NON-ELECTRIC APPLICATION OF GEOTHERMAL RESOURCES
AT
DESERT HOT SPRINGS, CALIFORNIA

A DISCUSSION OF THE FINAL CONCLUSION OF AGRICULTURAL
AND
SPACE HEATING APPLICATIONS

SPEAKER

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AT
SACRAMENTO, CALIFORNIA
ON
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AGENDA FOR A PRESENTATION
TO THE
DEPARTMENT OF ENERGY

AT

SACRAMENTO
ON APRIL 28, 1978

OF

NON-ELECTRIC GEOTHERMAL PROJECT
AT
DESERT HOT SPRINGS

Subject	Speaker
Introduction	R. Oberstar, City of Desert Hot Springs
Overview of Project from Conception to Finalization	Y. Nakamura, J. P. L.
Agricultural Application	J. Bickerstaffe, Rogers Engineering Co.
Follow-on Project	J. Bickerstaffe, Rogers Engineering Co.
Resource Management	R. Anglin, J. P. L.
Contingency Planning	R. Anglin, J. P. L.
Future Plans of the City of Desert Hot Springs	C. Christensen, City of D. H. S.
Conclusion	Y. Nakamura, J. P. L.
Self Start Manual	Y. Nakamura, J. P. L.

ROGERS ENGINEERING CO., INC.
JOB NO. S-76023

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1.0 INTRODUCTION

This final discussion summarizes the investigation performed throughout the project on geothermal applications to agricultural operations, and the study work done on the suggested follow-on project.

The purpose of the studies was to determine whether an economically feasible project could be developed utilizing the geothermal aquifer for heating and cooling of a greenhouse complex, or the heating of a number of municipal buildings.

2.0 AGRICULTURE COMPLEX DESIGN

The choice of the product to be grown is of importance only in respect to the market potential for income generation. The market research which was conducted indicated that the European cucumber would be ideally suited to the study from production and market aspects. Tomatoes, roses and other cut flowers could also be considered, however, the time schedule for the project dictated that one choice be made and examined.

2.1 Greenhouse Design Criteria

2.2 The basic concept of a greehouse as originally developed in Europe is to collect the heat from the sun to provide an environment at a higher temperature than that normally found locally.

However, in Desert Hot Springs where high temperatures are experienced during the summer months, there will be a requirement to cool the greenhouse to provide the optimum growing environment for the European cucumbers.

2.3 The optimum parameters to be considered for growing European cucumbers are as follows:

Temperature range of 75°F to 90°F optimum 80°F

Humidity 85%

Minimum nighttime and winter temperatures 65°F

The outdoor temperature is 110°F average in the summer months in Desert Hot Springs, and the summer humidity is around 15 to 20% ambient. Therefore, the greenhouse will require cooling.

2.4 Nighttime and winter minimum temperature should not fall below 65°F inside the greenhouse or the crop will experience a slowdown in growth rate.

3.0 Greenhouse Construction

3.1 The current greenhouse production of European cucumbers is achieved in the following types of greenhouse construction, the Quonset type and Frame type, (see Figure 1). The Quonset type is ideal for a single unit "backyard" type operation. However, the Frame type can be conveniently linked together to form large area production facilities. For the purposes of this report, only the Frame type is considered. Methods used in the construction of Frame greenhouses are:

- Wood frame with polyethylene cover
- Metal frame with polyethylene cover
- Metal frame with glass panels
- Metal frame with fiberglass panels

The latter type is the most common and economic type in terms of longevity.

The height of the greenhouse side walls should be 8 ft. This will allow the plants to grow to a height which is workable for fruit collection without the use of ladders or platforms.

3.2 Current designs of a greenhouse usually include the following:

A cooling and humidification system and a heating system. The cooling is usually done by means of evaporative cooling which also adds humidity. The evaporative unit consists of a screen at one end of the building over which water is sprayed. At the other end of the building is placed an extraction fan which draws air across the screen and along the full length of the building interior and exhausts to the outside. Experience indicates that maximum building length be held up 100 to 125 feet for effective cooling using this method. At least one air change per minute is required in the greenhouse to obtain correct cooling by this method.

3.3 Calculations made for the Desert Hot Springs area indicate that the temperature inside the greenhouse is likely to be 90°F with 85% relative humidity using 2 changes per minute, when a coat of whitewash is applied to the greenhouse. The whitewash coat is applied to the outside of the greenhouse in the summer to reduce the heat gain from the sun to the greenhouse interior by reflecting a major portion of the sun's rays. This 90°F temperature condition is likely to occur for about 3 to 4 hours per day during the summer months, and is not likely to be detrimental to the cucumbers.

4.0 Basic Systems for Heating and Cooling

The geothermal reservoir temperatures are in the range of 90°F to 180°F. Though this is an ideal temperature range for heating and hot water usage, it is approximately 100°F too low for efficient (90-100%) mechanical operation of absorption type air conditioning system. To obtain units which are economically efficient, that is, reduce the size of the equipment and the initial capital cost, the temperature source would have to be in the 300°F range. The main load problem in Desert Hot Springs is cooling, and the greenhouse requires an exceptionally large amount of cooling because of the need to allow sunlight in for cucumber growth which generates heat, but requires the temperature to be controlled below ambient at the same time. The two recommended methods for heating and cooling the greenhouse are described below.

4.1 Heating Systems

Heating a greenhouse complex is not as difficult a problem as the cooling. The main design consideration is to ensure the introduction of the hot air at a low level between the rows of plants to allow the air to rise slowly. This method will reduce condensation build-up around the base of the plant stems which can cause stem rot.

4.1.1 One-Pass Heating System With Humidification

The one-pass heating system, shown on Figure 2, utilizes a heating coil in the first stage of the inlet air duct followed by a second stage consisting of a spray chamber for humidification and a third stage having a reheat coil. Calculations have shown that this method of adding heat and humidification will be the most economical method of providing the correct temperature and humidity conditions. The heating bills for this type of building are extremely high because of the tremendous exposed surface which has virtually no insulation value, and the high volume of air passing through to provide the minimum of one air change per minute. This is an ideal application of a resource like geothermal hot water, since the heating costs will be considerably lower than those experienced with oil or gas.

4.2 Cooling System

4.2.1 Evaporative Cooling System

An evaporative cooling system based on one air change through the building every two minutes is shown in Figure 3. This system is the best candidate from the economic viewpont and, is currently and successfully being used for cooling of greenhouses.

4.3 Other heating and cooling systems such as Recirculation Heating & Chilled Water Accumulation System were studied but rejected on a cost basis or other problems.

5.0 <u>Greenhouse Complex Arrangement</u>

5.1 General Arrangement

Figure 4 shows a greenhouse of approximately 2 acres which is a commercial production size installation capable of making a profit in production of European cucumbers.

A typical installation for a 2 acre production would probably consist of a series of greenhouses with 20' to 30' bays, 120' long, side by side, on a one acre lot contiguous to a similar arrangement on an adjoining acre. The two installations would have a conveyor system located between them to deliver harvested cucumbers into a packing plant located in a warehouse adjoining the greenhouse complex. A small office for dispatching and receiving would be located in the warehouse. Since the cucumbers would sometimes have to be stored awaiting transportation, the warehouse would include a cold storage room cooled to 55 to 55°F.

6.0 <u>Planting Systems</u>

6.1 The choice of planting systems can be natural or hydroponic.

6.2 The natural system consists of placing plants in a bed of sand and soil mixture with drip irrigation and is considered the basic and most economical system for the Desert Hot Springs application. The plants can be laid out on rows of two abreast, 24 inches apart, on 18 inches spacing with 4.5' aisles between the rows. Figure 5 shows a typical layout of cucumber plants.

6.3 The soil at Desert Hot Springs should be ideal for growing the cucumbers and therefore a natural planting system with drip irrigation should be sufficient.

7.0 Production Rate

7.1 Plant density is such that typical annual yields are 15 lbs. per plant per crop, or 240,000 lbs. per acre. Three crops-plus per year are possible and are being currently achieved in the USA which translates to annual production of approximately 240 tons from a 2 acre complex. At the present time, about 70 acres of greenhouse production is devoted to cucumbers in the United States.

