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REGIONAL OPERATIONS RESEARCH PROGRAM FOR DEVELOPMENT OF GEOTHERMAL ENERGY IN THE SOUTHWEST UNITED STATES

FINAL TECHNICAL REPORT
JUNE 1977 TO AUGUST 1978

JANUARY 1979

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EMD Project No. 76-262

REGIONAL OPERATIONS RESEARCH PROGRAM FOR DEVELOPMENT OF GEOTHERMAL ENERGY IN THE SOUTHWEST UNITED STATES

Final Technical Report
June 1977 to August 1978

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ABSTRACT

This report describes the work accomplished from June 1977 to August 1978 of the Regional Operational Research Program for the Development of Geothermal Energy in the Southwest United States. The scope of work is as described in New Mexico State University technical proposal entitled, "Regional Operations Research for the Development of Geothermal Energy, Southwest United States," dated March 11, 1977.

This report described the efforts by the Core and State Teams in data acquisition, electric and non-electric economic studies, development of computer support functions and operations, and preparation of geothermal development scenarios.

TABLE OF CONTENTS

		Page
ABSTRACT		ii
LIST OF TABLES		v
LIST OF FIGURES		vii
ACKNOWLEDGEMENTS		viii
SUMMARY		x
I.	INTRODUCTION	1
II.	PROJECT DISCUSSION: FORECASTING AND OPERATIONS	5
2.1	Resource Knowledge and Scenario Assumption	7
2.2	Legal and Institutional Factors	9
2.3	Electricity Production From Geothermal Energy	10
2.4	Non-Electric Utilization of Geothermal Energy	11
2.5	Data Base and Region Program Progress Monitor	12
III.	LEGAL AND INSTITUTIONAL FACTORS IN THE DEVELOPMENT OF GEOTHERMAL RESOURCES	13
3.1	Federal Geothermal Program	15
3.2	Federal Laws and Regulation Relevant to Geothermal Energy	16
3.3	Activities During Development of a Federal Geothermal Resource	19
3.4	Federal Response to Legal and Institutional Barriers to Geothermal Development	27
3.5	Previous State and Regional Studies of Institutional Factors	35
3.6	Summary of Previous Regional and State Policy Studies	42
IV.	GEOTHERMAL DEVELOPMENT AND THE PRODUCTION OF ELECTRICITY	69
4.1	Research Philosophy	69
4.2	Sensitivity of Profits to Policy Parameters	71
4.3	Aggregated Power on Line Estimates	75
4.4	Policy Analysis and Recommendations	86
4.5	Review and Summary of Policy Analysis	90
4.6	The Market for Electricity	91
4.7	Electric Energy Consumption	91

TABLE OF CONTENTS (Continued)

		Page
V.	GEOTHERMAL DEVELOPMENT FOR SPACE HEATING	99
	5.1 Geothermal Space Heating in the United States: The Historical Record	101
	5.2 A Technical Screening of the Regional Low Temperature Resource Endowment	103
	5.3 Simulation Results	113
	5.4 Scenario Forecasts	126
VI.	DATA BASE AND REGIONAL PROGRAM PROGRESS MONITOR	137
	6.1 Market Area Determination	137
	6.2 Data Base Design	142
	6.3 The Data Base Management System	142
	6.4 Leasing and Drilling Information	143
	6.5 Data Base Functions	143
	REFERENCES	201
	DISTRIBUTION	204
APPENDICES		
	1. SUMMARY OF GEOTHERMAL ALGORITHM - ELECTRIC USES (GIRORA-ELECTRIC)	1-1
	2. A DISTRICT SPACE HEATING MODEL - GIRORA: NONELECTRIC	2-1
	3. THE GEOTHERMAL RPPM DATABASE	3-1
	4. SUMMARY OF FEDERAL, STATE, AND PRIVATE ACTIONS RECOMMENDED TO ACCELERATE GEOTHERMAL ENERGY DEVELOPMENT IN THE SOUTHWEST REGION	4-1
	5. SUMMARY OF STATE TEAM SCENARIOS	5-1
	6. ARIZONA STATE TEAM REPORT	6-1
	7. COLORADO STATE TEAM REPORT	7-1
	8. NEVADA STATE TEAM REPORT	8-1
	9. NEW MEXICO STATE TEAM REPORT	9-1
	10. UTAH STATE TEAM REPORT	10-1

LIST OF TABLES

		Page
2.1	Hydrothermal Resources Present in the Five State Region	8
3.1	Stages of Geothermal Development on Federal Land and Agency Responsibility	20
3.2	Land Ownership in Southwest Region	46
3.3	Mineral Acreage Reserved to the State and to the United States in Million Acres	46
3.4	Acreage of State and Federal Geothermal Leases	48
3.5	Status of Lease Sales on Federal KGRA's	49
3.6	Age of Noncompetitive Lease Application Still Pending for Federal Land	51
3.7	Leasing of State Land	53
3.8	State Geothermal Lease Provisions	54
3.9	Exploratory and Development Activities in the Southwest Region	56
3.10	State Agencies Which Participate in Geothermal Development in Arizona	58
3.11	State Agencies Which Participate in Geothermal Development in Colorado	59
3.12	State Atencies Which Participate in Geothermal Development in Nevada	60
3.13	State Agencies Which Participate in Geothermal Development in New Mexico	61
3.14	State Agencies Which Participate in Geothermal Development in Utah	62
3.15	Preliminary Assessment of Agencies and Permits Involved in Geothermal Development in Utah	64
4.1	Base Case Values Geothermal Energy Producer	72
4.2	Elasticity (E) of R with Respect to Selected Variables at 225°C (437°F)	74
4.3	Values of Choice Variables and Parameters: Optimistic and Pessimistic Market Scenarios	76
4.4	Electric Power Estimated in Megawatts for Arizona	77
4.5	Electric Power Estimated in Megawatts for Colorado	78
4.6	Electric Power Estimated in Megawatts for Nevada	79
4.7	Electric Power Estimated in Megawatts for New Mexico	83
4.8	Electric Power Estimated in Megawatts for Utah	83
4.9	Electric Power Estimated in Megawatts for the Five States	84
4.10	Results of the Forecasting Model	93

LIST OF TABLES (Continued)

		Page
4.11	Sensitivity Analysis Parameters for Projections of Electricity Consumption	95
5.1	Distribution of Low Temperature Geothermal Resources by State	104
5.2	Preliminary Values for Technological Screening Criteria	107
5.3	Distribution by State of Low Temperature Geothermal Resources Which Pass Initial Technological Screening	109
5.4	The Baseline Case Values	114
5.5	Optimistic and Pessimistic Scenarios	128
5.6	Distribution by State of Low Temperature Geothermal Resources Which Pass Technological and Economic Screening	132
5.7	Summary Table of Technological and Economic Feasibility of Low Temperature Geothermal Resources in the Southwest	136

LIST OF FIGURES

		Page
3.1	Typical Exploration and Development Sequence	21
3.2	Interagency Geothermal Coordinating Council	29
3.3	Geothermal Regulatory Activities: Pre-Lease Activities	31
3.4	Geothermal Regulatory Processes: Post-Lease Acrivities	32
3.5	Colorado. Time-Phased Activities	66
4.1	Time-Phased Scenarios Under Conditions of Minimum Competition	85
4.2	Time-Phased Scenarios Under Some Competition for Development Resources	87
4.3	Time-Phased Scenarios With Policy Incentives	89
4.4	Projections of Demand for Electricity in the Five State Region	96
4.5	Projections of Required Plant Capacity in the Five State Region	97
5.1	Low Temperature Sites in Southwestern Region	105
5.2	Technologically Feasible Low Temperature Sites in Southwestern Region	111
5.3	Estimated Energy Potential of Low Temperature Geothermal Energy before and after Technological and Economic Screening	112
5.4	Sensitivity of R to Changes in Temperature	116
5.5	Sensitivity of R to Changes in Distance (in miles)	117
5.6	Sensitivity of R to Changes in Population	119
5.7	Sensitivity of R to Changes in Royalty Rates	120
5.8	Sensitivity of R to Changes in Bond Rate	121
5.9	Sensitivity of R to Changes in Energy Prices	123
5.10	Sensitivity of R to Changes in Depletion Allowance	124
5.11	Sensitivity of R to Changes in Investment Credits	125
5.12	Sensitivity of R to Changes in Load Factor	127
5.13	Estimated R for Optimistic and Pessimistic Scenarios	129
5.14	Estimated Energy Potential of Low Temperature Geothermal Energy before and after Technological and Economic Screening	134
5.15	Economically Feasible Low Temperature Sites in the Southwestern Region	135
6.1	Resource Area Data Sheet	138
6.2	Drilling Data Sheet	140

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EXECUTIVE SUMMARY

This report describes the work accomplished in the first fourteen months of the Regional Operations Research Program for Development of Geothermal Energy in the Southwest United States.

The work is being performed by a core team at New Mexico State University/New Mexico Energy Institute, with subcontracts to state teams from Arizona, Colorado, Nevada, New Mexico, and Utah.

The objectives of the program are:

(1) To develop realistic but aggressive scenarios with certainty factors for the development of each identified geothermal resource area in Arizona, Colorado, Nevada, New Mexico, and Utah.

(2) To delineate the public actions, together with their schedules required, for the scenarios to materialize.

(3) To develop a computer-base data storage and retrieval system of a regional program progress monitor of the level of a preliminary working model which is capable of displaying program approach, but not loaded with all available data.

The major accomplishments of this project during this contract year have been:

- Establishment of core team, state teams, and regional and state advisory groups.
- Identification of locations and geophysical conditions of potential geothermal sites.
- Modeling of geothermal energy development activities including technological, economic, and institutional factors.
- Review and analysis of legal and institutional factors in geothermal energy development.
- Design and creation of computer data base system and software to support economic analyses, scenario design, and progress monitoring.
- Development of local, state, and regional power-on-line time phased scenarios for geothermal energy in the Southwest.

At the outset, it is useful to review and compare what was known about potential geothermal sites at the beginning of the contract year as compared with the assessments at the close of the contract year. The following table displays by state the large growth in the number of potential geothermal sites in the region. As indicated, the number of potential electric sites increased from twenty-nine to eighty, and the number of potential nonelectric

sites increased from fifty-three to five hundred. As is indicated, the potential number of sites increased more than seven-fold due to the active state team and Core Team review of available literature and parallel low temperature assessment programs that were ongoing during the contract year.

TABLE I

	Temperature greater than 150°C		Temperature Less than 150°C	
	USGS 726	Current Report	USGS 726	Current Report
Arizona	2	13	6	40
Colorado	1	13	13	46
Nevada	20	32	25	329
New Mexico	3	13	3	41
Utah	3	9	6	44
TOTALS	29	80	53	500

Geothermal resources with temperatures in excess of 150° C are considered candidates for generating electricity. Since the production technology is established, the future potential of geothermally produced electricity hinges upon its market competitiveness with alternative fuel sources. Accordingly, a simulation model was developed in order to estimate an internal rate of return on investment in geothermal energy development. The internal rate of return on investment is a general indicator of profitability which provides a measure of the financial attractiveness of geothermal energy.

The examination of the electricity producing potential of geothermal energy consists of an analysis of each of the known high temperature geothermal resources in the Southwest. Primary data were gathered by personnel within each of the states, and on this basis the internal rate of return on producer's equity is calculated for each source site. Several sets of plausible circumstances were proposed, and a unique rate of return was calculated for each. Based upon the estimated profitability of each geothermal resource, an ordinal ranking of resource sites was prepared. Those sites with the highest rate of expected return on investment are expected to come "on line" first, while the least profitable are expected to come "on line" last if at all. In this manner, a time-phased growth path of high temperature geothermal resources was created.

The analysis indicates (1) that the principal impediments to growth in the use of geothermal energy for producing electricity are geophysical or engineering in nature (e.g., subsurface temperatures and flowrates), or at least, are not subjected to policy manipulation; (2) that, of the available policy options, the investment tax credit rate and the bond rates are the most potent alternatives for stimulating development. Traditional

policy tools, such as depletion allowances or royalty rates, seem to be of much less value.

With current levels of economic policy variables, a minimum of 4,000 and a maximum of 20,000 MW of electricity could be brought on line by year 2020. Adequate incentives in the form of bond rate subsidies and investment tax credits could raise the lower estimate to 8,000 MW by 2020, while the maximum estimate cannot be affected by financial incentives.

In addition to the high temperature geothermal resources, the Southwest has also been generously endowed with low temperature ($T \leq 150^{o}C$) resources as well. These resources can be employed for space heating and cooling, water heating, and cooling, and numerous agricultural, aquacultural, and industrial applications. To date, only district space heating applications have been considered.

Because of the large number of low temperature resources, the market potential of geothermal space heating applications was examined in 2 stages. First, the total population if resource sites was considered for its technological acceptability. These resources that are usable given current production techniques were separated from those which are not usable, and the latter were eliminated from further consideration.

In the second stage, the economic potential of the remaining resources was indicated on the basis of an estimated internal rate of return on investment. Those resources which are not expected to generate a minimum acceptable return were then eliminated from further consideration. The remaining resources constitute the estimated regional supply aggregate of low temperature geothermal resources.

The "in ground" potential of low temperature geothermal resources in the Southwest is estimated to be 39,000 MBtuh. Most of these resources are remote from population centers, and because of the inherent cost factors in transmitting geothermal fluid over large distance, these sites do not prove to be economically feasible. In fact, of the approximately 39,000 MBtuh of geo-heat potential available in these sites, based on estimated internal rate of return, only 27 of the sites or approximately 1800 MBtuh offer realistic potential for district space heating purposes under currently forecast conditions. However, this low figure represents a conservative level. As site exploration and development continue, and as population growth rates and trends are incorporated in the model, it can be expected that an increase in geothermal usage will result.

Based on the state teams power-on-line time phased scenarios, a regional power-on-line scenario was aggregated. Appendices 5 through 10 contain details of the state teams scenarios as well as the regional aggregation.

Concerning the progress toward attaining DOE goals for geothermal development, the following table compares DOE goals for the ten state Rocky Mountain Range and Basin with the estimated geothermal potential sites in the Southwest Region. For the Southwest Region, the optimistic electrical development assumes implicitly that technology will be developed to make feasible the generation of electricity from sites with temperatures in the

range of 150° to 300° C. The pessimistic scenario assumes that only sites with a temperature greater than 190° C will be developed. As indicated previously, the nonelectric potential that is displayed in this table is for district space heating only. It is estimated that a significant increase in industrial process heat applications, agriculture, aquaculture, and other uses of low and moderate geothermal potential will be developed during the next 40 years. However, at this time, techniques have not yet been refined to develop and analyze this latter potential. As is indicated by the table, the Southwest Region alone under the optimistic scenarios can be expected to attain approximately 60% of the ten state region electric capacity in the optimistic case. District space heating, although apparently attractive, is constrained by the limited population of the Southwest Region. As the model is refined to incorporate population growth rate trends and other factors, the nonelectric potential can be expected to increase.

TABLE II

DOE GOALS FOR RMB&R REGION FOR 2020
VS
CALCULATIONS FOR SOUTHWEST REGION

	Rocky Mountain Range Basin	Southwest Region[2]	
	DGE Goals[1]	Optimistic	Pessimistic
Electric Capacity (MWe)	35,000	20,000	3,000
MEGW Equiv. (Direct Thermal)	60,000		600[3]
Electrical Quads/yr	2.91	1.66	0.32
Direct Thermal Quad/yr	1.80	--	0.02
Total	4.71	1.66	0.34
Barrels of Oil (Equivalent)	793×10^6/yr	300×10^6/yr	60×10^6/yr
Cost Avoidance Oil Import	$11 Billion	$4.2 Billion	$0.8 Billion

[1]Data Extracted from "Regional Hydrothermal Commercialization Plan," DOE/DGE, July 14, 1978

[2]Data for five Southwestern State based on calculations using GIRORA Models.

[3]This is economically feasible, district space heating only, assuming no population growth, for low temperature sites only.

CHAPTER I
INTRODUCTION

During the past several years, the United States has been relying increasingly on imported oil to meet its energy needs. This trend will continue unless greater use is made of all available domestic energy resources. To achieve this objective the Department of Energy (DOE), through its Division of Geothermal Energy, has established as one of its goals: to stimulate commercial development of geothermal energy as a reliable, operationally safe, and an environmentally acceptable energy resource[1]. To provide early momentum to this effort, DOE has initiated several research, development and demonstration type projects and administrative and policy initiatives to stimulate rapid exploration of "liquid dominated hydrothermal" resources. This class of geothermal resources, in comparison with the various other types of geothermal resources (e.g., vapor dominated, geopressured, hot dry rock, etc), is considered most likely to make a significant contribution to the nation's energy supplies in the near future.

According to the estimates presented in USGS 726 [2], geothermal energy has the potential of contributing thousands of quads to the nation's energy resources. However, there are significant environmental, technological and socio-economic problems which considerably impede the rapid development of the geothermal resources. These problems must be identified and mitigated to realize the geothermal potential that exists. Many of these problems are beyond the capability of U. S. industry to solve, and will require the assistance of action by the public sector. At the national level, this has been recognized by the congress and the administration, who in 1970 passed the Geothermal Steam Act (PL 91-581) to open up federally owned lands for leasing for geothermal development and in 1974 passed the Geothermal Research, Development and Demonstration Act (PL 93-410) to stimulate the environmentally acceptable development of geothermal energy.

As geothermal energy is a regional resource by its nature, its development will require approaches which recognize its regional character. At the same time, there will be many problems common to all regions. In recognition of this factor, DOE (ERDA) has established a regional planning activity, to identify

the specific problems associated with geothermal development in each region of the country, and has established a national planning activity to coordinate the activities of the regional planners and recommend actions and policy initiatives for DOE (ERDA) activities on the basis of maximum national benefit.

One of the regions so established by DOE (ERDA) is the Southwest Region, which consists of the states, Arizona, Colorado, Nevada, New Mexico, and Utah. This region contains a relatively large number of high temperature hydrothermal convective resources. To exploit the possibilities, DOE (ERDA) has contracted with the New Mexico Energy Institute at New Mexico State University for assistance in the development of a plan for stimulating the development of Southwest Region's geothermal resources. In addition, the New Mexico Energy and Minerals Department and the Four Corners Regional Commission have jointly financed the efforts by the New Mexico Energy Institute.

The USGS, in its circular 726, estimates that the recoverable energy content of identified hot water resources show 150°C in the Southwest Region could produce 1312 megawatt - centuries of electrical power, equivalent to an installed capacity of 4374 megawatts for 30 years using current conversion technology. In addition, 3.57×10^{17} calories (equivalent to 1560 MW for 30 years) is available as usable heat for direct thermal applications, such as space heating, agriculture, aquaculture and process heating.

The USGS further estimates that as much as five times this amount of energy may be recoverable from as yet unidentified hydro-thermal resources, and perhaps even more from hot dry rock. If it is assumed that the utilization of geothermal energy can be made economically competitive with other energy resources and that it is in the public interest to utilize the available domestic resource to help meet the growing energy demands in the region/nation and reduce dependence on imported energy sources, then the questions to be addressed are:

1) How rapidly can geothermal energy resources be developed in an environmentally acceptable manner; given the present level of knowledge of the resource, present technology, development status, present environmental knowledge and concerns, and present socio-economic conditions;

2) What action alternatives are available to the public sector to stimulate the rapid development of geothermal resources; and

3) What set of these alternatives will most effectively supply the needed stimulation while protecting all legitimate interests of the public.

An attempt is made to answer these questions during the first year effort of the operations research study for the Southwest Region. This report covers the findings of the study on the state by state and aggregated region basis.

CHAPTER II

PROJECT DISCUSSION: FORECASTING AND OPERATIONS

The project undertaken by the New Mexico Energy Institute at New Mexico State University is a multi-faceted, multi-discipline regional operations research in the development of geothermal energy resources for the Division of Geothermal Energy (DGE) of the Department of Energy, the Four Corners Regional Commission and the New Mexico Energy and Minerals Department.

In the five states of the study area, it has been broadly estimated that there are geothermal energy resources in excess of 1,800,000 megawatt-years. Over 800,000 acres of land lie in known geothermal resource areas (KGRA's) in the states, and over 25,000,000 acres have been established as prospectively valuable. However, there are a large number of barriers to the exploitation of the energy resources. Available technology does not exist to develop all of these resources. Public utilities are uncertain about the quality and quanity of this resource. This uncertainty, together with the national economic situation, means that available capital for the development of the resource is limited. Institutional barriers, in the form of federal, state and local government laws and regulations, such as environmental controls, tax laws, and land use policies, may inhibit the aggressive exploration and exploitation of the resource. A major task of the contract is to identify these factors and to quantify the relative importance of these factors in terms of their effect on the rate of deployment of this energy resource in the Southwest Region.

The broad method chosen to identify the above barriers and to achieve the DGE's mission, namely, to accelerate the actual commercial utilization of geothermal energy, is the development of a series of scenarios, the outputs of which are a prediction of the amount of commercial power (electric and non-electric) brought on line versus time. Hence a scenario will constitute the mission for the DGE mission-oriented approach to geothermal energy resource development. Since most forms of geothermal energy represent local resources

and since many of the problems associated with commercial geothermal development are local or regional in nature, the local and regional problems are addressed in developing the scenarios. In considering the local problems within each of the five states, the key energy officials in the states were consulted. Each state team leader was responsible for data collection and gathering information from local governments and industries.

The preliminary development scenarios, based on inputs from the regional and local interest groups together with supplemental data concerning the extent and quality of the geothermal resources will show the locally preferred time phasing of power on line. State teams were tasked to supply this kind of information.

The economics of harnessing the geothermal resource (either for electricity production or for direct application) play a major role in the future development of geothermal energy resources. In this free market society, geothermal energy must compete with other sources of energy. The economic analysis must show a distinct advantage for geothermal energy if utilities are to be induced to make extensive financial commitments to the development of this relatively new technology. Associated with the scenario for geothermal energy development are projections of costs of power from alternate resources. Analyses of these projections are very useful in the planning process. For instance, the projections may show that geothermal energy in a particular region will not be economically viable for some years in the future. In order to accelerate geothermal energy development in that case, the gap between the geothermal costs and the lowest cost alternatives must be closed. Economic analyses are required to determine the impacts of several possible alternative actions on the cost of goethermal power such as, technology improvements, tax incentives, government subsidies, and loan guarantees.

One obvious way to decrease the cost of geothermal power is to improve the efficiency of the energy conversion process through research and technology development programs. This is a very desirable approach in that it contributes towards energy resource conservation by providing more energy per unit of resource. However, there are limits to increases in efficiency which can be achieved through research and development. Thermal cycle efficiency is limited to carnot cycle efficiency for a given reservoir, and heat sink temperatures and mechanical efficiency must be less than unity. Further, as the quality of resources decreases (which is an uncertain element) the cost of power tends to increase due to the intrinsic decrease in cycle efficiency associated with

lower temperatures and the need for more expensive equipment (such as heat exchangers and pumps). The increase in the cost of geothermal power tends to delay the commercial use of lower quality resources until technology improves or other policy initiatives which are economically supportive are adopted. If the analyses show that the amount of technology improvement cannot close the gap between the costs of geothermal and alternate energy sources, then it is desirable to consider policy initiatives which temporarily close the gap. Modifications to tax regulations, government guaranteed loans, or even government subsidies are possible techniques for artifically altering the economics of geothermal energy development.

2.1 Resource Knowledge and Scenario Assumptions

The Southwest Region is rich in geothermal resources. They include the familiar hydrothermal systems typified by those under development at Valles Caldera, New Mexico, and Roosevelt Hot Springs, Utah. In addition, they have hot igneous (hot dry rock) and conduction dominated systems which may ultimately prove to be much more extensive and valuable than the hydrothermal systems. A summary of the number of hydrothermal systems present in the five state region is given in Table 2.1. These estimates are obtained from United States Geological Survey (USGS), local researchers at New Mexico State University, and the appropriate state teams. The high temperature hydrothermal systems (i.e., temperatures over 150°C) are especially important because of their potential for near term commercial development for electric power generation. In addition, they can support industrial processes which demand high temperatures, such as paper pulp digestion, timber drying and aluminum extraction. Medium temperature geothermal systems (temperatures between 65 and 150°C) can be used for direct applications such as domestic space heating, greenhouse heating and other industrial uses which do not demand very high temperatures. Finally, low temperature systems, commonly known as warm springs can be utilized for mushroom growing, balneological baths, and other agriculture and aquaculture applications. The subject of the report basically constitutes the scenarios for electric power generation utilizing high temperature resources and district space heating using the medium temperature resources.

There are large uncertainties in the resource estimates. The assessment of geothermal potential presented in this report is based on limited data available. As USGS has indicated, no single estimate of geothermal energy from

Table 2.1

Hydrothermal Resources Present in the Five State Region

State	Number of Hydrothermal Resources			
	Temperature Over 150°C	Temperature Between 65° & 150°C	Temperature Less Than 65°C	Total
Arizona	13	15	25	53
Colorado	14	24	21	59
Nevada	32	52	276	360
New Mexico	13	20	26	59
Utah	8	13	32	53
TOTAL	80	124	380	584

a particular area included in the assessment should be relied upon as an established fact. For some areas, the information was relatively good, but for other areas it was very poor at the time the estimates were made.

It is expected that further research and exploration will show a significant number of additional geothermal fields in the region besides those listed in Table 2.1. Further exploration could also considerably modify the estimates for the sites identified. Further discoveries, according to USGS, could be possibly five times the volume and heat content of the high temperature systems (>150°C) already identified. The discoveries could result from:

1) New knowledge of the extent of an already identified system that appreciably increases its estimated volume.
2) The temperature of an identified system being higher than first estimated (possibly enough to raise some of the medium temperature resources into the higher temperature category).
3) The discovery of previously unknown systems.

In addition to the geological and geophysical data, more analyses need to be done to develop the scenarios. Most important of these are the identification of the institutional factors present and the economical analysis for the feasibility of electricity production and domestic space heating. They are considered in detail in this report.

2.2 Legal and Institutional Factors

One of the major impediments for the rapid development of geothermal energy is the existence of nontechnical barriers. The nontechnical factors which inhibit the activities of geothermal industry are legal and institutional factors. Many geothermal developers believe that institutional factors are the major cause of the large time delays and high costs associated with the development of geothermal energy. The time involved in getting permits for leasing, drilling, environmental assessments and other legal factors all contribute to time delays. The impact of permitting delays can be very serious, which may affect the economic exploration of the resource. In the Southwest Region, the permitting process and time delays involved vary from state to state. The details of the permitting process and their impact is described in Chapter III.

2.3 Electricity Production from Geothermal Energy

Experimental production of electricity from geothermal energy began in Lardarello fields in 1904[3]. By 1931, sufficient quantities of electricity were being generated to begin selling electricity to the Italian Railway System. After being destroyed in World War II, the generating facilities were rebuilt and expanded. The Lardarello fields currently generate enough electricity to supply a city of 600,000 at U. S. consumption rates. Commercial generation of electricity from geothermal energy in the U. S. began in 1960 at The Geysers, California. By 1973, the U. S. was the largest producer of electricity from geothermal steam[3]. Currently 1000 MW of electricity are generated from geothermal steam worldwide, half of which is produced at The Geysers.

Although worldwide production of electricity from geothermal resources continues to increase yearly, it is doubtful that the overall contribution of this production will be large in the near future. Assuming the production in the world continues to increase at the present rate, 3000 MW will be produced by 1980. This projected production still would constitute less than one percent of the current energy demands.

There are several inherent technological problems in producing electricity from geothermal energy. One major problem is locating a geothermal source with the necessary heat content to produce electricity. Generating electricity from geothermal water at temperatures 150°C or less is generally not economical due to the low efficiencies (less than 7 percent) and large flow rates required[4]. However, it is quite likely that the competitive economics of electrical generation using lower temperature geothermal resources will improve as the technology in the field advances and conventional energy costs continue to rise.

Another problem associated with using geothermal energy is that geothermal water tends to have a higher mineral content than ground water. This high mineral content produces scaling problems in equipment and inhibits production capabilities. Calcium carbonate deposits also cause scaling problems in wet steam utilization. These problems can be eliminated by using binary cycle for energy conversion in contrast to the more traditional flash cycle. In a binary cycle, heat from the geothermal fluid is transferred to a secondary fluid, usually having a low boiling point (e.g., iso-butane) through heat exchangers. The advantages are two-fold: one, the corrosion and scaling problems are reduced and the other, the amount of usable heat

(enthalpy) is greater in the binary fluid. Even the moderately high temperature resources (temperatures between 150° and 200°C) can be more efficiently exploited with the binary cycle technology. Of course, the cost of heat exchangers and the other necessary equipment adds to the capital cost of the power plant.

The details of the economic analysis and sensitivity analysis and their impact on scenario generation for geothermal electricity production are discussed in Chapter IV of this report.

2.4 Non-Electric Utilization of Geothermal Energy

The production of a significant amount of electricity from geothermal energy is years in the future. In comparison, the utilization of geothermal energy for non-electrical purposes holds great possibilities in the near future. The advantages of non-electric utilization of geothermal energy are[5]:

1) Approximately one-third of the fossil fuel consumption is used for residential purposes, the majority of which could potentially be supplied from low temperature geothermal sources.
2) Low temperature resources are more numerous and generally less polluting than high temperature sources, which are required for electrical production.
3) The efficiency of non-electrical utilization is greater than for electrical production.
4) Technology is sufficiently advanced to allow immediate development where the resources exist.

Space heating accounts for 18 percent of U.S. yearly energy consumption[4]. Since known geothermal sites are seldom close to large population center, geothermal energy cannot be presently used to supply the bulk of space heating demands. However, as exploration techniques improve and as new geothermal sites are discovered, an increase in the application of geothermal energy to space heating can be expected. In addition to the space heating applications there are several industrial uses of low temperature geothermal energy. The use of this energy for industrial applications basically depends on the heat requirements of the particular industry, quality of the geothermal resource and the proximity of the industry to the resource.

In this report, the economics of space heating is considered. Applications to industrial processes need extensive data and individual economic analyses, and are not considered in this report. The economic model developed

for space heating, sensitivity analysis and scenario generation is discussed in Chapter V.

2.5 Data Base and Region Program Progress Monitor

In order to perform the studies described in the previous sections, extensive amounts of data are required. The data can be broadly classified into six categories, namely,

1) Data relating to the geothermal energy resource,
2) Data relating to the utilization of the resource,
3) Data relating to legal and institutional factors,
4) Data relating to economics of resource exploitation,
5) Data relating to technology development, and
6) Data relating to regional industry status.

Data are collected as much as possible in all the above areas and are stored in the data base. Part of this data is automated, and is entitled Regional Program Progress Monitor (RPPM). The complete description of the RPPM is given in Chapter VI.

CHAPTER III

LEGAL AND INSTITUTIONAL FACTORS IN THE DEVELOPMENT OF GEOTHERMAL RESOURCES

While the potential for geothermal resources is great, only a very small fraction of this potential has been realized. Virtually everyone agrees that numerous technical and nontechnical factors are impeding the rapid development and utilization of the resource. While not ignoring the technical barriers, this chapter will stress the nontechnical factors which impact upon efforts to accelerate the development of geothermal resources. The nontechnical factors of concern will be restricted to the legal and institutional factors which may inhibit the activities of the geothermal industry.

It has been estimated that over $75 billion of capital financing will be needed over the next 20 years if the potential for geothermal resources is to be achieved.(6) There is, however, a great hesitancy on the part of industry to commit this degree of financing to the task. The belief is almost universal that the cause of this hesitance is two-fold: (a) restrictive laws, court decisions, and regulations and (b) actions (and inactions) of a large number of individuals who singly and jointly make decisions that are unresponsive to the needs of the industry. In short many, if not most, developers believe or talk as if they believe that institutional factors are the major cause of the long delays and high costs associated with the development of this natural resource.

