future Prospects for Nonelectrical Uses of Geothermal Resources; Lawrence Livermore Laboratory, University of California, UCRL-51926; October 15, 1975.
65. Howard, J.H.; Principal Conclusions of the Committee on the Challenges of Modern Society Non-Electrical Applications Project; reprinted by Lawrence Livermore Laboratory; University of California; Livermore, California; 1975.
66. Huguenin, John E.; Heat Exchangers for Use in the Culturing of Marine Organisms; Contribution No. 3382 from the Woods Hole Oceanographic Institute; 1976.
67. Huguenin, John E. and Ryther, John H.; "The Use of Power Plant Waste Heat in Marine Aquaculture"; Marine Technology Society Tenth Annual Conference Proceedings; 1974.
68. International Engineering Co., Inc.; Proposal For Engineering and Economic Study: Non-Electric Applications of Geothermal Heat; made to the U.S. Energy Research and Development Administration, Division of Geothermal Energy; April 1976.
69. Jacobs, R.L. and McMaster, J.A.; "Economical Solution to Heat Exchanger Corrosion"; Materials Protection and Performance; July 1972; p. 33.
70. Jesse, E.V. and Machado, M.J.; Trends in Production and Marketing of California Fresh Market Tomatoes; 75-BL/1871; University of California; Davis; 1974.
71. Johnson, Bill; "Aquaculture at Oregon Institute of Technology"; Geo-Heat Utilization Center Quarterly Bulletin; Oregon Institute of Technology; Klamath Falls, Oregon; July 1976.
72. Johnson, Hunter, Jr.; Greenhouse Crop Wholesale Prices; unpublished; 1977.
73. Johnson, Hunter, Jr.; Greenhouse Cucumber Production; Leaflet 2775; University of California; Riverside; 1975.
74. Johnson, Hunter, Jr.; Greenhouse Tomato Production; Leaflet 2806; University of California; Riverside; 1975.

75. Johnson, Hunter Jr.; Greenhouse Vegetable Production; OSA #249; University of California; Riverside; 1974.
76. Johnson, Hunter, Jr.; Some References for Greenhouse Vegetable Production and Hydroponics; University of California; Riverside; 1975.
77. Johnson, Hunter, Jr. and Rock, Robert C.; Sample Costs for Producing Greenhouse Tomatoes and Cucumbers in California; University of California; Riverside; 1975.
78. Karmeli, David and Keller, Jack; Trickle Irrigation Design; Rain Bird Sprinkler Manufacturing Corp.; Glendora, California; 1975.
79. Keifer, Elizabeth; "The Pitfalls and Promise of Fish Farming"; San Francisco Sunday Examiner and Chronicle; October 10, 1976.
80. Kinrus, Aron; Information on Mushroom Growing and the Mushroom Industry; American Mushroom Institute; Kennett Square, Pennsylvania; February 1977.
81. Kneebone, Leon R.; "Composts for Mushroom Culture"; Market Growers Journal; June 1955; pp. 16-17.
82. Kneebone, Leon R.; Mushroom Research Theses at the Pennsylvania State University; Mushroom Research Center; Pennsylvania State University; November 1976.
83. Knight, Allen W.; Laboratory Studies on Selected Nutritional, Physical and Chemical Factors Affecting the Growth, Survival, Respiration, and Bioenergetics of the Giant Prawn, Macrobrachium Rosenberqii; Water Science and Engineering Paper No. 4501; University of California Hydrobiology Laboratory; Davis; March 1976.
84. Knott, James E.; Handbook for Vegetable Growers; John Wiley & Sons, Inc.; New York; 1957.
85. Kreith, Frank; Principles of Heat Transfer; Second Edition; International Textbook Company; Scranton, Pennsylvania; 1966.
86. Kruger, Paul, and Otte, Carel, Editors; Geothermal Energy; Stanford University Press; Stanford, California; 1973.
87. Lambert, Edmund B.; Mushroom Growing in the United States; USDA Farmers Bulletin No. 1875; 1963.
88. Lambert, Louis F.; Practical and Scientific Mushroom Culture; Louis F. Lambert, Inc.; Coatesville, Pennsylvania; 1965.

89. Lee, Charles H.; "Transpiration and Total Evaporation"; in Hydrology, edited by Oscar E. Meinzer; Dover Publications, Inc.; New York; 1942.
90. Lee, Jasper S.; Commercial Catfish Farming; The Interstate Printers and Publishers, Inc.; Danville, Illinois; 1973.
91. Leedahl, Alton O.; "The Closed-Loop Food Production System: A New Concept"; Agricultural Engineering; July 1976; pp. 33-35.
92. Leitner, G.F.; Energy Analysis for Water Chillers and Effect of "ON-LOAD" Cleaning of Condenser Tubes on Performance: Some Case Histories; Purdue Research Foundation; Purdue University; 1976.
93. Lindal, B.; "Industrial and Other Applications of Geothermal Energy"; in Geothermal Energy, edited by Christopher H. Armstead; UNESCO; Paris; 1973.
94. Linsley, Ray K., Jr., Kohler, Max A., and Paulhus, Joseph L.H.; Hydrology for Engineers; McGraw-Hill Book Company, Inc.; New York; 1958.
95. Lund, J.W., Silva, Jay F., Culver, Gene, Lienau, P.J., Svanevik, L.G., and Anderson, S.D.; Corrosion of Downhole Heat Exchangers; for ERDA/INEL Contract No. E(10-1)-1548; Geo-Heat Utilization Center; Klamath Falls, Oregon; October 1976.
96. Mariner, R.J., Rapp, J.B., Willey, L.M., and Presser, T.S.; The Chemical Composition and Estimated Minimum Thermal Reservoir Temperatures of Selected Hot Springs in Oregon; United States Geological Survey Open-File Report; Menlo Park, California; March 1974.
97. Marshall, T., and Braithwaite, W.R.; "Corrosion Control in Geothermal Systems"; in Geothermal Energy, edited by Christopher H. Armstead; UNESCO; Paris; 1973; pp. 151-160.
98. McIlhenny, W.F., and Zeitoun, M.A.; "A Chemical Engineer's Guide to Seawater"; Chemical Engineering; November 3 and November 17, 1969.
99. Milora, Stanley L., and Tester, Jefferson W.; Geothermal Energy as a Source of Electric Power; The MIT Press; Cambridge, Massachusetts; 1976.
100. Mother Earth News, Editor; Handbook of Homemade Power; Bantam Books, Inc.; New York; 1974.
101. Muhlfeld, Liz; "Fish, the Need to Know"; Rockerfeller Foundation Illustrated; December 1976.
102. Nakanishi, H., Iwai, N., and Miyazaki, M.; "Geothermal Power Plant"; Toshiba Review; November 1970; pp. 4-11.

103. Olmsted, F.H., Glancy, P.A., Harril, J.R., Rush, F.E., and VanDemburgh, A.S.; Preliminary Hydrogeological Appraisal of Selected Hydro-Thermal Systems in Northern and Central Nevada; United States Geological Survey Open-File Report 76-76; Menlo Park, California; 1975.
104. Onorato and Co.; Wholesale Quotations; San Francisco; 1977.
105. Patterson-Kelley Company; Quotation; San Francisco; 1977.
106. Peterson, Richard E., and El-Ramly, Nabil; "The Worldwide Electric and Nonelectric Geothermal Industry"; Geothermal Energy Magazine; November 1975; pp. 4-14.
107. Pflauser Company; Quotation; Rochester, New York; 1977.
108. Porter, Charles W.; "Mushroom Market Developments"; Mushroom Industry Short Course; Pennsylvania State University; June 1972.
109. Potter, Charles H.; Greenhouse, Place of Magic; A Sunrise Book; New York; 1976.
110. Pudlock, Jay R.; Comparative Costs of Metallic Corrosion Resistant Shell and Tube Heat Exchangers; ASTM B-10 Committee Symposium; New Orleans, Louisiana; November 19, 1975.
111. Reistad, Gordon M.; Analysis of Potential Non-Electric Applications of Geothermal Energy and their Place in the Economy; UCRL-51747; Lawrence Livermore Laboratory, University of California; February 14, 1975.
112. Rodale, J.I.; The Complete Book of Composting; Rodale Books, Inc.; Pennsylvania; 1975.
113. Roper IBG; Greenhouse Quotation; San Jose, California; 1977.
114. Rosenbruch, Jimmie C., and Bottge, Robert G.; "Geothermal Agricultural Applications - Hobo Wells Hydroponics"; Geothermal Energy Magazine; October 1976; pp. 36-38.
115. Shang, Yung C. and Fujimura, Takuji; The Production Economics of Fresh Water Prawn (Macrobrachium Rosenbergii) Farming in Hawaii; Draft; Hawaii Institute of Marine Biology and Anuenue Fisheries Research Center; 1977.
116. Short, Ted H., Badger, Philip C. and Roller, Warren L.; "OARDC's Solar-Heated Greenhouse"; Agricultural Engineering; July 1976; pp. 30-32.
117. Sims, William L.; Growing Mushrooms; Leaflet 2640, University of California; Cooperative Extension; 1976.
118. Singh, Ram Bux; Bio-Gas Plant; Mother's Print Shop; Hendersonville, N.C.; 1975.