7.2 The greenhouse complex under study can grow a maximum of 825 plants per module. A module equals 30' by 120' of enclosed greenhouse area.

Each module would be harvested for 12 weeks, then plants would be chopped down, the beds resowed and a new harvest started. Figure 6 shows the planting, harvest and resowing schedule.

Based on this schedule the annual production was calculated and found to be approximtely 1 million lbs/year, allowing for a 10% loss due to damage, or insufficient quality to total yearly production is approximately 900,000 lbs. for the 2 acres.

From data gathered by growers in other areas it has been determined that a good yield for this type of crop is 10,000 lbs./1,000 sq. ft./year. The complex in this study will produce 11,500 lbs./1,000 sq. ft./year.

8.0 Income Generated By Crop

8.1 Based on the 90% of total grown crop production it is estimated that an income of approximately $617,000 will be generated. This figure is based on the market price obtainable in the Los Angeles market during 1977, see Figure 7.

9.0 Fuel Costs

9.1 The heating system for this greenhouse complex design will be a geothermal hot water to air heat exchanger system. The system would use approximately 4,000 gpm of 110°F water. The gathering system for the heating would comprise 11 wells operating at 350 gpm/well.

9.2.1 An electric rate schedule was calculated for the Desert Hot Springs area. The rate was found to be $0.028/kWh for agricultural use based on the A-1 schedule of the Imperial Irrigation District (IID).

9.1.1 The annual cost for heating consists of the 11 well pumps and 33 air distribution fans (3 per module for 11 modules). The total cost was found to be $27,355 per year.

9.2 The cooling system is of the evaporation type as described earlier in paragraph 4.2.1. The cost of cooling comprises the kWh costs of operating the air distribution fans and the water spray pumps. These costs were found to be $29,778/year.

10.0 Annual Labor Charges

Based on information obtained from the University of California Agricultural Extension and field observation of a cucumber facility near San Diego, it was estimated that 11 full-time employees would be required to operate the two acre greenhouse complex. The total yearly salary including overhead was calculated to be $114,000 approximately.

11.0 Fixed Annual Costs

11.1 The fixed annual costs cover the necessary work and materials required to enable production of the cucumbers. This includes tilling, planting, sterilization of the soil, fertilization, pest control, purchase of plants, planting, pruning and hanging. The total cost per year for the above on a 2 acre complex is estimated to be $23,170.

11.2 The breakdown of the fixed costs is shown on Table 1

12.0 Capital Investment

12.1 The capital investment covers the cost of constructing the complex and the purchase of the land. The total cost of construction is estimated to be $932,657, a breakdown of the construction cost is shown on Figure 8.

13.0 Return on Initial Investment

13.1 Calculations were made at a 10% and 12% interest rate to provide for the Return on Initial Investment figure. The interest rates were chosen as realistic rates in the current money market.

13.2 The 10% rate yielded a return of $191,568/year and the 12% rate yielded a $204,345/year return.

14.0 Net Profit

14.1 The profit for the greenhouse complex will consist of the remaining funds available from the annual income after all debit charges are substracted from it.

14.2 Table 2 summarizes all the cost factors for the 2 acre all year round production of European cucumbers.

14.3 Table 2 shows the net profit to be:

a) for 10% rate of interest on capital Profit = 180,281

b) for 12% rate of interest on capital Profit = 167,504

15.0 Overall Cost Study for a 2 Acre Complex with a Reduced Growing Period

15.1 A study was undertaken to determine if a reduced growing period affects the overall profitability of the 2 acre complex.

15.2 Table 3 summarizes the cost factors for this study and as can be seen the effect of reduced growth is detrimental to the profit picture.

16.0 Fossil Fuel Displacement

16.1 A two acre greenhouse complex operating on an all year round production schedule would consume approximately 19,000 gallons of #2 fuel oil per month. The total cost for the heating season of 3 months duration would be $21,500.

As can be seen from the above the costs are approximately equal and therefore no net savings in energy will result.

However the energy use for the geothermal has been changed from oil to electrical without any change in price, resulting in a savings of oil and an environmental savings by not having to burn the oil.

Conclusion

The two acre greenhouse complex has a viable economic possibility in the Desert Hot Springs area when operated over a 12 months period for production of European cucumbers. Other products could also be tried, however until the economics are calculated the viability is unkown.

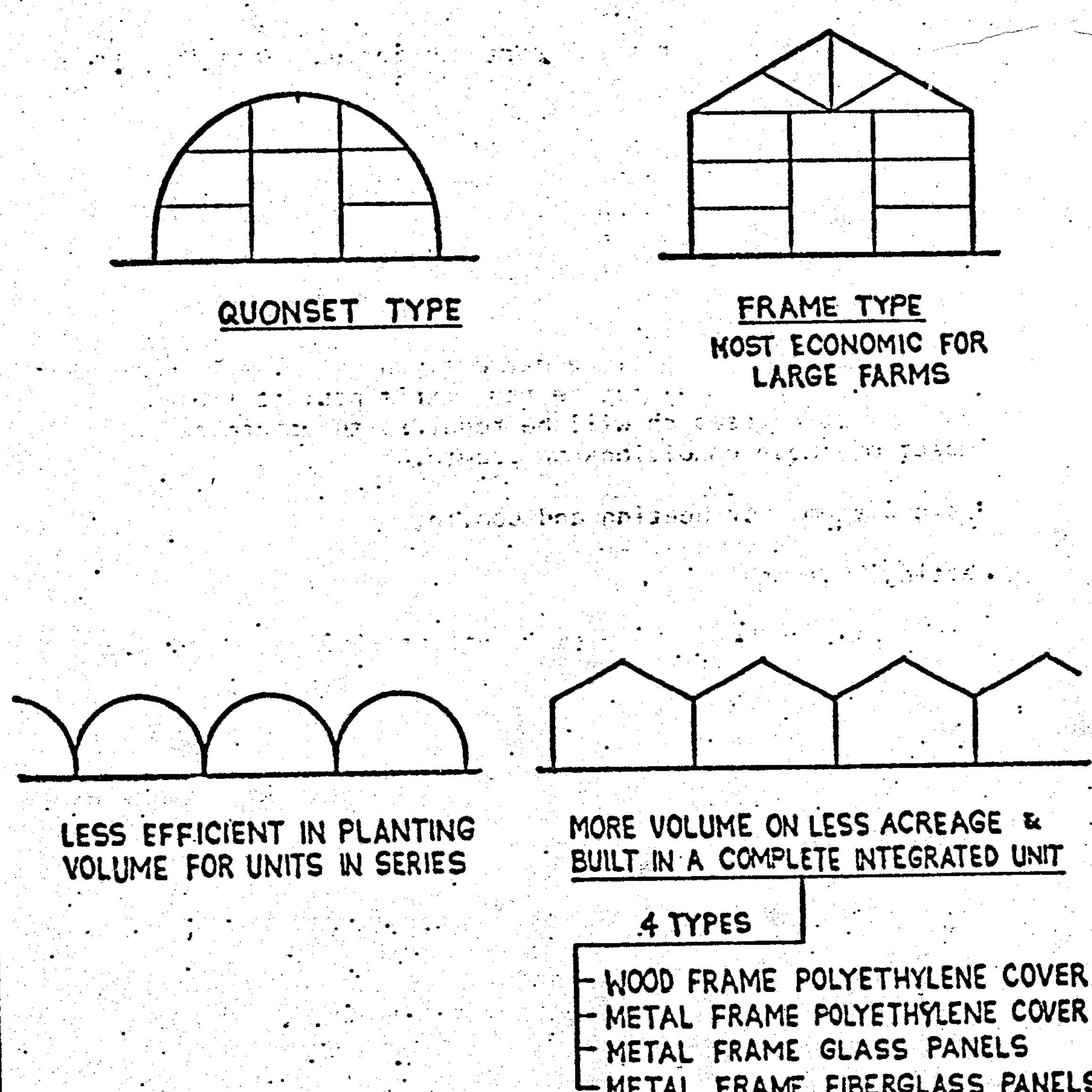
In view of the fact that the 2 acre complex is economically viable for an all year round growing season it becomes obvious that a larger facility would also be economically viable. The reasons for this are as follows: i) the labor force required is directly proportional to the size of the complex, ii) the heating and cooling costs are directly proportional also, and iii) the production rate is directly proportional, and it follows that if 2 acres is economic then so will four, ten or any size complex. The limiting factor would ultimately be market saturation which would decrease the price of the product in the market place.