That belief has been challenged by others who contend that the principal impediments to the rapid development of geothermal resources spring not from institutional factors but rather are due to uncertainties associated with the resource itself, the technology necessary to develop the resource, and overall economic risk.(7) Even those promoting this latter point of view recognize, however, that legal and institutional factors can accentuate the uncertainty and risk associated with geothermal potential.

If the number of studies and reports concerned with legal and institutional factors is accepted as a measure of the intensity of the belief that these factors are important, the belief is indeed intense. In July 1976, there were 118 references to articles concerned with legal and institutional issues in a bibliography which cited over 5400 research articles in the area of geothermal resources.(8) By January 1978, the Department of Energy published a bibliography containing 485 references to legal and institutional research in the area.(9)

Hence, in 18 months there was a 300 percent increase in the number of articles concerned with legal and institutional impediments to geothermal development.

The overall goal of the legal and institutitutional aspect of the Southwestern Regional Operations Research Program has been to identify the individuals and agencies whose single and mutually interactive participation affect the rate of geothermal resource development. These participants in the development process may be categorized into four major classes as a function of the locus, if not the magnitude of their potential effect: (a) federal agencies and regulations; (b) state agencies and regulations; (c) the policies and decisions of resource developers and utility operators; and (d) the attitudes and actions of local officials and residents.

During the past year the Southwest Regional Program has concentrated on identifying the state agencies and the state laws and regulations that affect geothermal development within the Southwest Region. The issues involved at the federal level and between the federal and state levels of operation were also reviewed. Using the bibliography referred to above, previous studies concerned with the role of policy variables in other states were also analyzed.

The institutional studies conducted by the Southwestern Regional Program had three specific goals. First, it is recognized that institutional factors are a major element in regional aggregated scenarios which depict the time-phased activities required to develop geothermal energy. Hence, these studies were necessary to the creation of those scenarios. Second, it was reasoned that through an analysis of the development scenarios it would be possible to identify factors which act as constraints and other factors which serve as opportunities to the development of geothermal resources. Third, based upon the knowledge acquired from an examination of development scenarios policy initiatives would be recommended which would overcome or mitigate the constraints and exploit the opportunities to geothermal development.

A fourth goal of the program was to assist in the development of a knowledgeable and properly motivated infrastructure that could and would promote the development of geothermal resources within each state in the region. It has been noted that whether the climate for the use of geothermal energy sources will be positive or negative is often directly related not only to state policies but also to the attitudes of elected state officials.[10] Hence, by the very act of conducting these investigations it was hoped that there would be an increase in public perception of the issues at hand and that

these perceptions would lead to a higher degree of political interest and an increase in necessary political leadership.

None of the goals listed are unique to the program centered at New Mexico State University. Significant efforts directed at the same goals have occurred at the national level through the efforts of such groups as the National Conference of State Legislatures,[6] at regional level by such groups as the Pacific Northwest Regional Commission,[7,11,12] and at the state level by such groups as the Batelle Human Affairs Research Centers.[13] In fact the institutional constraints and opportunities identified by the Southwest Operations Research Program are distinctive primarily to the extent that they are often unique to the five states which comprise the regional area. While there is no intention to deemphasize the significance nor the generality of the results to be reported, the most noteworthy accomplishment of these efforts may have been the establishment of knowledgeable proponents of geothermal energy in the executive branch of each state and to have facilitated an interaction among local, state, and regional agencies.

The following discussion of legal and institutional factors affecting geothermal development is organized into three parts: (a) a review of federal laws, regulations and procedures; (b) a review of state and regional studies; and (c) a description of legal and institutional factors in the Southwest Region.

3.1 Federal Geothermal Program

An examination of the federal geothermal program is necessary to obtain an understanding of institutional factors which affect the development of geothermal resources in the Southwest. There are at least four reasons why the federal program has a large impact on regional programs: (a) most identified and expected resources are on federal land; (b) the national energy policies serve as a model for and actually stimulate the formation of state policies; (c) the principal source of economic incentive for geothermal development will be through tax relief, grants, and loans which originate in federal legislation, and (d) the federal government is the originator and the enforcer of most environmental protection and conservation regulations.

This part of Chapter III is divided into three sections. Section 3.2 summarizes federal laws and regulations which affect geothermal development. Section 3.3 describes the activities and responsibilities of different participants at each stage of geothermal development and utilization. Section 3.4

discusses the overall organization and purpose of the federal geothermal program and discusses several activities designed to mitigate legal and institutional barriers to geothermal development.

3.2 Federal Laws and Regulations Relevant to Geothermal Energy

Essentially all major phases of geothermal energy development are subject to federal laws and regulations. The three laws which enable and control the development of geothermal resources on federal lands and which attempt to encourage development on any land are briefly summarized below.

Geothermal Steam Act of 1970

The Geothermal Steam Act of 1970 is one of the most significant laws affecting the pace and direction of geothermal energy development. It controls leasing of federal lands and all phases of post-lease operations on those lands. Prelease and leasing requirements are regulated by the Department of Interior, Bureau of Land Management through Title 43, Chapter II of the Code of Federal Regulations (43 CFR, Group 3200). Post-lease operations are administered by the Department of Interior, U. S. Geological Survey through Title 30, Chapter II of the Code of Federal Regulations (30 CFR, Parts 270-271). On other than federal lands, state and local regulations have generally been patterned after those of the Geothermal Steam Act. On federal lands the implementation of federal regulations is guided by Geothermal Resource Operational Orders issued by U. S. Geological Survey. Geothermal Resources Operational Orders have been issued and are titled: Exploratory Operations, Drilling Completion, and Spacing of Geothermal Wells; Pluggings and Abandonment of Wells; General Environmental Protection Requirements; Pipelines and Surface Production Facilities; and Production and Royalty Measurements, Equipment, and Testing Procedures.

Federal Nonnuclear Energy Research and Development Act of 1974

This is the Act which mandated the activities of the Energy Research and Development Administration. One of those activities is the active encouragement of geothermal energy technology development through commercial demonstration. The Act also provides for the acceleration of the commercial demonstration of environmental control systems for energy technologies.

Geothermal Energy Research, and Development, and Demonstration Act of 1974

This act authorizes and defines more specifically the responsibilities of the federal government in developing and demonstrating the commercial viability

of geothermal energy conversion. The objectives of the Act are to be accomplished in concert with private developers through grants, contracts, and loan guarantees.

In addition to enabling and implementing legislation, all geothermal development activity is subject to many environmental protection and conservation laws. The more prominent of these laws are briefly discussed below.

National Environmental Policy Act of 1969

This Act has had profound effects in calling public attention to the environmental consequences of major new projects. The Geothermal Steam Act was the first federal action to which it applied. The Act requires an environmental impact statement for all major federal actions affecting the quality of the human environment. The Act produced a ripple effect in that most states have similar laws for state actions. In most cases of major development, an environmental impact statement can be anticipated at some stage prior to commercial energy production, whether it is on federal, state, or private land. The impact statement must describe adverse impacts including those caused by any kind of pollution, on society and its environment. It also must discuss alternatives to the proposed development and their consequences and must describe irretrievable resource commitments.

Clean Air Act as Amended (1970)

The Clean Air Act also has several sections which may significantly affect geothermal energy development. For example, one section allows and provides for the establishment of intrastate and interstate Air Quality Control Regions in which the states must provide implementation plans for assuring air quality. Under another section the Administrator of the Environmental Protection Agency may publish air quality criteria. Based upon the criteria, he then publishes national primary (to protect public health) and secondary (to protect public welfare) ambient air quality standards for pollutants determined to have adverse effects.

Federal Water Pollution Control Act Amendments of 1972

Several sections of this Act apply to geothermal development. Probably the most significant sections are in Title III - Standards and Enforcement. One of these sections calls for the application of "best practicable control technology currently available" by July 1, 1977, for point sources other than publicly owned treatment works. This section further calls for the application

of "best available technology economically achievable" by July 1, 1983. This section further requires the elimination of all pollutants where technologically and economically achievable. Another section in Title II calls for the definition by the Environmental Protection Agency of such technologies, and effluent limits attainable thereby, through the issuance of "Effluent Guidelines" regulations. For the geothermal energy industry, those regulations have not yet been developed and are not currently scheduled. However, such regulations may be expected when the industry is firmly established and technologies have been demonstrated.

Noise Control Act of 1972

This Act contains broad noise control provisions for regulating and labeling products, many of which are used at geothermal facilities. In addition, the Environmental Protection Agency has been given coordination authority of all programs of other federal agencies relating to noise research and noise control. It has also been given authority to insure that all federal facilities comply with appropriate federal, state, and local noise regulations. Many states and local communities regulate noise, and the U. S. Geological Survey has noise regulations for developers on leased federal lands.

Safe Drinking Water Act (1974)

This Act is administered by the Environmental Protection Agency and allows and provides for state implementation of its provisions. Part C of the Act, "Protection of Underground Sources of Drinking Water," is of greatest significance to geothermal energy development in that it requires the promulgation of regulations to control underground injection. Reinjection is an integral part of most existing and proposed geothermal development.

Resource Conservation and Recovery Act of 1976

The provisions of this Act, administered by the Environmental Protection Agency, are principally concerned with solid wastes. Subpart C - Hazardous Waste Management, important to geothermal energy development, involves regulatory control of storage, treatment, and disposal of potentially hazardous wastes in landfills and surface impoundments. The potentially hazardous wastes may be liquid, solid, or a combination. Wastes considered potentially hazardous are those which may cause or contribute to adverse effects on human health or the environment when not properly controlled. Regulations to be developed under

the Act are likely to have significant ramifications for the geothermal industry in those cases where spent brine surface impoundments are used and where waste sludges are created, such as in the treatment of waters and noncondensible gases.

Toxic Substances Control Act (1976)

This Act is aimed principally at manufacturers and distributors of toxic chemicals in order to control indiscriminate proliferation of such materials in the environment. The provisions of the Act can conceivably apply to minerals which might be commercially produced from geothermal development.

Land Policy and Management Act of 1976; National Forest Management Act of 1976, Fish and Wildlife Coordination Act; Endangered Species Act; Wilderness Act; and Marine Protection, Research and Sanctuaries Act

These federal laws allow for prohibition of or advisory action against certain activities in the interest of preserving land values, wildlife habitats, and esthetic values. They also may allow for or require mitigating measures where harm may occur.

3.3 Activities During Development of a Federal Geothermal Resource

The process of acquiring the right to explore, develop, and produce geothermal resources on federal land is described in detail in a preliminary report by Roschen and Cook.[14] The six phases of development for any given area are described as prelease exploration, competitive or noncompetitive leasing, postlease exploration, development, production, and closeout or abandonment. A brief description of each phase as extracted from the Roschen and Cook report is given below. The responsibility of land management agencies (Bureau of Land Management, BLM; U. S. Forest Service, FS; and U. S. Fish and Wildlife Service, FWS) and the U. S. Geological Survey (GS) at each stage of development is summarized in Table 3.1. Figure 3.1 shows a typical exploration and development sequence, including points at which a company might discontinue or abandon its efforts.

Pre-lease Exploration

Prelease exploration is divided into "Casual Use" and "Exploration Operations."

(1) Casual Use. "Casual Use" as defined in 43 CFR 3209 means "activities that involve practices which do not ordinarily lead to any appreciable disturbance or damage to lands, resources, and improvements." The activities do not

Table 3.1

Stages of Geothermal Development on
Federal Land and Agency Responsibility

Land Management Planning	BLM/FS
Pre-lease Exploration Permit	BLM/FS (Primary) GS and FWS (Consulting)
Pre-lease Environmental Analysis	BLM and/or FS (Primary) GS and FWS (Consulting)
Non-Competitive Leasing Schedule	BLM/FS (Primary) GS/FWS (Consulting)
Non-Competitive Lease Application Review	BLM (Primary) FS/GS/FWS (Consulting)
Competitive Lease Sale Schedule	BLM/FS/GS/ Industry
Competitive Lease Sale	BLM (Primary) FS/GS/FWS/DOE (Consulting)
Development of Lease Stipulations	BLM/FS/GS/DOE
Issuance of Lease	BLM/DOE
Post-lease Environmental Analysis	GS (Primary) BLM/FS/FWS (Consulting)
Post-lease Review of Plans of Operation	GS (Primary) BLM/FS/FWS (Consulting)
Post-lease Permitting	GS (Primary) BLM/FS/FWS (Consulting)

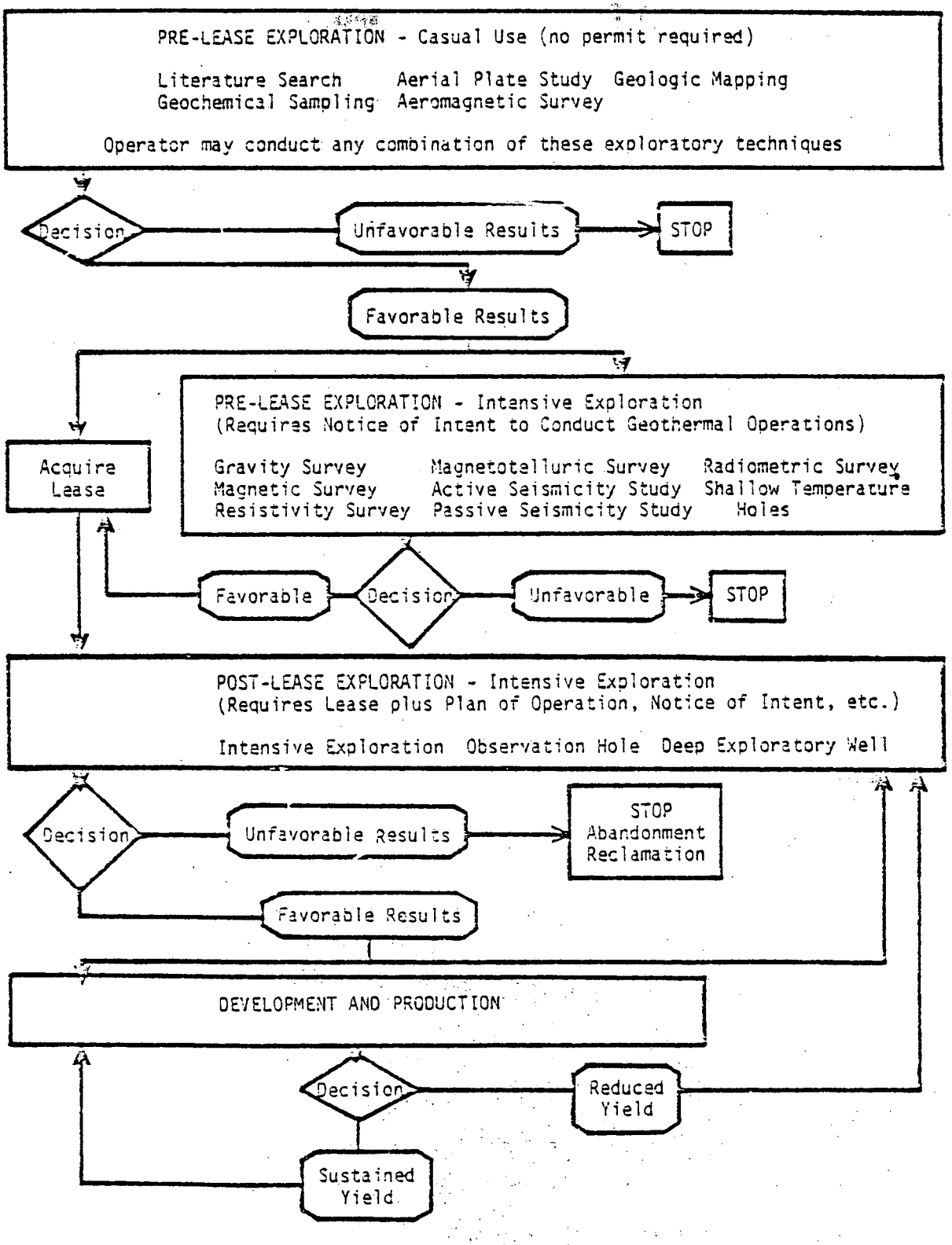


Figure 3.1 Typical Exploration and Development Sequence

Adapted from Raschen and Cook, 1976

involve use of heavy equipment or explosives, and do not involve vehicular movement except over established roads and trails. Casual use does not require a permit or environmental assessment. Casual use generally includes the following: literature review, geological reconnaissance, geochemical survey, and airborne surveys.

(2) Exploration Operations. Exploration operations have been defined in 43 CFR 3209 as "any activity which requires physical presence upon public land and which may result in damage to public lands, or resources." These operations may include, but are not limited to: geophysical operations; drilling of shallow temperature gradient holes (holes of no more than 152 m or 500 feet in depth); construction of roads and trails; and cross-country transit by vehicles over public lands.

Groups who wish to conduct exploration operations on BLM or FS land must file a "Notice of Intent to Conduct Geothermal Resource Exploration Operations" for each operation they propose. This "Notice" must be accompanied by a $5,000 surety bond or rider to a state-wide or nation-wide bond. The bond ensures compliance with all federal regulations and stipulations governing exploration operations.

Within 30 days after receiving the "Notice of Intent" and the attached bond or rider, the BLM and/or FS prepares an Environmental Assessment Record (EAR) evaluating the impacts of the proposed project. Fish and Wild Life Service and GS provide some input to this document in the form of special stipulations designed to reduce or eliminate anticipated adverse impacts. When this has been done, the BLM's Authorized Officer or the Forest Supervisor will attach all special stipulations necessary to protect the environment to the "Notice of Intent," and will approve the proposed project in writing.

After the exploration project has been concluded, a "Notice of Completion of Geothermal Exploration Operations" must be filed. The Bureau of Land Management will inspect the former project location within 90 days, and will notify the group responsible for the project whether they have complied satisfactorily with all the regulations and stipulations.

Leasing

The process of leasing federal geothermal resources is separated into competitive and non-competitive leasing.

(1) Competitive leasing. Competitive leases are usually issued to the highest qualified bidder on designated tracts of land within a Known Geothermal

Resource Area (KGRA). These tracts of land are selected by surface and subsurface geological features, drill log data, chemical analysis of water, or by competitive interest in areas.

When a sale is to be conducted, notice is published weekly in a paper of general circulation for four consecutive weeks. The notice specifies time, place, bidding requirements, land descriptions, royalty, rental terms, and any special stipulations. An application, with one-half of the bonus bid, is filed. On the date, at the time and place of the competitive bid, all bids are opened and displayed. The lessor has 30 days to accept or reject the bids. When a bidder is successful, he is required to sign three copies of the lease contract, to pay the first year's rental, to pay the balance of the bonus bid, to file the required bond or bonds, and to submit a proposed "Plan of Exploration." If these requirements are accomplished in the specified time frame, a geothermal lease contract is issued. Failure to comply within the time allowed will result in rejection of the bid and any money submitted with the bid will be forfeited. If a bidder is unsuccessful, the money tendered with the bonus bid is returned to the applicant with the information about the lease sale.

(2) Non-competitive leasing. Non-competitive leases are issued on any available federal lands outside of a KGRA. Geothermal resources supposedly have a lower potential in these areas. Certain lands are, or may be, withheld from leasing. A non-competitive lease is acquired in a manner similar to competitive leasing. An application, bond, or bonds, an application fee, and a proposed "Plan of Exploration" are sent to the proper BLM office. No bonus bids are required on non-competitive geothermal leases. When the application is approved, three copies of the lease contract are sent to the applicant. The applicant must sign the lease contracts and return them along with the first year's rent.

(3) Lease terms. The "Plan of Exploration" is required by federal regulations. This plan should describe briefly the activities that will be conducted on the lands described in the application.

The "Geothermal Resource Lease Contract" allows the federal government to lease geothermal resources and at the same time provides protection for other natural resources. Provisions within the contract require protection of the environment, antiquities, historic values, etc., in compliance with federal regulations. In addition, special stipulations needed to protect unique values of a particular area may be incorporated into the lease contract and compliance becomes mandatory.

Post-lease Exploration

After a lease is issued, federal regulations require that a "Plan of Operation" be filed and approved by the land management agency and GS before any activity other than "casual use" may commence. The "plan," accompanied by maps, will describe all exploration activities that will be conducted on the leased lands. The U. S. Geological Survey, the lead agency, studies the "Plan" and sends copies to the surface managing agency and other interested agencies for comments.

The GS must prepare an Environmental Analysis (EA) covering the specific site of the "Plan of Operation." A discussion of the proposed exploration, such as gravity, resistivity, and temperature gradient surveys, may be included in the "Plan." Generally, the proposal is to drill one or more geothermal resource exploratory wells. An on-site inspection with representatives of the lessee, GS, and the land management agency is then conducted to assess the potential impacts of the proposed operation. The "Plan" and a draft EA are presented to the Geothermal Environmental Advisory Panel (GEAP), who then advises the GS's Area Geothermal Supervisor on the environmental aspects of the "Plan of Operation." The GEAP also recommends mitigating measures to protect the environment. The EA is completed after input is obtained from the GEAP. After considering the effects upon the environment and developing the special conditions or stipulations deemed necessary to protect the environment, the Area Geothermal Supervisor and the appropriate land management agency jointly approve the "Plan of Operation."

Upon approval of the lessee's application(s) for "Permit to Drill," a permit is issued. The lessee then may commence only those operations authorized under the approved "Plan of Operations." The lessee's authorized operations are continuously monitored and inspected by the Area Geothermal Supervisor to ensure that the lessee complies with the applicable regulations and stipulations. Any additional exploratory operations proposed by the lessee require an additional "Plan of Operation." resulting in a procedure essentially the same as the preceding steps.

Pre-lease exploration methods have been defined previously; however, post-lease exploration uses many of these methods on a more intensive basis. For example, exploratory drilling methods, geological information holes and deep exploration wells requiring depths of more than 152 m (500 ft) may be used. These wells require large drilling rigs, a cleared and leveled drilling pad of

one to two acres, and construction of a service road to provide access for men and equipment. If an exploratory well discovers a geothermal reservoir, a series of tests are made to determine whether there is potential for an economically productive well.

Development

Once a successful exploratory well is drilled, plans are made to develop the geothermal resource. A new plan, called a "Plan of Development," must be filed. No development operations will commence until the "Plan" is approved by GS and the appropriate land managing agency. Another EA covering the activities within the "Plan of Development" is prepared by GS. The GEAP again recommends mitigating measures for protection of the environment, which may result in additional stipulations imposed upon the lessee. The lessee then may commence only those development operations authorized by the "Plan of Development."

Again, all activities must be in compliance with the regulations and stipulations. The development of the geothermal resource requires the drilling of a number of development wells. Development wells are drilled and completed in basically the same manner as the exploratory wells, and require the same considerations.

Production

After a sufficient number of development wells are drilled, plans are made for the most economical and feasible use of the geothermal resource. The "Plan of Development" may be revised and submitted to the GS for approval, and no action will proceed until the revised "Plan" is approved.

A number of procedures must be followed before production begins within a geothermal field. Prior to placing the subject wells on prolonged production, the lessee must collect data concerning existing air and water quality, noise, seismic and land subsidence activities, and the ecosystem of the leased lands for at least one year prior to the submission of a "Plan of Production." Additionally, the lessee must submit an annual report of compliance with environmental protection requirements, giving a full account of the actions taken. The use of the leased lands or other federal lands for geothermal production will be authorized only under a separate permit issued by the appropriate agency.

An EAR is a prerequisite to the issuance of a permit for the use of the leased lands or other federal lands for a power generation plant, pipeline, transmission line, or other facility. Granting of a permit is not a license

to construct the facilities. The construction, operation, and maintenance of a power generation plant can only be accomplished by obtaining a "Certificate of Public Convenience and Necessity." This certificate is granted by the Public Utilities Commission of the state having jurisdiction and regulatory authority over the company making application. Pipelines, power plants, and transmission lines may be constructed if the resource is such that electricity can be produced. A power plant and associated wells, similar to those at The Geysers, would occupy about 640 acres or one section of land within a township.

If the production of electricity is not feasible because of the reservoir conditions, the geothermal resource may be used for other purposes, such as greenhouses, hothouses, space heating - air conditioning, food processing, etc. These industrial uses may occur also in conjunction with electrical generating plants.

Close out

A sizable geothermal field would be abandoned gradually; in a small field, an abrupt cessation may be likely. If the exhausted production wells are strategically located, fluids reinjected into the reservoir through the exhausted wells may lengthen the life of the remaining field. If the wells are shut in, tests may reveal that the bottom hole temperatures and fluids have recharged after a lapse of time. Plugging and abandonment of geothermal wells must be done in accordance with Geothermal Resource Operation Order No. 3. In short, close-out or abandonment of all or a portion of a geothermal field requires abandonment of the subsurface, removal of the surface installations, and rehabilation of the surface.

Summary of Participants and Activities

As just discussed and as shown in Figure 3.1, the process of discovering, developing, and utilizing geothermal resources is quite complex. There are many separate classes of activities, carried out by individuals and agencies with different objectives and responsibilities, and the activities of these individuals occur in a context of potentially conflicting and restrictive rules and regulations.

The objectives of the investors and of industry representatives are to minimize the time and money involved in developing and utilizing geothermal resources, and to maximize their profits. As previously indicated, these individuals may decide to continue or to abandon their efforts at any point in

the process for any number of reasons. A particular resource area may prove to be of unacceptable volume or quality, or the technology required to exploit a resource may not be available or, if available, of uncertain reliability. The time and financial cost involved in preparing a site for drilling, actually drilling the well, developing a production field, and producing and distributing the resultant energy may or may not be acceptable in terms of investment potential.

However, in addition to these minimum costs for conducting their business, other factors also must be considered. These are the costs resulting from institutional issues. Time is required for activities like preparing plans of operation, processing permits, and gathering environmental data. Additional cost factors include the expense of environmental reports, bonds, and fees required by government permits, and mitigating technology required for obtaining permits.

The objectives of government agencies are generally not opposed to geothermal development, indeed they may be supportive of such development. However, by law and regulation, government agencies have the responsibility to assure that any activities associated with geothermal development are compatible with air and water standards, wildlife, and existing patterns of land uses. They must also hold public hearings before granting permits. Generally, they have a responsibility for controlling the pace of development, and they have a desire to achieve a politically acceptable resolution between pro-and anti-growth forces.

Public interest groups and private citizens may differ among themselves in terms of their attitudes toward geothermal development. In general, however, while they tend to have very little knowledge concerning the details of such developments, they are concerned with minimizing adverse environmental and socio-economic impact.[15,16]

Clearly, cooperative activity is required to achieve any degree of geothermal development. Each participant has a set of operating procedures based upon or imposed by a rational set of objectives. Since, however, there is actual or potential conflict, political cooperation is required.[12]

3.4 Federal Response to Legal and Institutional Barriers to Geothermal Development

The Federal Program

The overall purpose of the federal geothermal program is to stimulate commercial development by private industry and local public power authorities.

The program goal is to increase commercial utilization of geothermal energy from the present rate of 0.04 Quads per year to about 6.0 quads per year 2000 and to over 16.0 Quads by the year 2020.[17]

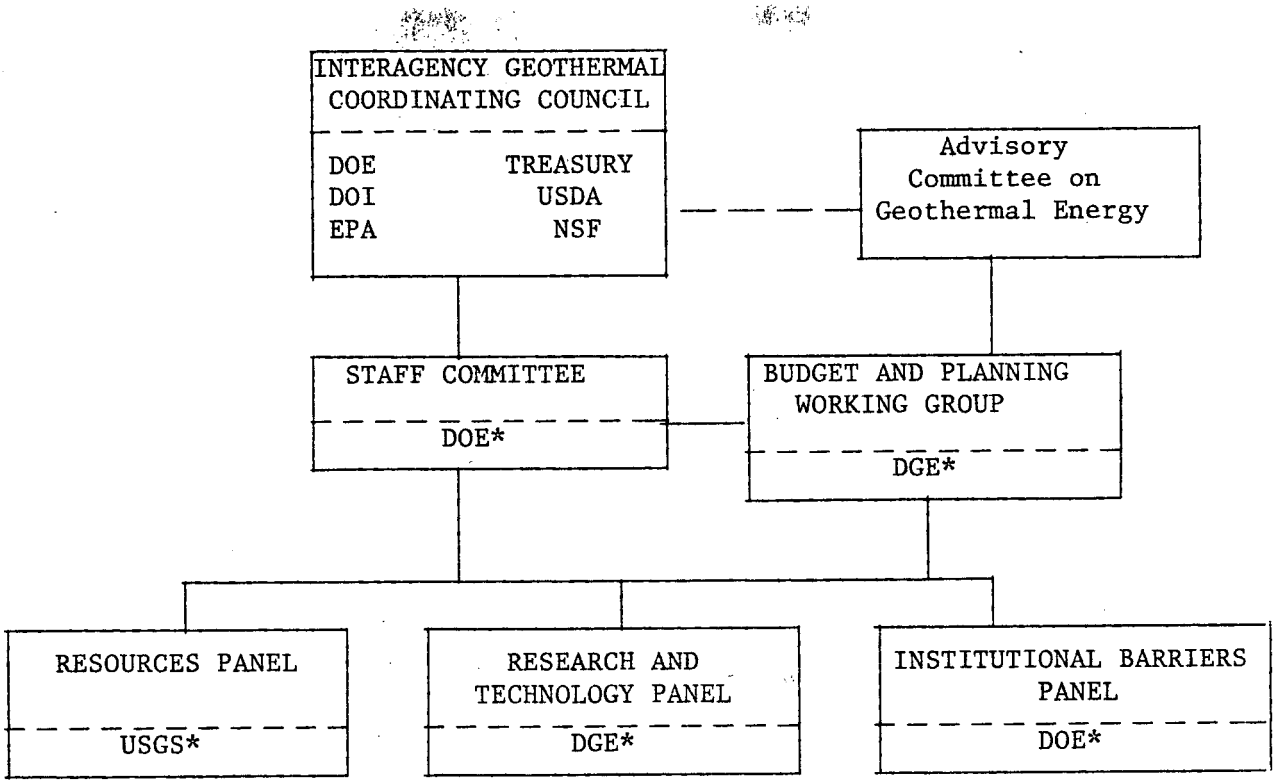
The federal program, which includes the programs of a number of federal agencies, is coordinated by the Interagency Geothermal Coordination Council (Figure 3.2). The council is quite young; it was established and had its first meeting on January 14, 1976.[18] The bulk of the federal research and development is now carried out by DOE and its Division of Geothermal Energy (DGE), and by the agencies of the Department of Interior (DOI), especially the U. S. Geological Survey. Environmental research, monitoring, and policy development receive the attention of the Environmental Protection Agency (EPA) and DOI's FWS, and the Water Resource Council as well as DOE. Institutional and policy research are being advanced by DOE and the Treasury Department. The Geothermal Loan Guaranty Program has been instituted by DOE.

In support of the commercialization component of the program, the federal government is working closely with state and local governments, industry, municipal authorities, and environmental and other public interest groups in identifying appropriate federal initiatives that would most effectively encourage investment in geothermal energy and promote public acceptance of its development. An Advisory Committee on Geothermal Energy has been established to facilitate exchange of information and advice with the non-federal sector.