119. Smil, Vaclav; "China Opts for Small Scale Energy Techniques"; Energy International; February 1976; pp. 17-18.
120. Sparrow, E.M., and Cess, R.D.; Radiation Heat Transfer; Brooks/Cole Publishing Company; Belmont, California; 1966.
121. Swink, D.G., Schultz, R.J. and Oswald, A.J.; "Geothermal Energy - An Integrated Use Plan"; Geothermal Energy Magazine; April 1976; pp. 21-23.
122. Thomasson, P.M.; Startup Considerations for a Once-Through Sea Water Cooling System; ASME Paper No. 73-IPWR-3; 1973.
123. Tongqiorqi, E., Editor; "Proceedings of the United Nations Symposium on the Development and Utilization of Geothermal Resources"; Geothermics; Volume 2; Parts 1 and 2; 1970.
124. Trane Company; Quotation; San Francisco; 1977.
125. Wehlage, Edward F.; The Basics of Applied Geothermal Engineering; Geothermal Information Services; West Covina, California; 1976.
126. Weldon, L.W., Blackburn, R.D., and Harrison, D.S.; "Common Aquatic Weeds"; Agricultural Handbook No. 352; Agricultural Research Service, USDA; 1969; p. 2.
127. White, D.E., and Williams, D.L., Editors; Assessment of Geothermal Resources of the United States - 1975; Geological Survey Circular 726; United States Department of the Interior, Geological Survey; Washington, D.C.; 1975.
128. Williams, D.W., McCarty, T.R., Morris, G.R., Gunkel, W.W., and Price, D.R.; "Utilization of Biogas for Farm Production Energy"; Transactions of the ASAE - 1976; pp. 1034-1040, 1044.
129. Wolverton, B.C., Barlow, R.M., and McDonald, R.C.; "Application of Vascular Aquatic Plants for Pollution Removal, Energy, and Food Production in a Biological System"; NASA Technical Memorandum TM-X-72726; National Space Technology Laboratories; Bay St. Louis, Mississippi; May 1975.
130. Wolverton, B.C., McDonald, R.C., and Gordon, J.; "Bio-Conversion of Water Hyacinths into Methane Gas: Part 1"; NASA Technical Memorandum TM-X-72725; National Space Technology Laboratories; Bay St. Louis, Mississippi; July 1975.
131. Uhlig, Herbert H.; Corrosion and Corrosion Control; Second Edition; John Wiley and Sons, Inc.; New York; 1971.
132. USDA Crop Reporting Service; Wholesale Quotations; San Francisco; March 9, 1977.

133. Zumberge, James H., and Ayers, John C.; "Hydrology of Lakes and Swamps"; in Handbook of Applied Hydrology, edited by Ven Te Chow; McGraw-Hill Book Company; 1964; pp. 23-1 to 23-33.

REFERENCE LIST 2

134. Armstrong, David A., Stephenson, Marian J., and Knight, Allen W.; "Acute Toxicity of Nitrite to Larvae of the Giant Malaysian Prawn, Macrobrachium Rosenbergii;" Aquaculture; 9(1976); pages 39-46.
135. Bacon, C. Forrest, Aminoto, Perry Y., Sherbourne, Roger W., and Slosson, James E.; Engineering Geology of the Geysers Geothermal Resource Area; California Division of Mines and Geology; Sacramento; 1976.
136. Ball, George J.; The Ball Red Book; Thirteenth Edition; West Chicago, Illinois; 1975.
137. Bloomster, C. H.; Fassbender, L. L., and McDonald, C. L.; Geothermal Energy Potential for District and Process Heating Applications in the U.S. - An Economic Analysis; Batelle Pacific Northwest Laboratories; Richland, Washington; 1977.
138. California Department of Fish and Game; A Review of the Life History of Tilapia Zillii with a Reassessment of its Desirability in California; State of California - The Resources Agency; Sacramento; 1973.
139. California Department of Water Resources; Clear Lake Water Quality Investigation; State of California - The Resources Agency; Sacramento; 1966.
140. California Department of Fish and Game; Evaluation of Introduction of Macrobrachium Rosenbergii into California for Commercial Culture; State of California - The Resources Agency; Sacramento; 1973.
141. California Department of Fish and Game; Evaluation of Introduction of Tilapia Sparmanii into California; State of California - The Resources Agency; Sacramento; 1972.
142. California Department of Water Resources; Land and Water Use in Putah-Cache Creeks Hydrographic Unit; State of California - The Resources Agency; Sacramento; 1964.
143. California Department of Food and Agriculture and California Department of Fish and Game; Laws and Regulations Governing the Importation, Transportation, and Possession of Live Wild Animals... into the State of California; State of California - The Resources Agency; Sacramento; 1975.
144. California Department of Fish and Game; Licensed Domestic Fish Breeders as of April 1, 1977; State of California - The Resources Agency; Sacramento; 1977.

145. California Department of Fish and Game; List of Selected References Dealing with Freshwater Fish and Related Subjects; State of California - The Resources Agency; Sacramento; 1976.
146. California Department of Fish and Game; Regulations Governing Domesticated Fish Breeder's License; State of California - The Resources Agency; Sacramento; 1977.
147. Carter, Jimmy; Executive Order 11990, Protection of Wetlands; Office of the President; Washington, D.C.; 1977.
148. Chakroff, Marilyn; Freshwater Fish Pond Culture and Management; Volunteers in Technical Assistance; Mt. Rainier, Maryland; 1976.
149. Chapman, Roger H.; Geophysical Study of the Clear Lake Region, California; California Division of Mines and Geology; Sacramento; 1975.
150. Dermengian, John, Editor; Geothermal Energy Magazine; West Covina, California; various issues 1977-1978.
151. Ecoview Environmental Consultants; A Draft Environmental Impact Report for Geothermal Development by McCulloch Oil and Geothermal Kinetic Systems for the Study Area on the Francisco Leasehold, Lake County, California; Napa, California; 1975.
152. Ecoview Environmental Consultants; A Draft Environmental Impact Report for Phillips Petroleum Company, Borax Lake, Lake County, California; Napa, California; 1976.
153. EG&G Idaho, Inc.; Geothermal R&D Project Report for Period October 1, 1976 to March 31, 1977; TREE-1134; National Technical Information Service; Springfield, Virginia; 1977.
154. Erkins, R. A.; The Erkins Seafood Letter; Bliss, Idaho; various issues 1977.
155. Fogleman, Sam F., Fisher, Leonard A., Black, Allan R., and Singh, D. P.; Total Energy Recovery System for Agribusiness; National Technical Information Service; Springfield, Virginia; 1977.
156. Geoble, Charles L.; 1976 Lake County Agricultural Crop Report; County of Lake/State of California; Lakeport, California; 1977.
157. Geonomics, Inc.; Direct Heat Applications of Geothermal Energy in the Geysers/Clear Lake Region; United States ERDA; Oakland, California; 1977.
158. Geothermal Resources Council, Editors; Direct Utilization of Geothermal Energy: A Symposium; Geothermal Resources Council; Davis, California; 1978.