The reduced growing season study revealed that the operation would not be economically feasible for the 2 acre complex.

Given the conditions for the 2 acre reduced growing season, it is reasonable to assume, based on the three factors given above for the year round production that any larger size unit will be ratioed accordingly.

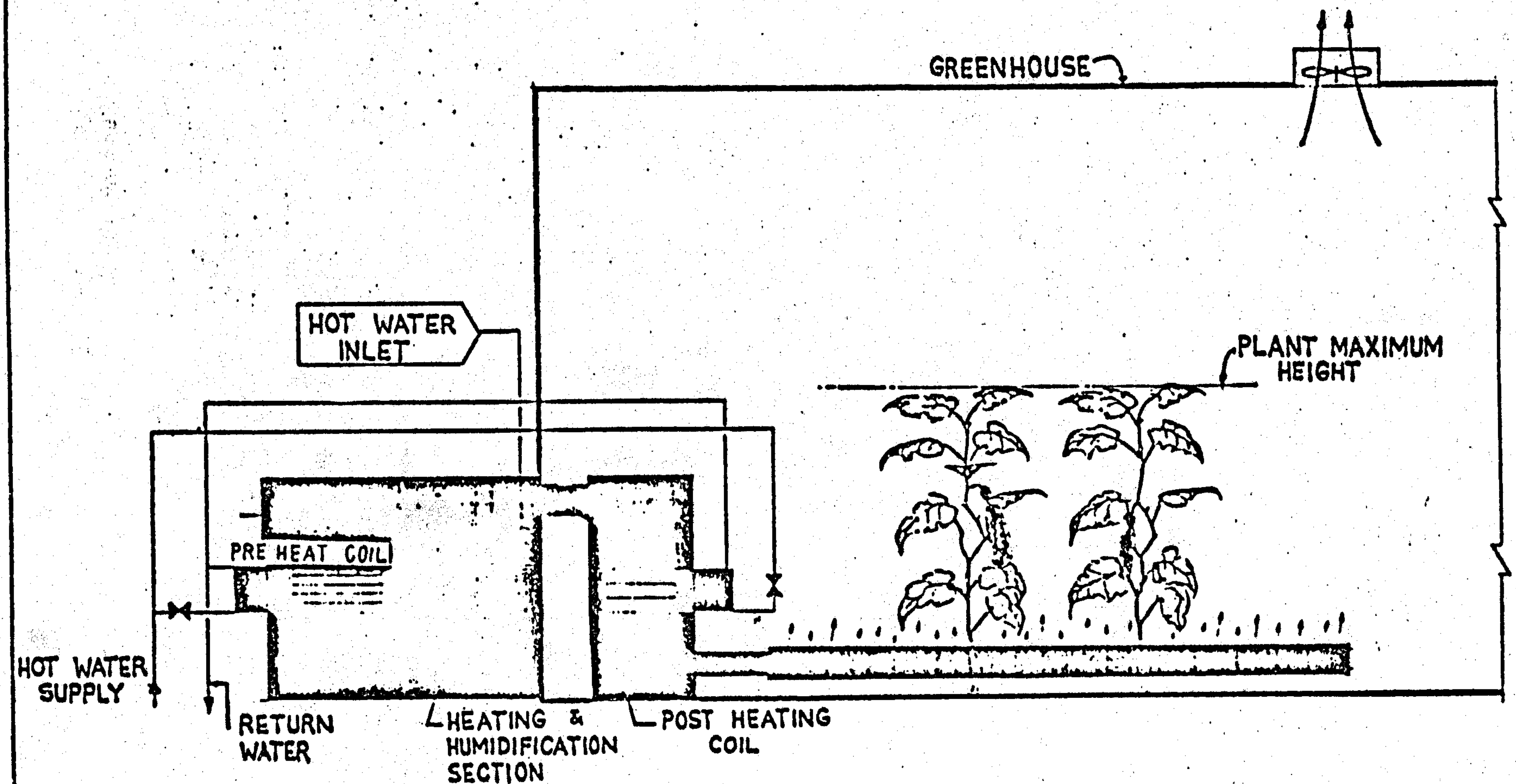
The conclusion of the report with reference to geothermal application for greenhouse operation with a reduced growing season is that it is not an economic operation and further that the additional expenditure for cooling during the hot summer months does not jeopardize the economic viability of year round operation of a greenhouse complex.

The market potential for the European cucumber appears to be expanding with a growing public awareness of the quality of the product. The current markets are the Los Angeles and San Francisco areas. However, with the ever-increasing costs of fuel for greenhouse conditioning, the chances of development of a competitive market in East Coast cities is increasing, especially in the winter months.