Institutional Barriers Panel

As shown in Figure 3.2, three panels were established under the Council's Charter: Resources Panel, Research and Technology Panel, and Institutional Barriers Panel. Each panel was given the responsibility for gathering relevant information and for developing recommendations for council's consideration. Of greatest concern to this chapter was the Institutional Barriers Panel (IBP). This panel was given the following responsibility:

> It is responsible for assessing legal, environmental, regulatory, and other aspects of federal, state, and local government policy as they relate to geothermal energy and for developing recommendations for changes and improvements in related laws, policies and procedures, and for examination of other institutional aspects of geothermal energy, including nongovernmental aspects.[18]



*Chairmanship Function

Figure 3.2 Interagency Geothermal Coordinating Council Adapted from 20, p. 128

A number of problems which affected geothermal development were identified by IBP. These problems included the following: federal taxation, federal-state utility rate structuring, and federal-state environmental protection and standard. A rather large number of problems were derived from the Geothermal Steam Act of 1970; these included issues associated with overlapping lease applications, cash bonus competitive leasing, acreage limitations, work requirements, and casual use exploration. Numerous recommendations were made by IBP to the Council. The necessary actions to implement the approved recommendations are underway in the various responsible agencies.[18,19,20]

In particular, the following actions were taken. Several amendments were proposed to the Geothermal Steam Act of 1970 and some of these were incorporated into the energy program the President proposed to Congress. Amendments also were proposed to the regulations designed to implement the Steam Act. In addition, amendments were proposed to the Internal Revenue Code of 1954 and to the Geothermal Research Development and Demonstration Act of 1974.[20]

In short, the action of the IBP through the Council has led to a number of activities which should change certain federal policies that were perceived to be impeding the development of geothermal resources. The panel has also reported that a high degree of interest in their activities was evident in their discussion with industry and in inquiries from members of Congress and others.

Cooperative Arrangements in the Department of Interior

In addition to the problems mentioned above, the IBP identified problems associated with delays in obtaining leases, environmental reviews, and various types of permits. At least in part through the activities of the Council, a Memorandum of Understanding for the Geothermal Program was approved by the directors of BLM, GS, and FWS.[21] This memorandum is an agreement among these DOI agencies to cooperate on a set of procedures for federal land management practices. Figure 3.3 and 3.4 illustrate the various participants and the administrative procedures for geothermal regulatory processes during pre-lease and post-lease activities, respectively.

As may be seen in Figures 3.3 and 3.4, three different offices of BLM, five offices of GS, three offices of FWS, the GEAP, and DOE, all have responsibilities in regulating and controlling geothermal development on lands under DOE control. Some of the activities shown in these two figures were also discussed in reference to Table 3.1, but here the routine steps in the process

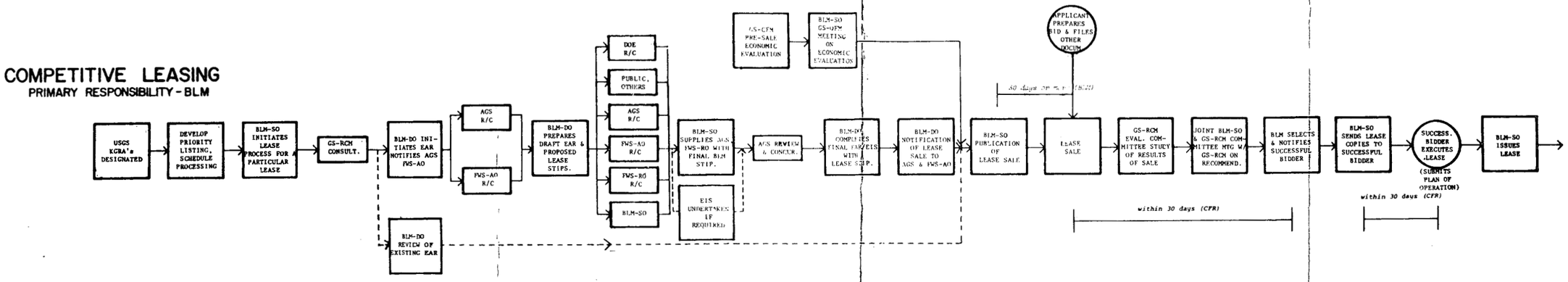


Figure 3-3 Geothermal Regulatory Activities: Pre-Lease Activities

(COMPILED FROM GEOTHERMAL STEAM ACT OF 1970, FEDERAL RULES AND REGULATIONS 43 CFR PART 3000 AND 30 CFR PARTS 270 & 271, AND MEMORANDUM OF UNDERSTANDING FOR THE GEOTHERMAL PROGRAM - USGS, BLM, FWS)

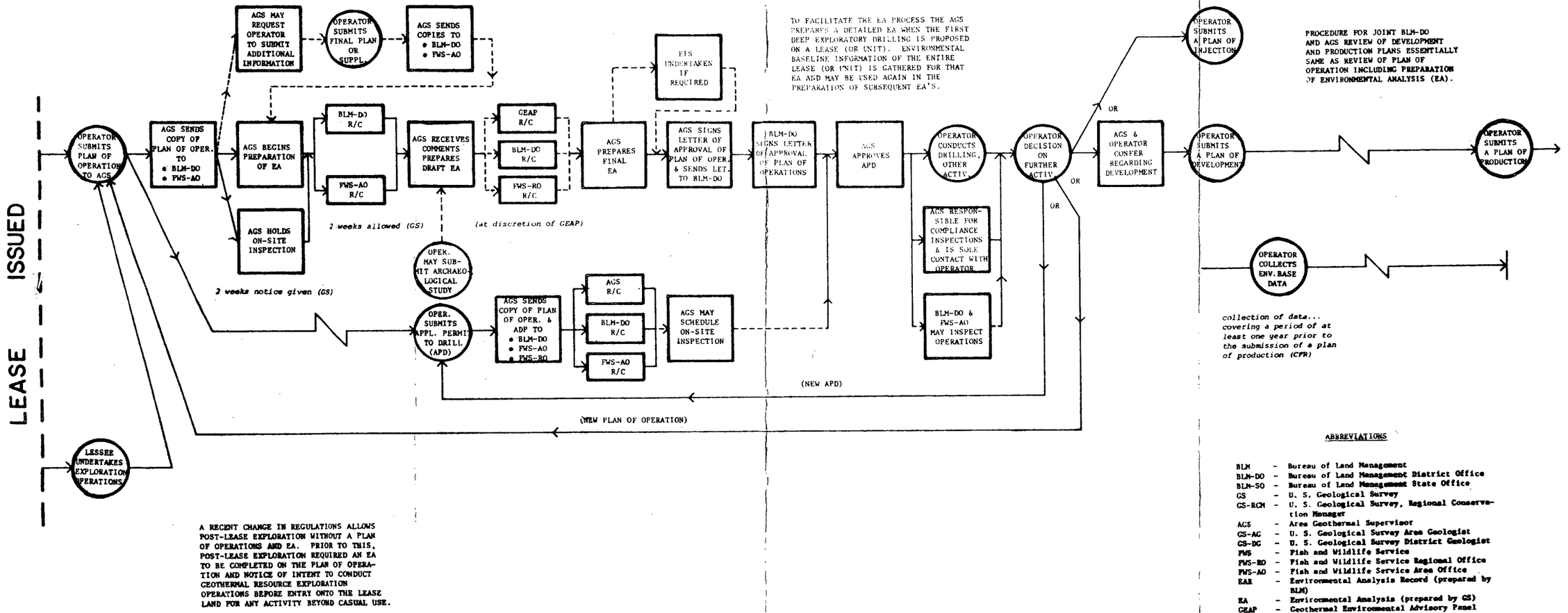


Figure 3-4 Geothermal Regulatory Processes: Post-Lease Activities

ABBREVIATIONS

BLM	-	Bureau of Land Management
BLM-DO	-	Bureau of Land Management District Office
BLM-SO	-	Bureau of Land Management State Office
GS	-	U. S. Geological Survey
GS-RCM	-	U. S. Geological Survey, Regional Conservation Manager
AGS	-	Area Geothermal Supervisor
GS-AG	-	U. S. Geological Survey Area Geologist
GS-DG	-	U. S. Geological Survey District Geologist
FWS	-	Fish and Wildlife Service
FWS-RO	-	Fish and Wildlife Service Regional Office
FWS-AO	-	Fish and Wildlife Service Area Office
EAR	-	Environmental Analysis Record (prepared by BLM)
EA	-	Environmental Analysis (prepared by GS)
GEAP	-	Geothermal Environmental Advisory Panel
R/C	-	Agency Review and Comment

such as the requirement of notification, comment, approval, signature, and transmittal among over a dozen agencies are described in considerable detail. The memorandum of understanding among the agencies of DOI and DOE serves as a vehicle for coordination of these activities. The net effect is to expedite pre-lease and post-lease activities and reduce many of the uncertainties associated with federal land management.

Interagency Geothermal Streamlining Task Force

While the Memorandum of Understanding was a major step toward improving the management of federal land, it only applied to the management of land under the control of DOI. In the Southwest Region, very large tracts of land with geothermal potential are on Department of Agriculture (DOA) lands administered by the U. S. Forest Service (FS). An Interagency Geothermal Streamlining Task Force was formed to assist in coordinating the activities of DOE, DOI, and DOA as they related to geothermal development.[22]

Specifically, the Task Force is developing recommendations to IGCC for appropriate action to implement the President's commitment to Congress that:

> "The Department of the Interior and Agriculture will streamline leasing and environmental review procedures to remove unnecessary barriers to development of geothermal resources."[22]

This objective was included in the President's comprehensive energy program submitted to Congress in April 1977. The commitment was prompted by the fact that although the Geothermal Steam Act was passed nearly seven and one-half years ago, there is still no commercial production of this resource on federal lands.

The Interagency Geothermal Streamlining Task Force has undertaken a study which includes a) a comprehensive analysis of the elements of the present program designed to identify the sources of delay and quantify delays which are actually occuring; and b) the determination of the potential effects upon program performance of a series of options for program modification. The effectiveness of alternative options will be assessed in terms of their relative ability to support the Department of Energy's projected geothermal power-on-line schedule while adequately protecting the public interest and the environment.

The study will also incorporate input provided by the public, industry, environmental groups, and state agency officials through a series of workshops held in the western states in June. The schedule for these meetings was widely publicized in order to obtain the broadest participation possible.

The Task Force developed a series of options for modifying the geothermal leasing and permitting program (described below) and comments on them were requested from the above groups. In addition, suggestions for additional alternatives were solicited.

Below are listed the three options that were proposed by the Task Force and the program modifications under consideration for each option. Various advantages and disadvantages were discussed for each alternative in the announcement distributed by the Task Force.[22]

Option 1. Improve the present system through changes in regulation and administrative procedures.

A. Use regional or areawide environmental analyses in pre-lease review and conduct site specific studies only during the post-lease permitting process.

B. Set time limits or timeframes (through administrative directive and/or regulations) for issuance of leases permits.

C. Improve coordination in all phases of pre and post-lease activities.

D. Improve uniformity and consistency of policies and procedures with respect to lease stipulation among the involved agencies.

E. Institute formal nomination procedures for KGRA's and non-competitive areas.

F. Allow no-surface-occupancy leases in wilderness study areas and other special areas where requested.

G. Modify KGRA regulations.

H. Allow issuance of non-competitive leases unless the area is in a KGRA at the time of application.

I. Provide budgets in proportion to workloads, organizational needs, and priorities.

Option II. Base leasing decisions on areawide environmental assessment in combination with land management plan.

Option III. Provide for separate environmental analysis of exploration and development phases, with initial review of exploratory impacts only and comprehensive review after a discovery is made.

The next part of this chapter reviews some of the studies which led to these recommendations.

3.5 Previous State and Regional Studies of Institutional Factors

The aim of this section is to review the assumptions, procedures, and results of some recent research conducted at the regional and state level on the legal and institutional barriers to geothermal development. Two excellent papers, one by Sacarto[6] and the other by Schuller et al,[13] adequately illustrate two approaches used in this type of research. These two papers show that very similar lists of needs and similar sets of recommendations are generated regardless of how the issue of state-level and institutional constraints to geothermal development are studied. The two general types of approach to the study of legal and institutional factors affecting geothermal development may be classified as (a) those which promote or encourage changes in the legal and institutional infrastructure which controls the geothermal process as a means of reducing the uncertainties, the delays, and the cost experienced by the legal and institutional framework so that participants can more efficiently learn the process and the steps required to adapt to it; and (b) those which promote stable policies. These two approaches and the recommendations they generate are discussed below.

Studies Promoting Policy Changes

In State Policies for Geothermal Development, Sacarto reviews for the National Conference of State Legislatures (NCSL) the various technical, economic, and institutional aspects of geothermal development as they exist and as they affect geothermal development in the thirteen western states and the gulf states of Texas and Louisiana.[6] Sacarto accepts the most optimistic projections for geothermal potential as a working hypothesis. These projections are that the potential for geothermal resources is huge. For electrical generation this energy projection is in the order of 100,000 MW over the next 20-30 years (one-fifth the current U. S. electrical capacity). The nonelectric applications are presumed to have equally great though unspecified potential. It is further assumed that these contributions can occur at prices competitive with energy currently generated from other sources and with relatively little environmental impact.[16]

Given those assumptions, Sacarto seeks to explain why the energy industry has not invested large sums of money into the development of geothermal resources. Sacarto recognizes that utilities tend to be wary of new, unfamiliar resources, especially those for which there is a requirement for site specific power plant

construction and for which there is still an uncertain technology for electric power generation. These uncertainties on the part of a generally conservative industry hinder the rapid development of the resource. Sacarto, however, places a major share of the inhibitory forces in state and federal policies. His comments on obstacles to geothermal development at the very beginning of his report set the stage for what follows in his report: . . . "State and federal policies that hobble geothermal development . . . cripple the geothermal industry . . . failed to encourage large scale development . . . accentuate the uncertainty and risk already inherent to geothermal exploration and development."(6)

After examining, in turn, features of the resource, factors which characterize and affect the exploration and development of a geothermal resource area, and the means by which various types of taxes are applied to geothermal development, Sacarto reviews how the states have characterized the resource and how they regulate the leasing of state lands and the development of the resource within the states. Based upon this review of the industry and the state and federal policies which affect the industry, Sacarto identifies six conditions needed by the industry if it is to pursue large scale development; utility confidence in the resource, equitable tax treatment, prompt exploration of extensive land areas, long and secure tenure for productive properties, prompt facility siting and development, and competitive access to various consumers.(6)

Sacarto recommends a set of nine policies which could be enacted by state governments to achieve these conditions. These policies and their objectives are as follows:

1. Policies designed to direct public attention to geothermal resources as an alternative form of energy and power. Both policy makers and the general public need to be exposed to more information concerning the immediate and longterm values available from geothermal resources.

2. Policies designed to create and nurture an interstate geothermal development compact. Such a compact would facilitate communications between the states and other participants in the geothermal process and thereby lead to improvements in geothermal legislation and regulations.

3. Policies designed to clarify the statutory definition of geothermal resources. Such clarification is necessary to remove

uncertainties associated with such issues as resource ownership, taxing policies, and regulatory processes. A distinction between geothermal resources and established water resources is especially important in the water scarce Southwest Region.

4. Policies designed to reduce the need for unreasonably high levels of water appropriation. Statutory assurance is needed by industry that water rights are necessary for only the water that is consumed by the geothermal process, not for the total volume which may be processed.

5. Policies designed to establish more uniform and more realistic provisions for assessing the value of undeveloped geothermal properties for the purpose of taxation. These policies would recognize that no income value can be attributed to prospective geothermal production before commercial quantities of the resource are actually produced and sold.

6. Policies designed to provide state tax benefits and encourage federal tax benefits to the geothermal industry. Income tax deductions for intangible drilling costs and percentage depletion allowance will enable the industry to attract the necessary investment capital.

7. Policies designed to establish more secure leasing provisions for state-owned land and encourage the establishment of federal lease provisions more suited to geothermal development. These provisions would include a reevaluation of terms, renewal arrangements, acreage limitations and lease adjustment clauses.

8. Policies designed to improve the market position of electric power produced from geothermal energy. These policies would encourage utilities to invest in geothermal projects through such means as financial incentives, demonstration projects, and siting priorities.

9. Policies designed to encourage nonelectric application of geothermal resources. The direct application of geothermal resources may, in the long run, be the most efficient and effective use of the resource.

The impact and thoroughness of the NCSL publication can be measured by the extent to which it is referenced by other investigators and by the estent to

which the recommendations made by Sacarto are also made by other independent investigators. For example, a special report by the staff of the Western Governors Regional Energy Policy Office in May, 1976, made recommendations for encouraging geothermal development which are essentially indistinguishable from those made by the NCSL report.[13]

A series of studies commissioned by the Northwest Energy Policy Project (NEPP) came up with conclusions which with one important exception, are in basic agreement with those of Sacarto.[7,11,12] In one of these studies, Johnson, et al,[7] agreed with Sacarto that the main hinderances to geothermal development in the Northwest are the economic risks faced by potential developers. They argue, however, that there is little the states can do to significantly mitigate those hindrances other than "to be aware of the potential and of the limitations of geothermal energy."[7] They emphasize that potential lands for development are federally controlled, the principal tax obligation is federal, and (by implication) the funds needed for effective stimulation of exploration and development must come from the federal treasury.

As part of another study in the same NEPP series of reports Hiatt focused on institutional constraints and opportunities for "unconventional energy sources" including a geothermal energy development.[10] Hiatt reviewed a wide range of state and local governmental actions which could be categorized as negative and positive incentives. He further gives examples of official action which would or could affect the development of geothermal energy sources. These actions, with regard to unconventional energy production, were grouped into four categories: no action, direct economic incentives, indirect efforts at promotion, and direct action toward production. When specifically addressing the public policy options application to geothermal energy Hiatt intensively drew upon Sacarto's work. In fact Hiatt's presentation of policy options and his recommendations were extracted from the State Policies Report published by NCSL.

Before leaving this subsection concerned with the status of and changes required in state policies, reference should be made to NCSL's Geothermal Policy Project. This new project was launched on January 16, 1978. "The objective of the project is to stimulate and assist the review of state policies that affect the development of geothermal resources. Successful completion of the project is to facilitate state statutory and regulatory environments that are consistent with efficient development of geothermal resources."[24] Hence, the project is an obvious extension of the previous work performed by Sacarto

for NCSL. The project has selected six states in which to concentrate its efforts during 1978. Two of these six states (New Mexico and Utah) are currently in the Southwest Region. This effort, funded by DOE, will complement the efforts being made by the Southwest Regional Program as reflected by the present chapter.

Studies Promoting Stable Policies

Schuller et al., concentrated on identifying and analyzing the nontechnical problems which hamper the production of electricity from geothermal resources in California.[13] The assumptions they made in performing that analysis and the possible solutions they proposed are equally appropriate for none electric applications and to regions outside of the state of California.

Schuller et al., like Sacarto and others, notes the discrepancy between the potential and the actual plans for the utilization of geothermal energy. They also accept the conclusion that nontechnical problems such as leasing, financing, and permitting appear to be a major reason for significant and costly delays in geothermal development. However, rather than focusing on the laws and regulations which might create or contribute to these nontechnical problems, Schuller et al., focuses on the behavior of the significant participants who must operate within the constraints imposed by the nontechnical problems.

In particular, Schuller et al., argue that "smoothing or making minor modifications to the existing regulatory process is likely to do more to speed the development of the geothermal industry than attempting wholesale changes to the process."[13] This argument is based on the concept of institutional learning which holds that in any process certain minimums of time, money, and trouble are required to learn the substance and procedures of the process. When the process is unstable and when the participants cannot devote continuous and undivided attention to the process, the learning will be even less efficient.

Even though there are large areas of uncertainty concerning the impacts of procedural and policy actions, there are a few individuals and organizations who have learned a great deal about the geothermal development process; they have learned what is necessary to operate effectively. Others are in various stages of aquiring the necessary knowledge. If the process remains stable, a type of institutional learning will continue. All the participants will continue to acquire useful knowledge which they can in turn share with others in the process. Hence, even if a policy or regulatory system is not as good in some sense as it might be, the participants can perform well within that system. Any new system of policies and regulations would require that all

participants begin the learning process all over again; the time, cost, and trouble of learning the new system may outweigh the gains the new system were to produce.

Schuller et al., examined the nontechnical problems within each of five technical stages in the development of geothermal resources (leasing, exploration, marketing the resource to a utility, constructing the power plant, and transmitting the electric power to consumers: as well as nontechnical problems associated with financing, environmental impact reporting, and the activity of several agencies unique to California. In each area, these investigators examined proposals made by various participants in the process (federal and state agencies, representatives of industry and public interest groups, and others).

All proposals were evaluated in terms of whether they would help participants adapt to, or promote relatively minor modifications in the existing system. Six classes of proposals were acceptable under that criterion.[13]

(1) Those that emphasized the value of gathering and disseminating information about the substance and procedure to those that need it (e.g., baseline environmental data, resource exploitation technology, mitigation technology, and discussion of procedural rules).

(2) Those that are aimed at refining and codifying substantive and procedural rules that may be a source of delay of difficulty because of their ambiguity (e.g., either more formal statements to increase the stability of a rule or more flexible rules which are sensitive to site specific peculiarities).

(3) Those that emphasize the use of technological or procedural innovations to mitigate problems of legal, institutional, or political nature (e.g., methods such as slant drilling and well head mufflers that can be used to satisfy environmental requirements).

(4) Those that emphasize the value of advance planning to reduce administrative costs, delays, and troubles, (e.g., careful preparation for negotiations between parties).

(5) Those that involve the selective resolution of political and legal problems (e.g., generating public support for the industry).

(6) Those that suggest the direction that should be taken by future research and development (e.g., proposals that encourage DOE and others to provide demonstration grants rather than basic research grants).

These six classes constitute only relatively minor changes that were designed to minimize the need for new institutional learning or to maximize the efficiency of any institutional learning which must occur. With the same criteria in mind, Schuller, et al., also gave support to two kinds of major change. In the latter two instances the criterion was that the change would require the acquisition of only minor amounts of new knowledge. These acceptable proposals for major change are as follows:

(1) Any major change that would increase the relative attractiveness of the geothermal industry in the investment area (e.g., tax credits for geothermal investments).

(2) Any major change that would reduce the number of participants through organizational integration (e.g., reservoir unitization, or vertically integrated companies).

The eight types of proposals listed above all meet the criterion that changes in policy should help participants adopt to, or promote relatively minor modifications in the existing system. Schuller et al., imposed the further restriction that acceptable proposals must in some way reduce the time, money, and trouble associated with (a) the process of bringing the proposal itself into law or into practice and (b) the effect of the proposal once it is put into practice. Clearly, there are proposals such as one which might seek to exempt the geothermal industry from environmental impact legislation, which would accelerate the development and utilization of geothermal resources if they became law, but which probably could not become law or perhaps could but only with large expenditures of time and money and large amounts of trouble.

The criteria developed by Schuller et al., for evaluating proposed changes in the geothermal process seem to recognize the needs of industry and also take into account the probable reactions of special interest groups and the realities of the American political scene. Schuller et al., used these same criteria to identify proposals that should be avoided. These included:

1. Proposals that add more steps in the regulatory process - - for example, proposals for environmental appeals boards.

2. Proposals aimed at removing geothermal development from local control or the environmental review process.
3. Proposals involving major overhauls of the existing lease system.
4. Proposals involving significant changes in normal patterns of property taxation.
5. Proposals using federal or state "expediters" to resolve conflicts or to provide information.

3.6 Summary of Previous Regional and State Policy Studies

The difference between those studies which promote changes in state policies and those which encourage caution in accepting proposals for changes in state policy may be more in style than in substance. The major recommendations each derives from their efforts are not significantly different.

Sacarto provides an excellent starting point for one just beginning an analysis of the institutional factors which may affect the development of geothermal resources. His report indicates what to look for, where to look, and what you might find as a result of your efforts. While his proposed policies for state government are clearly designed to most directly benefit the geothermal industry, they are not oblivious to the needs of the governmental and public sectors nor do they ignore the problems associated with adjusting to major revisions in policy and regulation. However, Sacarto's references to the needs of the government and public domains are primarily concerned with the more obvious consequences of geothermal development. For example, the statement that "irresponsible geothermal operations can pose clear dangers to public health and local environments."(6) Furthermore, the concerns expressed over the effects of major changes in policy are directed at the cost to industry for converting to the new approaches and the seriousness to industry of unforseen complications which the new procedures may introduce. With respect to major changes in leasing methods, Sacarto notes that "the procedures may fail in practice to protect the explorer."(6)

Schuller et al., provide a careful analysis of over 98 separate proposals for changes in the legal, institutional, and political context of geothermal development. In the process of doing so they provide future researchers with two important guides for success. First, Schuller et al., explicitly underscore the importance of behavior issues which must be taken into account when a decision is to be made concerning the policies and procedures. It

is a generally accepted truth that individuals and groups will react differently in familiar (though perhaps undersirable) situations than they will in situations which are unfamiliar and hence within which outcome are more uncertain. It is also true that individuals and organizations representing different legitimate interests will perceive the consequences of a given change in policy in quite different ways. Second, Schuller et al., have developed a systematic procedure for examining proposals for change and a set of well defined criteria for choosing among those proposals which should benefit future researchers in the area of policy regulations.

One proposal is common to both the Sacarto and the Schuller et al. studies. That is the proposal to encourage cooperative activities among the various industrial and governmental participants. This may be an especially important issue for participants operating at the state level. If Johnson et al. are correct in their observation that there is little state and local level policy action can accomplish by themselves,[7] their only recourse may be for state and local agencies to combine their efforts at promoting geothermal development and at promoting changes in federal policies for land management, regulation, and taxing. Industrial and federal policy making entities sometimes might view local participation as constraints on their ability to proceed responsibly. However, local participation should be viewed as an opportunity for securing local and public input, understanding, and even support.[11]

Institutional Factors Operating in the Southwest Region

The following discussion of state-level legal and institutional factors in the development of geothermal energy is organized into four sections: objectives, procedures, results concerning the current status of geothermal development, and results in terms of the identification of major participants within each state.

Objectives

The objectives of this section of the report are two-fold. The first objective is to identify for each of the southwest states the current status of geothermal development with the aim of isolating the contribution of legal and institutional factors. The goal is to identify how various state-level statutes or regulations and state level taxing or environmental protection procedures may have affected the rate of leasing, exploring, developing, and utilizing geothermal resources within each state.

The second objective is to identify the principal participants in the geothermal development process within each state. According to this approach, the factors of interest occur as a result of actions of and the interactions among participants in the development process. These actions and interactions are initiated and constrained by various statutes, regulations and policies, but they also may change as a result of institutional learning.

The major theme of the second objective is that the behavior of an individual participant (and the collective behavior of a group of individuals in the same institutional agency) is affected by the experiences that individual (or group) has had. Consequently, the perceptions attitudes, and behavior of participants in the geothermal development process can be predicted on the basis of concepts derived from the behavior sciences.

To underscore the importance of the behavioral aspects of the entire process, it must be emphasized that any given regulation or the consequences of any given action may be perceived quite differently by participants who have different responsibilities. For example, one developer has complained that it may take as long as six months to obtain a permit to drill a geothermal well. On the other hand, a state-level regulator was attempting to be quite positive when he pointed out that a permit to drill a geothermal well can be obtained in as little as twelve to eighteen months. The developer and the regulator should not be expected to automatically perceive the permitting process in the same way. The resulting conflict in goals and operating procedures may be resolved without any special mitigating action by anyone. Resolution of the conflicts may occur through a mutual learning process that will occur as the participants continue to interact with one another. At times, resolution of conflicts can be hastened by a change in technology or in the legal and regulatory content.

Three types of data were needed to achieve an understanding of the role of institutional factors in geothermal development in the Southwest. First, information concerning the status of geothermal development was needed for each state. In particular, it was necessary to determine how much activity was occuring at each stage in the development process. Second, information was needed concerning the current status of laws, regulations, and policies within each state. Third, information was needed about the various participants in the geothermal development process.

Information concerning the status of geothermal leasing, exploration and development was obtained from a number of independent sources. Information of

this type was provided in the resource data sheets the state teams provided for each resource area. Current information on the status of geothermal resource development was also available from BLM lease status reports and from the land departments within each state. Information concerning the legal and regulatory provisions, and the identify and characteristics of participants was obtained from reports prepared by data collectors working for the respective state teams.

Results - Current Status of Geothermal Activity

Leasing of Resource Areas

The issue of whether or not a geothermal resource is developed depends initially upon a developer's ability to acquire stable access to the geothermal reservoir. The relative accessibility of the reservoir depends upon ownership of resource, and that in turn often depends upon how the resource is legally defined.

In this regard, the states may have little control over who, if anyone, has access to the resource. The states generally own relatively small amounts of land surface. Table 3.2 shows the extent of federal, state, and private land ownership among the five southwestern states. No state owns more than about fourteen percent of its surface area and most own less than ten percent. Federal ownership accounts for from one-third to over four-fifths of the land. Private ownership of land is also quite high, ranging from just over thirteen percent to nearly sixty percent.

If the geothermal resource is defined as a type of water or mineral resource, it may be legally separated from the land surface. In this manner, ground water is considered a property of the subsurface estate and is controlled by the state as a public resource. Azirona is the only exception to this rule in the five southwestern states. In Arizona, ground water is generally attached to the surface, and hence its ownership may be determined through court orders.

Minerals are generally attached to subsurface estates, and ownership of these minerals also may be separated from ownership of the land surface. State and federal land management practice has often reserved mineral rights to the government while selling off the surface rights. Consequently, since surface and subsurface estates may be independently owned and controlled, the attachment of the geothermal resource to either estate or to neither estate will determine who has legal custody of the resource. Table 3.3 shows the amount

Table 3.2

Land Ownership in Southwest Region*
In Million Acres

State	Total Acreage	Federal		State		Private	
		Acres (M)	%	Acres (M)	%	Acres (M)	%
Arizona	72.688	32.433	44.6	9.222	12.7	31.033	42.7
Colorado	66.486	24.152	36.3	3.233	4.9	39.101	58.8
Nevada	70.264	60.725	86.4	0.086	0.1	9.453	13.5
New Mexico	77.766	26.388	33.9	11.032	14.2	40.436	51.9
Utah	52.697	35.060	66.5	4.923	9.3	12.714	24.2

*From Sacarto State Policies for Geothermal Development, November, 1976 (Ref. No. 6)

Table 3.3

Mineral Acreage Reserved to the State and to the United States*
In Million Acres

State	Mineral Subsurace Estate	
	Reserved by State	Reserved by U.S.
Arizona	1.000,000	5.662,640
Colorado	1.000,000	12.929,974
Nevada	---	0.738,593
New Mexico	2.000,000	24.275,069
Utah	0.919,000	3.765,561

*Adapted from Sacarto, State Policies for Geothermal Development, November, 1976. The acreage given for state mineral lands are only rough approximations. The acreage given for federal reserves are accurate as shown through 1948; approximately 15% more land was patented with mineral reserves through 1974.

of land acreage in each state reserved to the state and federal governments because of these mineral reservations.

The net effect of mineral and ground water reservations is to create considerable uncertainty about who controls access to the geothermal reservoir. The issue would of course be settled if there were a common definition of what is and is not a geothermal resource. However, as pointed out by Sacarto, there are important differences in how the five southwest states define the resource.[16] New Mexico and Utah explicitly distinguish between the thermal and mineral components of the geothermal resource and the waters which transmit those components. Arizona and Colorado make clear distinction between water, mineral, and geothermal resources. Following the definition used by the federal government, these latter two states include all products (including water) of the geothermal process in their definition of a geothermal process. To complicate the issue further, while Arizona includes any mineral or minerals, exclusive of fossil fuels and helium, in their definition of geothermal resources, Colorado explicitly states that geothermal resources are not mineral. Finally, to complete a summary of the five states, Nevada defines geothermal resources as simply heat and is adopting special regulations to govern their development in the state.

As a result of the widely varying and still unstable definition of geothermal resources across the five states, there is uncertainty concerning which level of government owns the resource and which agencies within the state government have regulatory control over leasing, exploration, and development of the resource.

While these uncertainties remain, leasing has nevertheless occurred. Table 3.4 shows the amount of federal and state lands that have been leased for geothermal exploration and development in the Southwest Region. The numbers in parentheses refer to the number of separate leases in each category. As may be seen, leasing activity varies considerably across the Southwest Region. The status of leasing is moderately high in both Colorado and New Mexico. The total acres leased in Colorado include 40,000 acres which have been dropped after the completion of exploratory drilling.