159. Geothermal Resources Council, Editors; Geothermal: State-of-the-Art; Geothermal Resources Council; Davis, California; 1977.
160. Glude, John B., Editor; NOAA Aquaculture Plan; National Oceanic and Atmospheric Administration, U.S. Department of Commerce; Washington, D.C.; 1977.
161. Hahn, Wise and Associates, Inc.; Conditions, Procedures, and Performance Standards for Geothermal Regulation: County of Lake; Lake County Planning Commission; Lakeport, California; 1972.
162. Hanchett, B. J., Editor; The Clear Lake Observer American; Clearlake Highlands, California; various issues 1977-1978.
163. Hanson, Joe A. and Goodwin, Harold L.; Shrimp and Prawn Farming in the Western Hemisphere; Halsted Press, A Division of John Wiley & Sons, Inc.; Stroudsburg, Pennsylvania; 1977.
164. Honey Lake Hydroponic Farms; Proposal for Direct Utilization of Geothermal Energy Resources - Field Experiments; made to the United States Department of Energy, Division of Geothermal Energy; 1977.
165. Jet Propulsion Laboratory; Geothermal Energy Resources in California; California Energy Resources Conservation and Development Commission; Sacramento, California; 1976.
166. Johnsrud, Roland R., Editor; Lake County Record-Bee; Lakeport, California; various issues 1977-1978.
167. Jones and Stokes Associates, Inc.; Draft Environmental Impact Report, County of Lake, Magma Energy, Inc., Watson #1 and #2 Drill Sites; Sacramento, California; 1975.
168. King, Art, Editor; Lake Sun; Kelseyville, California; various issues 1977-1978.
169. Lake County; Environmental Protection Guidelines; Board of Supervisors, County of Lake; Lakeport, California; 1975.
170. Nelson, S. G., Armstrong, D. A., Knight, A. W., and Li, H. W.; "The Effects of Temperature and Salinity on the Metabolic Rate of Juvenile Macrobrachium Rosenbergii"; Comparative Biochemistry and Physiology; Vol. 56, No. 4A (1977); pages 533-537.
171. Nelson, S. G., Knight, A. W., and Li, H. W.; "The Metabolic Cost of Food Utilization and Ammonia Production by Juvenile Macrobrachium Rosenbergii"; Comparative Biochemistry and Physiology; Vol. 57, No. 1A (1977); pages 67-72.
172. Pacific Northwest Sea Grant Program; Notes and Proceedings of Geothermal Aquaculture Workshop; Pacific Northwest Sea Grant Program; Boise, Idaho; 1977 (unpublished).

173. Roberts, Paul A.; Fish Culture Utilization of Geothermal Energy; United States ERDA; Idaho Falls, Idaho; 1975.
174. Sociotechnical Systems, Inc.; Draft Environmental Impact Report, Northern California Power Agency/Resource Funding Limited, Cobb Valley Geothermal Project; Lakeport, California; 1977.
175. State Geothermal Resources Task Force; Executive Summary and Recommendations; State of California - The Resources Agency; Sacramento, California; 1977.
176. State of California - The Resources Agency; Policy for Preservation of Wetlands in Perpetuity; State of California - The Resources Agency; Sacramento, California; 1977.
177. Stern, Henrietta L., Armstrong, David A., Knight, Allen W., and Chippendale, Deborah J.; Survival and Growth of Juveniles of the Giant Malaysian Prawn, Macrobrachium Rosenbergii, Fed Natural Plants; Seventh Annual Meeting of World Mariculture Society; San Diego, California; 1976.
178. Systems and Energy Group of TRW Inc.; Utilization of U.S. Geothermal Resources; Electric Power Research Institute; Palo Alto, California; 1976.
179. United States Bureau of Land Management; Surface - Mineral Management Status: Healdsburg Quadrangle; Bureau of Land Management; 1972.
180. United States Department of Commerce; Climatological Summary for Clearlake Park; United States Department of Commerce; San Francisco, California; 1953.
181. United States Department of Commerce; Climatological Survey for Lakeport, California; United States Department of Commerce; San Francisco, California; 1970.
182. Vollentine, Larry and Weres, Oleh; Public Opinion Concerning Geothermal Development in Lake County, California; LBL-4447; Lawrence Berkeley Laboratory; Berkeley, California; 1976.
183. Vollentine, Larry and Weres, Oleh; Public Opinion in Cobb Valley Concerning Geothermal Development in Lake County, California; LBL-5204; Lawrence Berkeley Laboratory; Berkeley, California; 1976.
184. Vollentine, L. R., Kunin, L., and Sathaye, J. A.; The Lake County Economy: Potential Socio-Economic Impacts of Geothermal Development; LBL-5944; Lawrence Berkeley Laboratory; Berkeley, California; 1977.

185. VTN Consolidated, Inc.; Final Environmental Impact Report, Union Oil Company, Jorgensen 1, 2 and 3 Exploratory Wells, Lake County, California; Irvine, California; 1976.
186. VTN-CSL; Economic Study of Low Temperature Geothermal Energy in Lassen and Modoc Counties, California; State of California Division of Oil and Gas and the Energy Resources Conservation and Development Commission; Sacramento, California; 1977.

A. PERSONAL COMMUNICATION SOURCES

Much information in this report has come from personal communications with individuals. These people are citizens of Lake County, members of organizations involved in the development of geothermal resources, government representatives at local, state, and national levels, members of the academic community, agribusiness practitioners, and other concerned individuals.

Information provided has included material of proprietary and confidential natures and has helped tremendously in the attempt to make the aspects of this study as realistic as practical.

We are indebted to the following individuals for their contributions to this study:

Dr. Magnus Agustsson; Horticultural School; Hveragerdi, Iceland.

Dr. Ed Barmettler; Assistant to the Dean, Professor and Economist, University of Nevada; Reno, Nevada.

Alexander Black; Chairman of the Board, GeoProducts Corporation; Oakland, California.

Kenneth L. Boren; President, GeoProducts Corporation; Oakland, California.

Gregg Braun; Oregon Institute of Technology; Klamath Falls, Oregon.

Rudy Cernoch; R. G. Cernoch and Associates; San Jose, California.

J. A. Combs; United Land and Timber, Inc.; Kelseyville, California.

Jim Davey; Senior Supervisor, Geothermal Group, Lawrence Berkeley Laboratory; Berkeley, California.

David Edson; Assistant Vice President, VTN Consolidated Inc.; Irvine, California.

Marilyn Eggers; Program Coordinator, U.S. Department of Energy, Geothermal Energy Division; Oakland, California.

Robert A. Erkins; Erkins Seafood Newsletter; Bliss, Idaho.

Dr. Takuji Fujimura; Director, Anuenue Fisheries Research Center; Hawaii.

Charles L. Geoble; Agricultural Commissioner, County of Lake; Lakeport, California.

David M. Hill; Senior Engineering Geologist, Energy Resources Conservation and Development Commission, State of California; Sacramento, California.

Al Holmes; President, Energetics Marketing and Management Associates, Ltd.; San Francisco, California.

Bill Jadiker; Cobb Mountain, Lake County, California.

Mary Jadiker; Lake County Energy Council and State Geothermal Task Force; Cobb Mountain, Lake County, California.

John Jago; Jago Resort, Lower Lake, California.

Donald F. Johnson; Planning Director, Planning Department, County of Lake; Lakeport, California.

Dr. Hunter Johnson, Jr.; Extension Vegetable Specialist, University of California at Riverside; Riverside, California.

Dr. William C. Johnson; Oregon Institute of Technology; Klamath Falls, Oregon.

Bob Jones; Supervisor, District One, Lake County; Lakeport, California.

Muriel Jordan; President, Geothermal Association for Lake County; Cobb, California.