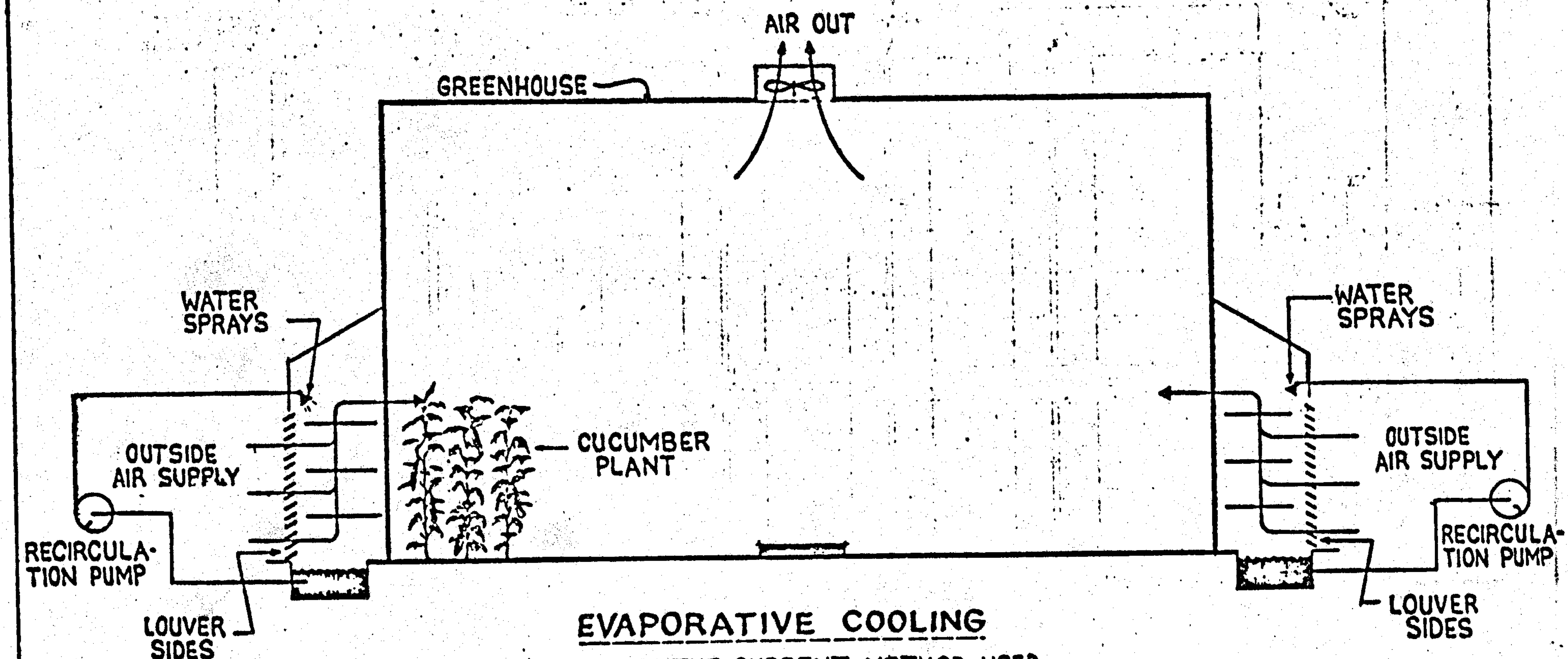
ALTERNATE BUILDING TYPES

FIG. 1



HEATER ON ONE PASS BASIS WITH HUMIDIFICATION

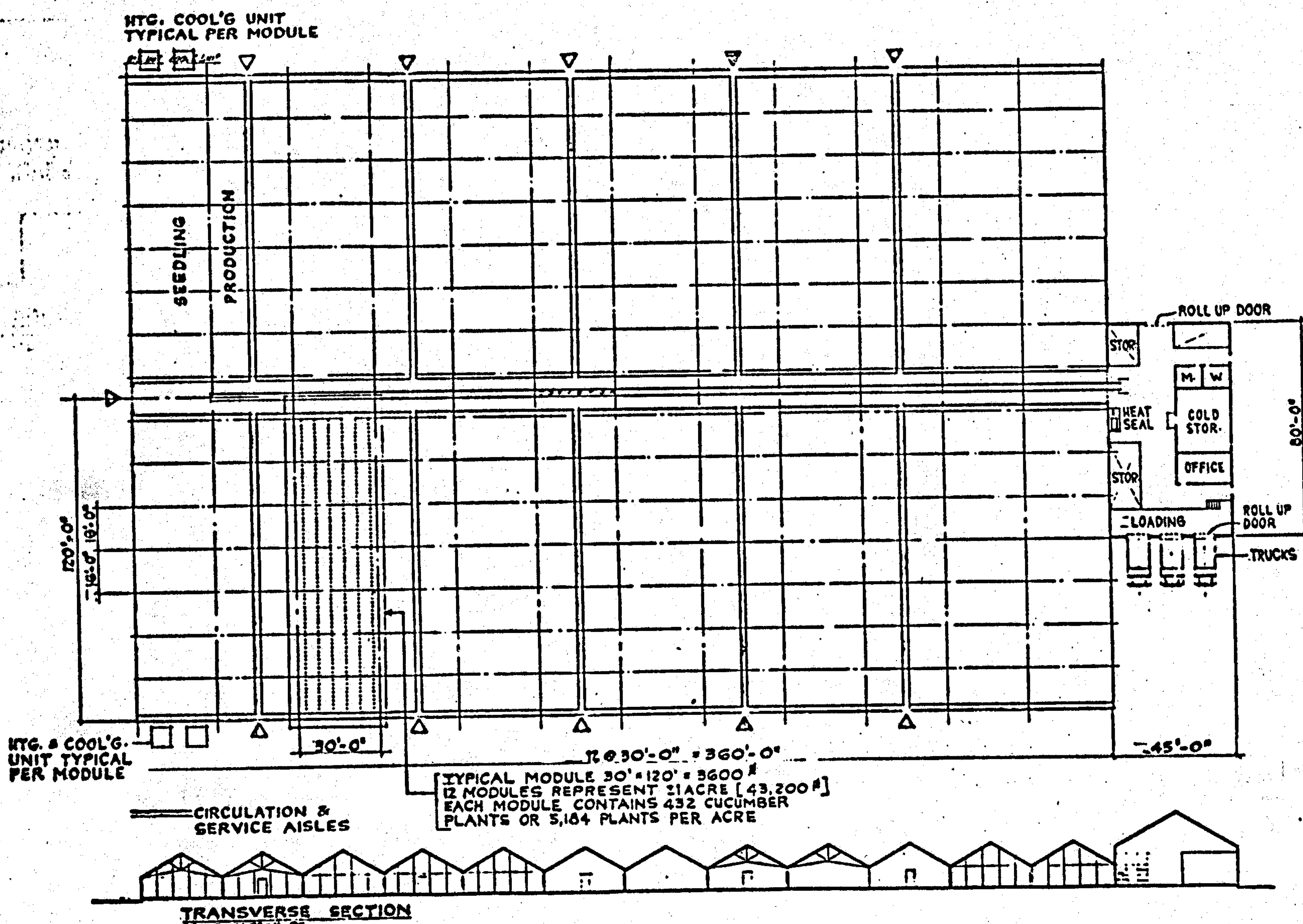
FIG. 2



EVAPORATIVE COOLING

THIS IS THE CURRENT METHOD USED IN OTHER AREAS TO COOL AND HUMIDITY THE GREENHOUSE INTERIOR.

FIG. 3



PROPOSED GREENHOUSE & WAREHOUSE DEVELOPMENT
DESERT HOT SPRINGS GEOTHERMAL PROJECT 5-76023

FIG 4

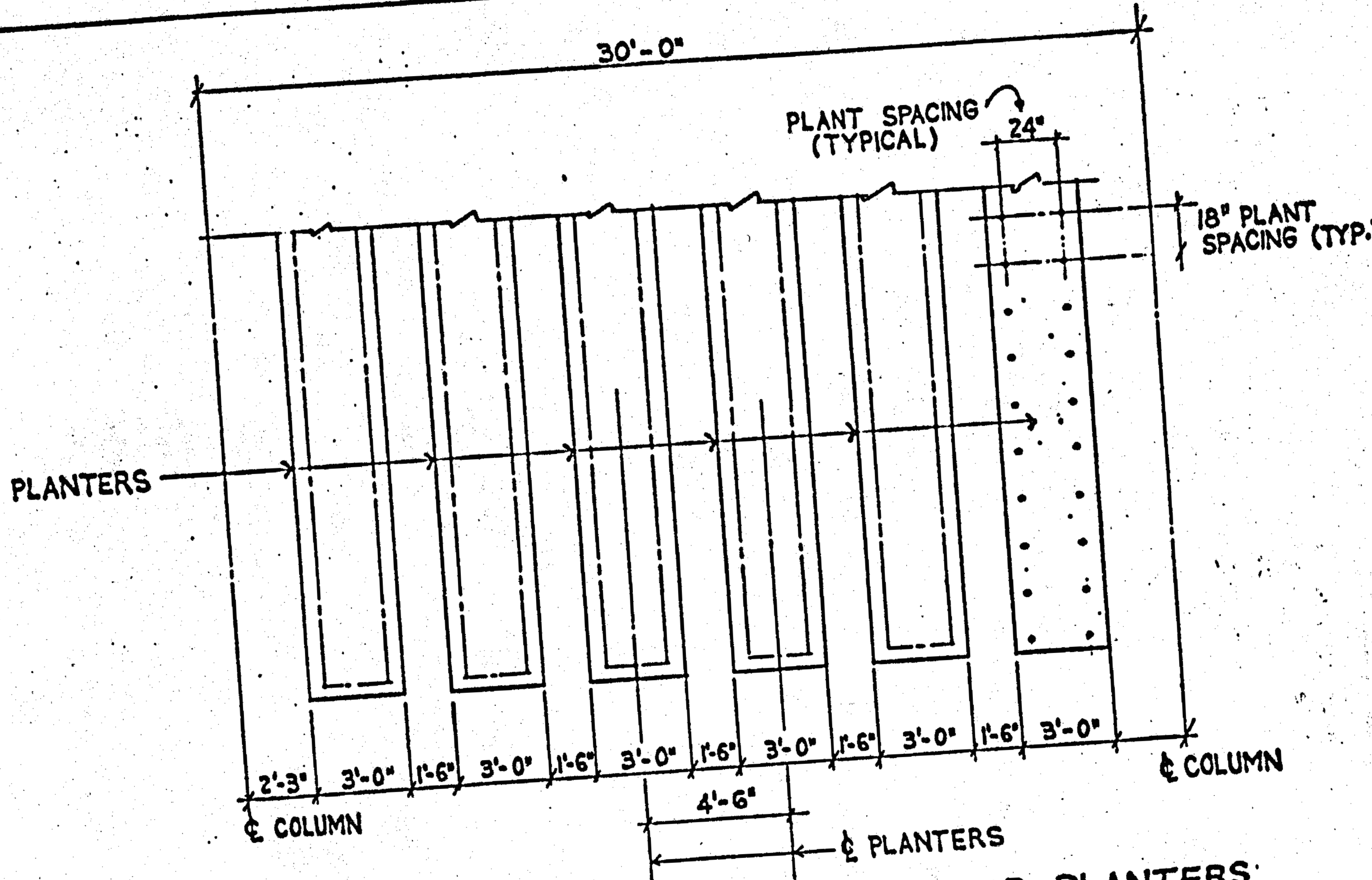


FIG. 5

TYPICAL LAYOUT OF CUCUMBER PLANTERS

GREENHOUSE PRODUCTION PATTERN FOR UNIFORM ANNUAL CROP DISTRIBUTION.