Taken together, the acreages of state and federal land leased for geothermal activity may appear quite high, suggesting that there are no barriers to geothermal development at the leasing stage. That may be a misleading conclusion. Table 3.5 shows a more detailed breakdown on the status of lease

Table 3.4

Acreage of State and Federal Geothermal Leases*

State	Federal Leases		State Leases
	KGRA	Non-KGRA	
Arizona	- - -	6,508 (?)	- - - -
Colorado	5,036 (3)	28,488 (25)	83,192 (27)
Nevada	152,662 (79)	729,309 (?)	- - - -
New Mexico	70,911 (40)	88,490 (45)	63,374 (147)
Utah	86,447 (50)	340,011 (199)	210,570 (221)
Totals	315,056 (172)	1,192,806 (269)	357,136 (395)

*From State Team Final Reports, August, 1978

Table 3.5

Status of Lease Sales on Federal KGRA's*

State	Theoretically Available for Leasing		Acres Offered		Acres Bid on		Acres Accepted	
	BLM	FS	BLM	FS	BLM	FS	BLM	FS
AZ	3,240	0	780	0	0	0	0	0
CO	11,271	1,513	11,271	0	5,036	0	5,036	0
NV	326,802	4,160	201,988	2,560	148,163	0	145,682	0
NM	190,320	1,224,004	101,693	29,375	62,482	18,050	62,482	18,050
UT	83,215	15,572	78,966	10,852	77,277	10,852	77,277	10,852
Total	614,848	1,245,249	394,698	42,787	292,958	28,902	290,477	28,902

*From Streamlining Task Force, April, 1978

Table 3.6

Age of Noncompetitive Lease Application Still Pending for Federal Land*

(as of April, 1978)

State	Less than 12 mos.		12-23 mo.		24-35 mo.		More than 35 mo.		Total	
	BLM	F S	BLM	F S	BLM	F S	BLM	F S	BLM	F S
Arizona	5	27	11	0	2	26	7	1	25	54
Colorado	0	0	0	0	0	0	9	27	9	27
Nevada	53	1	7	0	17	1	197	8	274	10
New Mexico	34	11	24	0	8	3	144	28	210	42
Utah	38	2	34	15	9	3	135	41	216	61
TOTALS	130	41	76	15	36	33	492	105	734	194

*From Streamlining Task Force, April 1978

applications has been pending for three or more years. The indicated long delay in issuing a decision for these non-competitive lease applications is slightly higher for BLM than for FS (67% vs. 54% for 3 or more years). However, as described earlier, about 55 percent non-competitive lease applications to FS are still pending compared to only 29 percent for BLM.

Unfortunately, the status of leasing activity for state lands is not as well documented as is the status of leasing activity for federal lands. The sparsity of information on the leasing status of state-owned geothermal resources is due in part to the small amount of land owned by the states in the Southwest (on the average about 8%). The absence of leasing data for state land is also due to moratoriums on the leasing of state-owned lands in Nevada and Arizona, and the absence of any state geothermal leasing activity in New Mexico since 1974. The absence of activity in this regard is due in part to legal challenges to non-competitive sale of state land (in Arizona), and in part to the need for regulatory policy (in Nevada).

Table 3.7 summarizes the status of procedures governing the leasing of state-owned land for geothermal exploration development. As may be seen the criteria for distinguishing between state KGRAs and state non-KGRAs differs among the southwestern states. Table 3.8 summarizes the terms of leases issued for state geothermal lands, and for comparison, for federal geothermal lands. As may be seen, there are considerable differences in leasing provisions among the southwestern states and between the states and federal government.

Five year primary lease terms are specified in the lease provisions of Arizona and New Mexico while Utah and the federal government allow for a 10 year primary lease term. Furthermore, the frequency with which lease terms may be negotiated is either unspecified (as in Arizona and Nevada), or is required every three, five, or ten years (for Utah, Colorado, and New Mexico, respectively). It is of course, very difficult to get an investor to commit large amounts of capital to develop geothermal resources when there is no guarantee that the developer will continue to have secure access to those resources after the initial primary lease term expires. This is especially true since once a resource is made productive, it may take 20-40 years to amortize the large investments that were required. The current status of leasing and lease adjustment provisions raise too much uncertainty for many prospective investors.

Table 3.7

Leasing of State Land*

State	Non-KGRA		KGRA	
	Newly Offered	If Applications Overlap	Bidding Factor	Designative Criteria
AZ	By Application	Cash Bonus Bidding or Qualification	Cash Bonus	Geology and/or Competitive Interest
CO	Specified by State Land Commissioner			
NV	Moratorium since 1974			
NM	Competitive (3-day filing)	By Application	Cash Bonus	Determined by Commissioner of Lands
UT	Cash Bonus (15-day filing)	By Application	No such Designation	

*From Sacarto State Policies for Geothermal Development, November, 1976

Table 3.8

State Geothermal Lease Provisions*

State	Primary Term	Renewal	Renegotiation of Rental and Royalties	Acreage Limits
AZ	5 years	2 years if drilling; for duration of commercial production	. . . . .	maximum lease; 2,560 (4 sections) confirmed to 6 miles square
CO	set in lease	for duration of commercial production; lacking production, at discretion of state land board	Minimum roy alty: 5 year intervals	. . . . .
NV	. . .	. . . . .	. . . . .	. . . . .
NM	5 years	so long as geothermal resources are produced or capable of being produced in commercial quantities	10-year intervals, beginning 20 years after lease date	minimum lease: 640 acres maximum lease:2,560acres maximum state holdings: 25,600 acres
UT	10 years	for duration of commercial production; or 1-year terms, in absence of production, upon payment of $5/acre advance royalty	3-year intervals	minimum lease: 40 acres maximum lease: 640 to 2,560 acres, at discretion of director of state lands
U.S.	10 years	for duration of commercial production	after production of steam; rentals and royalties at 20 years intervals; other terms at 10 year intervals	minimum lease: 640 acres maximum lease:2,560acres maximum state holdings: 20,480 acres

*From Sacarto State Policies for Geothermal Development, November, 1976.

The restrictions on the acreage that a developer may have in a given lease tract and limits on the total acreage a developer may hold in a given state generally follow federal acreage limitations. These state-level limitations are subject to the same criticisms as are levied against those federal acreage limitations. In short, the size of the limits is too small to provide security for any possible discoveries that are made and too small to permit the developer to most efficiently distribute his risks over a wide enough area to optimize his chances of success.

Exploration and Development of Resource Areas

Table 3.9 shows the status of exploration and development in each state. The number of exploratory thermal gradient wells which have been drilled is shown in the upper portion of the table, broken down when possible into shallow and deep wells. The status of applications for drilling permits is shown in the center portion of the table. The lower portion of the table shows the status of active field development within each state.

As may be seen in Table 3.9 the level of exploratory drilling within each of the five states parallels the level of leasing activities shown in Table 3.4. While little exploratory drilling has occurred in Arizona and Colorado, there have been large numbers of exploratory holes drilled in each of the other three states. Deep test wells have been drilled in only the four states in which there has been leasing activity. Relatively large amounts of drilling activity are likely to occur in the near future in the two most active states. Nevada has over 150 Notices of Intent on file, 25 of which are for deep exploratory wells. Developers in Utah have received permits to drill 51 deep wells and only 14 have been drilled.

Development of geothermal resources has progressed considerably on at least four sites: at least two in Nevada, Roosevelt Hot Springs in Utah, and Valles Caldera in New Mexico. In each of those areas, it is projected that there will be 50-55 MW demonstration plants with power on line before the mid 1980's.

It is of course very difficult to know how much progress there might be in the exploration and development of geothermal resources if there were no legal or institutional barriers. On the other hand, the data used in constructing Table 3.9 show that development is occurring and will continue to occur at an even faster rate in the near future. Overall, there is reason for optimism. Not only have plans for future field activity been formulated by

Table 3.9

Exploratory and Development Activities
in the Southwest Region*

Drilling	AZ	CO	NV	NM	UT
Exploratory wells	8	6	1000+	156	225+
Shallow (< 500 ft)	(15)	(5)	(11)	(-)	(-)
Deep (> 500 ft)	(3)	(1)	(51)	(-)	(-)
Deep-Test wells	--	1	64	17	19
Drilling Permits Approved	--	--	166	20	51
Applications on file	50+	6	150	--	--
Development	--	--	Desert Peak	Valles Caldera	Roose-velt

*From State Team Final Reports

developers, there are also several indications of meaningful changes in the structure and response times of agencies responsible for regulation. The activity of the IBP, the memorandum of understanding for cooperative procedures initiated and approved by agencies within DOI, and the activities of the streamlining task force all hold forth the promise of more enlightened behavior if not actual changes in the operating procedures of federal land management agencies.

In addition, the Environmental Protection Agency has produced a set of recommended interim guidelines for environmental standards which hopefully will be uniformly acceptable to all regulatory agencies, and hence, reduce the uncertainty which presumably served to constrain geothermal development. This type of action among the land management and regulatory agencies is extremely meaningful and represents the types of interagency cooperation that should increase as the nature of the problems and benefits associated with geothermal resources becomes better understood.

There is evidence for the existence of the type of institutional learning which is predicted to occur more frequently as all participants acquire more experience in the geothermal development business. For example, in Colorado lease time has decreased from 35 months for some applications filed in January 1974, to only 10 months for some applications filed in March 1975.

Many of the improvements in the status of institutional factors have occurred in the federal arena. It is expected that similar improvements will occur if meaningful integration of objectives and procedures occur among state agencies and between agencies at the state and federal levels.

Results - Identification of Major Participants

In addition to identifying the status of leasing, drilling, and development activities within each state, an attempt was made to identify which state agencies were participants in one or more stages of the geothermal development process. Tables 3.10 through 3.14 summarize the results obtained from the efforts.

These tables show the names of state agencies which become participants and the stage in the development process in which this involvement occurs. Whenever possible, the magnitude and nature of the participants' involvment is also specified in the table. An asterisk is used to indicate that a participant is the lead state agency at a given stage in the development process. The letter P indicates that the agency must issue a formal permit before development may occur. The letter C indicates that the agency must consent or must give its approval before development of a geothermal resource may continue.

Table 3.10

STATE AGENCIES WHICH PARTICIPATE IN GEOTHERMAL DEVELOPMENT IN ARIZONA

PARTICIPANT / STAGE	Arizona Oil & Gas Commission	Land Department	Water Commission	Water Quality Control Commission	Air Pollution Control Hearing Board	Office of Environmental Planning	Environmental Planning Commission		Department of Mineral Resources	Power Authority	Power Plant & Transmission Siting Comm.	Tax Commission			County Agencies		
PRELEASE CASUAL EXPLORATION																	
PRELEASE INTENSIVE EXPLORATION	*	C															
LEASING		*							?								
POST LEASE EXPLORATION	*	C P	?	?	?	?			?								
FIELD DEVELOPMENT AND PRODUCTION	*	C		?	?	?	?		?	?	?	?			?		
ABANDONMENT	*	C			-	?											

Table 3.11

STATE AGENCIES WHICH PARTICIPATE IN GEOTHERMAL DEVELOPMENT IN COLORADO

PARTICIPANT / STAGE	Colorado Oil & Gas Commission	Board of Land Commissioners	State Engineer	Department of Health	Dept. of Health Air Pollution Control	Dept. of Health Water Quality Control	Water Conservation Board	Land Reclamation Board	Division of Property Taxation				Department of Regulatory Agencies		Public Utilities Commission	County Agencies	
PRELEASE CASUAL EXPLORATION																	
PRELEASE INTENSIVE EXPLORATION	*																
LEASING	A	*						A								A	
POST LEASE EXPLORATION	*		C														
FIELD DEVELOPMENT AND PRODUCTION	*		C	?	P	P	?	?	?				?		P	?	
ABANDONMENT	*							?								C	

CRS 31-32-201 & 31-12-101 laws establish conditions for municipal govnts.

Table 3.12

STATE AGENCIES WHICH PARTICIPATE IN GEOTHERMAL DEVELOPMENT IN NEVADA

PARTICIPANT / STAGE	Nevada Division of State Lands	Division of Water Resources	Division of Water Planning	Division of Mineral Resources	Division of Environmental Protection	Dept. of Conservation & Natural Resources	State Contractors Board	Department of Human Resources	Public Service Commission	Department of Energy	Environmental Commission	County Agencies					
PRELEASE CASUAL EXPLORATION																	
PRELEASE INTENSIVE EXPLORATION						?											
LEASING	*																
POST LEASE EXPLORATION		*			P		P										
FIELD DEVELOPMENT AND PRODUCTION		*	?	?	P	?		P	*	?	?	?					
ABANDONMENT		*															

Table 3.13

STATE AGENCIES WHICH PARTICIPATE IN GEOTHERMAL DEVELOPMENT IN NEW MEXICO

PARTICIPANT / STAGE	Oil Conservation Division	State Engineer	Commissioner of Public Lands			Natural Resources Department	Water Resources Division	Health & Environment Department	Environmental Improvement Division	Environmental Improvement Board	Water Quality Control Commission			Energy Resources & Development Division		Public Service Commission	County Agencies
PRELEASE CASUAL EXPLORATION																	
PRELEASE INTENSIVE EXPLORATION				1													
LEASING			*														
POST LEASE EXPLORATION	*	P							C								
FIELD DEVELOPMENT AND PRODUCTION	X	P				?	?	?	C	C	?			?		?	?
ABANDONMENT	*	P															

TABLE 3.14

STATE AGENCIES WHICH PARTICIPATE IN GEOTHERMAL DEVELOPMENT IN UTAH

PARTICIPANT / STAGE	Division of Water Rights	Division of State Lands	Department of Transportation	Department of Business Regulation	Bureau of Water Quality	Bureau of Air Quality	Bureau of Solid Waste Management	Board of State Lands	Public Service Commission	Division of Public Utilities	Tax Commission				County Agencies		
PRELEASE CASUAL EXPLORATION	*																
PRELEASE INTENSIVE EXPLORATION	*																
LEASING		*															
POST LEASE EXPLORATION	*							?									
FIELD DEVELOPMENT AND PRODUCTION	*	?	P	P	P	P	P	?	?	?	?				P		
ABANDONMENT	*																

The letter A indicates that a state or local agency is requested to provide comment or advice concerning how the lead agency might proceed. A question mark indicates that an agency is probably involved in a given stage of the development process but that the exact magnitude or nature of that involvment is unknown.

Available state documents were analyzed to obtain this latter information. In addition, the quarterly reports of each state team were analyzed to identify any references to state agency involvment in the process. The charts and tables which describe the organization of state governments were analyzed to provide information as to which state agencies were or could be involved as participants in the development of geothermal resources in the state.

Even when a large number of participants is involved, there is reason to question the legal status and the precise nature of the role those participants have in the geothermal development process. Except for the State of California, there have been no fully developed geothermal reservoirs in the United States, hence agencies which are participants at advance stages in the geothermal development process have had no first-hand experience with the activity they are to monitor or regulate. Also, as a result of the relative newness of the development process, it is not clear to what extent or in what manner two or more state agencies will interact while they carry out their respective responsibilities.

Table 3.15 summarizes information concerning the role of various state and local agencies in the geothermal development process in Utah. The table shows the types of permits that must be issued by each of several lead agencies in the State of Utah. Also, shown in the table is the stage of development at which these agencies become participants and the approximate amount of time needed by these agencies to issue a permit.

Figure 3.5 shows time-phased activities of institutional entities which participate in the leasing of state lands for geothermal development in the state of Colorado. Several things should be noted with respect to the information in Figure 3.5: (a) The leasing of state land is under the control of the Board of Land Commissioners whose responsibility is to maximize the income from state lands. (b) Colorado rules and regulations require the Land Commissioners to send copies of the developer's application to at least the three other agencies specified for their review and comment. (c) The leasing of state-owned land may occur through either competitive or non-competitive bidding processes but due to limited interest in geothermal leasing only non-competitive leases have

Table 3.15

Preliminary Assessment of Agencies and Permits Involved in Geothermal Development in Utah *

	Permit	Required Prior To:	Estimated Time For Issuance	Notes
County Agencies				
County Planning Commission (1,2)	Zoning	Depends on county zoning ordinances	Variable	Already accomplished in some counties
County Clerk (1)	Business License	Sale of electricity		
County Commission or Health Department (1,2,3)	Health Code Enforcement Building Inspection	Use of buildings	Varies	
State Agencies				
Division of State Lands (4,5)	Lease State Lands	Exploration or use of lands	Few Days to 2-3 weeks	May be competitive bidding in some cases but that does not significantly increase issue time
	Special Use Permit	Surface disturbance (Construction of plant)	Not known--possibly about 2 months	Has not yet been applied for in Utah
Department of Transportation (6)	Encroachment Permits	Use of state highway lands for utility lines	Few days	Would be necessary for use of or crossing of State Highway Rights of Way with utility lines such as power lines, water mains, sewage pipes etc.
	Oversized Vehicles Permit	Use of highway for oversized vehicles	About a day	
Division of Water Rights (7,8)	Permits for Thermal Gradient Wells	Drilling of thermal gradient wells	Few days to few weeks	Letter of approval
	Permit for Exploratory "Test" Wells	Drilling of exploratory wells	Few days to few weeks	Letter of approval

Table 3.15 (Continued)

	Permit	Required Prior To:	Estimated Time For Issuance	Notes
Continued from:				
Division of Water Rights (7,8)	Notification of Reservoir Test	Reservoir tests		
	Appropriation of Water	Use of water	6 months or longer	May depend on how fast the developer wants approval
	Production and Injection Wells			Covered by Appropriation of water if included in the Plan of Operations
Environmental Health Services				
Bureau of Water Quality (3)	Construction Plan Review and Permit	Construction	About 2 months	Pre-planning work:
	Public Water Supply Approval	Use of building	1 to 2 months	
	Draft and Certification of Discharge Permit (Sanitary)	Use of building	1 to 2 months	In conjunction with EPA which issues the permit
	Liquid Waste Disposal System Approval	Use of building	1 to 2 months	
Bureau of Air Quality (9)	Construction Plan Review and Approval	Construction	About 3 months	In conjunction with EPA
	Discharge Permit	Use of plant	About 3 months	Plant discharges
Bureau of Solid Waste Management (3)	Solid Waste Disposal			
Department of Business Regulation (10)	Certificate of Convenience and Necessity or Approval of Contract Between Utility and Electricity Producer	Sale of Electricty	3 to 4 months	Certificate of convenience and necessity if utility owns plant; if utility buys power, approval of contract is required

*From the Utah Final Report (29, pp. 62-63)

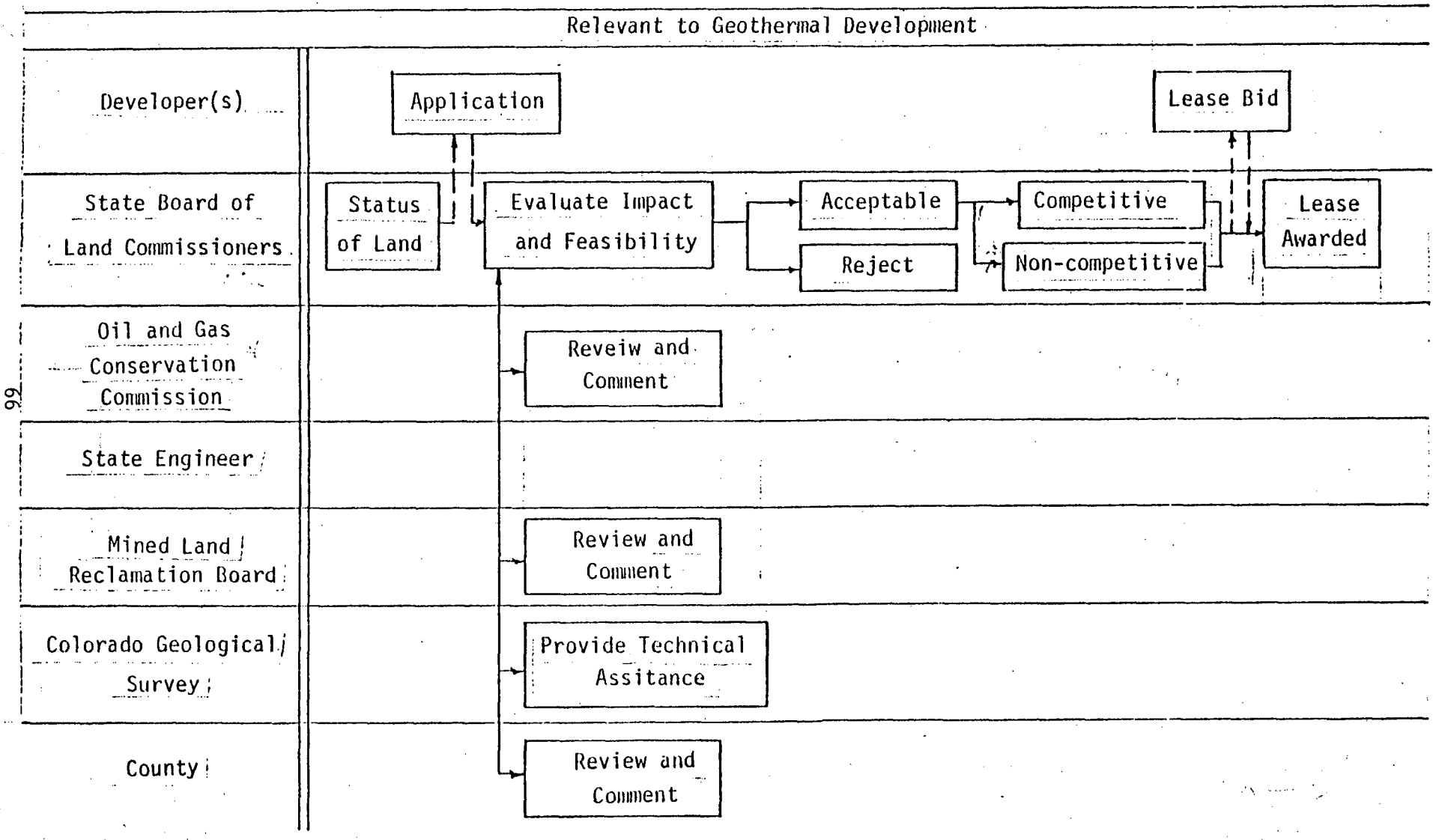


Figure 3. 5 Colorado. Time-Phased Activities

been issued. (d) The state team estimates that the entire process of leasing state lands could be completed in seven to eight months.

Except for Colorado, a single office appears to have sole responsibility for leasing state-owned lands. None of the states have any formal regulations for prelease casual exploratory activity. With the possible exception of Colorado, there are no legal and binding provisions at the state level for an environmental assessment before state land is leased for geothermal development. Drilling permits are handled by oil and gas commissions in three states, (Arizona, Colorado, and New Mexico), and in Arizona that commission has sole responsibility for all water and environmental issues that might arise with respect to field exploration and development. Drilling permits are regulated by state engineers assigned to Department of Water Resources or Water Rights in two states (Nevada and New Mexico), and in both cases the state engineer has the lead responsibility for all aspects and impacts of field exploration and development operations.

In summary, there is considerable variability in the status of legal and institutional factors across the five states which comprise the Southwest Region. It appears that each state has developed slightly different procedures for interacting with federal agencies. An informed sampling of opinions conducted by Dr. Richard T. Meyer confirms the extent to which these findings are almost universally accepted by government and industry representatives. (Dr. Meyer's work is in Appendix D.) The bottom line is that leasing and permitting processes are cumbersome and time consuming. Therefore, the successful development of geothermal resources may depend upon the creation of a national policy which will alleviate some of these fragmented policies and procedures.

CHAPTER IV

GEOTHERMAL DEVELOPMENT AND THE PRODUCTION OF ELECTRICITY

This section covers the logic underlying the research performed, the tools used, and the results of the research concerning the potential contribution of geothermal development to electricity production in the Southwest Region (Arizona, Colorado, Nevada, New Mexico and Utah). First, the underlying philosophy of the research program is described. Next, the sensitivity of profits to changes in physical and policy variables circumscribing the development of geothermal electric power is discussed. Then, site-by-site profitability as determined by GIRORA-Electric and aggregation of resulting power estimates is described and power-on-line projections are discussed. In addition, the sensitivity of power-on-line estimates to policy initiatives is discussed. Finally, preliminary estimates of electric power supply and demand conditions are presented. The impact of the development of geothermal electric plants is discussed under three possible sets of alternative assumptions. The complete description of the GIRORA-Electric model and the associated computer program (written in FORTRAN IV) is given in Appendix 1. We turn first to a discussion of the philosophy underlying the research accomplished concerning the development of geothermal electric power.

4.1 Research Philosophy

Underlying all considerations of this research was the assumption that electric plants driven by geothermal energy, and the fields which deliver that energy, will be developed by the private or non-federal government sectors. For the most part, this means private developers in conjunction with regulated electric utilities (although exceptions may and will likely exist). A concomitant assumption is that a geothermal resource will be developed only if it is economic to do so (that is, economic feasibility is a necessary but not sufficient condition). Because private developers and electric utilities are the actors, it is necessary to consider economic feasibility (profitability) from their point of view.

The second principal assumption is that geothermal energy is only one of a variety of energy sources at the disposal of an electric utility (or anyone, for that matter, in need of electric power). A concomitant of this second assumption is that geothermal energy must compete in the marketplace for energy. Because geothermal energy is a marginal energy source (marginal in the sense that it is a relatively small source), and in this region enters the scene chronologically late, it must compete at prices established by other fuels (coal, nuclear, oil, gas, and hydroelectric).

The result of the first two principal assumptions is that if geothermal energy is not profitable for both the geothermal developer and the electric utility, at a price which enables the electric power thus generated to be competitive with that generated by other fuels, the resource will not be developed. This is the bottom line. Given other institutional, attitudinal, and economic factors, a particular resource may not be developed, even if it is economically competitive.

Moreover, even though a particular resource is economically competitive and faces no non-economic barriers, being a marginal fuel, it may not be developed for lack of effective demand. This could occur under two conditions: (1) increases in the price of electricity result in sufficient consumer substitutions to reduce quanity of electricity demanded below some critical level, or (2) general economic growth is insufficient to require the capacity that would be added by a geothermal development. The first condition may have some general applicability, while the second might occur only in remote, sparsely populated areas (due to the portability of electricity).

At each juncture, government policy makers may have an option to affect the environment in which private developers make decisions or perceive opportunities. It was the aim of the research effort described below (1) to ascertain what elements under the influence of DOE-DGE could efficiently alter the profitability of geothermal resources as perceived by investors, (2) to identify the magnitude of impact policy action might reasonably be expected to have, and (3) to estimate in a preliminary way the level of market potential for electricity generated by geothermal energy.

Because geothermal energy is not free, it is an economic resource which should be developed efficiently with due concern for its place in a total energy perspective. Private entrepreneurs cannot discount the value of national balance of payments deficits or other social concerns, when considering

the desirability of an investment. It must be DOE-DGE's role to consider this broader perspective and insure the availability of sufficient incentives (or the absence of disincentives) so that private entrepreneurs will perceive geothermal energy as an attractive opportunity.

The criterion for evaluation chosen for this research is the rate of return on equity investment. There are a variety of criteria which could be used, each having its own special strengths and weaknesses. The one chosen for this research seems most appropriate because of the overall capital insensitivity of the process. It should be added that in the process of ranking geothermal sites, or judging the relative effectiveness of policy actions, any criterion of profitability or economic feasibility would yield approximately the same answer as another, so long as the methodology is consistent.

As will be noted in the next section, the simulation model used to evaluate geothermal electric projects uses the rate of return as the basis for comparison rather than the price of electricity. This is due to our assumption that geothermal energy must compete at the margin with established fuels. The price of electricity is then an independent rather than dependent variable. Moreover, using a rate of return on equity as the dependent variable focuses our attention on the profit motive of the developer. The developer can invest in geothermal energy or any other income-yielding prospect. If the rate of return on geothermal energy is not high enough (at a price where it can effectively compete), the developer will place investments elsewhere.

4.2 Sensitivity of Profits to Policy Parameters

Having developed and calibrated GIRORA-Electric (calibrated with other models of the genre), the next step up was to determine the sensitivity of the output, rate of return (R), to changes in policy parameters. This was done by first establishing an estimate of R, given a "baseline" set of policy, geophysical, and market parameters. The "baseline" parameters are not held to be "typical" or "characteristic". Resource areas in Southwest Region could be characterized as being of a wide variety of temperatures, salinity, distance to demand areas, etc. On the other hand, all will be confronted, given the nature of electricity markets, with similar market parameters, and, of course, federal policy parameters. Table 4.1 lists the more important parameters for the "baseline" case.

Table 4.1
Base Case Values
Geothermal Energy Producer

Variable		Value
BR:	Bond Rate	0.085
CRRT:	Investment Tax Credit Rate	0.12
FR:	Flow Rate	585,794 lb/hr
TEMP:	Initial Downhole Temperature	190°C
EPK:	Equity Proportion of Capital	0.30
DPK:	Debt Proportion of Capital	0.70
λ:	Royalty Rate	0.10
Z:	Depletion Allowance Rate	0.0
EXP:	Exploration Period	0 years
DVP:	Development Period	8 years
TXRT:	Income Tax Rate	0.50
IRR:	Internal Rate of Return	0.15

Electric Utility

Variable		Value
CAP:	Capacity	50,000 Kilowatts (Net)
LF:	Plant Factor	0.80
UF:	Plant Use of Power (Proportion)	0.18
PB_e:	Base Price of Electricity (Busbar)	0.021 ($/kwh; current $)
$\dot{P}$:	Escalation Rate of Base Price	0.05
EK:	Equity Proportion of Capital	0.50
DK:	Debt Proportion of Capital	0.50
UR:	Regulated Return to Equity	0.12
BR:	Bond Rate	0.085
TXRT:	Income Tax Rate	0.50

The next step was to vary relevant parameters, one at a time, to determine the sensitivity of R to changes in each parameters. The measure used here for such sensitivity is elasticity (E). Elasticity is a concept in economics which means the percent change in one variable given a one percent change in another. The formula used to calculate elasticity is given below, where R is the rate of return and IV is the independent variable. The subscripts 1 and 2 refer to the values of each variable at subsequent positions.

$$E = -\frac{R_2 - R_1}{(R_2 + R_1)/2} \div \frac{IV_1 - IV_1}{(IV_2 + IV_1)/2}$$

The average value is used as a base for both variables so that E takes on the same value whether one is moving from a higher to lower or lower to higher set of variable values. The values of E for selected variables are given in Table 4.2.

Briefly, the elasticity of R with respect to plant capacity in megawatts (CAP) is -0.268. This means that for every 1 percent <u>increase</u> in plant capacity, we might expect about a 0.27 percent <u>decrease</u> in the rate of return. The calculated E for the depletion allowance rate is 0.051. This means that for every 1 percent <u>increase</u> in the depletion rate, there would be a 0.05 percent increase in the rate of return.

The larger the value of E, the greater the impact of changes in a variable on R. Of the various <u>policy</u> variables analyzed in Table 4.2., E ranges from 2.433 for the investment tax credit rate (when resource temperature is 190°C) to 0.051 for the depletion allowance rate. Others are: Bond rate, -1.714 (at temperature 190°C) or -0.156 (at temperature 225°C); Royalty Rate, -0.0208.

Market variables which might be affected by policy action are: Capacity Cost for Binary Plants, -2.625; Exploration Period, -0.044; Development Period, -0.468 and Base Price of Electricity, 0.632.

Those variables which have the highest E are those which impact capital costs in low temperatures (binary) systems. This is due to the greater capital insensitivity of these systems relative to flash systems.

After observing the variability of R with changes in individual independent variables, we must also consider the <u>range</u> of R as several variables are changed simultaneously. This gives a range for expected values of R under a variety of circumstances.