Art King; Publisher, Lake Sun; Kelseyville, California.

Dr. Allen W. Knight; Principal Investigator, Hydrobiology Laboratory, University of California at Davis; Davis, California.

A. B. Longyear; The Fred Longyear Company; Sacramento, California.

Dr. Richard H. Matherson; President, Agricultural Growth Industries, Inc.; Concord, California.

Frank Mattina; Konocti Realty; Kelseyville, California.

Robert McGill; Senior Land and Water Use Analyst, Northern District, Department of Water Resources, State of California; Red Bluff, California.

Jack Miller; Assistant Geothermal Officer, Division of Oil and Gas, State of California; Santa Rosa, California.

R. E. "Dick" Millett; Construction Superintendent, McCulloch Oil Corporation; Bakersfield, California.

V. A. "Kip" Neasham; Lakeport, California.

Leslie A. Nieves; Research Economist, Battelle Pacific Northwest Laboratories; Richland, Washington.

Dennis L. Olmstead; Assistant Geothermal Officer, Division of Oil and Gas, State of California; Sacramento, California.

Leo E. Ray; Fish Breeders of Idaho, Inc.; Buhl, Idaho.

Glenn Sawyer; Chief, Water Conservation and Use Section of the Division of Planning, Department of Water Resources, State of California; Sacramento, California.

Dr. Bjorn Sigurbjornsson; Director, Agricultural Research Institute; Reykjavik, Iceland.

Bob Snyder; Owner, B&M Hygro Farm; Lakeport, California.

A. D. "Doug" Stockton; Geothermal Officer, Division of Oil and Gas, State of California; Sacramento, California.

Nancy H. Stolesen; Projects Coordinator/Northern California, McCulloch Geothermal Corporation; Lakeport, California.

Hilary Sullivan; Program Coordinator, U.S. Department of Energy, Division of Geothermal Energy; Oakland, California.

Tom Taylor; Exclusion Biologist, Department of Food and Agriculture, State of California; Sacramento, California.

Michael Tolmasoff; Northern Sonoma County Air Pollution Control Board; Santa Rosa, California.

Carl Townsend; Biologist, Agricultural Commissioner's Office, County of Lake; Lakeport, California.

Fayne L. Tucker; Director, Lake County Air Pollution Control District; Lakeport, California.

Larry Vollentine; Planner, Planning Department, County of Lake; Lakeport, California.

Mark A. Walters; Environmental Control Officer, Planning Department, County of Lake; Lakeport, California.

Syd Willard; Geologist, Energy Resources Conservation and Development Commission, State of California; Sacramento, California.

Ted W. Wooster; Environmental Services Supervisor, Department of Fish and Game, State of California; Yountville, California.

Bernice Wright; Geothermal Association for Lake County; Cobb, California.

With apologies for omissions.

B. CALIFORNIA DEPARTMENT OF WATER RESOURCES

MAP SYMBOLS

**STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES**

STANDARD LAND USE LEGEND

Revised April 15, 1970

The minimum breakdown of land use is according to the "Class" symbol. More detail is obtained by adding the subclass number to the class symbol, or by use of special additional symbols. Any or all of the following information can be delineated.

1. Types of agricultural, urban, or recreational development, and kinds of native vegetation.
2. Kinds of crop for a given period.
3. Intercrop practices.
4. Source of water supply.

AGRICULTURAL CLASSES

(precede with "n" or "i")

G - GRAIN AND HAY CROPS

1. Barley	3. Oats
2. Wheat	6. Miscellaneous and mixed hay and grain

R - RICE

F - FIELD CROPS

1. Cotton	7. Grain sorghums
2. Safflower	8. Sudan
3. Flax	9. Castor beans
4. Hops	10. Beans (dry)
5. Sugar beets	11. Miscellaneous field
6. Corn (field or sweet)	

P - PASTURE

1. Alfalfa & alfalfa mixtures	3. Mixed pasture
2. Clover	4. Native pasture

T - TRUCK AND BERRY CROPS

1. Artichokes	11. Peas
2. Asparagus	12. Potatoes
3. Beans (green)	13. Sweet Potatoes
4. Cole crops	14. Spinach
6. Carrots	15. Tomatoes
7. Celery	16. Flowers and nursery
8. Lettuce (all types)	18. Miscellaneous truck
9. Melons, squash, and cucumbers (all types)	19. Bushberries
10. Onions and garlic	20. Strawberries
	21. Peppers (chili, bell, etc.)

D - DECIDUOUS FRUITS AND NUTS

1. Apples	8. Prunes
2. Apricots	9. Figs
3. Cherries	10. Miscellaneous deciduous
5. Peaches and Nectarines	12. Almonds
6. Pears	13. Walnuts
7. Plums	

C - SUBTROPICAL FRUITS

1. Grapefruit	5. Avocados
2. Lemons	6. Olives
3. Oranges	7. Miscellaneous subtropical fruits
4. Dates	

V - VINEYARDS

(subclasses not mapped unless specified)

1. Table grapes	3. Raisin grapes
2. Wine grapes	

S - SEMIAGRICULTURAL AND INCIDENTAL TO AGRICULTURE

(precede subclasses 1, 2, and 3 with "n", 4 with "i", and 5 with "n" or "i" as the case may be)

1. Farmsteads	3. Dairies
2. Feed lots (livestock and poultry)	4. Lawn areas
	5. Cemeteries

I - IDLE

1. Land cropped within the past three years but not tilled at the time of survey.
Exception: If it can be determined that the land was cropped during one of the three previous "growing seasons"*, map the condition by indicating the crop and season.
2. New lands being prepared for crop production.

UNCLASSIFIED

E - ENTRY DENIED

NATIVE CLASSES

(do not precede with "n" or "i")
(subclasses not mapped unless specified)

NV - NATIVE VEGETATION

1. Grass land	4. Heavy brush
2. Light brush	5. Brush and timber
3. Medium brush	6. Forest

NR - RIPARIAN VEGETATION

1. Swamps and marshes	3. Brush
2. Meadowland	4. Trees

NW - WATER SURFACE

Lakes, reservoirs, and rivers

NB - BARREN AND WASTELAND

1. Dry stream channels	4. Salt flats
2. Mine tailing	5. Sand dunes
3. Barren land	

NC - NATIVE CLASSES UNSEGREGATED

*See "growing seasons" under "Additional Symbols", this legend.

URBAN CLASSES

U - URBAN - residential, commercial, and industrial

(May be used alone when further breakdown is not required)

UR - RESIDENTIAL - one and two family units, including trailer courts

(May be used alone when further breakdown is not required)

Development Factor

	<u>Type of development (houses per acre)</u>	<u>Percent developed</u>
0.	0.5 to 2	75 - 100
1.	3 to 4	75 - 100
2.	3 to 4	50 - 75
3.	5 to 6	75 - 100
4.	5 to 6	50 - 75
5.	5 to 6	25 - 50
6.	7 or more	75 - 100
7.	7 or more	50 - 75
8.	7 or more	25 - 50
9.	7 or more	0 - 25

Water Use Factor

(Percent of the total area that is irrigated)

0.	0 - 10	5.	50 - 60
1.	10 - 20	6.	60 - 70
2.	20 - 30	7.	70 - 80
3.	30 - 40	8.	80 - 90
4.	40 - 50	9.	90 - 100

Example:*

*Refer to "Discussion of Land Use Legend" for an example of a method used in arriving at this symbol.

UC - COMMERCIAL

Indicate the number of stories following the appropriate subclass:

(May be used alone when further breakdown is not required)

1. Miscellaneous establishments (offices and retailers)
2. Hotels
3. Motels
4. Apartments, Barracks (3-family units and larger)
5. Institutions (hospitals, prisons, reformatories, asylums, etc., having a reasonably stable 24-hour resident population)
6. Schools (yards to be mapped separately if large enough)
7. Municipal auditoriums, theaters, churches, buildings and stands associated with race tracks, football stadiums, baseball parks, rodeo arenas, etc.
8. Miscellaneous high water use (specify use. To be used to indicate a high water use condition not covered by the above categories.)