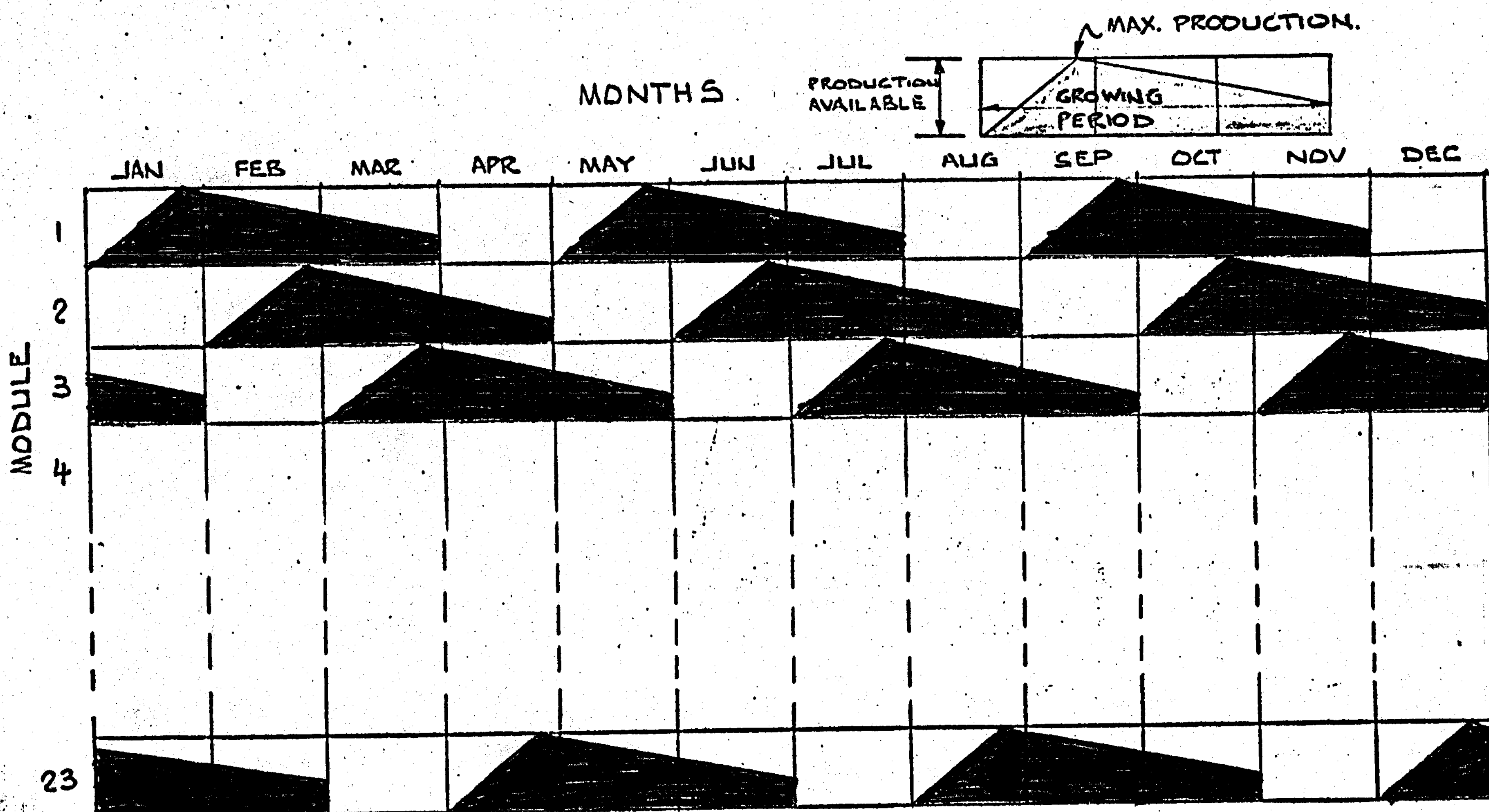
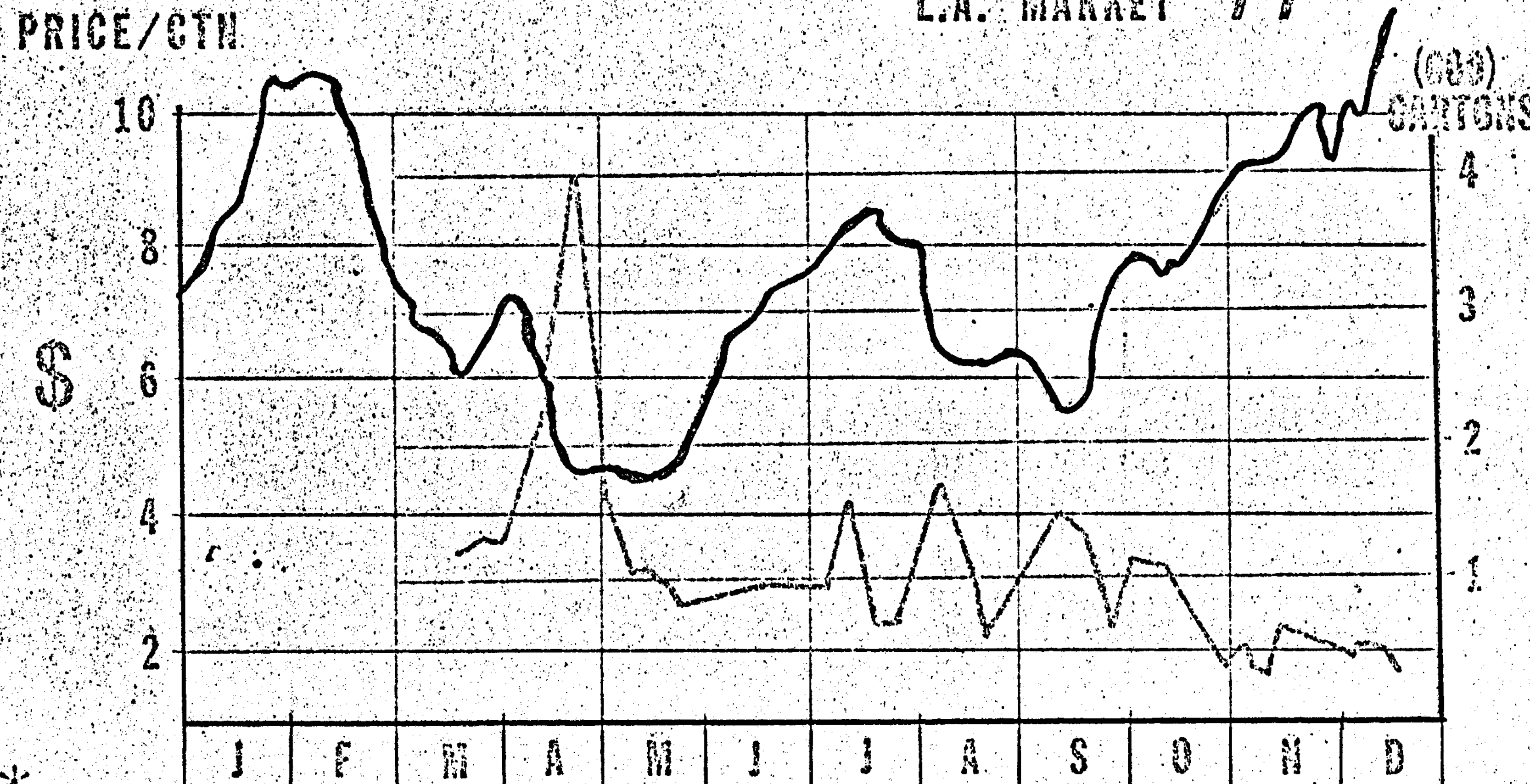


FIG. 6

GREENHOUSE CUCUMBERS

WHOLESALE MARKET PRICE*

L.A. MARKET '77



* BASED ON 14-18 COUNT CARTON

	J	F	M	A	M	J	J	A	S	O	N	D
AVE PRICE PER CARTON ¢	9.25	9.25	7.25	5.65	5.10	6.75	7.80	7.25	7.10	8.22	9.27	10.40
AVE. PRICE PER LB ¢/12	0.77	0.77	0.604	0.47	0.425	0.56	0.65	0.604	0.59	0.685	0.77	0.866

FIGURE 7

MODIFIED TABLE 3/30/78. (per Rogers Eng. Co & U.C. Riverside)

TABLE 1

FIXED COSTS

CUCUMBERS: Sample cultural costs for greenhouse production, 1974. Based on soil bed culture, 3 crops per year labor @ 4.35 /hour, plant density 825 Plants / module

Per 2 acres growing space / crop.