Table 4.2 Elasticity (E) of R with Respect to Selected Variables at 225°C (437°F)

Variable	E
Power Plant Capacity	-0.268
Depletion Allowance	0.051
Investment Tax Credit at 225°C	0.851
Investment Tax Credit at 190°C	2.433
Royalty Rate	-0.208
Base Price of Electricity $/kwh	0.632
Load Factor	1.838
Producer Debt/Equity Ratio	0.134
Flow Rate	1.156
Exploration Period, years	-0.044
Development Period, Years	-0.468
Bond Rate at 225°C	-0.156
Bond Rate at 190°C	-1.714
Temperature	2.703

Considering such a range is a more reasonable approach to forecasting than simple point estimates. This is because the future cannot be predicted with any precision and thus those factors which might impact geothermal development cannot be predicted with any great precision. Looking at a range, however, permits us to realistically analyze the likely effects of policy initiatives.

Table 4.3 lists the parameter values for what is here discussed as "pessimistic" and "optimistic" market scenarios and a "baseline" R for each potential electric site (estimate for base temperature over 150°C) in the Southwest Region. In Tables 4.4 through 4.8, megawatt estimates are given for each site under the conditions specified by sets of parameter values. A required return to equity of 15 percent is assumed. Those sites which do not receive a required return under a given set of parameter values are rated at zero megawatts. The estimates are given at three levels: pessimistic, baseline, and optimistic.

If a positive megawatt value is shown, it is the maximum thirty-year usable energy estimate of the resource given estimated temperature and volume. (In many cases the volume is a default value from USGS Circular 726[2], thus making the "optimistic" estimate possibly conservative). The optimistic case is the maximum probable energy that could be obtained under any circumstances. Table 4.9 summarizes the megawatt estimate for the Southwest Region from Tables 4.4 through 4.8.

4.3 Aggregated Power On Line Estimates

Under conditions of minimum competition for development inputs (drilling rigs, labor, casing, pipe, etc.), and given the projected scenarios for development of individual sites, a time-phasing of power on line can be constructed for the region. This is illustrated in Figure 4.1. Figure 4.1 contains three basic projections for this time-phasing, one "optimistic", one "baseline", and one "pessimistic". Each is the region-wide aggregation of megawatt estimates for the five states for each year according to site-by-site projections. The range between the two extreme projections represents the most highly probable range for the development of geotheraml electricity production, given minimum competition for development inputs.

For a planning outlook, however, this perspective must be modified. The range illustrated in Figure 4.1 could be realized only if sufficient resources are devoted to the production of drilling rigs and the training of geothermal drilling teams. An obvious policy recommendation is that DOE-DGE should assure an environment in which such resources may be readily available.

Table 4.3 Values of Choice Variables and Parameters: Optimistic and Pessimistic Market Scenarios

	"Pessimistic"	"Optimistic"
Load Factor	60%	75%
Base Price of Electricity	21 mils/kwh	30 mils/kwh
Escalation factor for Price of Electricity	5%	6.5%
Debt/Equity ratio of Utility	1	1
Debt/Equity ratio of Producer	1.5	1.86
Utility's Return (regulated)	15%	12%
Tax Rate	48%	48%
Bond Rate	8.5%	7.5%
Investment Tax Credit	12%	12%
Flow Rate	250,000 lb/hr	400,000 lb/hr
Royalty Rate	10%	5%
Depletion	0%	22%
Exploration Time	5 years	5 years
Development Time	8 years	5 years

Table 4.4 Electric Power Estimated in Megawatts for Arizona

Site	Temp °C	Estimated Power in Megawatts		
		Pessimistic	Baseline	Optimistic
Power Ranch	184	0	0	50
Clifton H.S.	160	0	0	50
Verde H.S.	150	0	0	50
Statewide (Kingman)	50-200	0	0	0
White Mountains (Flagstaff)	210	0	100	1000
Yuma	150-180	0	50	50
Hyder Valley	200	0	50	500
Wilcox*	205	0	0	100
Springerville*	210	0	100	500
Tucson*	60-120	0	0	50
Safford	210	0	100	100
Total		0	400	2450

* Indicates that the resource is hot dry rock.

Table 4.5 Electric Power Estimated in Megawatts for Colorado

Site	Temp °C	Estimated Power in Megawatts		
		Pessimistic	Baseline	Optimistic
Mt. Princeton/Cottonwood Creek	170-200	0	100	100
Poncha Springs	175-200	0	0	200
Cebolla Hot Springs	145	0	0	200
Total		0	100	500

Table 4.6 Electric Power Estimated
In Megawatts for Nevada

Site	Temp °C	Estimated Power in Megawatts		
		Pessimistic	Baseline	Optimistic
The Needles Rocks	200	0	245	245
Surprise Valley	185	0	0	45
South Smoke Creek Desert	200	0	65	65
Anaho Island	185	0	0	45
Dyke Hot Spring	200	0	245	245
Baltazor Hot Spring	185	0	0	45
Bill Creek Reservoir	200	0	65	65
Bog Hot Springs	170	0	0	40
Howard Hot Springs	200	0	65	65
Pinto Hot Springs	185	0	0	45
Cordero Mercury Mine	185	0	0	45
Hot Sulpbur Spring	185	0	0	180
The Hot Springs	170	0	0	40
Humboldt Wells	200	0	245	245
Mineral Hot Springs	185	0	0	90
San Emidio Desert	200	0	245	245
Gerlach, N.E.	200	-	-	-
Double Hot Spring/Black Rock Hot Spring	200	0	735	735
Gerlach	200	0	370	370
Colona	185	0	0	45
Fly Ranch	185	0	0	45
Fly Ranch, N.E.	185	0	0	45
Trego	185	0	0	45
MacFairlane's	185	0	0	45
Sulphur	185	0	0	45
Rye Patch	185	0	0	540
Colado	185	0	0	180
South Eugene Mountains	185	0	0	180
Golconda	185	0	0	-
Hot Springs (Tipton)Ranch	200	0	245	245

Table 4.6 (Continued)

Site	Temp °C	Estimated Power in Megawatts		
		Pessimistic	Baseline	Optimistic
Hot Pot	185	0	0	45
Sand Dunes	185	0	0	-
Winnemucca Mountain	90	0	0	-
Leach Hot Springs	200	0	735	735
Kyle Hot Springs	200	0	245	245
Battle Mountain	185	0	0	-
Smith Creek Valley	200	0	245	245
Beowawe Geysers	245	1220	1220	1220
Horseshoe Ranch Spring	185	0	0	45
Hot Springs Point	185	0	0	180
Duff Creek	185	0	0	45
Darrough's Hot Spring	185	0	0	45
Elko Hot Springs	185	0	0	-
Walh Hot Springs	185	0	0	45
Bruffey's Hot Springs	185	0	0	45
Kolbe Hot Springs	185	0	0	45
Spenser Hot Springs	185	0	0	45
Carlin	185	0	0	-
Sulphur Hot Springs	200	0	490	490
Monte Neva Hot Springs	185	0	0	180
Ruby Lake	200	0	245	245
Cherry Creek Hot Spring	170	0	0	40
Steamboat Spring/Huffaker	21 5	0	400	400
Steamboat Spring/Huffaker	60	0	0	-
Moana Spring/Lawton	60	0	0	-
Comstock Mining District	155	0	0	38
Washoe Valley	60	0	0	-
Desert Peak	215	0	665	665
Brady's Hot Springs	215	0	265	265
Huxley	200	0	65	65
Eagle Salt Works	215	0	-	-

Table 4.6 (Continued)

Site	Temp °C	Estimated Power in Megawatts		
		Pessimistic	Baseline	Optimistic
Hot Springs Mountains	215	0	265	265
Hazen	200	0	65	65
Brady's Hot Springs	215	0	-	-
Carson Sink/Alkali Flat West Side	200	0	65	65
Carson Sink/Alkali Flat East Side	200	0	65	65
Lone Rock	185	0	0	45
Soda Lake/Upsal Hogback	215	0	400	400
Soda Lake/Upsal Hogback	215	0	-	-
Stillwater	215	0	530	530
Carson Lake	185	0	0	65
Lee Hot Springs	185	0	0	63
Eight Mile Flat	185	0	0	63
Stillwater	215	0	-	-
Dixie Hot Springs	200	0	245	245
Sou Hot Springs	185	0	0	135
McCoy Springs	185	0	0	135
Hyder Hot Spring	200	0	145	145
Senator	185	0	0	-
Dixie Comstock Mine/ Homboldt Marsh	185	0	0	135
IXL	170	0	0	-
Buffalo Hot Springs	185	0	0	135
Jersey Valley	200	0	145	145
Wabuska Hot Springs	170	0	0	40
Wabuska Hot Springs	170	0	0	-
Wilson Hot Springs	170	0	0	40
Hind's Hot Springs	155	0	0	-
Dead Horse Wells/Wedell Spgs	170	0	0	165
West Gabbs Valley	170	0	0	165
Sodaville Springs	140	0	0	-
Fish Lake Valley	260	390	390	390

Table 4.6 (Continued)

Site	Temp °C	Estimated Power in Megawatts		
		Pessimistic	Baseline	Optimistic
Silver Peak Hot Springs	200	0	63	63
Silver Peak Hot Springs	200	0	-	-
Southern Clayton Valley	170	0	0	40
Warm Springs	170	0	0	45
Railroad Valley/Pancake Range	170	0	0	45
Hot Creek Canyon	170	0	0	45
Hot Creek Valley	155	0	0	38
Lunar Crater	185	0	0	180
Caliente Hot Springs	65	0	0	-
Sarcobadus Flat/Beatty	65	0	0	-
TOTALS		1610	9478	13600

Table 4.7 Electric Power Estimated
In Megawatts for New Mexico

Site	Temp °C	Estimated Power in Megawatts		
		Pessimistic	Baseline	Optimistic
Lightening Dock	170	10	20	100
Kilbourne Hole	155	10	20	50
Radium Springs	130	0	0	50
Valles Caldera	260	1900	2000	2000
Lower Frisco H.S.	150	0	0	50
TOTALS		1920	2040	2250

Table 4.8 Electric Power Estimated
in Megawatts for Utah

Site	Temp °C	Estimated Power in Megawatts		
		Pessimistic	Baseline	Optimistic
Roosevelt	230	300	500	500
Cove Fort	200	0	200	200
Thermo	185	0	100	100
West Cove Ft.	200	0	200	200
North Cove Ft.	200	0	200	200
TOTALS		300	1200	1200

Table 4.9 Electric Power Estimated
In Megawatts for the Five States

State	Estimated Power in Megawatts		
	Pessimistic	Baseline	Optimistic
Arizona	0	400	2450
Colorado	0	100	500
Nevada	1610	9478	13600
New Mexico	1920	2040	2250
Utah	300	1200	1200
Total for the Region	3830	13218	20000

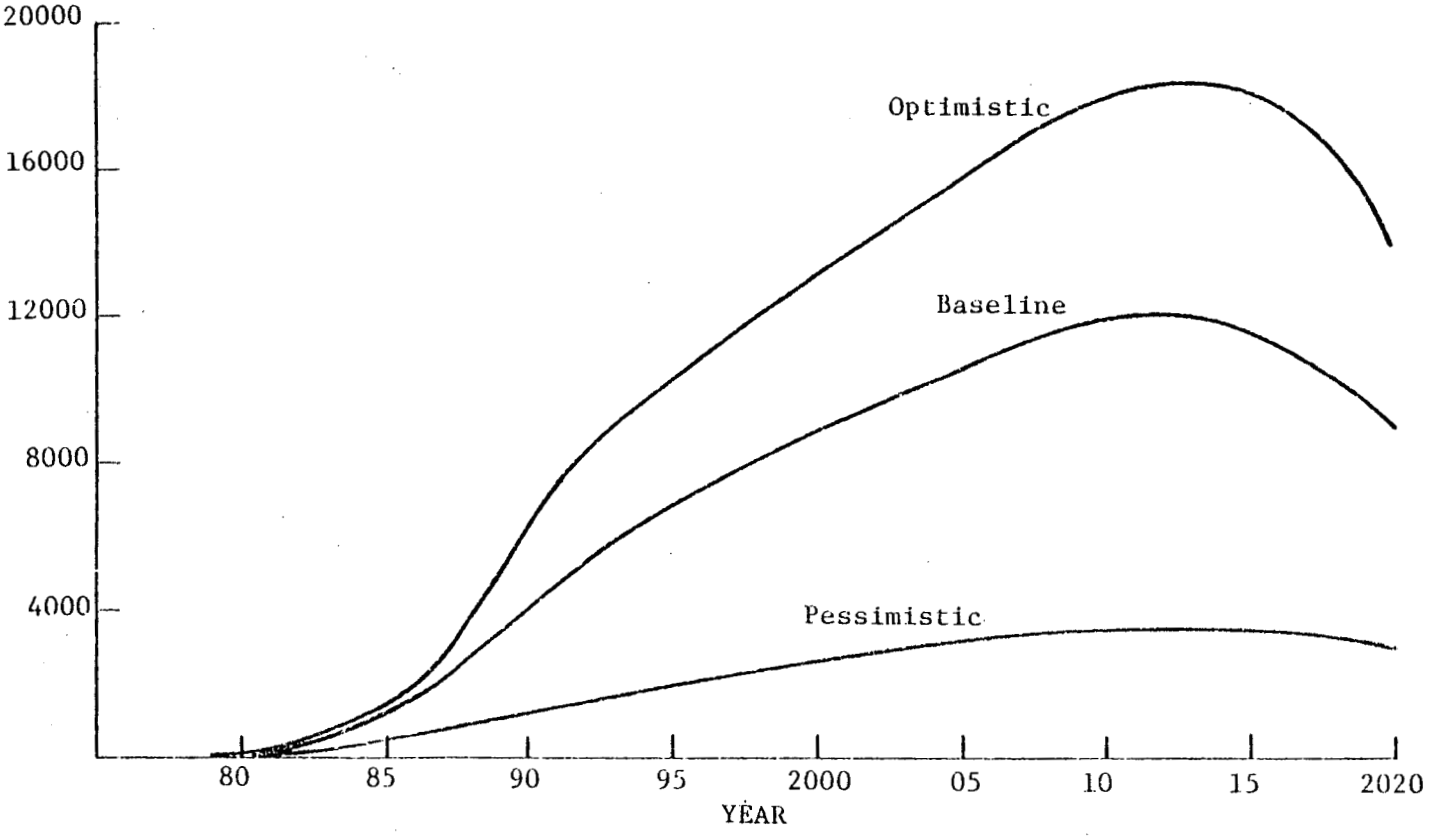


Figure 4.1 Time-Phased Scenarios Under Conditions of Minimum Competition

However, in the presence of development resource competition one could expect a time-phasing more along the lines of that presented in Figure 4.2. Assuming that the provision of development resources grows at a more or less constant rate, the slope of the initial growth phase must be less steep while the period of maximum output is more extended. Since it is likely that some competition for development resources will exist, we will assume for the sake of policy analysis that the power on line time-phasing suggested in Figure 4.2 is the relevant case. It must be kept in mind, however, that this time-phasing is subject to policy initiatives.

4.4 Policy Analysis and Recommendations

The final step is to consider the sensitivity of the time-phased aggregations to changes in policy parameters. In order to accomplish this, however, the logic of these aggregations must be reviewed. The aggregations are the sum of the parts which are site-specific estimations of power and the time-phasing of those sites.

The three cases illustrated for the time-phased aggregations are the result of an essentially "go" or "no-go" decision for each site. The "optimistic" boundary is the result of a "go" decision for all sites within the region, as a brief review of Tables 4.4 through 4.8 will show. Thus, the upper bound of our range of likely power-on-line estimates can increase or change only subject to the following conditions: (1) the volume or temperature estimates are altered, or (2) as noted earlier, the supply of development resources is increased or decreased. Thus, the effect of DOE-DGE policy can only be to raise the middle estimate and lower boundry of the range or to alter the rate of development by ensuring a timely supply of development resources.

The policy parameters indicated previously, then, can only affect the position of two of the three estimates, the "baseline" and the "pessimistic" projections for power on line, in Figure 4.2. The following policy analysis is, therefore, directed at the sensitivity of these lower two estimates to changes in policy parameters.

It must be recalled that the lower estimates are the result of the confluence of a variety of negative influences on the rate of return (R). Moreover, as a result of this confluence, the "pessimistic" case results in zero or lower

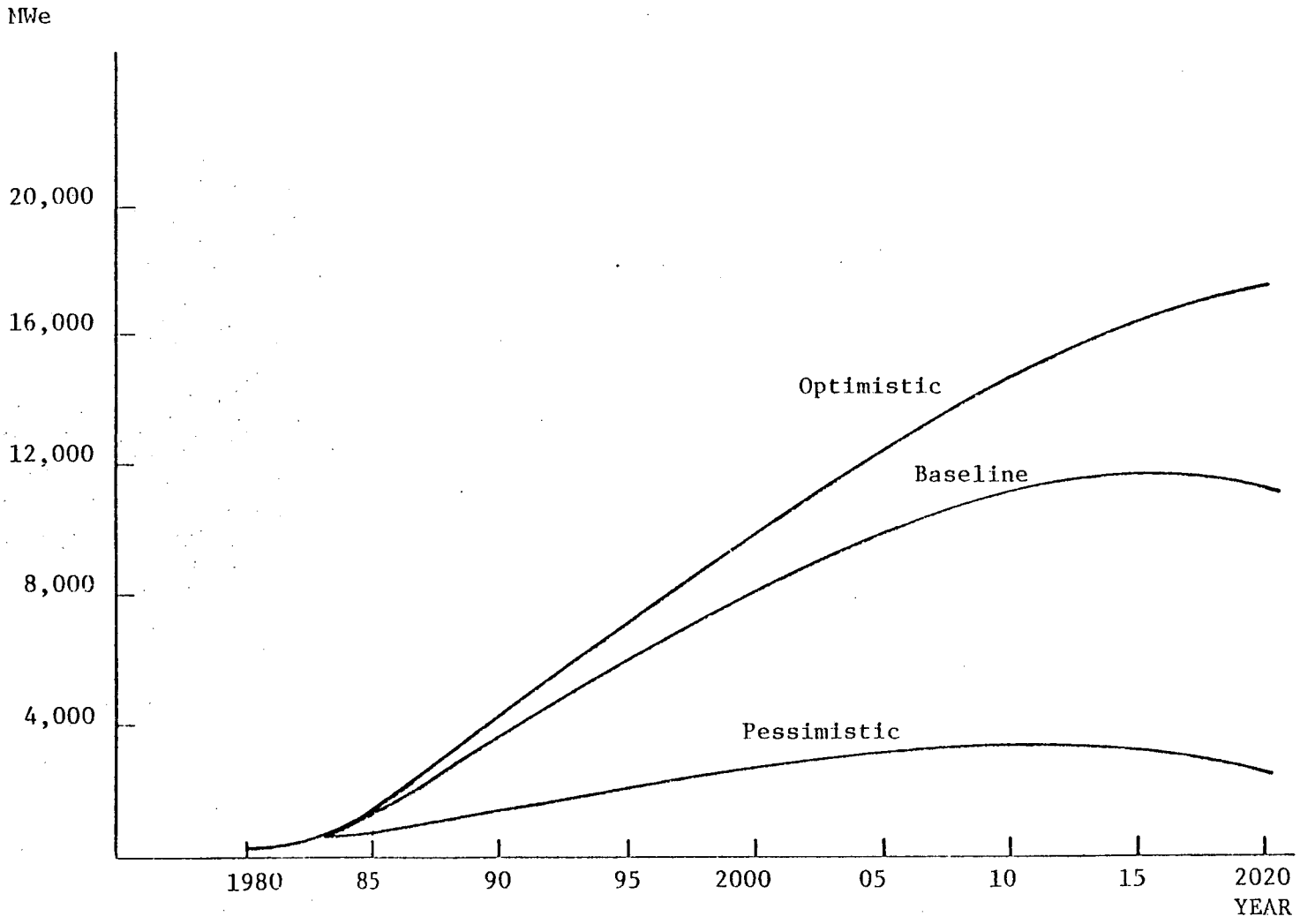


Figure 4.2 Time-Phased Scenarios Under Some Competition for Development Resources

estimates for R for all sites having down-hole temperature of 200°C or lower. If the "go" or "no-go" decision point for a site is at an approximate R of, say 15 percent per annum, substantial increases in R are necessary for sites below 230°C in the pessimistic scenario. Given the very low E of R with respect to either the depletion allowance or the royalty rate, it should not be surprising that substantial changes in either of these policy variables will not noticeably affect the lower bound or the "baseline" case of our estimated range. Eliminating the royalty rate or establishing a 22 percent depletion allowance will accomplish two things: (1) increase the probability that the actual power output will fall within the range given, and (2) increase the profitability of these sites which will be developed in any event. This second result is not meant to indicate criticism. Increasing the cash flow of geothermal enterprises could inspire developers to take on riskier geothermal projects. The impact of this activity cannot, however, be measured at this time.

A further word about result (1) above is necessary. An estimated range of high and low prospects for geothermal development in the Southwest Region has been illustrated. We are saying that it can be expected that, with no assistance beyond what currently exists, the development path for geothermal energy will fall within the indicated range. It cannot be said with any certainty what the likelihood is that this will occur. The likelihood may be a 60 percent probability or a 90 percent probability. We are only saying the probability is somewhat greater than 50 percent that the actual development path will fall within that range. We cannot be more certain than that until more precise estimates of reservoir volume and the distribution of flow rates is obtained. With this information, it would then be meaningful to assign probability weights to other parameters, and through Monte Carlo simulation techniques estimate a probability value for the range and also probability values for paths within that range. In the absence of such information we can specify the magnitude of movement, but not the magnitude of the change in probabilities.

In contrast with the two policy parameters mentioned above, an increase in the investment tax credit of 4 percentage points (say, from 12 percent to 16 percent) or a decrease in the bond rate by 2 percentage points (from 8.5 percent to 6.5 percent) would add perhaps 7,000 megawatts of power onto the total found under the "baseline" case in Table 4.5, and perhaps 4800 megawatts to the "pessimistic" case. The lower two estimates would experience a shift as illustrated in Figure 4.3.

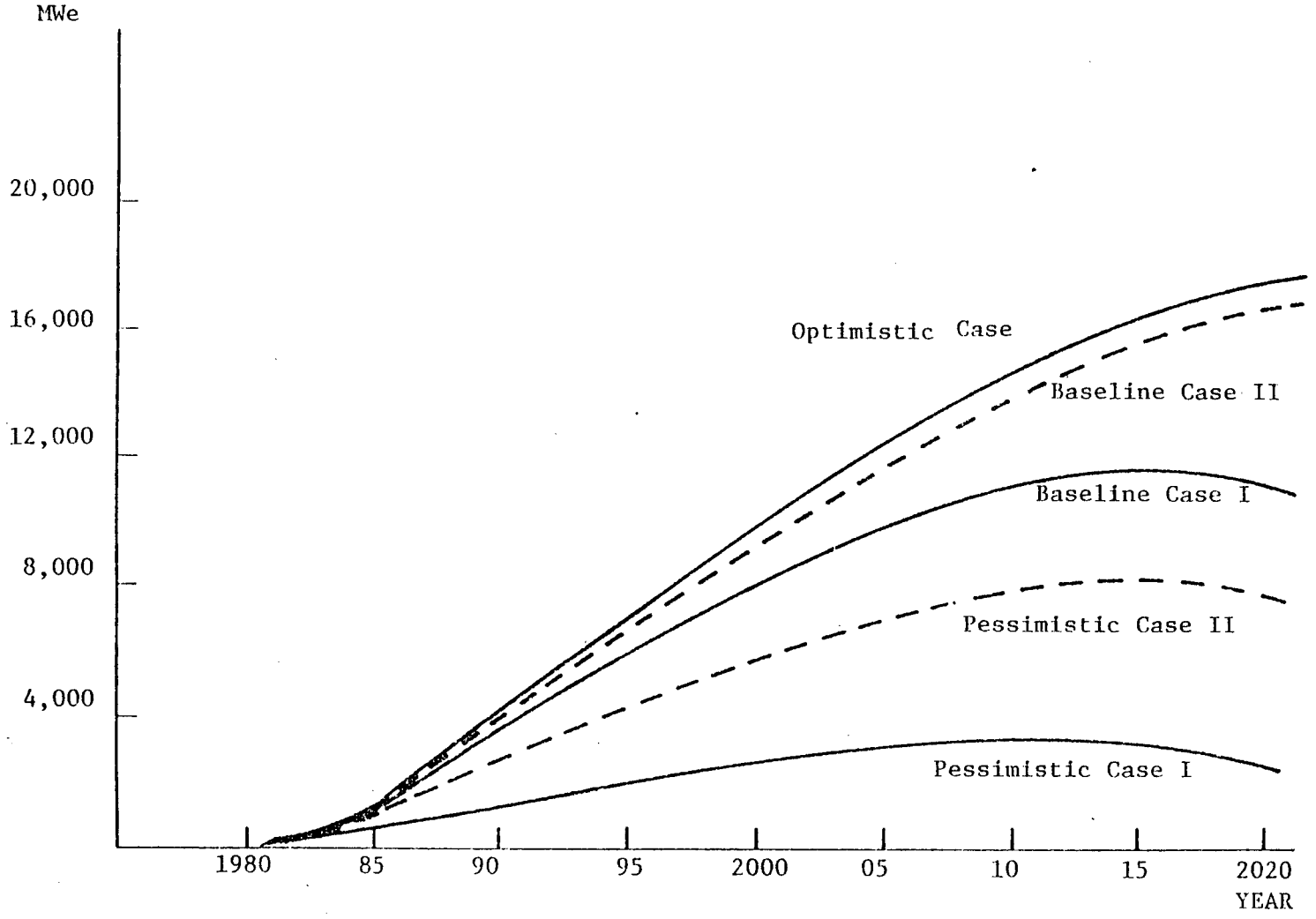


Figure 4.3 Time-Phased Scenarios With Policy Incentives

The occasion for this result is that under the original "pessimistic" case, no site with a temperature below 230°C was "on line" due to the insufficient profit level, nor were sites below 190°C in the "baseline" case. Most of such sites would use a binary cycle plant which is more capital-intensive than flash cycle plants. It is the former plants which would receive the relatively greater incentives from changes in the investment tax credit rate and the bond rate.

A combination of both an increase in the investment tax credit rate by 4 percentage points and a decline in the bond rate by 2 percentage points would perhaps add another 2000 megawatts to the "pessimistic" case and bring the "baseline" case approximately to the maximum. In short, it could be said with a great deal of certainty that altering those two policy parameters in the amounts indicated would result in the possiblity of between 11,000 and 20,000 megawatts of geothermally generated electricity being on-line by about the year 2020 within the region. There is almost no doubt that by the year 1990 almost 6,000 megawatts of electricity could be on-line. In the absence of these two policy initiatives, the probability that only 3000 MW would be on-line would be equal to that of 5000 MW being on-line. It should be added here, at least parenthetically, that any policy action which reduces the cost of capital to both the geothermal producers and the electric utilities in an amount equivalent to the policy actions indicated would have a similar result.

4.5 Review and Summary of Policy Analysis

Under "optimistic" conditions for development, almost all resource areas within the Southwest Region will probably develop. Under "pessimistic" conditions, in the absence of financial incentives on the part of government agencies, only those sites with temperatures greater than 230°C are likely to develop. To insure the speedy development of geothermal resources, DOE-DGE should concentrate its efforts on those activities which will enhance the viability of low temperature electric sites. Any activity which will lower the cost of capital by an amount equivalent to an increase in the investment tax credit rate by four percentage points and to decrease in the bond rate by two percentage points would result in an additional 5000 to 7000 megawatts of electricity generated from lower temperature sites in the Southwest Region by the year 2015. This would be a significant addition to the Southwest's electrical-generating capacity.

4.6 The Market for Electricity

As noted under the "Research Philosophy" section above, even if all other conditions are favorable for the development of a geothermally-powered electric plant, the demand for the additional capacity may not exist. Because geothermal energy is a "marginal" power source, in the absence of sufficient demand utilities will probably not substitute geothermal plants, e.g., for coal-fired plants.

In order to estimate the potential utility of geothermally powered electric plants, it was necessary to accomplish two tasks. First, it was essential to estimate the relationship between the quantity of electricity demanded and other casual factors, and project those casual factors to the year 2020 to estimate electricity need through the time period. Second, it was necessary to ascertain the planned generating capacity within the region to determine whether or not a deficiency might develop. We turn first to a discussion of electric energy consumption and its projection.

4.7 Electric Energy Consumption

Economic theory tells us that the quantity purchased of any commodity is a positive function of income, the number of consumers, and the prices of substitutes, and a negative function of price. In addition, the consumption of any commodity should also be a positive function of the consumption of complementary products. In order to economically estimate the relationship between the quantity of electricity and other assumed casual factors, it is necessary to specify a mathematical relationship between variables. This was done following Mount, Chapman, and Tyrrell[30].

We begin by specifying that electricity consumption is a function of its own price, the price of natural gas (a substitute), per capita income, population, and the stock of electricity using consumer durables. We furthermore specify a model that constrains electricity consumption to a constant elasticity of growth with respect to its casual variables. This may appear restrictive, but (1) observation of long run trends suggests such an assumption, (2) the resulting model yields a good fit with historical data, and (3) it is the common practice[31].

$$QE_t = ae^{\lambda t} PE^{\beta_1} PNG_t^{\beta_2} PCI_t^{\beta_3} POP_t^{\beta_4}$$

QE_t = Quantity of Electricity consumed in year t

PE_t = Average Price of Electricity in year t

PNG_t = Price of Natural Gas in year t

PCI_t = Per Capita Income in year t, constant dollars

POP_t = Population in year t

a, λ, β_1, β_2, β_3, and β_4 are constants to be estimated

e = Natural logarithm constant

For the purposes of estimation, equation (4.1) is transformed to the linear equation (4.2). The short-run elasticity of QE with respect to each variable i is $(\beta_i/1\text{-}N) \times 10^2$. Equation (4.2) was estimated using pooled cross-section and time series data. Estimation of β_i using strictly time-series data can result in multi-collinearity due to the strong trend element

$$\ln QE_t = \ln a + \lambda t + \beta_1 \ln PE_t + \beta_2 \ln PNG_t + \beta_3 \ln PCI_t + \beta_4 POP_t \quad (4.2)$$

in all independent variables. Estimation using strictly cross section data yields no reason for confidence in projection through time[32]. The variable λ is introduced to account for the adjustment of consumers to consumption levels through time and insures homoedasticity of estimated parameters.

Table 4.10 presents the results of the regression analysis and a test calibration of the estimated model.

Using this estimation of the relationship between the quantity of elasticity consumed and the casual variables, the next step was to project the quantity of electricity demand through the year 2020. This, of course, involves first, the projection of casual variable values through 2020, thus engaging the researcher in a guessing game concerning the future. For example, although it is doubtful that the population of the United States will grow much more rapidly than one percent per annum at any time in the future, migration may result in population increases within the area of 1.2 to 1.5 percent. Real per capita income may grow at a rate between 2.5 and 3.5 percent. The range of likelihood around these potential growth rates is fairly small and so 1.35% annual population growth was assumed and a 3% annual growth was assumed for real income.