Example: UC 23
(3-story hotel)

UI - INDUSTRIAL

(Should not be used without subclass unless specified)

1. Manufacturing, assembling, and general processing
2. Extractive industries (oil fields, rock quarries, gravel pits, public dumps, rock and gravel processing plants, etc.)
3. Storage and distribution (warehouses, substations, railroad marshalling yards, tank farms, etc.)
6. Saw mills
7. Oil refineries
8. Paper mills
9. Meat packing plants
10. Steel and aluminum mills
11. Fruit and vegetable canneries and general food processing
12. Miscellaneous high water use (specify use. To be used to indicate a high water use condition not covered by the above categories)

UV - VACANT

(Should not be used without subclass unless specified)

1. Miscellaneous unpaved areas (vacant lots, graveled surfaces, playing fields, nonirrigated freeway strips, raw lands within metropolitan areas, etc.)
4. Miscellaneous paved areas (parking lots, runways, freeways, oiled surfaces, flood control channels, tennis court areas, auto sales lots, etc.)

RECREATIONAL CLASSES

RR - RESIDENTIAL

Permanent and summer home tracts within a primarily recreational area. The estimated number of houses per acre is indicated by a number in the symbol. Example: RR-3 (3 homes per acre)

RC - COMMERCIAL

Commercial areas within a primarily recreational area. (Includes motels, resorts, hotels, stores, etc.)

RT - CAMP AND TRAILER SITES

Camp and trailer sites within a primarily recreation area.

ADDITIONAL SYMBOLS

(i) - IRRIGATION

Denotes an irrigated crop and precedes class symbol.

Example: iG1 - irrigated barley.

Note: Refer to Fallow, Idle, and Abandoned for special uses of "i".

(n) - DRY FARM

Indicates a dry farmed crop and precedes class symbol.

Example: nG1 - dry farmed barley.

(S) - SEED CROP

Indicates any crop grown for seed and is used following crop symbol.

Example: iPl-S - irrigated alfalfa seed crop.

(Y) - YOUNG NON-BEARING ORCHARDS AND VINEYARDS

Follows crop symbol.

Example: iC3-Y - young non-bearing irrigated oranges.

(A) - ABANDONED ORCHARDS AND VINEYARDS

Trees or vines must be in such a condition that renewal of cultural practices would restore economic production.

Indicated by (A) following crop symbol.

Example: iDl-A - indicates an apple orchard previously irrigated but now abandoned.

(F) - FALLOW LANDS

Must be tilled at time of survey.

- (1) If no crop residue is apparent or identifiable then the "F" symbol will follow the agricultural class symbol for the crop most representative of those grown in the area.

Example: 1TF - Fallow truck crop land (with facilities for irrigation)

- (2) If the crop residue is apparent and identifiable but is not from the current crop season covered by the survey then the field is considered fallow and mapped as the class of the crop residue.

Example: Surveyor found an old sugar beet residue not from current season. Land would be mapped 1FF.

- (3) However, if the crop residue is identifiable as that of a crop which was grown during the survey period, then map the field as though crop existed.

Example: 1T6 - Carrot residue from current growing season.

(Z) - RECLAMATION

Land being leached for the removal of harmful salts. This symbol will be used following either the "Idle" symbol or symbols of crops grown as a step in the reclamation process.

Examples: 1I2-Z, 1R-Z

(M) - MILITARY AREAS

Indicates lands owned or controlled by the military and is used following the land use symbol.

Example: 1F1-M - irrigated cotton within a military area.

(B) - BURNED OVER AREAS (not mapped unless specified)

Indicated by "B". The type and density of natural cover destroyed by fire is obtained by examination of aerial photo.

Example: NV2-B

(P) - PARKS

Indicates all types of parks, both public and private and is used following the land use symbol.

Example: 1S4-P - irrigated land area within a park.

(X) - PARTIALLY IRRIGATED CROPS

Crops irrigated for only part of their normal irrigation season.

Example: 1P3-X - partially irrigated mixed pasture.

(a,b,c,d) - GROWING SEASON

Indicated by appropriate symbol following crop symbol:
"a" - Spring; "b" - Summer; "c" - Fall; "d" - Winter
Example: 1T12-d - Winter potatoes; 1T12-a - Spring potatoes

(fraction) - INTERCROPPING

Indicated by a fractional symbol. The crop symbol appearing first in order in the preceding legend will be mapped in the numerator.

Exception: When orchard or vineyard is intercropped with some other crop class, the orchard or vineyard symbol will appear in the numerator.

Examples: $\frac{1D5}{G1}$ Peaches intercropped with barley $\frac{1D5}{D13}$ Walnuts intercropped with peaches

(percentages) - MIXED LAND USE

Indicated by percentages following land use symbols. No more than 3 symbols are to be used in describing the area.

Example: 1D5 - 40
NV - 20
UC32 - 40

For additional information, refer to "Additional Symbols" on page 9 of the discussion of the land use legend.

<u>Source of Irrigation Water</u>	<u>Pump</u>	<u>Gravity</u>
Natural Stream
Drain
Well
Other sources including lake, pond, reservoir, and oxbow

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES

LAND CLASSIFICATION STANDARDS

Land :	Characteristics
Class :	

Irrigable Lands

- V Smooth lying valley lands with slopes up to 6 per cent in general gradient, in reasonably large-sized bodies sloping in the same plane; or slightly undulating lands which are less than 4 per cent in general gradient. The soils have medium to deep effective root zones, are permeable throughout, and free of salinity, alkalinity, rock or other conditions limiting crop adaptability of the land. These lands are suitable for all climatically adapted crops.
- Vw Similar in all respects to Class V, except for the present condition of a high water table, which in effect limits the crop adaptability of these lands to pasture crops. Drainage and a change in irrigation practice would be required to affect the crop adaptability.
- Vs Similar in all respects to Class V, except for the presence of saline and alkaline salts, which limits the present adaptability of these lands to crops tolerant to such conditions. The presence of salts within the soil generally indicates poor drainage and a medium to high water table. Reclamation of these lands will involve drainage and the application of additional water over and above crop requirements in order to leach out the harmful salts.
- Vh Similar in all respects to Class V, except for having very heavy textures, which makes these lands best suited for the production of shallow-rooted crops such as rice and pasture.
- VI Similar in all respects to Class V, except for having fairly coarse textures and low moisture-holding capacities, which in general make these lands unsuited for the production of shallow-rooted crops because of the frequency of irrigations required to supply the water needs of such crops.
- Vp Similar in all respects to Class V, except for depth of the effective root zone, which limits use of these lands to shallow-rooted crops, such as irrigated grain and pasture.
- Vr Similar in all respects to Class V, except for the presence of rock on the surface or within the plow zone in sufficient quantity to prevent use of the land for cultivated crops.
- Vhs Similar in all respects to Class V, except for the limitations set forth for Classes Vh and Vs, which makes these lands best suited for the production of shallow-rooted, salt-tolerant crops.
- Vls Similar in all respects to Class V, except for the limitations set forth for Classes VI and Vs, which makes these lands best suited for the production of deep-rooted, salt-tolerant crops.