Cultural operation	Labor Hours	Labor Cost	Material and equipment Item	Material and equipment Cost	Total cost
				$	$
Tillage	156				
Pre-Plant Fertilization.	48		Fuel and repairs	234	
Media sterilization	35		Fumigant and fuel	120	
Planting	315		Plants,	700	
Support strings	500		String,	1860	
Prune and train	1750		Clips,	897	
Fertilizer and irrigation	180		Fertilizer materials	400	
			Water,	1799	
Pest control	535		Pest control chemicals	504	
Fuel					
Power					
Plant removal	310				
Total preharvest costs	3829	16,656		6514	23,170

Total Annual Cost = \$23170 × 3 = \$69510

ROGERS ENGINEERING CO., INC.
CONSULTING ENGINEERS

COST ESTIMATE

JOB NO. S76023
FOR
PROJECT
DWG. NO.

ITEM TITLE Desert Hot Springs Greenhouse Complex & Office/Dispatch area

DATE 1/24/78 REVISED
SHEET OF
PREPARED BY JAB CHECKED BY
PRELIM. ☐ % FINAL ☐

ACCOUNT NO.	DESCRIPTION	QUAN.	UNIT	UNIT LABOR	LABOR	UNIT MATERIAL	MATERIAL	OTHER	TOTAL
	SUMMARY SHEET								
	SHT 1. } OFFICE/DISPATCH								9532 00
	SHT 2. } OFFICE/DISPATCH								46057 00
	SHT 3. } OFFICE/DISPATCH								23882 00
	SHT 6 CIVIL/STRUCT. } GREENHOUSE BUILDING.								341700 00
	SHT 7. ELECT. } GREENHOUSE BUILDING.								12000 00
	SHT 8 MECHANICAL } GREENHOUSE BUILDING.								337620 00
									770791 00
	CONTRACTORS PROFIT 10%								77079
									847870
	CONTINGENCY 10%								84787
	TOTAL								932657

GE-001 SUB TOTAL

FIGURE 8

ALL YEAR PRODUCTION OF CUCUMBERS

TABLE 2

ITEM	COST ($)
INITIAL CAPITAL INVESTMENT	932,657
ANNUAL LABOR CHARGES	114,084
FUEL COSTS - HEATING	30,212
- COOLING	29,778
FIXED ANNUAL COSTS	69,510
RETURN ON INITIAL INVESTMENT @ 10%	191,568
@ 12%	204,345
ANNUAL INCOME	615,433
NET PROFIT @ 10% RATE OF RTN ON CAPITAL	180,281
@ 12% RATE OF RTN ON CAPITAL	167,504

NINE MONTH PRODUCTION OF CUCUMBERS

TABLE 3

ITEM	COST ($)
INITIAL CAPITAL INVESTMENT	932,657
ANNUAL LABOR CHARGES	114,084
FUEL COSTS - HEATING	30,212
- COOLING	18,432
FIXED ANNUAL COSTS	67,779
RETURN ON INITIAL INVESTMENT @ 10%	191,568
@ 12%	204,345
ANNUAL INCOME	442,237
NET PROFIT @ 10% RATE OF RTN ON CAPITAL	47,837
@ 12% RATE OF RTN ON CAPITAL	5,059

STUDY OF SUGGESTED FOLLOW-ON PROJECTS

1.0 CITY HALL HEATING SYSTEM

The selection made by the City Council for the final candidate system study for geothermal heat utilization was the heating of the City Hall at the City of Desert Hot Springs. Analysis of this candidate system disclosed several key points. City Hall is located near that portion of the geothermal aquifer which contains 90°F water. Since space heating and water heating require a minimum source temperature in the region of 150°F, the available 90°F source cannot be used. The nearest known geothermal source of 150°F would require the installation of approximately 1-1/2 miles of source pipeline.

Therefore, the system would require a minimum of two wells, one for production and the other for injection, plus installation of approximately three miles of pipeline and appropriate conversion equipment in City Hall. In view of the limited heating season and the low heating requirements of City Hall, it is obvious that a geothermal heating system for City Hall alone is not an economically viable project.

2.0 EXPANDED HEATING SYSTEM

Based on the above, the decision was made to consider what effect an additional heating load would have on the economics of the system.

This additional load was achieved by considering additions to the City Hall:

(a) Wardman Park - consisting of a swimming pool, recreation hall, Wardman Hall, and the Scout Hall

(b) Elementary School

(c) Library

(d) Provisions for the new proposed Community Center

Table 1 shows the heating load requirements for the proposed system.

The maximum heating load occurs during winter period, which is to be expected considering the climatic conditions of Desert Hot Springs. Unfortunately, this imbalance in annual resource utilization is not changed greatly by heating the swimming pool in the summer months. Without the possibility of air conditioning in the summer months, which is excluded by the limited resource temperature, there does not appear to be any way to achieve a uniform (or even close to uniform) annual load.

3.0 SYSTEM LAYOUT AND REQUIREMENTS

3.1 System Layout

Figure 1 shows a map of the Desert Hot Springs area with the indicated locations of the various city buildings and facilities in the network, as well as the estimated isotherm boundaries. Also shown on the map are the proposed locations of the source and injection wells.

The supply well could be located in the area adjacent to the junction of Pierson Boulevard and Miracle Hill Road, inside the 150°F isotherm. The supply pipeline would be laid underground, buried in sand, and would run from Miracle Hill Road down Pierson Boulevard to the corner of Pierson and Cactus Streets. At this junction the line would divide into two branches. One of the branches would run along Cactus Street to Eighth Street to provide the space heating for Wardman Park. The other branch would continue along Pierson Boulevard from Cactus Street to West Drive, before distributing to the City Hall, Library, Proposed Community Center, and Elementary School.

The return pipeline would follow the same route except that it would be connected to an injection well located at a suitable site between Palm Drive and Verbena in the 90°F isotherm. The above layout is proposed on the assumption that access to the locations for the wells and necessary right-of-ways are obtainable.

3.2 System Requirements

Based on data obtained from city officials at Desert Hot Springs, calculations were made to establish the average heating loads, equivalent geothermal flow rates, pipe sizes and pressure drops for the proposed network. The geothermal water flow requirement, based on a 150°F source and a 30°F temperature drop through the various heating devices, requires development of one production well and one injection well.

Based on the required geothermal flow rates shown in Table 1 and an assumed duty cycle for the various facilities in the network, an annual energy cost (i.e., pumping cost) could be calculated for the proposed network.

4.0 CONSTRUCTION COST

A construction cost estimate was made considering all the mechanical equipment, piping, valves, electrical equipment, excavation and backfill, and total labor costs for the installation of the system. Table 2 shows a summary of these costs. The total estimated construction cost for the complete installed and working system is approximately $250,000.

5.0 OPERATING COSTS

The normal operating cost for the existing heating systems is $3,930 per year (Table 1). The geothermal heating system would require an energy input for pumping which is calculated to be approximately 39,430 kWh per year. This results in an annual pumping cost of $1,104, based on average electric power costs of 28 mills per kWh.

As can be seen from the above figures, the annual operating expense for the proposed geothermal system represents a substantial savings over the present system. These figures, however, represent only the annual operating costs and do not include the required capitalization for the geothermal system (versus no capitalization for the current system).