Table 4.10 Results of the Forecasting Model

$QE = (1.39)PE^{-.134}\ PNG^{-.095}\ PCI^{.234}\ POP^{1.978}\ e^{.009t}$

Percentage of Variance Explained = 100%

Year	Actual (GWH)	Calibration Predicted (GWH)	% error
1961	21.900	21.824	-0.35%
1962	23.500	23.646	0.62%
1963	25.700	27.713	0.05%
1964	27.481	27.210	-0.99%
1965	28.760	28.835	0.26%
1966	29.800	29.910	0.37%
1967	31.519	31.605	0.27%
1968	33.730	33.879	0.44%
1969	37.879	37.709	-0.45%
1970	41.079	40.944	-0.33%
1971	44.679	44.665	-0.03%
1972	49.740	49.491	-0.50%
1973	54.538	54.822	0.52%
1974	57.203	57.524	0.56%
1975	59.211	58.939	-0.46%

The range of uncertainty for projections in the growth of electricity consumption is due then to uncertainty concerning the price of electricity and the price of natural gas. In 1976, National Economic Research Associate (NERA) in a study for the Arizona Nuclear Power Project used company data to arrive at higher and lower estimates for real price escalations in electricity and natural gas[33]. NERA estimated a range in real price escalation for electricity of about 1% - 3.5% per annum and in natural gas of about 1.8% - 5% per annum. These are consistent with other estimates[34]. We have, therefore, produced four projections for electricity consumption using (1) a high growth rate in price for electricity and also a high rate for natural gas, (2) high for electricity, low for gas, (3) low for electricity, high for gas, and (4) low for gas and electricity. These are designated in Table 4.11 as I, II, III, and IV, as well as illustrated in Figure 4.4.

These projections have been translated into megawatts of required capacity and illustrated in Figure 4.5 according to the following formula. The number for GWH has been translated into MW by multiplying GWH by 10^6 8760. This average MW figure has been multipled by 1.5 in order to account for peak loading. Another 0.15 has been added for reserve capacity.

Electric utilities have been polled within the region and capacity increments already in the planning or building state ascertained. There are currently some 20,708 MW on line and by 1986, an additional 16,083 MW are planned. Assuming that approximately ten percent of the increment is for replacement and that, on average, power plants consume 18 percent of power produced, and an additional ten percent is lost in transmission, planned effective capacity for 1986 is 25,965 MW, where it is currently 15,282 MW. If it is further assumed that the current proportion of export to sales remains constant at about 26 percent, the effective planned domestic (within the subject five states) capacity in 1986 is about 19,214 MW. Given reasonable growth projections as illustrated in Figure 4.5, this capacity should carry the region up to about 1990-1995. Depending upon replacement needs, additional capacity may be required prior to 1990. By the year 2020, this region may require an additional 30,000 MW (net) of electric capacity for domestic consumption alone, and perhaps another 10,000 to 15,000 MW (net) for export. Power plants driven by geothermal steam could provide 15-30 percent of the region's total electric capacity if it can become an economically viable alternative.

Table 4.11 Sensitivity Analysis Parameters

For Projections Of Electricity Consumption

CASE	I	II	III	IV
PCI	3.0%	3.0%	3.0%	3.0%
POP	1.35%	1.35%	1.35%	1.35%
PE	3.5%	3.5%	1.0%	1.0%
PNG	5.0%	1.8%	5.0%	1.8%

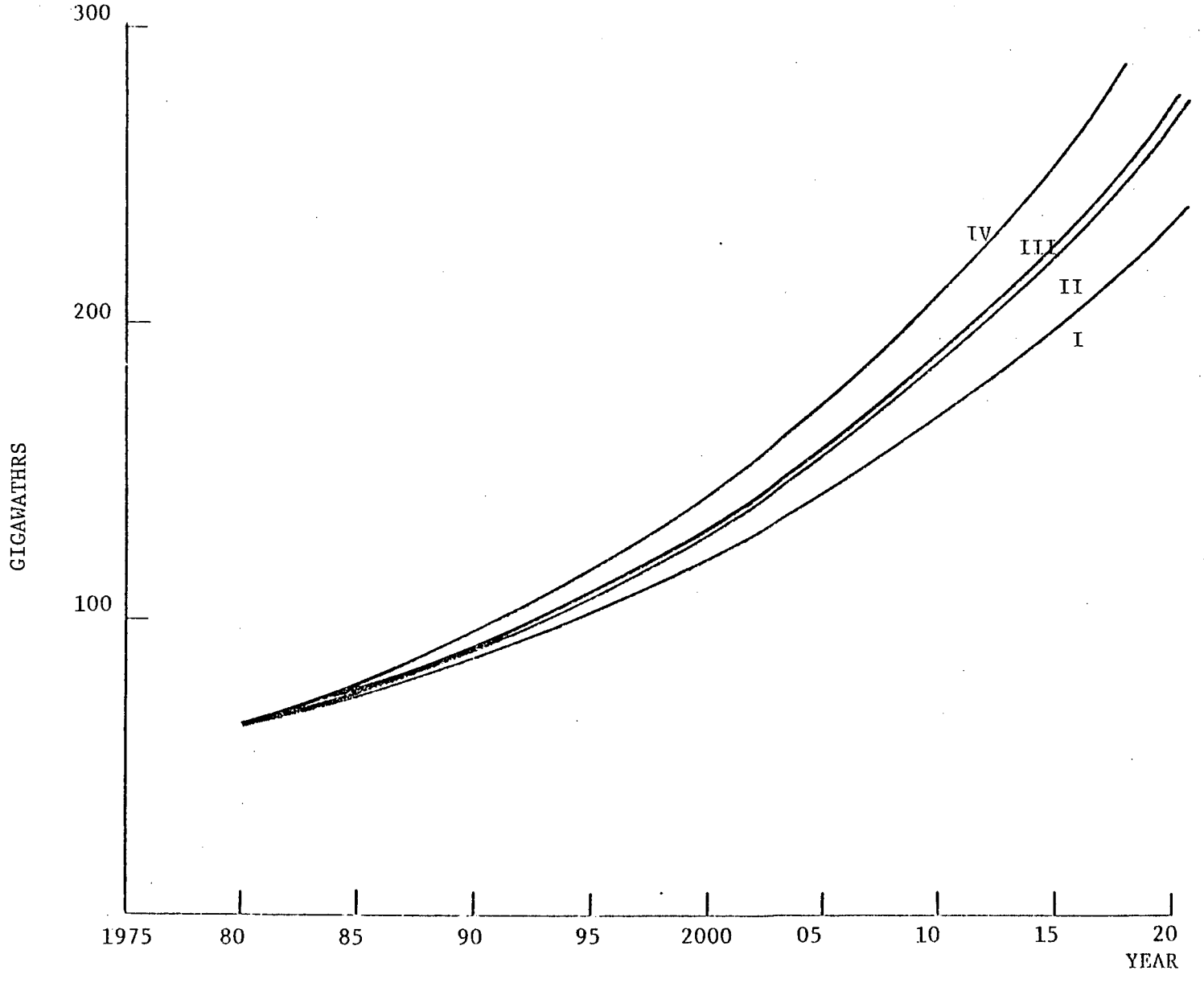


Figure 4.4 Projections of Demand for Electricity in the Five State Region

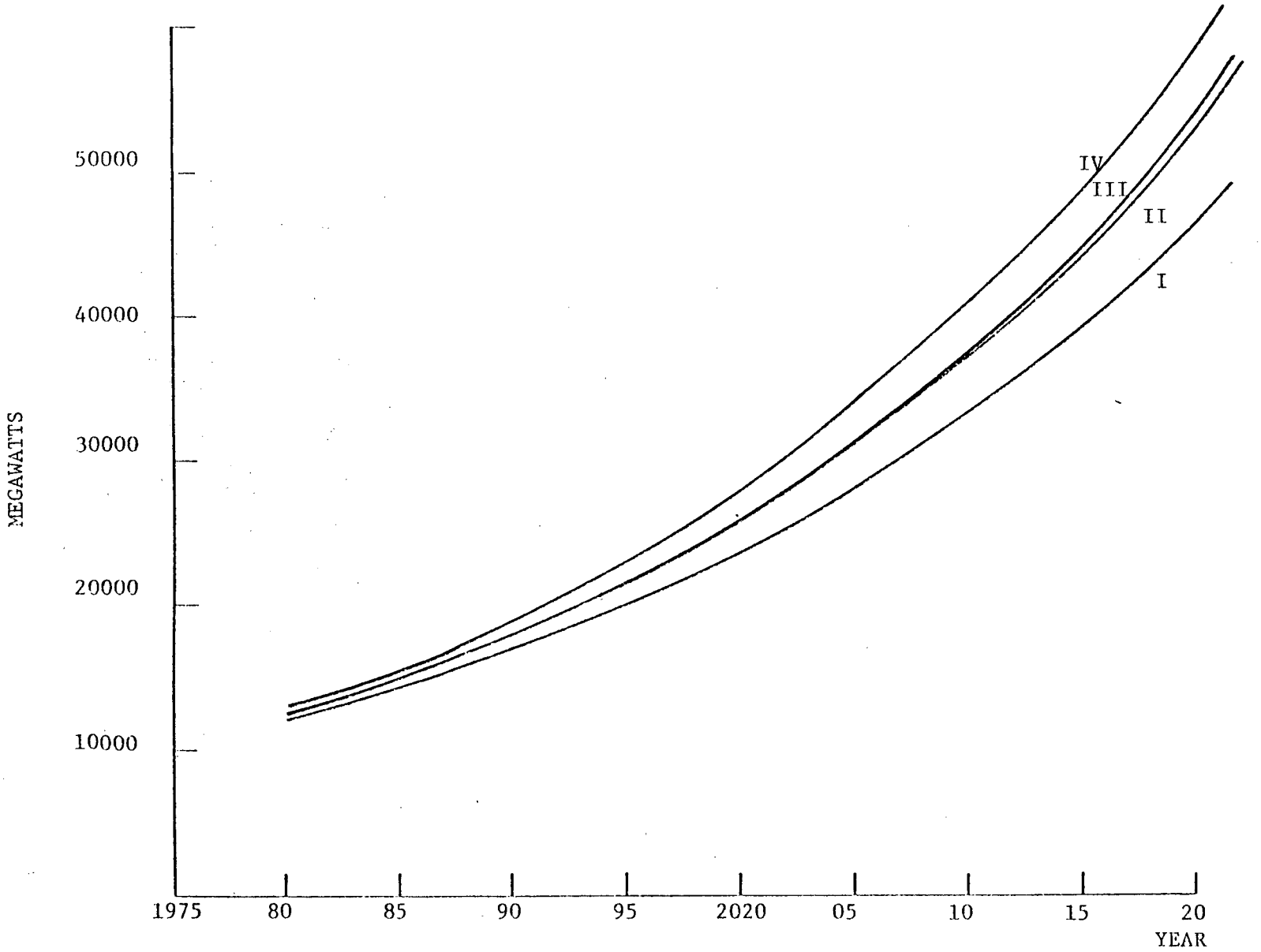


Figure 4.5 Projections of Required Plant Capacity in the Five State Region

CHAPTER V

GEOTHERMAL DEVELOPMENT FOR SPACE HEATING

Much of the anlaysis of geothermal energy potential in the United States in recent years has shifted from the study of electricity generation to non-electrical applications. These latter uses are often referred to as direct applications,[35] in contrast to electricity generation which is an indirect application. There are a number of factors which have generated widespread concern for direct applications.

First, recent documentation of geothermal resources in the United States has revealed a large disparity in the endowment of low temperature versus high temperature resource sites. For example, 504 low temperature ($T \leq 150°$) and 80 high temperature ($T > 150°$) sites have now been identified in the region.[36] The sheer abundance of low temperature geothermal resources seems therefore, to warrant further investigation.

Early estimates of the energy potential offered by low temperature anomalies were promising. The most widely cited of these estimates was Reistad's.[37] Reistad calculated that if all geothermal resources up to 200°, 150°, and 100° C could be used for space heating, 40, 30, and 20 percent, respectively, of total United States energy needs could be met. Although these projections are impressive, some stringent assumptions were employed in the calculations. In particular, many low temperature sites included in these projections could not be harnessed because of the imperfect mapping of market supply and demand sites.

A second reason for the recent upsurge of interest in direct geothermal applications is that such a large proportion of the nation's energy demands are for relatively low temperature space heating needs. Reistad estimated that $10,857 \times 10^{12}$ BTU or 18 percent of the 1968 United States fuel consumption was for space heating alone[37]. If geothermal energy proves practical, this demand may be easily be met. Further energy needs, such as water heating and cooling, air conditioning, and refrigeration might also be met from low temperature geothermal resources.

Kunze and Richardson combined Reistad's geothermal supply estimates with some energy demand projections combined at the Stanford Research Institute[38]. The objective of this exercise was to determine the proportion of 1985 space heating needs that could be met with geothermal energy. Ignoring some admittedly

pertinent economic considerations, they estimated that roughly 35 percent of the projected space heating needs could be geothermally supplied.[38] Again, however, the locational problem of matching supply and demand sites was ignored.

A final explanation for heightened interest in low temperature geothermal resources is that present and future low temperature energy needs are not efficiently served by existing technology using traditional fossil fuels. For these reasons at least, developmental prospects of low temperature geothermal energy in the Southwest Region will be examined in this chapter.

While the overall research approach for high temperature and low temperature resources is similar, there are, nevertheless, several distinguishing features of each analysis. One such factor which differentiates the analysis of direct from indirect applications is the mere number of candidate sites. As indicated above, the number of low temperature resources exceeds the number of high temperature resources by a margin of roughly 6 to 1. Thus, in the preliminary analytical stages, at least, the breadth of analysis is much greater in considering direct applications.

Another distinguishing feature of low temperature geothermal resources is the nature of the low temperature applications. These anomalies are not considered adequate for electricity generation. However, the range of alternative uses include space heating and cooling, water heating and cooling, and a broad range of potential industrial process applications. Of these, only space heating will be considered in this analysis. Accordingly, the energy consuming sector in the low temperature analysis will be a district heating unit rather than an electric utility company, as in the high temperature analysis. The analytical methodology will differ accordingly.

Finally, the evaluation of low temperature geothermal resource development is characterized by the limited portability of geothermal fluid. Warm air which has been heated with low temperature geothermal fluid cannot be transported interregionally as can electricity produced from high temperature geothermal resources. Thus, differences in the technological characteristics of the ultimate products produced by geothermal resources also influence the analytical framework to be employed.

Given the factors cited above, the examination of the regional potential of low temperature geothermal energy will be organized as follows:

1. A brief review of the limited amount of experience with geothermal space heating in the United States will be presented. Factors which

have been found crucial to the developmental prospects of low temperature space heating will be identified.

2. A complete assessment of the regional resource endowment will be compiled. The resource base will be subdivided into two groups, depending upon whether resources are usable or unusable given current recovery and production technologies.
3. An economic simulation model, GIRORA NON-ELECTRIC, will be employed to evaluate the financial feasibility of existing resources.
4. The significance of numerous policy variables and geophysical resources will be assessed.
5. Regional supply aggregates of low temperature geothermal energy will be forecasted for several sets of circumstances.

5.1 Geothermal Space Heating in the United States: The Historical Record

The historical record of experience with geothermal space heating in the United States is a limited one. Klamath Falls, Oregon, is the sole location in which space heating is presently employed on a broad scale. In order to place the following research in perspective, a brief review of the Klamath Falls experience with geothermal energy will be presented. Since detailed economic and engineering data are available elsewhere, the following discussion will be limited to a general description of the Klamath Falls experience and a summary of some pertinent findings which may prove helpful in the pages to come.

Klamath Falls is located in a KGRA in southern Oregon. Residents in this area have relied upon geothermal energy for space heating and other needs for over 70 years. However, a number of factors have spurred additional local demand since the mid 1960s.

First, the use of geothermal hot water for heating the buildings on the campus of the Oregon Institute of Technology began in 1964. This provided a sort of large scale demonstration project, the results of which have been encouraging. The savings in annual operating costs are estimated to be a full $225,000 compared to the cost of conventional heating [39]. Such evidence of feasibility has no doubt contributed to decisions to heat schools, hospitals, and other large residential and commercial buildings in Klamath Falls.

A second factor which spurred interest in geothermal space heating was the establishment of the Geo-Heat Utilization Center at Oregon Institute of Technology.[40] Funding for this undertaking was originally provided by the Pacific Northwest

Regional Commission of Vancouver, Washington, in 1975. With additional support from the state of Oregon, the Center actively disseminates information and prepares research proposals pertaining to geothermal energy. Perhaps its most ambitious undertaking is the current effort to ogranize and to plan for the implementation of a large scale district heating unit in Klamath Falls.

A third factor which has stimulated interest in geothermal energy in Klamath Falls has grown steadily in recent years. There are now approximately 400 shallow-depth wells being used to heat roughly 500 structures; these range from 27 to 550 meters in depth. Space heating is used to warm private residences, schools, and a broad array of businesses. Water temperature varies between 40° and 110°C, with temperatures over 80° desirable. The principle heat extractive system is the closed loop downhole heat exchanger.(41)

Some of the more recent experiences at the Oregon Institute of Technology in Klamath Falls has been fully documented, and it offers evidence of the local potential for further space heating. Several hot water wells have been dug from 400 to 600 meters deep in an area immediately adjacent to the campus. These are used to heat eight buildings of approximately 530,000 square feet. The sum of the annual operating cost plus depreciation is $25,000 or $0.005/sq. feet. This compares favorably with the estimated annual cost of $250,000 ($0.05/sq. ft.) for conventional fuels.(39)

The long experience at Klamath Falls have proven sufficient to identify a number of consideratons which are germane to developmental prospects of geothermal space heating. The first is the nature of economic costs and benefits. In the case of costs, large capital investment expenses are incurred "up front", i.e., before the system becomes operable. These costs include expenditures for drilling and casing, equipment, and building retrofitting where necessary. The costs are usually written off over 30 years, but the intial expense is sufficiently large to present a potential barrier to smaller users.

In the case of the economic benefits, the results of experience are more encouraging. As mentioned above, the annual operating costs are estimated to be a fraction of that for more conventionally fueled heating systems. In addition, the risk of supply disruption or internationally imposed price increases is eliminated. Thus, a long run incentive from a risk aversion perspective is also present.

A second consideration in evaluating the space heating potential of geothermal energy is the size of the user market. Given current production techniques,

the technical efficiency of a space heating system is greater and the economic cost is lower as the market size,(i.e., population) grows. The pivotal factor in this relationship is the potential for raising the load factor of the geothermal physical plant. Insofar as a larger market permits the fuller utilization of system capacity, the incentive for harnessing geothermal energy for district heating will be stronger. In the analysis to follow, therefore, only the development of geothermal energy for district heating will be considered.

A final consideration is the nature of the resource itself. Two properties in particular are important: the temperature and the location of the resource vis à vis the market. Given the existing state of production technology, the hotter the resource and the closer the resource to the point of consumption, the more financially attractive geothermal investment becomes. Conversely, the cooler the resource and the farther it is from the point of consumption, the less profitable geothermal investment is.

All the consideratons discussed above are recognized in the following analysis. The nature of the revenues and cost flows are included in the specifications of the model. The user population, resource, temperature, and the distance to the market are explicitly considered below in evaluating prospective resources. The complete description of the GIRORA-Nonelectric and the associated computer progrm written in FORTRAN IV is given in Appendix 2.

5.2 A Technical Screening of the Regional Low Temperature Resource Endowment.

A complete compilation of known low temperature anomalies identified by the Core Team and state personnel is presented in the data base section of the report. For each of these sites, the location (state and county), the latitude and longitude, a set of estimated temperatures, and the estimated reservoir volume are presented.

The distribution by state of low temperature geothermal resource sites is summarized in Table 5.1. In addition, the estimated energy potential in MBtuh is calculated for each state. The distribution of neither is balanced. For example, 328 of the 504 (65 percent) known anomalies are found in Nevada. Each of these resource sites is designated with a dot (.) in Figure 5.1. Viewed from another perspective, if the energy supply potential of these resources is calculated in MBtuh, a full 78 percent of the total is located in Nevada. Thus, just as in the case of the high temperature resources, Nevada is also rich in low temperature geothermal resources as well.

TABLE 5.1

Distribution of Low Temperature Geothermal

Resources by State

State	Number of Resource Sites	Estimated Supply Potential in MBtuh
Arizona	40	1892
Colorado	45	1460
Nevada	328	30423
New Mexico	46	2969
Utah	45	2201
Total	504	38945

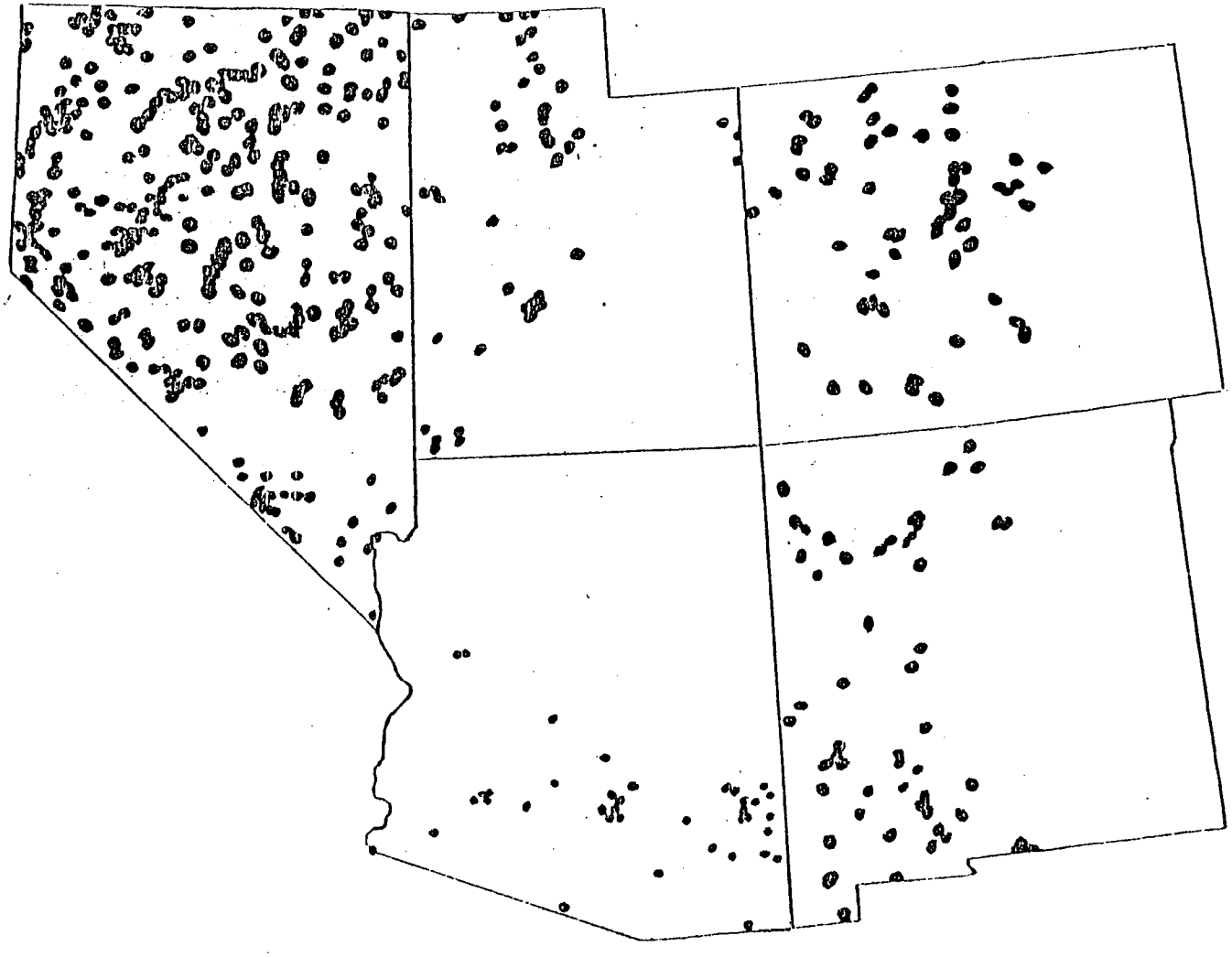


Figure 5.1 Low Temperature Sites in Southwestern Region

The large number of resource sites and the estimated Megawatt years of energy designated in Table 5.1 present a misleading impression of the true geothermal energy potential in the Southwest region. Given the nature of resources and the state of production technology, many of these resources offer no current energy potential. The first task which must be undertaken, therefore, is to eliminate from further consideration any resource which, for one reason or another, is not a feasible supply site.

Accordingly, the initial inventory of low temperature resource sites was subjected to a technological screening. The objective of this exercise was to divide the population of sites into two samples. The first sample consists of sites which are currently usable given the existing state of production technology in the industry. Those sites which fall in the second subgroup are resources which, for one reason or another, are not considered usuable given the present state of "know how." As production techniques advance, however, these latter resources may in time become of substantive importance.

Three criteria were employed to partition the total resource base. The first is the temperature of the resource. A minimum resource temperature is required for effective space heating just as a minimum temperature is required for electricity generation from hotter resources. Earlier space heating experience in Klamath Falls, Oregon, and Boise, Idaho, were consulted in designating a minimum temperature.

The second criterion is the distance between the geothermal resource and the nearest user market. This consideration is intended to exclude from further study all resources which are not sufficiently proximate to a market to be realistically employed.

The final criterion employed for partitioning low temperature resources is the size of the potential market. A minimum feasible market size, which is measured in terms of population, is defined. If there is or is not a market of sufficient size, within the designated distance, a resource will or will not be considered usable.

The preliminary values for the technological screening criteria are presented in Table 5.2.

The technological screening described above was designed to group geothermal sites on the basis of objective (rather than subjective) benchmarks. Insofar as these criteria (temperature, distance, and demand) accurately differentiate between the currently feasible and infeasible, then some rough measure of the

TABLE 5.2

Preliminary Values for Technological

Screening Criteria

Distance	$\leq$ 50 Miles
Market Population	$\geq$ 1000 persons
Resource Temperature (T)	65° $\leq$ T $\leq$ 150°C

technological supply potential of low temperature resources is known. This estimate is certainly more realistic than earlier estimates (e.g., by Reistad), in that the locational configureation of supply and demand sites is explicitly recognized.

The technological screening also allows for the evaluation of the impacts of future technological innovations. The initial partitioning process can easily be reitereated for various temperatures, distances, and demand measures. Each successive iteration will thus provide a new estimate of the regional technological supply potential given a different state of production "know how."

The results of the preliminary technological screening are informative. The original cost of candidate sites has been reduced to 82. The complete list of the remaining sites is presented in Table 5.3; the sites are distributed by state, and the estimated supply potential is also calculated. Figure 5.2 then presented a visual summary of the location of each of these resources.

Both Table 5.3 and Figure 5.2 convey a noteworthy impression: of the original 504 sites, only 16 percent are feasible given current production expertise. Thus, a rough but realistic evaluation of the regional geothermal supply potential considerably depresses earlier estimates. A set of histograms presented in Figure 5.3 effectively portrays the reduction in the aggregate supply potential attributable to the technological screening.

Each of the remaining sites will next be considered to evaluate its economic potential for space heating. A number of economic considerations which have not yet been introduced will contribute to this judgement. In effect this exercise will constitute a second screening on the basis of economic rather than technological criteria.

The primary output of the GIRORA-Nonelectric model then is the calculated internal rate of return, R. This estimate of profitability is analytically useful for a number of reasons. First, of course, the estimated value of R provides a general measure of market profitability. As technologically feasible geothermal resources are more or less profitable, private firms are more or less likely to develop them. Second, if an internal rate of return can be calculated for each geothermal site, then an ordinal ranking of resource areas may be compiled on the basis of estimated profitability. Assuming that the most profitable sites will be developed first, this ranking will provide a unique ordering of sites to be brought "on line." Such information is already in demand to facilitate planning and development efforts.

Table 5.3

Distribution by State of Low Temperature Geothermal Resources Which Pass Initial Technological Screening

State	Site	Estimated Supply Potential, MBtuh
Arizona	Gillatd H.S.	70
	Eagle Creek H.S.	82
	Coolidge H.S.	117
	Coffers H.S.	30
	Cat Tank	35
	Safford Area	22
	Castle H.S.	110
	Yuma	156
	Littleton	160
	Wilcox	29
	Casa Grande (North)	120
	Casa Grande (South)	114
Colorado	Craig Warm Water	21
	Roub H.S.	20
	Steamboat Springs	54
	Hot Sulphur Springs	27
	Idaho H.S.	50
	Glenwood H.S.	16
	South Canyon H.S.	4
	Colonel Chinn H.S.	3
	Hartsell H.S.	17
	Brown Canyon Thermal	37
	Poncha H.S.	54
	Don K Ranch	30
	Mineral H.S.	41
	Shaws Warm Spring	4
	Dutch Crawley	8
	Pagosa Springs	15
	Wagon Wheel Gap	22
	Cebolla H.S.	37
	Orvis	3
	Duray	20
	Lemon	18
	Rico	60
	Pinkerston	7
	Tripp & Trimble	20
Nevada	Cherry Creek H.S.	78
	Hot Pot Bloosom	32
	Mineral H.S.	7
	Hot Springs Point	8
	Warm Springs	10
	Sou H.S.	9
	Elko H.S.	44

Table 5.3 (cont.)