LAND CLASSIFICATION STANDARDS (Continued)

Land : Class :	Characteristics
Vps	Similar in all respects to Class V, except for the limitations set forth for Classes Vp and Vs, which restrict the crop adaptability of these lands to shallow-rooted, salt-tolerant crops.
Vpr	Similar in all respects to Class V, except for the limitations set forth for Classes Vp and Vr, which restrict the crop adaptability of these lands to noncultivated crops.
Vrl	Similar in all respects to Class V, except for the limitations set forth for Classes Vr and Vl.
H	Rolling and undulating lands with slopes up to a maximum of 20 per cent for rolling large-sized bodies sloping in the same plane; and grading down to a maximum slope of less than 12 per cent for undulating lands. The soils are permeable, with medium to deep effective root zones, and are suitable for the production of all climatically adapted crops. The only limitation is that imposed by topographic conditions, which affect the ease of irrigation and the amount of these lands that may ultimately be developed for irrigation.
Hl	Similar in all respects to Class H, except for having fairly coarse textures and low moisture-holding capacities which in general makes these lands unsuited for the production of shallow-rooted crops because of the frequency of irrigations required to supply the water needs of such crops.
Hp	Similar in all respects to Class H, except for depth of the effective root zone, which limits use of these lands to shallow-rooted crops.
Hr	Similar in all respects to Class H, except for the presence of rock on the surface or within the plow zone in sufficient quantity to restrict use of the land to noncultivated crops.
Hpr	Similar in all respects to Class H, except for depth of the effective root zone and the presence of rock on the surface or within the root zone in sufficient quantity to restrict use of these lands to noncultivated crops.
Hrl	Similar in all respects to Class H, except for the limitations set forth for Classes Hr and Hl.
M	Similar in all respects to Class H, except for topographic limitations. These lands have smooth slopes up to 30 per cent in general gradient for large-sized bodies sloping in the same plane, and slopes up to 20 per cent for rougher and more undulating topography. These lands will probably never become as highly developed as other "H" classes of land.
Ml	Similar in all respects to Class M, except for having fairly coarse textures and low moisture-holding capacities which in general makes these lands unsuited for the production of shallow-rooted crops and presents a great erosion hazard.

LAND CLASSIFICATION STANDARDS (Continued)

Land :	Characteristics
Class :	
Mp	Similar in all respects to Class M, except for depth of the effective root zone, which limits use of these lands to shallow-rooted crops.
Mr	Similar in all respects to Class M, except for the presence of rock on the surface or within the plow zone in sufficient quantity to restrict use of these lands to noncultivated crops.
Mpr	Similar in all respects to Class M, except for depth of the effective root zone and the presence of rock on the surface or within the root zone, which limits use of these lands to noncultivated shallow-rooted crops.

URBAN AND RECREATIONAL LANDS

UD	The total area of cities, towns, and small communities presently used for residential, commercial, recreational and industrial purposes.
U	Potential future urban areas which probably will be devoted to intensive residential, commercial, recreational and industrial development. These lands are also classed according to the four major topographic classes used for the classification of irrigable lands, i.e., V, H, M, and N. These classes are used as a guide in applying appropriate percentage factors to determine the net developable acreage from the gross area.
SR	Existing and potential suburban residential areas which have a low population density. These lands are further subdivided into either a high or low water using category. This is indicated by a number in the symbol, i.e., SR-1 includes those lands where it is expected the entire area will be utilized for lawns, gardens, small orchards, etc., and has a high water use. SR-2 indicates lands where a large percentage of the area is expected to be non-water using, hence an area of low water use. All the SR lands are also classed according to the four major topographic classes used for the classification of irrigable lands, i.e., V, H, M, and N.
AR	Existing and potential areas of a combination agricultural and residential class which includes small acreages of agriculture together with residences, and from which some agricultural income is derived. The average number of acres per residence is indicated by a number in the symbol. These lands are also classified according to the standards for irrigable lands which indicate their suitability for various types of agriculture.
RR	Existing and potential permanent and summer home tracts within a primarily recreational area. The estimated number of houses, under conditions of full development, is indicated by a number in the symbol, i.e., RR-3 is suitable for three houses per acre.

LAND CLASSIFICATION STANDARDS (Continued)

Land : Class :	Characteristics
RC	Existing and potential commercial areas which occur within a primarily recreational area and which include motels, resorts, hotels, stores, etc.
RT	Existing and potential camp and trailer sites within a primarily recreational area.
P	Existing and potential county, state, and federal parks, racetracks, fairgrounds, and other very low water using areas.

MISCELLANEOUS CLASSES

F	Presently forested lands, or lands subject to forest management, which meet the requirements for irrigable land but which, because of climatic conditions and physiographic position, are better suited for timber production or some type of forest management program rather than for irrigated agriculture.
Va	Smooth lying valley lands which are affected by such heavy concentrations of salts that further detailed studies would be required to determine the feasibility of reclaiming these lands for irrigated agriculture.
Vm	Swamp and marsh lands which usually support a heavy growth of phreatophytes and are covered by water most of the time.
N	Includes all lands which fail to meet the requirements of the above classes.

C. ECONOMIC TABLES

The tables in this section present the bases for the economic study results reported in the body of the report. The following will clarify aspects of these tables:

- Capital costs for the first five years of Total Energy Recovery System for Agribusiness are based on most recent published data updated to 1978 and 1977/1978 budget quotations from suppliers, adjusted to Lake County using commonly available indices. The capital costs presented in Table C-1 reflect an assumed basic inflation rate of six percent per year and are rounded to the nearest one thousand dollars. Land and electrical capital costs are included in "Site Work". Contingency is defined as additional unidentified project costs expected to be required and fully spent; this is a standard engineering estimation procedure.
- Table C-2 presents the operating bases for the site specific 1978 TERSA. The abbreviations for Labor, Operation, and Maintenance introduced here are utilized in Table C-3.
- TERSA five year operating figures based on earlier economic tables are reported in Table C-3. This table is rounded to the nearest one hundred dollars, indicates a basic yearly inflation of six percent, assumes a starting labor salary of four dollars per hour to reflect the requirement for semi-skilled laborers, and includes salary for an overall project manager.
- Table C-4 presents an economic summary indicating discounted cash flow rate of return on investment based on fifty percent of net remaining after taxes.

TABLE C-1
(Sheet 1 of 5)

YEAR 1 TERSA CAPITAL COST SUMMARY
MT. KONOCTI-THURSTON LAKE

<u>Item</u>	<u>Quantity</u>	<u>Basis</u>	<u>Total Cost</u>
Site Work	Lump Sum	\$20,000	\$ 20,000
Hot Water System			
• Wells	2	\$25,000 each	\$ 50,000
• Piping, Valves, Appurtenances	Lump Sum	\$70,000	\$ 70,000
• Pumps, Motors, Appurtenances			
• Heat Exchangers	2	\$20,000 each	\$ 40,000
Irrigation Water System			
o Wells	1	\$10,000	\$ 10,000
o Piping, Valves, Appurtenances	Lump Sum	\$20,000	\$ 20,000
o Pumps, Motors, Appurtenances			
Greenhouses, Complete	10 @ 3720 sq ft	\$ 5.10/sq ft	\$190,000
Prawn Ponds, Complete	-	-	-
Biogas System, Complete	-	-	-
Process Heat Facilities	-	-	-
Other Facilities	1 Trailer	\$ 5,000	\$ 5,000
Miscellaneous Costs	Lump Sum	\$35,000	\$ 35,000
Subtotal			\$440,000
+15% Contingency			+\$ 66,000
TOTAL			<u>\$506,000</u>

TABLE C-1
(Sheet 2 of 5)

YEAR 2 TERSA CAPITAL COST SUMMARY
MT. KONOCTI-THURSTON LAKE

Item	Quantity	Basis	Total Cost
Site Work	Lump Sum	\$ 5,000	\$ 5,000
Hot Water System			
• Wells	-	-	-
• Piping, Valves, Appurtenances	Lump Sum	\$11,000	\$ 11,000
• Pumps, Motors, Appurtenances	-	-	-
• Heat Exchangers	-	-	-
Irrigation Water System			
• Wells	-	-	-
• Piping, Valves, Appurtenances	Lump Sum	\$ 5,000	\$ 5,000
• Pumps, Motors, Appurtenances	-	-	-
Greenhouses, Complete	10 @ 3720 sq ft	\$ 5.41/sq ft	\$201,000
Prawn Ponds, Complete	2 @ 1/2 acre	\$ 5,000/acre	\$ 5,000
Biogas System, Complete	-	-	-
Process Heat Facilities	-	-	-
Other Facilities	-	-	-
Miscellaneous Costs	Lump Sum	\$ 5,000	\$ 5,000
Subtotal			\$232,000
+15% Contingency			+\$ 35,000
TOTAL			<u>\$267,000</u>