TABLE 3

COMPARISON ON BASIS

OF

PRESENT WORTH

OF

MUNICIPAL HEATING SYSTEM

Capital Expenditure	$251,780
Present Worth of Existing System Fuel Costs	$ 42,735
Present Worth of New System Pumping Costs	$ 12,005
Present Worth of Energy Savings	$ 30,730
Present Worth of Maintenance Costs	$ 9,458
Present Worth of Straight Line Depreciation	$ 54,135
Present Worth of New Savings	-$176,373

6.0 CAPITALIZED COST ANALYSIS

The capitalized cost analysis can be considered from two different approaches: First, will the realized cost savings in annual operating expenses justify the required capital expense?; second, should the above premise prove false, how much capital expense would the annual savings justify in order to investigate the possibility of funding the remaining portion through EDA Public Works grants or other sources?

In order to address the first question, the following assumptions were made: A system life of 20 years, financing at 10%, straight-line depreciation and a 48% corporate tax rate. For these assumptions, the net annual cost of the initial $251,780 capital investment would be $23,531, far in excess of the $2,826 per year saved on operating costs. Thus, the geothermal heating network is clearly uneconomic if the entire cost of the capitalization must be incurred by the city.

In regard to the second question, the annual energy savings of $2,826 over the 20-year life of the project would justify an initial capital investment of only $30,225 (including the tax benefit from the depreciation of the city's portion of the investment). In other words, the city would have to secure a grant for approximately $222,000 before it would be an economic proposition for the city.

There are several important thoughts that are germane at this time. These deal with a number of tangible as well as intangible issues that have a direct bearing on the above analysis and any conclusions that might be drawn from the results. First, the assumption was made that no capital expense was required on the current heating system over the next 20 years! This is obviously very conservative and penalizes the geothermal system. Every dollar spent in the future for replacement of a portion of the current system has some present worth that can be directly subtracted from the required capital investment for the geothermal system.

A second important observation can be made regarding some very conservative assumptions about the future energy situation. The current heating system at Desert Hot Springs is primarily committed to natural gas (with the exception of electric heating at the elementary school). The previous analysis assumed no energy cost escalations for either natural gas or electric energy over the next 20 years, in spite of much recent talk of gas curtailment, gas deregulation (which could potentially double the cost of natural gas overnight), and the ultimate possibility that natural gas supplies will be exhausted in the foreseeable future.

In order to assess the impact that projected fuel escalation rates would have on the economic viability of the project, the analysis was repeated assuming various escalation rates between 0-10 percent per year. The results are shown plotted in Figure 3 as a function of the amount of capital the city could afford to spend versus the various escalation rates. Note that, for an assumed rate of 7 percent per year, the capital investment justified by the city has increased to $53,800. For the above analysis, both natural gas and electric energy rates were assumed to increase at the same rate, which probably again penalizes the geothermal system excessively. Another approach might be to escalate the natural gas cost at a more rapid rate than electric cost.

Finally, none of the above economic analysis considered any potential energy investment tax credits for which the new geothermal system might be eligible.

7.0 CONCLUSION

From the outset of the Desert Hot Springs study, certain facts were obvious in connection with a space conditioning network. Since the city is located in a desert locale, the air conditioning load is considerably higher than the space heating load. Thus, any space conditioning network there that cannot provide air conditioning (as was the case for Desert Hot Springs) is immediately at a distinct economic disadvantage due to the poor annual utilization factor. Also, for retrofit situations, a further economic disadvantage exists for the geothermal system since there is no capital cost associated with the existing system.

With this background, it comes as no surprise to find that a geothermal heating network for the aforementioned city facilities is not feasible based on straight economic considerations and fully financed by the City of Desert Hot Springs. However, there are numerous positive notes to be pointed out with respect to the proposed network.

In addition to displacing almost 145,000 equivalent kWh (natural gas and electric) of fossil fuel, the geothermal system provides a certain degree of energy independence, particularly with regard to natural gas. As was mentioned earlier, the future prospect of gas curtailment and/or deregulation could drastically alter the economic analysis previously presented in favor of the geothermal system.

As Figure 2 shows, the geothermal system is capable of supporting from $30,000 to $70,000 in capital investment, for energy cost escalation rates of 0-10 percent per year, respectively. Thus, if some source of funding, such as an EDA Public Works Grant or a DOE Program Opportunity Notice (PON) for a field experiment, could be secured for the remainder of the required $250,000 capital investment, the proposed system would be economically feasible. A PON for a field experiment could also be very helpful in locating a hotter isotherm closer to the proposed heating network. Over half of the total project cost was associated with the main supply line from the source well and the main return line back to the injection well.

TABLE 1

HEATING LOADS, REQUIREMENTS AND COSTS FOR THE PROPOSED HEATING NETWORK

BUILDING	HEAT LOAD REQUIRED (BTU/HR)	GEOTHERMAL FLOW REQ'T. (GPM)	CURRENT HEATING COST/YEAR ($)
WARDMAN HALL	499,500	33.3	840
RECREATION HALL *	101,400	6.7	100
SCOUT HALL *	166,500	11.1	179
ELEMENTARY SCHOOL	250,000	16.6	1584
CITY HALL	169,000	11.2	62
LIBRARY	136,600	9.1	62
COMMUNITY CENTER (FUTURE)	338,500	22.5	126
SWIMMING POOL *		50.0*	465
TOTAL FOR GIVEN YEAR		110.5 (w/o pool)	3418
TOTAL FOR RANDOM YEAR **		127.1 (w/o pool)	3930

* SUMMER LOAD ONLY, ALL OTHER LOADS ARE WINTER.