Nevada (cont.)	Sodaville Springs	40
	Walley H.S.	116
	Hind's H.S.	110
	Carson Lake	35
	Wilson H.S.	85
	Eightmile Flat	35
	Wellington	63
New Mexico	Radium Springs	141
	Ojo Caliente	141
	Gila H.S. (Below Bridge)	63
	Gila H.S. (Middle Fork)	14
	Montezuma H.S.	141
	Mamby's H.S.	90
	Turkey Creek	34
	Las Alturas	129
	Berino-Mesquite	129
	Ponce De Leon	40
	T or C	25
	W. Mesa - Black Mountain	98
	Derry Warm Spring	27
	Guadalupe Spring	128
	Hot Well	104
	San Ysidro	104
	Hueco-S. Tularosa	66
	Aleman	116
	Sandiego Mts.	134
Utah	Joseph H.S.	153
	Red Hill H.S.	147
	Crystal H.S.	147
	Abraham H.S.	136
	Wasatch H.S.	130
	Monroe H.S.	130
	Ogden H.S.	117
	Stinking Springs	117
	Meadows Springs	110
	Hooper H.S.	110
	Utah H.S.	99
	Becks H.S.	92
	Crystal H.S.	92

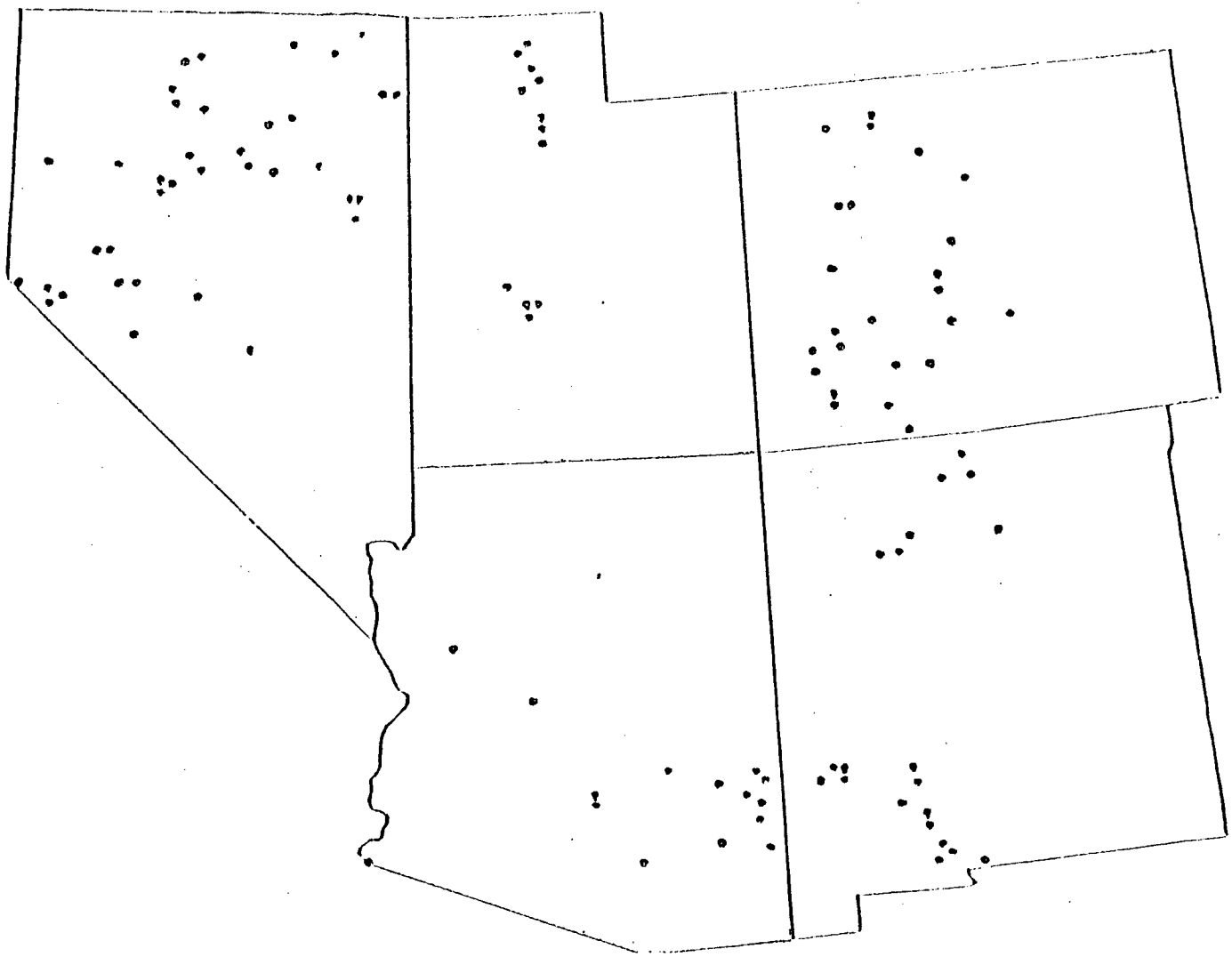


Figure 5.2 Technologically Feasible Low Temperature Sites in Southwestern Region

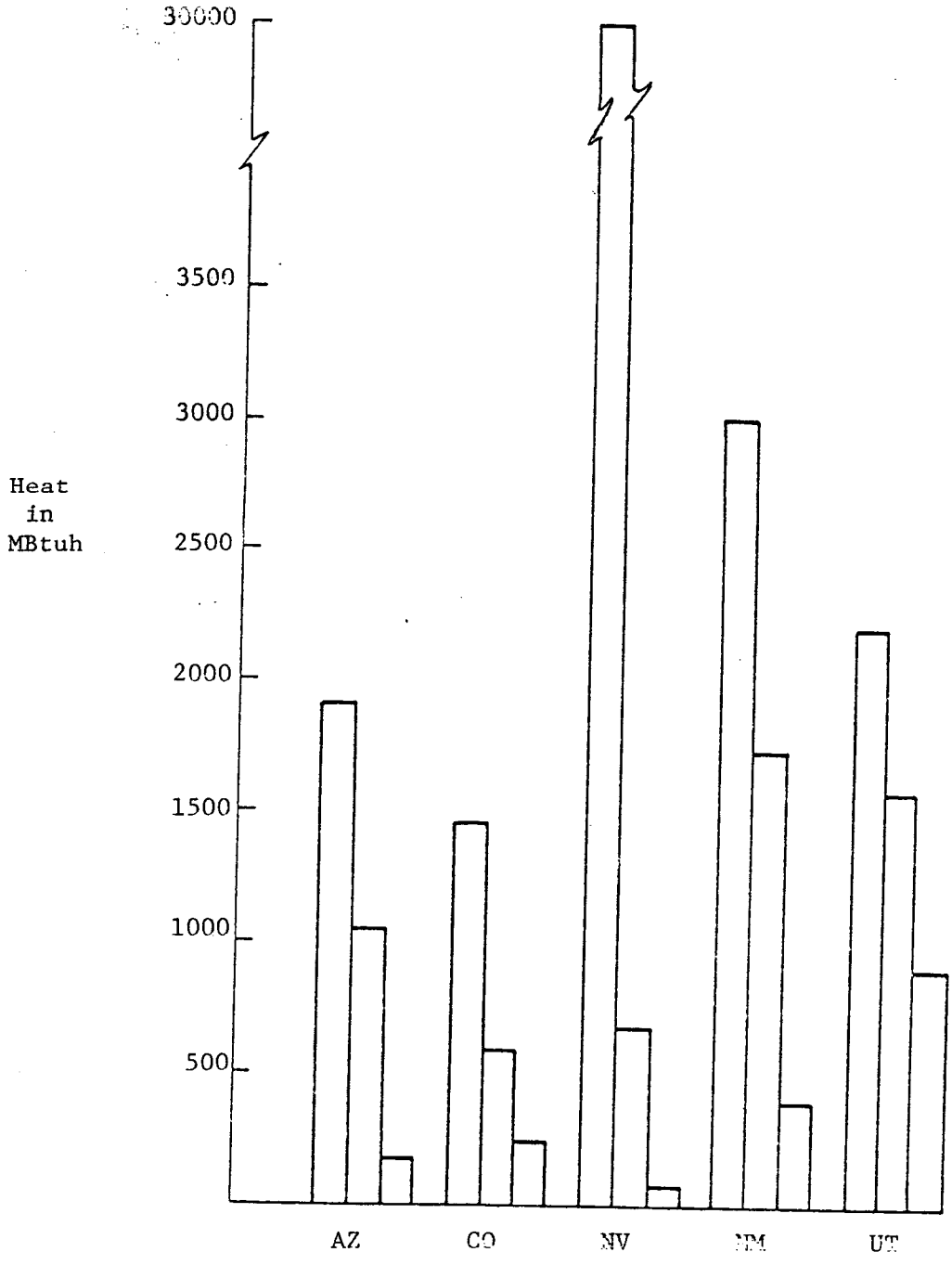


Figure 5.3 Estimated Energy Potential of Low Temperature Geothermal Energy before and after Technological and Economic Screening

The calculation of a site specific internal rate of return is invaluable for yet another reason. By altering the values of selected variables and parameters within the model, the sensitivity of the rate of return to a number of pertinent factors can be determined. In the following pages, the results of such simulation exercises are presented.

5.3 Simulation Results

Simulation experiments with GIRORA have yielded a number of interesting and highly informative results. Three exercises were undertaken. First, a baseline scenario was proposed, and the resulting internal rate of return was estimated. This might be considered the case of a hypothetical geothermal developer working on a hypothetical geothermal resource site. The second exercise consisted of conducting sensitivity analysis. Changes in selected parameters of the model were proposed, and the resulting impacts upon the internal rate of return were measured. Finally, several market scenarios were proposed and the rates of return were forecasted. An "Optimistic" and a "Pessimistic" scenario were specificed based upon selected values of key determinates of R. The purpose of this exercise was to define, insofar as possible, practical limits to the bounds of potential geothermal resource development.

The Baseline Case

The baseline case depicts a geothermal resource being harnessed to provide space heating. Table 5.4 summarizes the values specified for all manual inputs and major choice and parametric model variables.

A geothermal resource with a temperature of 100°C is assumed to be the candidate resource. It is located five miles from a population center of 5,000 persons for whom space heating is to be provided. The load factor of the unit is assumed to be 0.6 and the price of natural gas with which geothermal energy must compete is $\$3.00/10^6$ BTU. As for the geothermal producers, an investment tax credit rate of 0.12 is assumed; a royalty rate of 0.15 is assumed; the depletion allowance is zero; and the cost of debt capital is 8.5 percent. Finally, a debt equity ratio of 0.7/0.3 is assumed.

The estimated rate or return for this baseline case is 11.0%. Under the conditions specified, therefore, the prospects for space heating appear to be encouraging. Accordingly, the results of the sensitivity analysis become increasingly important, since they will reveal which factors might prove most influential in altering the internal rate of return on investment.

TABLE 5.4

The Baseline Case Values

Parameter or Variable	Base Case Value
Temperature	100°C
Distance	5 miles
Population	5,000
Load Factor	0.6
Price of Natural Gas ($/$10^6$BTU)	$3.00
Investment Tax Credit Rate	0.12
Royalty Rate	0.15
Depletion Allowance	0.0
Producer Bond Rate	0.085
Equity Capital Share	0.3
Internal Rate of Return (R)	11.0%

The Sensitivity Analysis

The values of the physical, geophysical and policy factors specified in Table 5.4 are variables in this model. Each of these factors exerts impacts upon the rate of return which are, for the most part, clearly defined but quantitatively unspecified. For the sake of convenience, these factors have been grouped into several classes. The first class includes the geophysical foactors, and the second class includes policy variables and parameters. The role of the geophysical factors in influencing R will be examined first.

Consider the ramifications of variations in resource temperature upon the estimated rate of return. In this analysis, the temperature span considered ranges from 80° to 150° C. The differing values of R at each temperature are illustrated in Figure 5.4.

The changes in resource temperature clearly exert only minimal impacts upon R. If all other parameters and variables considered are maintained at their base case values, the rate of return is 11 percent at 80°C, and it rises to just over 12.5 percent at a temperature of 150°C. Such a finding, that lower temperature resources generate nearly as high a return as the hotter resources is encouraging given the the abundance of relatively lower temperature anomalies in the Southwest.

Consider next the importance of the distance to the market as a determinant of the internal rate of return. Given the potentially large size of the transmission expense, changes in distance can be expected to exert substantial impacts upon R. Figure 5.5 depicts the effects of differences in distance between 0 and 25 miles when all other base case values are held constant. In order to maximize the information provided, the estimated rate of return is plotted against the resource temperature. In this manner, the interactive impacts of changes in distance and temperature become evident.

The distance over which geothermal fluid must be transported strongly invluences R values for a given resource site. For example, at distance of 5, 15, and 25 miles, the rate of return falls from 12.75 to 10.0 to -0.25 percent at 120°C. In the case of a user who is located on site (distance = 0), an estimated 21.5 percent return would be earned. For space heating purposes, therefore, the distance between the resource and the user is of major importance in determining the financial return on investment in geothermal energy development.

The third geophysical parameter in which we are interested is the population of the district heating unit. Variations in population will alter both revenues

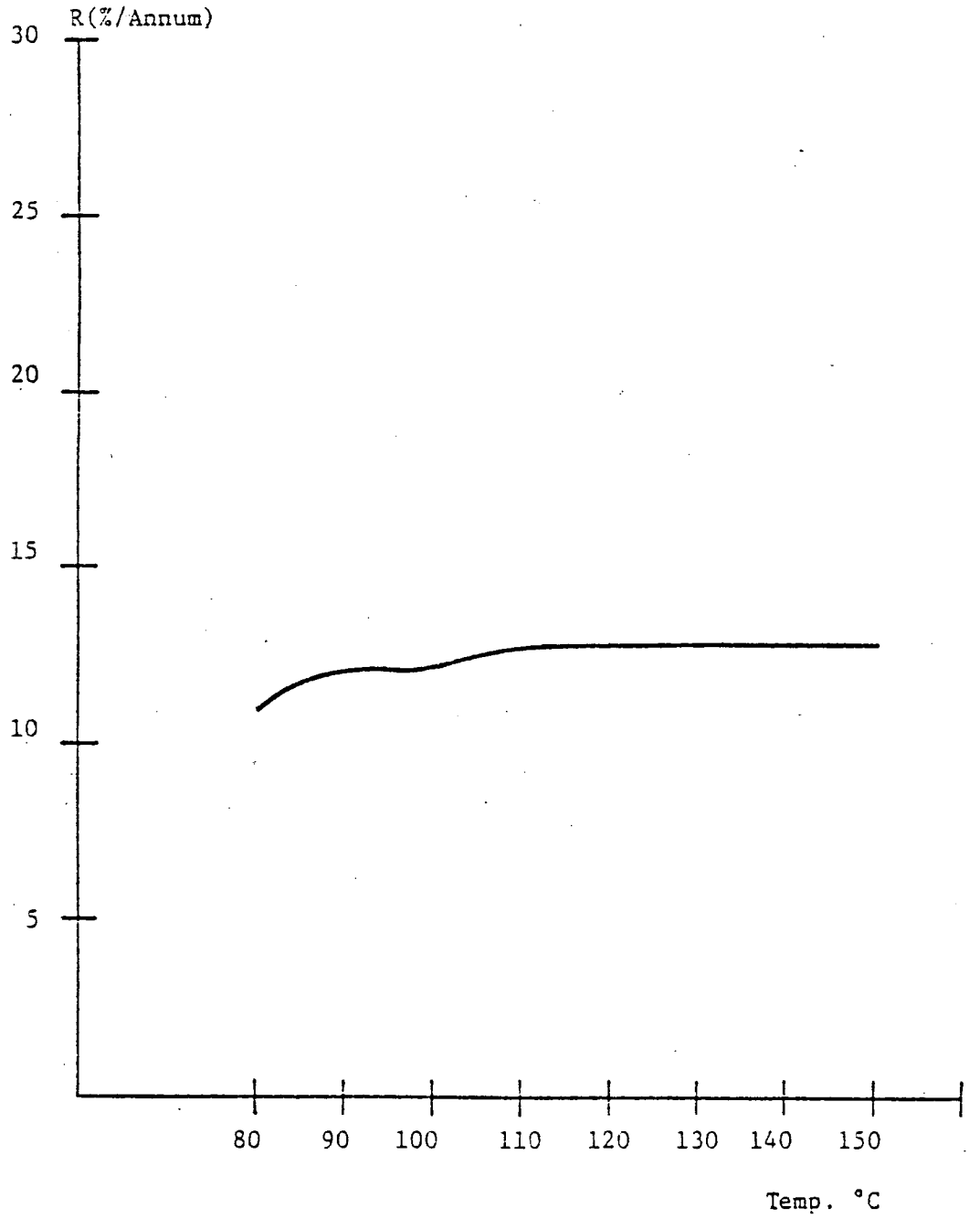


Figure 5.4. Sensitivity of R to Changes in Temperature.

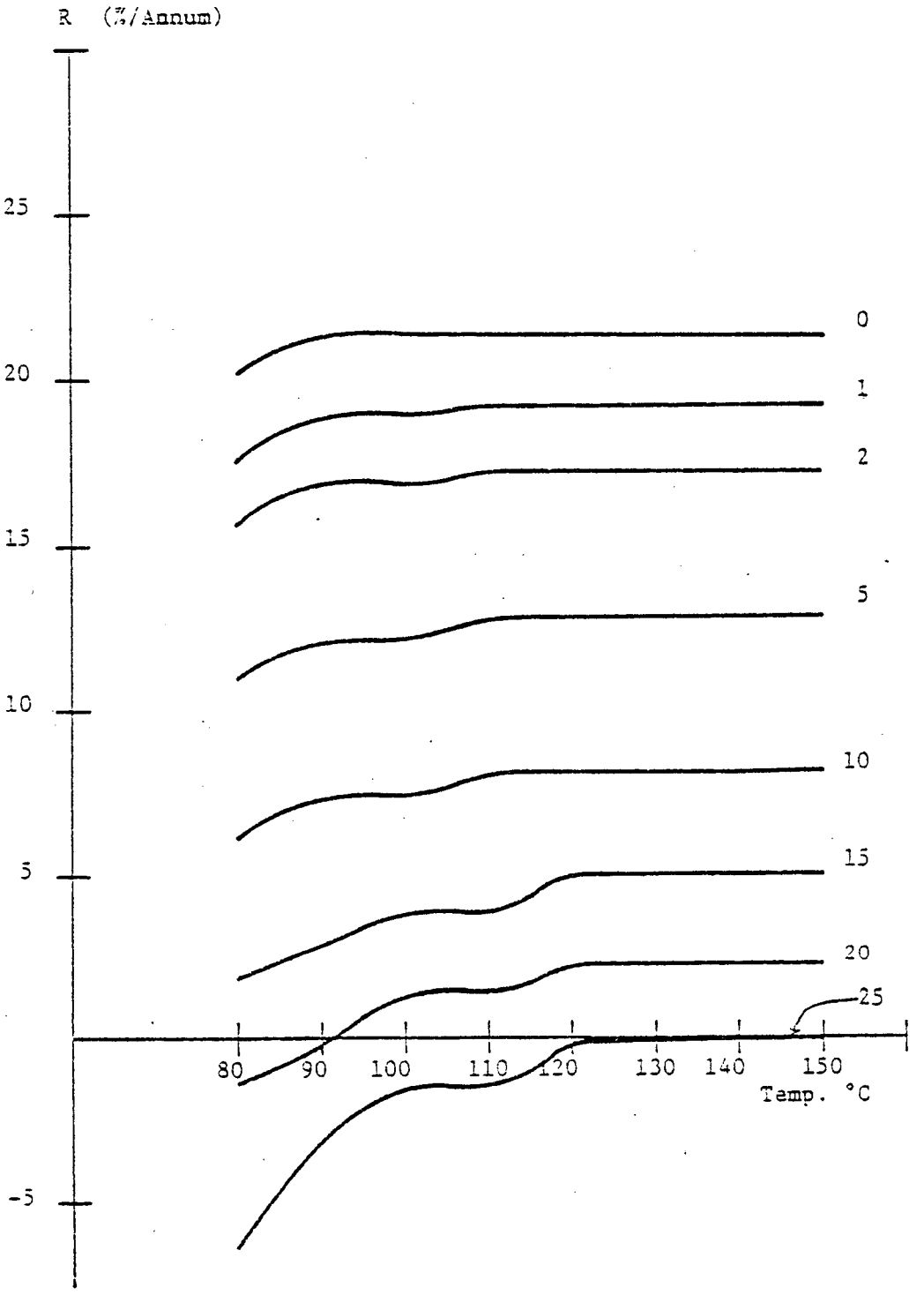


Figure 5.5. Sensitivity of R to Changes in Distance (in miles)

earned and investment costs sustained. To clarify the net impacts upon R, population sizes of 1000, 2000, 3000, 4000, 5000, 10,000, 15,000, and 25,000 have been proposed. Figure 5.6 summarizes the results for various temperatures between 80° and 150°C.

The results are highly informative. Changes in the rate of return are directly related to changes in population at all temperatures. For example, at 120° C, the return on investment rises from 1000 to 25,000. These findings indicate that sizeable financial incentives exist for investment in space heating for relatively larger versus smaller communities.

The analysis above of the roles of the physical and geophysical resource characteristics in determining the return on investement in geothermal energy provided clear results: for anomalies with temperatures between 80° and 150°C, those which are closer to the largest populations offer the greatest financial incentive. Among the other factors in the model which are of concern are a class of parameters and variables which are, in some sense, policy tools. Some of these have been traditionally employed for stimulating natural resource development. Six policy tools are considered here. These include the royalty rate, the bond rate of the producer, the price of home heating fuels with which geothermal energy must compete, the depleting allowance, the investment tax credit rate, and the system load factor. The role of each of these in determining R is considered below.

The influence of the royalty rate in determining R is ascertained by altering its value from 0.10 to 0.20. Figure 5.7 presents the results of these calculations Changes in royalty rates appear to exert quite modest impacts upon R. A reduction of royalty rates from 0.20 to 0.10 raises the rate of return from 12 percent to 13.75 percent. In and of itself, therefore, changes in the royalty rate do not appear to be of major importance in influencing the rate of return.

Consider next the results of alterations in the bond rate of the producer in revising the internal rate of return. Government loan guarantee programs are frequently considered as a means for insuring a supply of venture capital at a minimum cost. In this manner, reductions in interest charges from such programs reduce the cost of financial capital, thereby raising the internal rate of return.

Figure 5.8 reveals that relatively large changes in the bond rate generate relatively small absolute variations in the rate of return. For example, at 120° C, reducing the bond rate from 8.5 percent to 6.5 percent raises the return

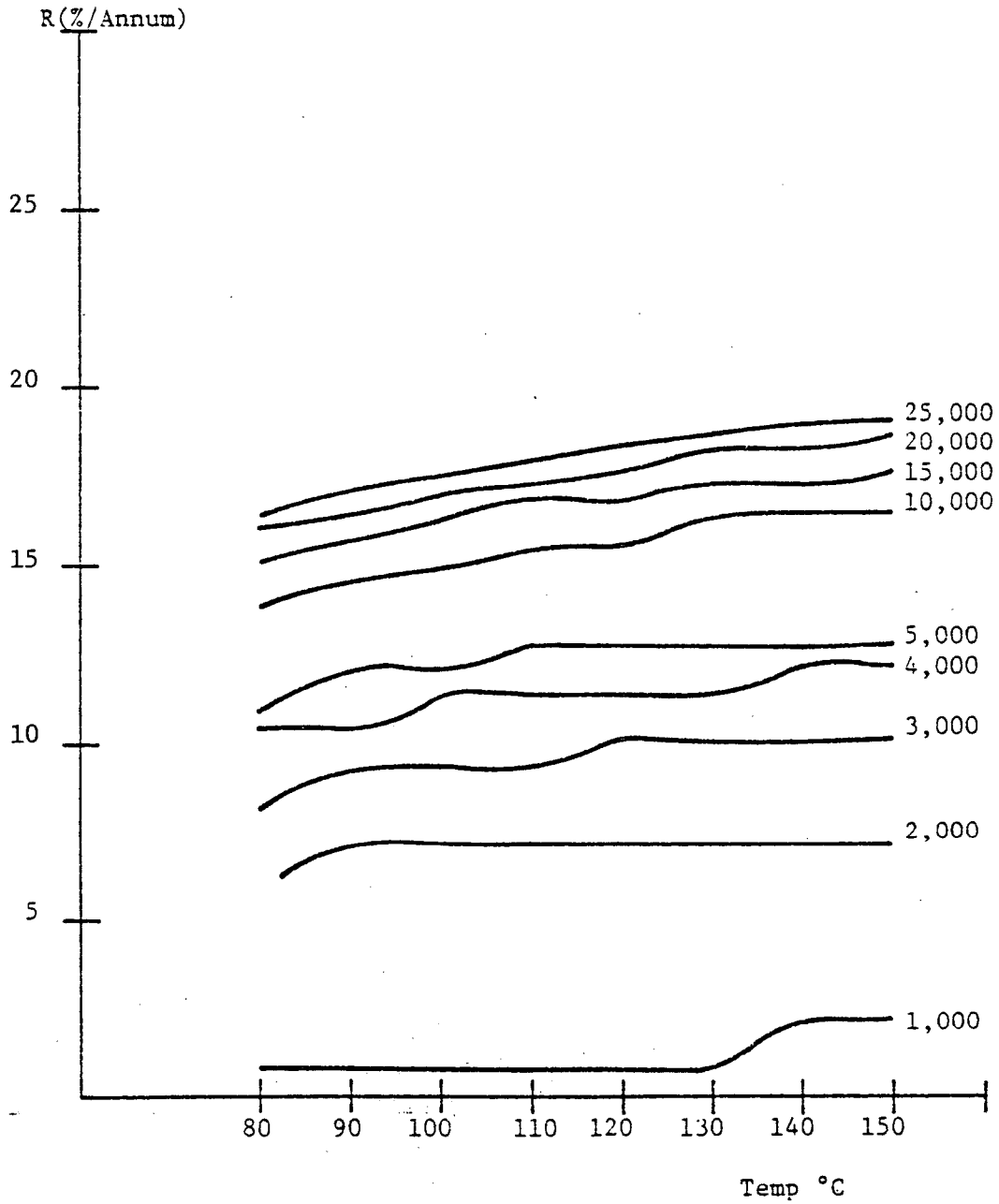


Figure 5.6. Sensitivity of R to Changes in Population

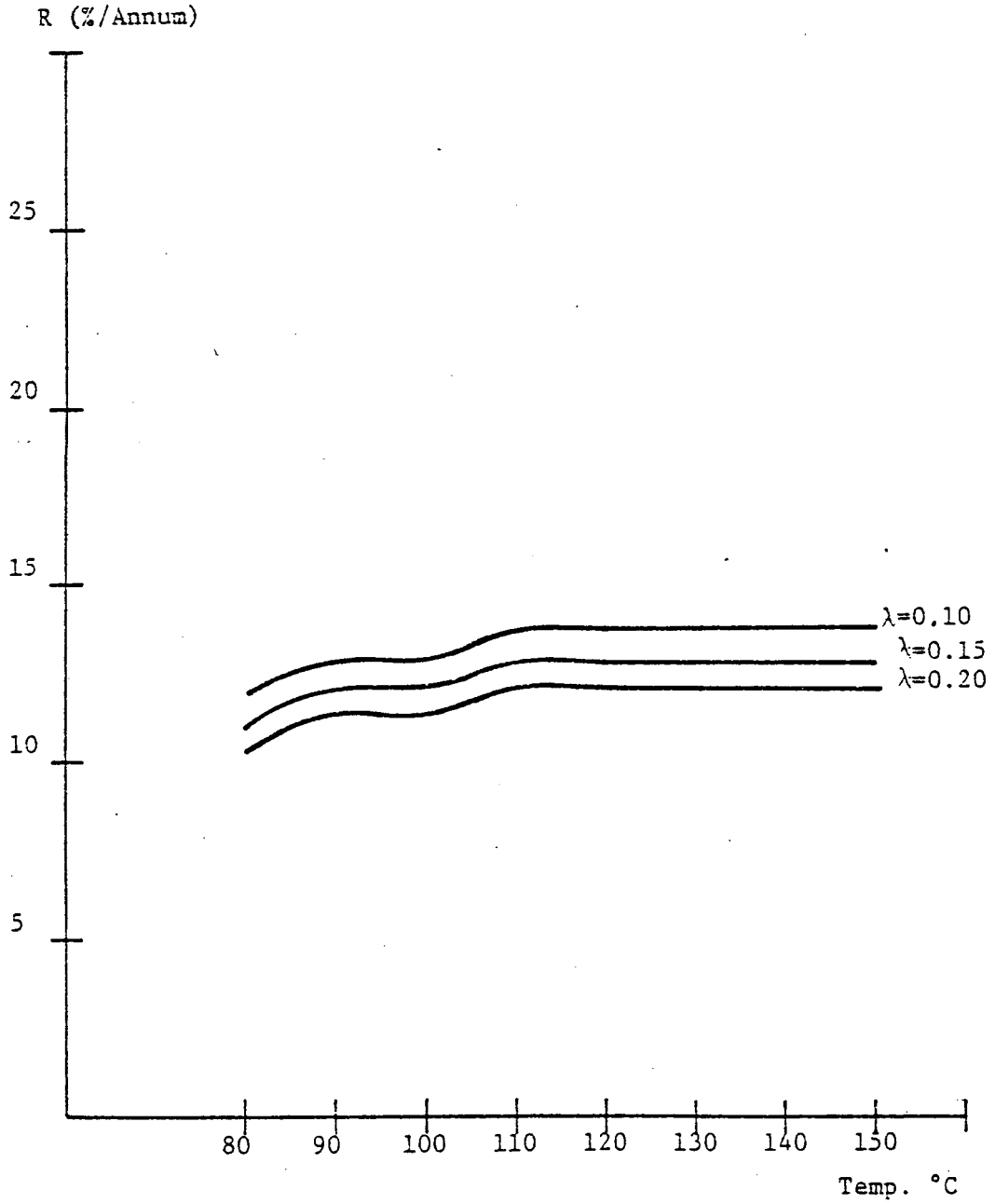


Figure 5.7. Sensitivity of R to Changes in Royalty Rates

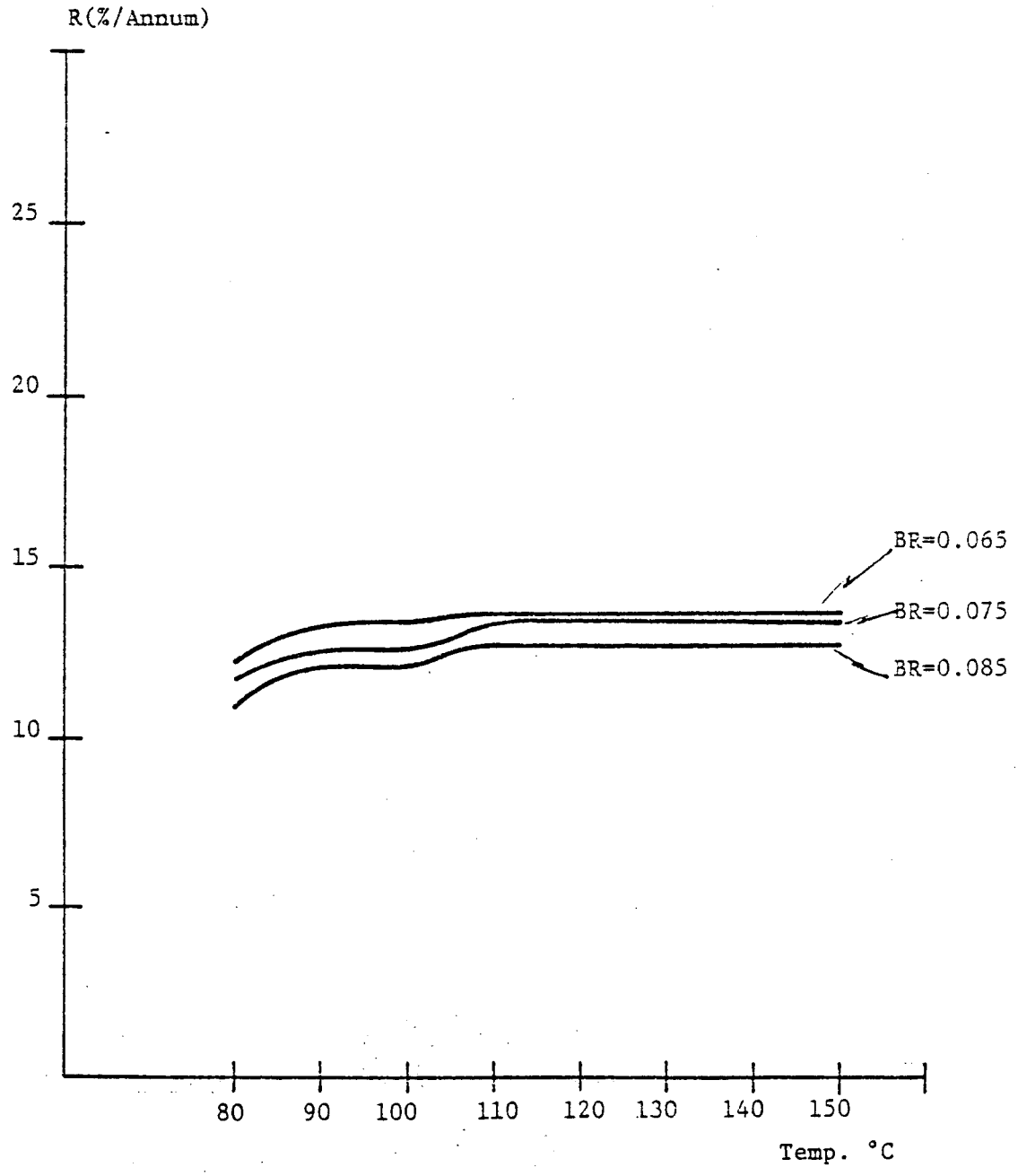


Figure 5.8. Sensitivity of R to Changes in Bond Rate

from 12.75 to 13.75 percent. Furthermore, the leverage which financial capital rates exert upon R is limited at all temperatures between 80° and 150° C. Clearly, reductions in the bond rate do enchance the attractiveness of geothermal investment, in the expected manner, but these effects are of relatively minor importance.

A third policy variable is the price of natural gas. This is the space heating fuel with which geothermal energy must compete throughout much of the Southwest. As natural gas prices rise, the potential revenue recoverable from geothermal energy will rise as well. Accordingly, dollar increments in gas prices from \$3.00 to \$8.00/10^6 BTU have been proposed.