TABLE C-1
(Sheet 3 of 5)

YEAR 3 TERSA CAPITAL COST SUMMARY
MT. KONOCTI-THURSTON LAKE

<u>Item</u>	<u>Quantity</u>	<u>Basis</u>	<u>Total Cost</u>
Site Work	Lump Sum	\$ 6,000	\$ 6,000
Hot Water System			
• Wells	-	-	-
• Piping, Valves, Appurtenances	Lump Sum	\$11,000	\$ 11,000
• Pumps, Motors, Appurtenances	Lump Sum	\$ 5,000	\$ 5,000
• Heat Exchangers	-	-	-
Irrigation Water System			
• Wells	-	-	-
• Piping, Valves, Appurtenances	Lump Sum	\$ 6,000	\$ 6,000
• Pumps, Motors, Appurtenances	Lump Sum	\$ 2,000	\$ 2,000
Greenhouses, Complete	10 @ 3720 sq ft	\$ 5.73/sq ft	\$213,000
Prawn Ponds, Complete	2 @ 1/2 acre	\$ 6,000/acre	\$ 6,000
Biogas System, Complete	2 units	\$ 9,000/unit	\$ 18,000
Process Heat Facilities	Lump Sum	\$ 6,000	\$ 6,000
Other Facilities	Notes 1, 2	\$80,000	\$ 80,000
Miscellaneous Costs	Lump Sum	\$25,000	<u>\$ 25,000</u>
Subtotal			\$378,000
+15% Contingency			<u>+\$ 57,000</u>
TOTAL			<u>\$435,000</u>

Note 1 - Packing Shed and Office @ \$45,000

Note 2 - Refrigeration Facilities @ \$35,000

TABLE C-1
(Sheet 4 of 5)

YEAR 4 TERSA CAPITAL COST SUMMARY
MT. KONOCTI-THURSTON LAKE

Item	Quantity	Basis	Total Cost
Site Work	Lump Sum	\$25,000	\$ 25,000
Hot Water System			
• Wells	2	\$35,000 each	\$ 70,000
• Piping, Valves, Appurtenances	Lump Sum	\$80,000	\$ 80,000
• Pumps, Motors, Appurtenances			
• Heat Exchangers	1	\$25,000	\$ 25,000
Irrigation Water System			
• Wells	1	\$15,000	\$ 15,000
• Piping, Valves, Appurtenances	Lump Sum	\$25,000	\$ 25,000
• Pumps, Motors, Appurtenances			
Greenhouses, Complete	10 @ 3720 sq ft	\$ 6.07/sq ft	\$226,000
Prawn Ponds, Complete	2 @ 1/2 acre	\$ 6,000/acre	\$ 6,000
Biogas System, Complete	2 units	\$10,000/unit	\$ 20,000
Process Heat Facilities	Lump Sum	\$15,000	\$ 15,000
Other Facilities	Laboratory	\$25,000	\$ 25,000
Miscellaneous Costs	Lump Sum	\$30,000	\$ 30,000
Subtotal			\$562,000
+15% Contingency			<u>+\$ 84,000</u>
TOTAL			<u>\$646,000</u>

TABLE C-1
(Sheet 5 of 5)

YEAR 5 TERSA CAPITAL COST SUMMARY
MT. KONOCTI-THURSTON LAKE

Item	Quantity	Basis	Total Cost
Site Work	Lump Sum	\$10,000	\$ 10,000
Hot Water System			
• Wells	-	-	-
• Piping, Valves, Appurtenances	Lump Sum	\$10,000	\$ 10,000
• Pumps, Motors, Appurtenances	-	-	-
• Heat Exchangers	-	-	-
Irrigation Water System			
• Wells	-	-	-
• Piping, Valves, Appurtenances	Lump Sum	\$10,000	\$ 10,000
• Pumps, Motors, Appurtenances	-	-	-
Greenhouses, Complete	10 @ 3720 sq ft	\$ 6.44/sq ft	\$240,000
Prawn Ponds, Complete	2 @ 1/2 acre	\$ 6,500/acre	\$ 13,000
Biogas System, Complete	2 units	\$11,000/unit	\$ 22,000
Process Heat Facilities	Lump Sum	\$15,000	\$ 15,000
Other Facilities	-	-	-
Miscellaneous Costs	Lump Sum	\$15,000	\$ 15,000
Subtotal			\$335,000
+15% Contingency			+\$ 50,000
TOTAL			<u>\$385,000</u>

TABLE C-2
TERSA 1978 OPERATING BASES
MT. KONOCTI-THURSTON LAKE

Site

- L+O+M*: 6% of Cumulative Capital Investment**

Hot Water System

- L+O+M: 4% of Cumulative Capital Investment**

Irrigation Water System

- L+O+M: 4% of Cumulative Capital Investment**

Greenhouses (One Annual Crop Each of Tomatoes and Cucumbers)

- Sales:
 - Tomatoes yield 6 pounds per square foot, FOB price \$0.50 per pound
 - Cucumbers yield 7 pounds per square foot, FOB price \$0.38 per pound
- Combined Crop Labor: 1/3 hour per square foot per year
- Combined Crop O+M: \$0.45 per square foot per year, including packing supplies

Prawn Ponds (One Equivalent Annual Crop)***

- Sales: yield 4500 pounds per acre per year, FOB price \$4.00 per pound
- Labor: 1250 hours per acre per year
- O+M: \$5000 per acre per year

Biogas System

- Labor: 250 hours per unit per year
- O+M: 2% of Cumulative Capital Investment**

Process Heat Facilities

- Labor: 20% of Cumulative Capital Investment**
- O+M: 2% of Cumulative Capital Investment**

Other Facilities

- L+O+M*: 6% of Cumulative Capital Investment**

Miscellaneous

- L+O+M*: add 15% each Cumulative Capital Investment** as contingency.

* Labor + Operation + Maintenance

** Based on initial value

*** Based on continuous operation

TABLE C-3
(Sheet 1 of 5)

YEAR 1 TERSA OPERATING FIGURES
MT. KONOCTI-THURSTON LAKE

<u>Item</u>	<u>Quantity</u>	<u>Labor Cost</u>	<u>L+O+M or O+M Cost</u>	<u>Gross Sales</u>	<u>Net</u>
Site	Lump Sum	-	\$ 1,200	-	\$ -1,200
Hot Water System	Lump Sum	-	\$ 6,400	-	\$ -6,400
Irrigation Water System	Lump Sum	-	\$ 1,200	-	\$ -1,200
Greenhouses:					
• Tomatoes (50% yield)	37,200 sq ft	\$24,800	\$ 8,400	\$55,800	\$ 22,600
• Cucumbers	-	-	-	-	-
Prawn Ponds	-	-	-	-	-
Biogas System	-	-	-	-	-
Process Heat Facilities	-	-	-	-	-
Other Facilities	Lump Sum	-	\$ 300	-	\$ -300
Miscellaneous	Lump Sum	-	\$ 2,100	-	\$ -2,100
Management	Lump Sum	<u>\$20,000</u>		-	<u>\$-20,000</u>
Subtotals		\$44,800	\$19,600		\$ -8,600
15% Contingency		\$ 6,700	\$ 2,900		<u>\$ -9,600</u>
Net					<u>\$-18,200</u>

TABLE C-3
(Sheet 2 of 5)

YEAR 2 TERSA OPERATING FIGURES
MT. KONOCTI-THURSTON LAKE

Item	Quantity	Labor Cost	L+O+M or O+M Cost	Gross Sales	Net
Site	Lump Sum	-	\$ 1,500	-	\$ -1,500
Hot Water System	Lump Sum	-	\$ 6,800	-	\$ -6,800
Irrigation Water System	Lump Sum	-	\$ 1,200	-	\$ -1,200
Greenhouses:					
• Tomatoes (100% yield)	74,400 sq ft	\$105,200	\$35,500	\$236,600	\$200,800
• Cucumbers (50% yield)	74,400 sq ft			\$104,900	
Prawn Ponds	1 acre	\$ 5,300	\$ 5,300	-	\$-10,600
Biogas System	-	-	-	-	-
Process Heat Facilities	-	-	-	-	-
Other Facilities	Lump Sum	-	\$ 300	-	\$ -300
Miscellaneous	Lump Sum	-	\$ 2,400	-	\$ -2,400
Management	Lump Sum		<u>\$22,000</u>	-	<u>\$-22,000</u>
Subtotals		\$132,500	\$53,000		\$156,000
15% Contingency		\$ 19,900	\$ 8,000		<u>\$-27,900</u>
Net					<u>\$128,100</u>