** INCLUDES A 15 PERCENT CONTINGENCY FACTOR TO EXTRAPOLATE FROM FIXED DATA FOR A SELECTED YEAR TO NOMINAL YEAR.

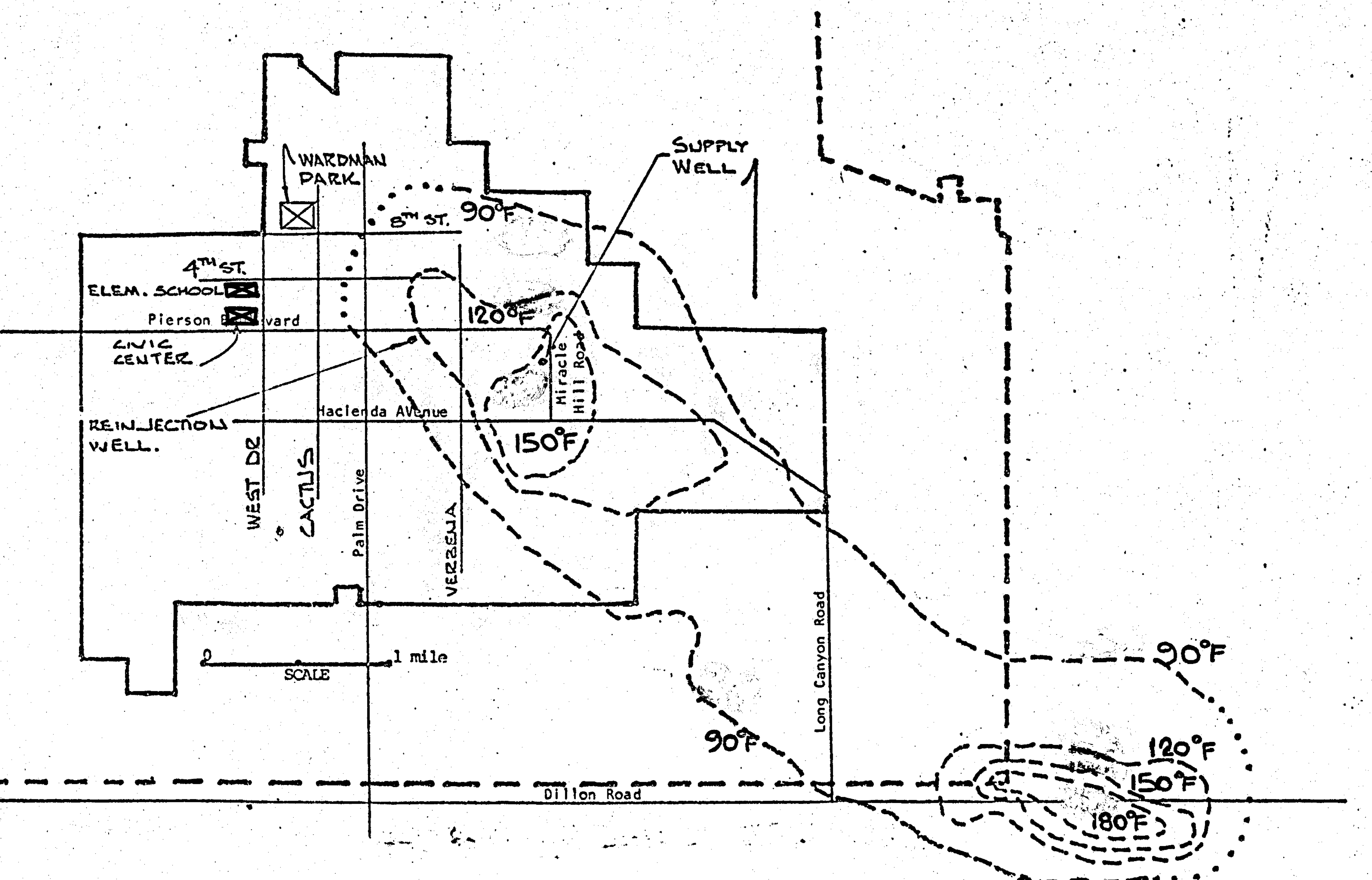


FIGURE 1. LOCATION OF BUILDINGS AND WELLS FOR SPACE HEATING SYSTEM.

TABLE 2

CAPITALIZATION COST SUMMARY

ITEM		REPAIRED CAP. INVEST. ($)
GATHERING AND REINJECTION SYSTEM		31,112
PIPELINE SYSTEM	- PIPING	170,427
	- VALVES	5,846
MECHANICAL EQUIPMENT		8,850
CIVIL ENGINEERING	- TRENCHING	5,143
	- BACKFILL	27,669
ELECTRICAL		2,733
TOTAL		$251,780

CAPITAL INVESTMENT JUSTIFIED BY ANNUAL ENERGY SAVINGS.

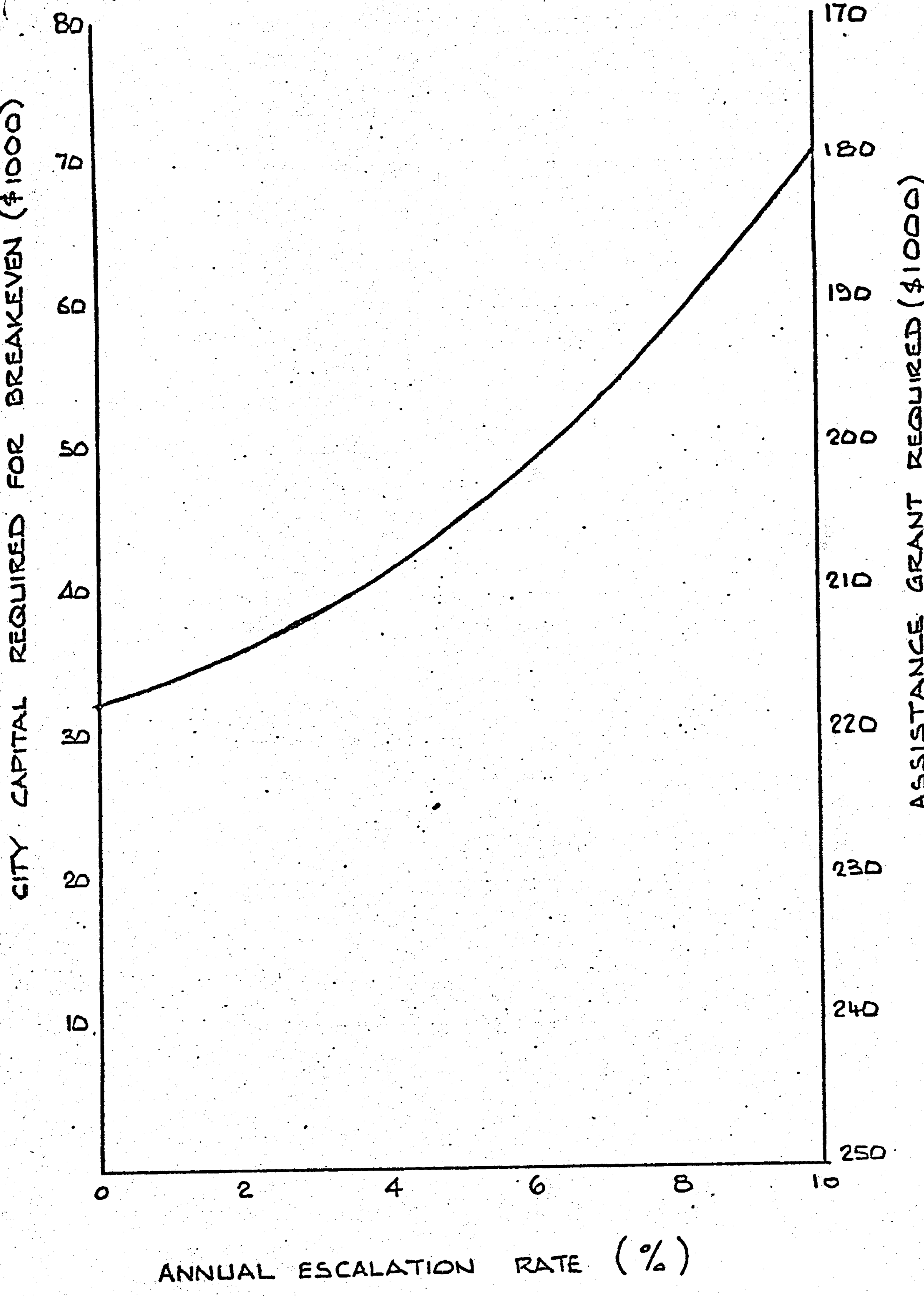


FIGURE 3

SLIDE ARRANGEMENT

GREENHOUSE COMPLEX

Slide No.	Description
1	FIGURE 1 SHOWING GREENHOUSE DESIGNS
2	EXTERIOR OF A GREENHOUSE SHOWING INLET SCREENS TO WATER SPRAYS
3	EXTERIOR OF GREENHOUSE SHOWING EXHAUST FANS
4	INTERIOR OF GREENHOUSE, MAIN WALKWAY
5	INTERIOR OF GREENHOUSE, SPACING BETWEEN ROWS OF CUCUMBER PLANTS
6	INTERIOR OF GREENHOUSE, SHOWING PRIMARY STAGES OF PLANT GROWTH
7	(DITTO)
8	INSIDE GREENHOUSE, VIEWS OF WATER SPRAY
9	SCREENS SHOWING DISTRIBUTION PIPING
10	SCHEMATIC SHOWING HEATING SYSTEM FOR GREENHOUSE
11	SCHEMATIC SHOWING EVAPORATIVE COOLING SYSTEM FOR GREENHOUSE
12	ARRANGEMENT OF 2 ACRE COMPLEX
13	LAYOUT OF PLANTING AISLES
14	GREENHOUSE PRODUCTION PATTERN
15	YEAR ROUND PRICES FOR CUCUMBERS ON L. A. MARKET
15	TABLE 2 ALL YEAR ROUND PRODUCTION
15	TABLE 3 NINE MONTH PRODUCTION

SLIDE ARRANGEMENT

MUNICIPAL HEATING SYSTEM

Slide No.	Description
16	DRAWING SHOWING PIPELINE ROUTE AND AQUIFER UNDERLYING THE CITY
17	SCHEMATIC OF VARIOUS BUILDINGS ON THE SYSTEM
18	TABLE 1 - HEATING LOADS
16	DRAWING OF PIPELINE ROUTE
20	DRAWING OF INDIVIDUAL BUILDINGS
21	FIGURE 2 CONSTRUCTION COST ESTIMATE
22	TABLE 2 PRESENT WORTH ECONOMICAL COMPARISON
23	FIGURE 3 GRAPH OF PAYBACK PERIOD vs % OF TOTAL INVESTMENT