TABLE C-3
(Sheet 3 of 5)

YEAR 3 TERSA OPERATING FIGURES
MT. KONOCTI-THURSTON LAKE

<u>Item</u>	<u>Quantity</u>	<u>Labor Cost</u>	<u>L+O+M or O+M Cost</u>	<u>Gross Sales</u>	<u>Net</u>
Site	Lump Sum	-	\$ 1,900	-	\$ -1,900
Hot Water System	Lump Sum	-	\$ 7,500	-	\$ -7,500
Irrigation Water System	Lump Sum	-	\$ 1,500	-	\$ -1,500
Greenhouses:					
• Tomatoes (100% yield)	116,000 sq ft	\$167,200	\$58,700	\$376,200	\$483,800
• Cucumbers (100% yield)	116,000 sq ft			\$333,500	
Prawn Ponds (25% yield)	2 acres	\$ 11,200	\$11,200	\$ 9,500	\$ 12,900
Biogas System	2 units	\$ 2,200	400	-	\$ -2,600
Process Heat Facilities	Lump Sum	\$ 1,200	\$ 100	-	\$ -1,300
Other Facilities	Lump Sum	-	\$ 5,100	-	\$ -5,100
Miscellaneous	Lump Sum	-	\$ 3,900	-	\$ -3,900
Management	Lump Sum	<u>\$ 24,200</u>	<u> </u>	-	<u>\$-24,200</u>
Subtotals		\$206,000	\$90,300		\$422,900
15% Contingency		\$ 30,900	\$13,500		<u>\$-44,400</u>
Net					<u>\$378,500</u>

TABLE C-3
(Sheet 4 of 5)

YEAR 4 TERSA OPERATING FIGURES
MT. KONOCTI-THURSTON LAKE

Item	Quantity	Labor Cost	L+O+M or O+M Cost	Gross Sales	Net
Site	Lump Sum	-	\$ 3,400	-	\$ -3,400
Hot Water System	Lump Sum	-	\$ 14,500	-	\$-14,500
Irrigation Water System	Lump Sum	-	\$ 3,100	-	\$ -3,100
Greenhouses:					
• Tomatoes (100% yield)	148,800 sq ft	\$236,300	\$ 79,800	\$531,700	\$687,000
• Cucumbers (100% yield)	148,800 sq ft			\$471,400	
Prawn Ponds (50% yield)	3 acres	\$ 17,900	\$ 17,900	\$ 32,200	\$ -3,600
Biogas System	4 units	\$ 4,200	800	-	\$ -5,600
Process Heat Facilities	Lump Sum	\$ 4,200	\$ 400	-	\$ -4,600
Other Facilities	Lump Sum	-	\$ 6,600	-	\$ -6,600
Miscellaneous	Lump Sum	-	\$ 5,700	-	\$ -5,700
Management	Lump Sum	<u>\$ 26,600</u>		-	<u>\$-26,600</u>
Subtotals		\$289,800	\$132,200		\$613,300
15% Contingency		\$ 43,500	\$ 19,800		<u>\$-63,300</u>
Net					<u>\$550,000</u>

TABLE C-3
(Sheet 5 of 5)

YEAR 5 TERSA OPERATING FIGURES
MT. KONOCTI-THURSTON LAKE

<u>Item</u>	<u>Quantity</u>	<u>Labor Cost</u>	<u>L+O+M or O+M Cost</u>	<u>Gross Sales</u>	<u>Net</u>
Site	Lump Sum	-	\$ 4,000	-	\$ -4,000
Hot Water System	Lump Sum	-	\$ 14,900	-	\$-14,900
Irrigation Water System	Lump Sum	-	\$ 3,500	-	\$ -3,500
Greenhouses:					
• Tomatoes (100% yield)	186,000 sq ft	\$313,100	\$105,700	\$704,500	\$910,500
• Cucumbers (100% yield)	186,000 sq ft			\$624,700	
Prawn Ponds (75% yield)	4 acres	\$ 25,200	\$ 25,200	\$ 68,200	\$-17,800
Biogas System	6 units	\$ 7,600	\$ 1,200	-	\$ -8,800
Process Heat Facilities	Lump Sum	\$ 7,200	\$ 700	-	\$ -7,900
Other Facilities	Lump Sum	-	\$ 6,600	-	\$ -6,600
Miscellaneous	Lump Sum	-	\$ 6,600	-	\$ -6,600
Management	Lump Sum	<u>\$ 29,300</u>		-	<u>\$-29,300</u>
Subtotals		\$382,400	\$168,400		\$846,700
15% Contingency		\$ 54,400	\$ 25,300		<u>\$-82,700</u>
Net					<u>\$764,000</u>

TABLE C-4
TFRSA ECONOMIC SUMMARY
IN \$1000

NAME	1	2	3	4	5	6	7	8	9	10
CAPITAL INVEST.	506.0	267.0	435.0	646.0	385.0	0.0	0.0	0.0	0.0	0.0
NET CASH FLOW	-18.2	64.0	189.0	275.0	382.0	404.9	429.2	455.0	482.3	511.2
INVEST. FLOW	-524.2	-203.0	-246.0	-371.0	-3.0	404.9	429.2	455.0	482.3	511.2
RATE OF RETURN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.40	9.70
DISCOUNT AT 8%	-524.2	-188.0	-210.9	-294.5	-2.2	275.6	270.5	265.5	260.6	255.7
PRES. VAL AT 8%	2418.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISCOUNT AT 10%	-524.2	-184.5	-203.3	-278.7	-2.0	251.4	242.3	233.5	225.0	216.8
PRES. VAL AT 10%	1754.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISCOUNT AT 12%	-524.2	-181.3	-196.1	-264.1	-1.9	229.8	217.5	205.8	194.8	184.3
PRES. VAL AT 12%	1243.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NAME	11	12	13	14	15	16	17	18	19	20
CAPITAL INVEST.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NET CASH FLOW	541.9	574.4	608.8	645.4	684.1	725.1	768.7	814.8	863.7	915.5
INVEST. FLOW	541.9	574.4	608.8	645.4	684.1	725.1	768.7	814.8	863.7	915.5
RATE OF RETURN	12.70	14.80	16.50	17.70	18.70	19.40	20.00	20.50	20.90	21.30
DISCOUNT AT 8%	251.0	246.3	241.8	237.3	232.9	228.6	224.4	220.2	216.1	212.1
PRES. VAL AT 8%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISCOUNT AT 10%	208.9	201.3	194.0	186.9	180.1	173.6	167.3	161.2	155.3	149.7
PRES. VAL AT 10%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISCOUNT AT 12%	174.5	165.1	156.3	147.9	140.0	132.5	125.4	118.7	112.3	106.3
PRES. VAL AT 12%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

D. ACKNOWLEDGMENTS

Any report effort is the result of overall contributions of individuals and the responsible organization as a whole. Within the IECO organization, certain individuals have particularly made possible the realization of this report and their assistance is gratefully acknowledged:

- Ho M. Lee was responsible for the graphic presentation
- Nene Cabillan was in charge of manuscript preparation, assisted by Conchita C. Rocillo and Richard Whitman
- varied contributions were made by Jimmy Chang, John R. Fontenrose, Margarita Goskirk, Don Guisti, Linda Haggerston, Lee Hannah, Rose Imazumi, Dave Keck, Tina Pereira, Lou Pigott, Norm Rountree, Dev Singh, and Maddy Steele.