Figure 5.9 reveals that increases in the price of competing fuel bear heavily upon the rate of return to geothermal investment. At 120°C, an increase in natural gas prices from \$3.00 to \$6.00 raises the rate of return from 13 percent to 24.5 percent. On average, each one dollar rise in price generates an increase in R of four percentage points. Deregulations of energy prices in the U.S. would clearly provide strong impetus to geothermal energy development.

The depletion allowance is yet another potential policy option which may influence the return to geothermal energy development. The depletion allowance was assumed zero in the base case, and its value was raised to 0.11 and 0.22 in the sensitivity analysis. The results, illustrated in Figure 5.10, are similar to those for the royalty and bond rates. Although the direction of the changes in R are as expected, the magnitude of the absolute change is limited. Increasing the depletion rate from 0 to 0.22 raises the rate of return roughly 2.5 percentage points at all temperatures. By itself, therefore, the depletion allowance offers relatively limited policy potential as a means of improving the profitability of geothermal energy investment.

A final traditional policy variables which is considered is the investment tax credit rate. A range of investment tax rates has been specified between 0.04 and 0.20. Figure 5.11 verifies that this is also a relatively insignificant factor in affecting the absolute value of R. Raising the tax credit rate from 0.04 to 0.20 only increases R by 1.5 percentage points, from 12.25 to 13.75 percent. As in the case of the royalty rate, bond rate and depletion allowances, the tax credit alone is also of little consequence in determining the profitability of low temperature resources.

A parameter in the model which might be loosely considered a policy option is the load factor. The load factor is a measure of the efficiency of utilization

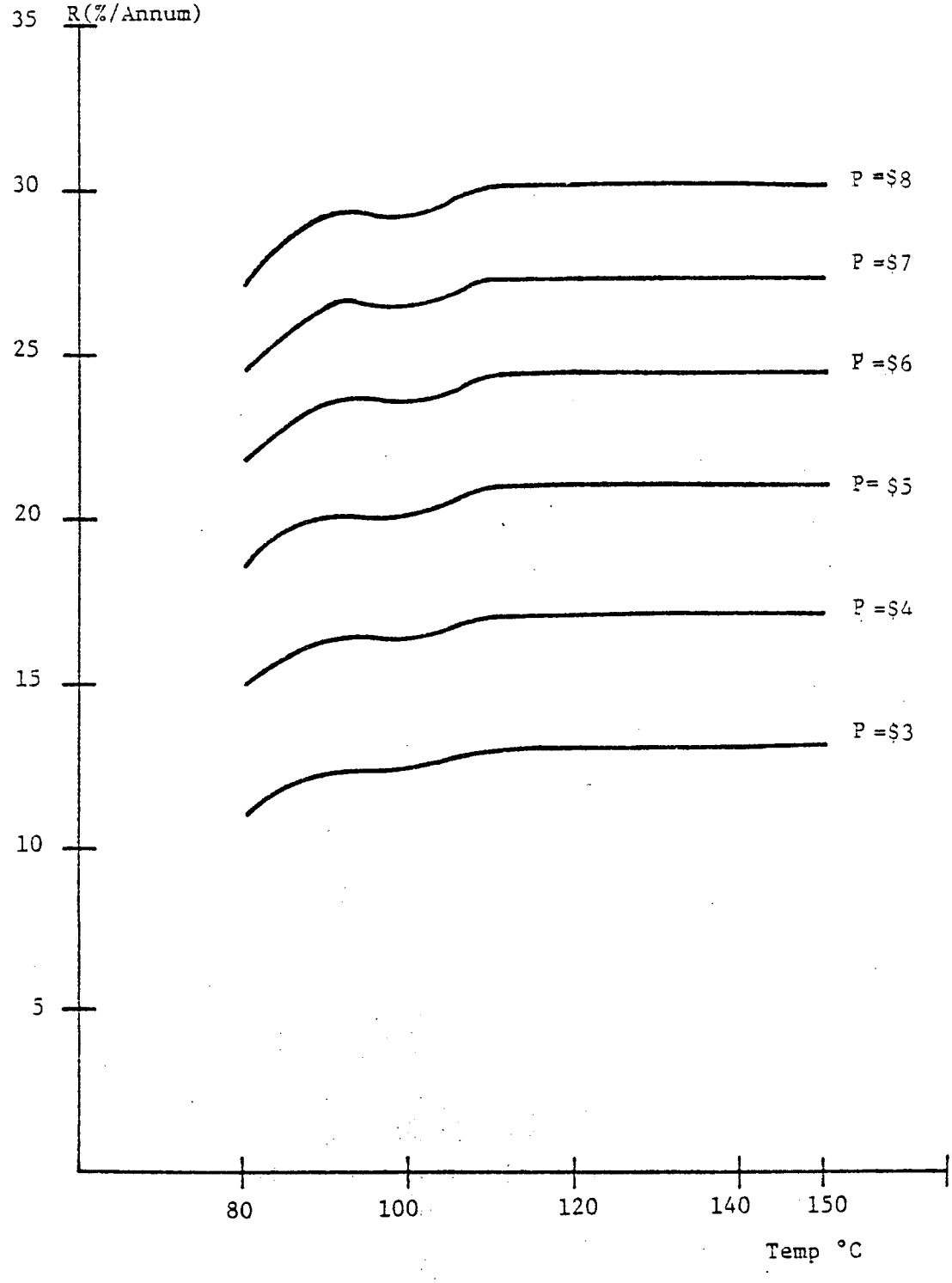


Figure 5.9. Sensitivity of R to Changes in Energy Prices

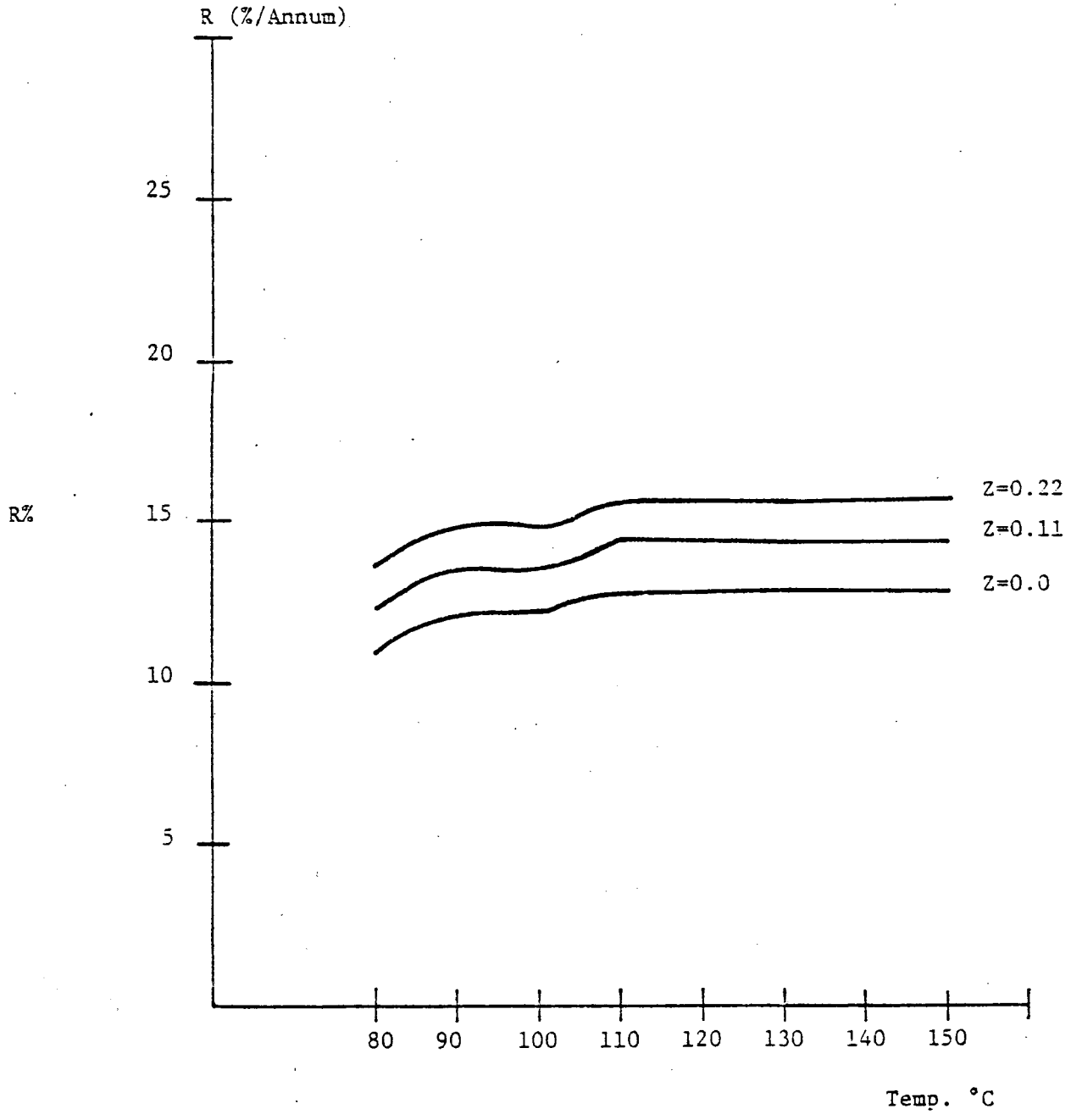


Figure 5.10. Sensitivity of R to Changes in Depletion Allowances

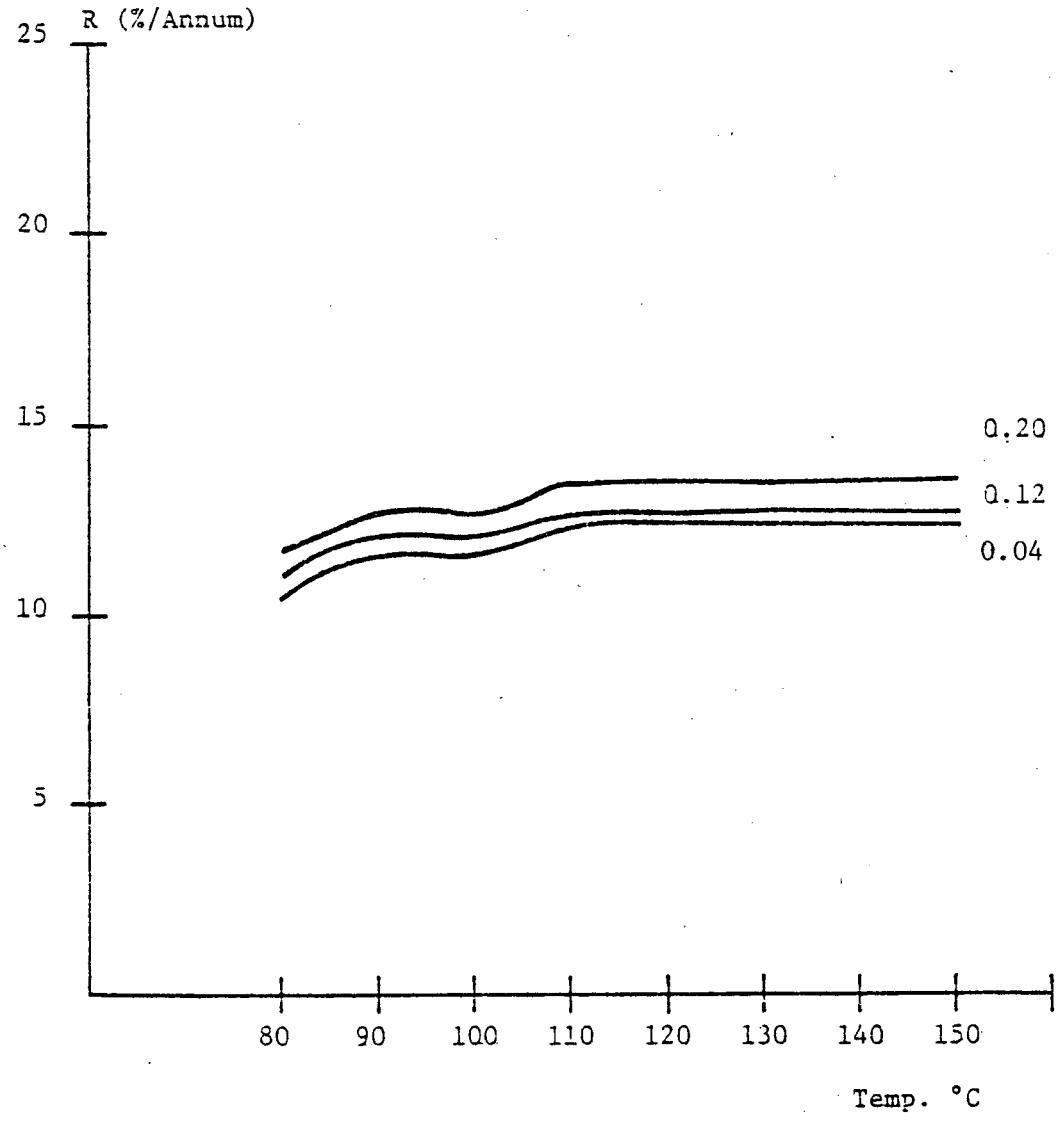


Figure 5.11. Sensitivity of R to Changes in Investment Credits

of the entire physical plant. For a space heating system of a given capacity, the greater or lesser the load factor, the greater or lesser will be the revenues earned; and the greater or lesser the revenues earned for a given investment outlay, the more or less profitable the investment will be. Although the load factor has not been a traditional policy tool, increases in system load factors are subject to policy manipulation.

Figure 5.12 illustrates the impacts of variations in the user load factor at 120° C, the rate of return for load factors of 0.5, 0.6, 0.7, and 0.8 are 10.5 percent, 12.75 percent, 15 percent, and 17.25 percent respectively. Thus, raising the load factor by 40 percent rates R by roughly 70 percent, a highly favorable trade-off. Insofar as the load factor potential may vary from community to community, these findings suggest that the fullest appreciation should be granted the load factor.

5.4 Scenario Forecasts

In the sensitivity analysis above, the impacts of altering a single variable or parameter value were calculated. A more meaningful analysis could be provided if a number of properties of the base case scenario could be varied simultaneously. This exercise would provide valuable infomration on two counts. First, it would elucidate the interactive impacts upon R of several variables or parameters; and second, if the complete set of policy factors are altered simultaneously, the results would infer the full potential of public policy in influencing the profitability of investment in geothermal energy.

Accordingly, Pessimistic and Optimistic forecasting scenarios were prepared. Each scenario consisted of a designated set of policy variable values, with all other values assuming their base case magnitudes. The Pessimistic scenario posited an energy market in which policy conditions are relatively hostile to geothermal energy development. In return the Optimistic scenario pictured an environment which is relatively receptive to geothermal development. The differences in the return on investment between each case provide a measure of the potential of public policy for influencing geothermal energy development.

The scenario values specified for the six policy variables are presented in Table 5.5. The estimated internal rates of return between the scenarios differ darmatically at all temperatures as seen in Figure 5.13. In the Pessimistic setting, with circumstances generally hostile to development R is 9.5 percent at 120°. At the same temperature in the Optimistic scenario, R is a healthy 50 percent. Quite evidently, the combined efforts of all of the policy variables

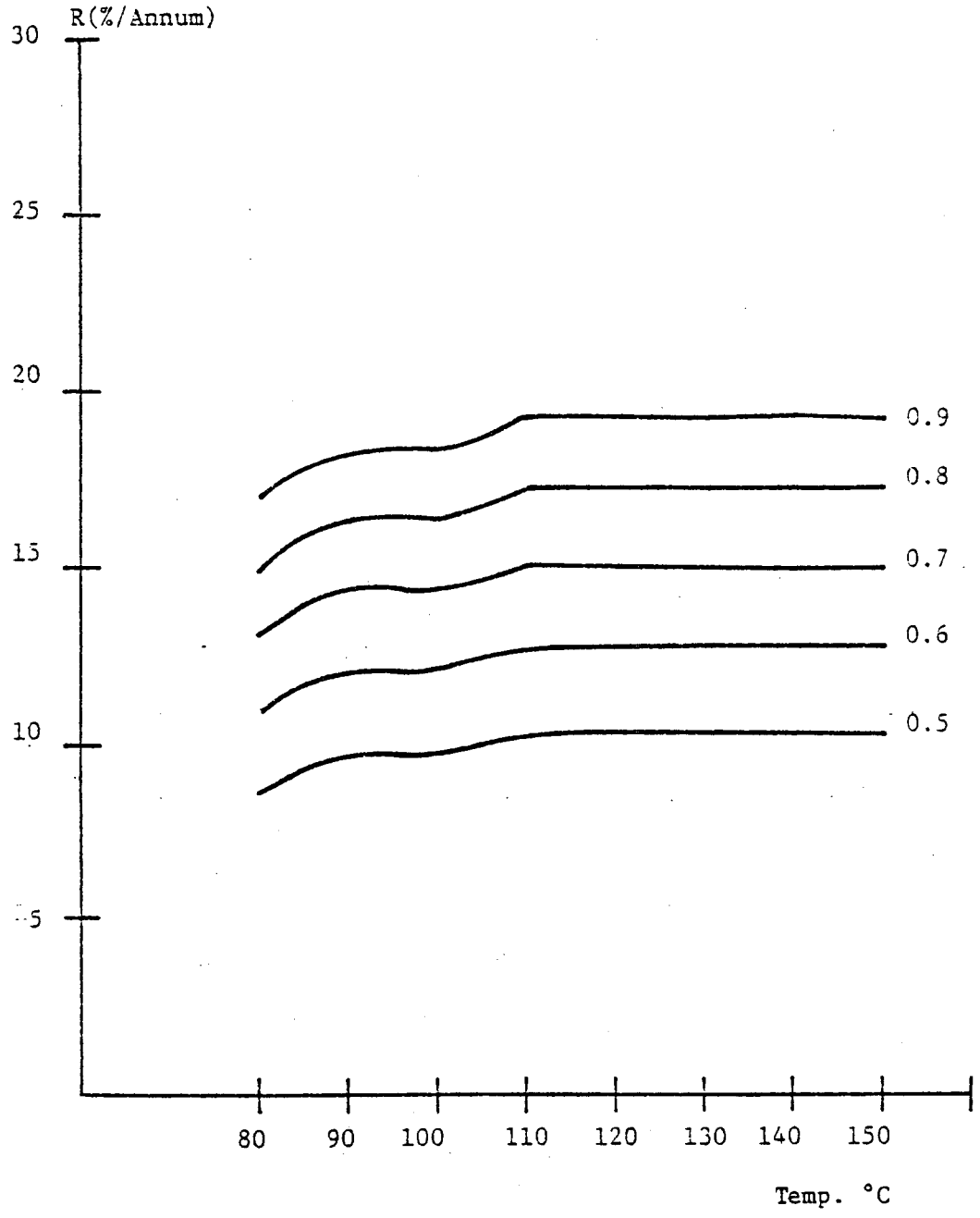


Figure 5.12. Sensitivity of R to Changes in Load Factor

TABLE 5.5

Optimistic and Pessimistic Scenarios

Parameter or Variable	Pessimistic	Optimistic
Load Factor	0.5	0.9
Price ($/$10^6$ BTU)	$3.00	$8.00
Royalty Rate	0.2	0.1
Tax Credit	0.0	0.2
Bond Rate	0.085	0.065
Depletion Allowance	0.0	0.22

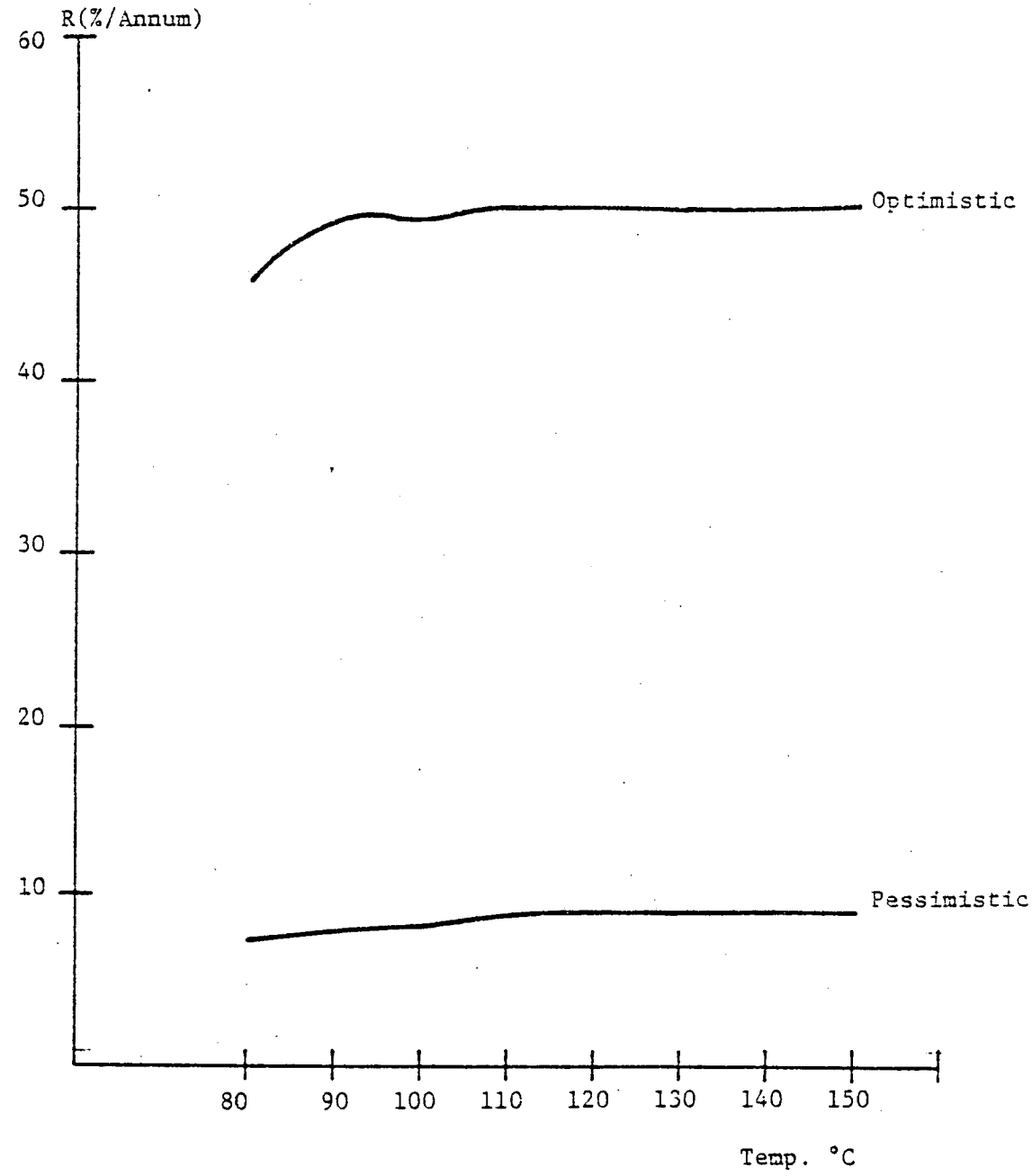


Figure 5.13. Estimated R for Optimistic and Pessimistic Scenarios

considered in Table 5.5 are sufficient to generate a large range of possible return on investment. This finding suggests that a carefully orchestrated mix of policies is capable of inducing space heating applications of geothermal energy on a much broader basis than would otherwise occur.

5.5 Summary of Simulation Results

A simulation model has been developed which evaluates the financial feasibility of harnessing geothermal energy for district space heating. The output of the model consists of an estimated internal rate of return for any specific geothermal anomaly. This rate of return is the discount rate which equates present values of estimated net revenues earned with investment costs incurred throughout the investment life of a geothermal reservoir. Ceteris paribus, the greater the estimated internal rate of return, the more finanically attractive geothermal energy becomes for direct heating applications.

For a hypothetical geothermal anomaly, i.e., a baseline reservoir, sensitivity analysis has revealed a number of important findings. First, the geophysical characteristics of low temperature resources, including the reservoir temperature, the distance to market, and the market size, collectively impose severe constraints upon the development of geothermal resources. Specifically, unless a space heating district of good size is located quite near to a relatively "hot" geothermal reservoir, the internal rate of return will be very low or even negative.

A second finding relates to the effectiveness of the traditional policy tools for enhancing the financial return to geothermal energy development. By and large, most of the policy options considered, including the royalty and investment tax crdit rates, the depletion allowance, and the cost of capital, are of limited individual effectiveness in raising the internal rate of returns. Increases in alternate fuel prices and geothermal plant load factors are the exceptions.

Several contrasting market scenarios were proposed, and the rates of return for each were estimated. The purpose of this exercise was to identify the range of possible returns given a most favorable and a least favorable set of circumstances. The results indicate that under such market extremes, effectively combined policy initiatives and efficient load factors may generate moderate improvements in rates of return.

5.6 Scenario Forecasts of Low Temperatures Geothermal Energy Potential in the Southwest

The modeling analysis presented above has provided experience factors for the expected profitability of a hypothetical low temperature geothermal resource

which has been harnessed for district space heating. The findings (i) present a "ballpark" estimate of expected profitability under certain conditions; (ii), identify the release or retention of a number of factors as determining profitability; and (iii), evaluate the effectiveness of public policy in altering profitability. All of these finds are relevant, however, only for a hypothetical service.

The profitability of geothermal resources which are actually located in the Southwest may now be examined. Those resources which passed the technological screening (Table 5.3) are of greatest concern. Ceteris paribus, the most profitable among these will be developed first and the least profitable will be developed last; those resources which will not earn some minimum return will not be developed at all. GIRORA-Nonelectric will differentiate the former from the latter.

For each of the technologically feasible sites, an internal rate of return will be estimated. The return will be unique to each site, calculated on the basis of its temperature, distance to market, and market population. The minimum acceptable return has been designated as 12 percent. This is the return frequently allowed non-profit, publicly regulated enterprises, and it is considered the minimum acceptable figure for a privately financed business.

The geothermal resources which are expected to earn in internal rate of return greater than or equal to 12 percent are presented in Table 5.6. The number is relatively small: of the 82 candidate sites, only 30 (36 percent) will earn at least 12 percent. Alternatively considering potential of the original 5602 only 2071 (37 percent) successfully pass the economic screening. Thus, only one-third of the geothermal sites (and one-third of the potential MBtuh) which survived the technological screening will generate a minimum acceptable return on investment.

On the basis of the technological and economic screening exercises, several geothermal supply scenarios may be proposed. The first of these depicts the gross energy potential (MBtuh) of the low temperature resources located in the Southwest. The second scenario presents the expected energy potential of the technologically usual resources, as defined earlier. The final scenario measures the energy potential of geothermal resources subject to the technological and economic screenings. Each of these scenarios provides an increasingly realistic appraisal of the true potential of low temperature geothermal energy in the Southwest.

Table 5.6

Distribution by State of Low Temperature Geothermal Resources
Which Pass Technolgical and Economic Screening

State	Site	Estimated Supply Potential, MBtuh
Arizona	Gillard H.S.	24
	Safford Area	22
	Yuma	116
	Littleton	160
	Casa Grande (North)	18
	Casa Grande (South)	24
Colorado	Idaho H.S.	50
	Poncha H.S.	54
	Don K Ranch	30
	Pagosa Springs	15
	Lemon	18
	Rico	60
	Pinkerton	7
Nevada	Cherry Creek H.S.	30
	Elko H.S.	40
	Walley Hot Springs	116
New Mexico	Radium Springs	25
	Montezuma H.S.	30
	Las Alturas	129
	T or C	25
	Hot Well	40
	Sandiego Mountains	134
Utah	Crystal H.S.	147
	Wasatch H.S.	130
	Ogden H.S.	117
	Stinking Springs	117
	Hooper H.S.	110
	Utah H.S.	99
	Becks H.S.	92
	Crystal H.S.	92

The scenarios are illustrated in Figures 5.14 and 5.15. The former summarizes the MBtuh potential by state, and the latter identifies the resources which pass both screenings. The summary table, Table 5.7 , conveys a sobering impression. Only 6 percent of the regional low temperatures sites, providing 6 percent of the MBtuh in the Southwest, survive both screening processes.

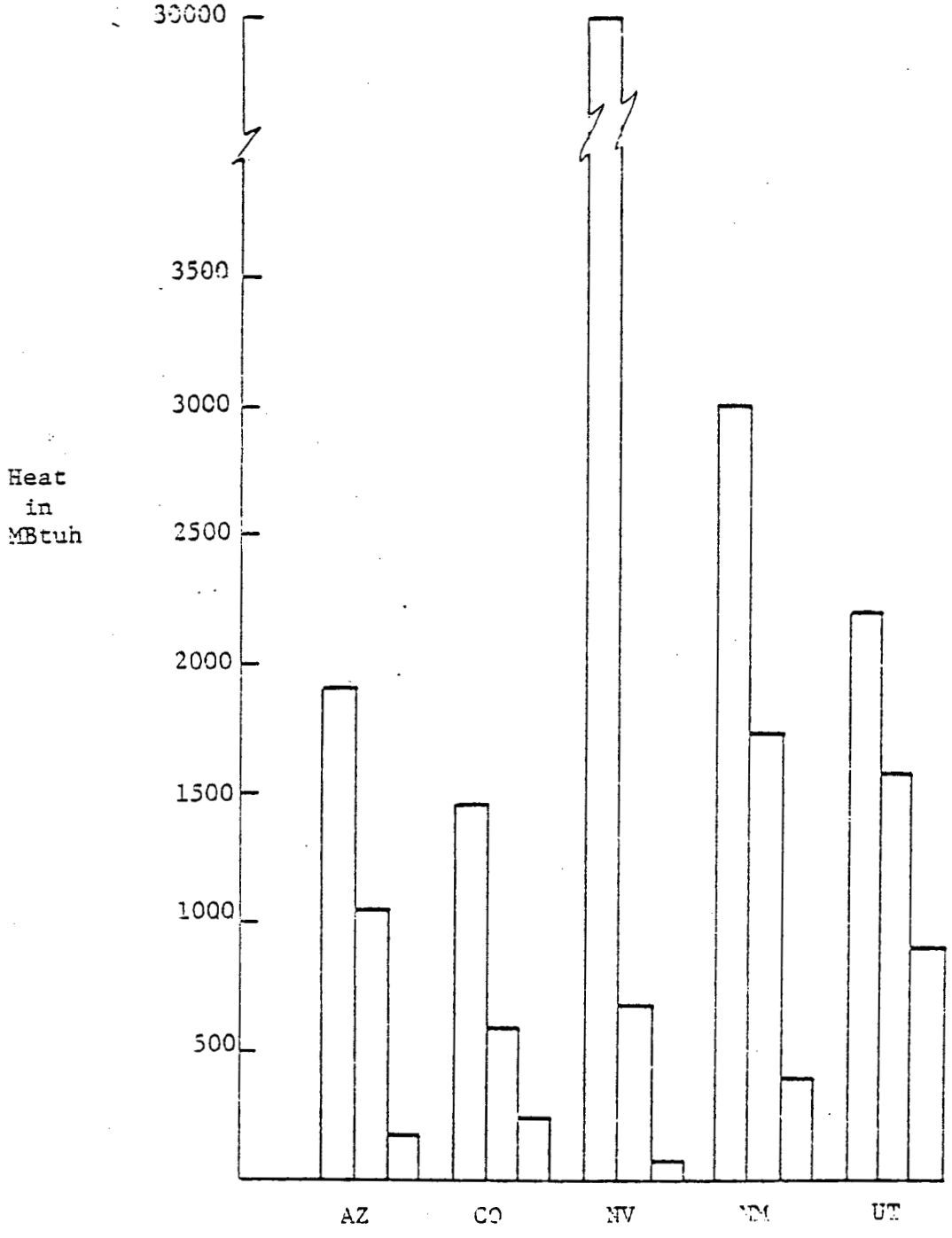


Figure 5.14 Estimated Energy Potential of Low Temperature Geothermal Energy before and after Technological and Economic Screening

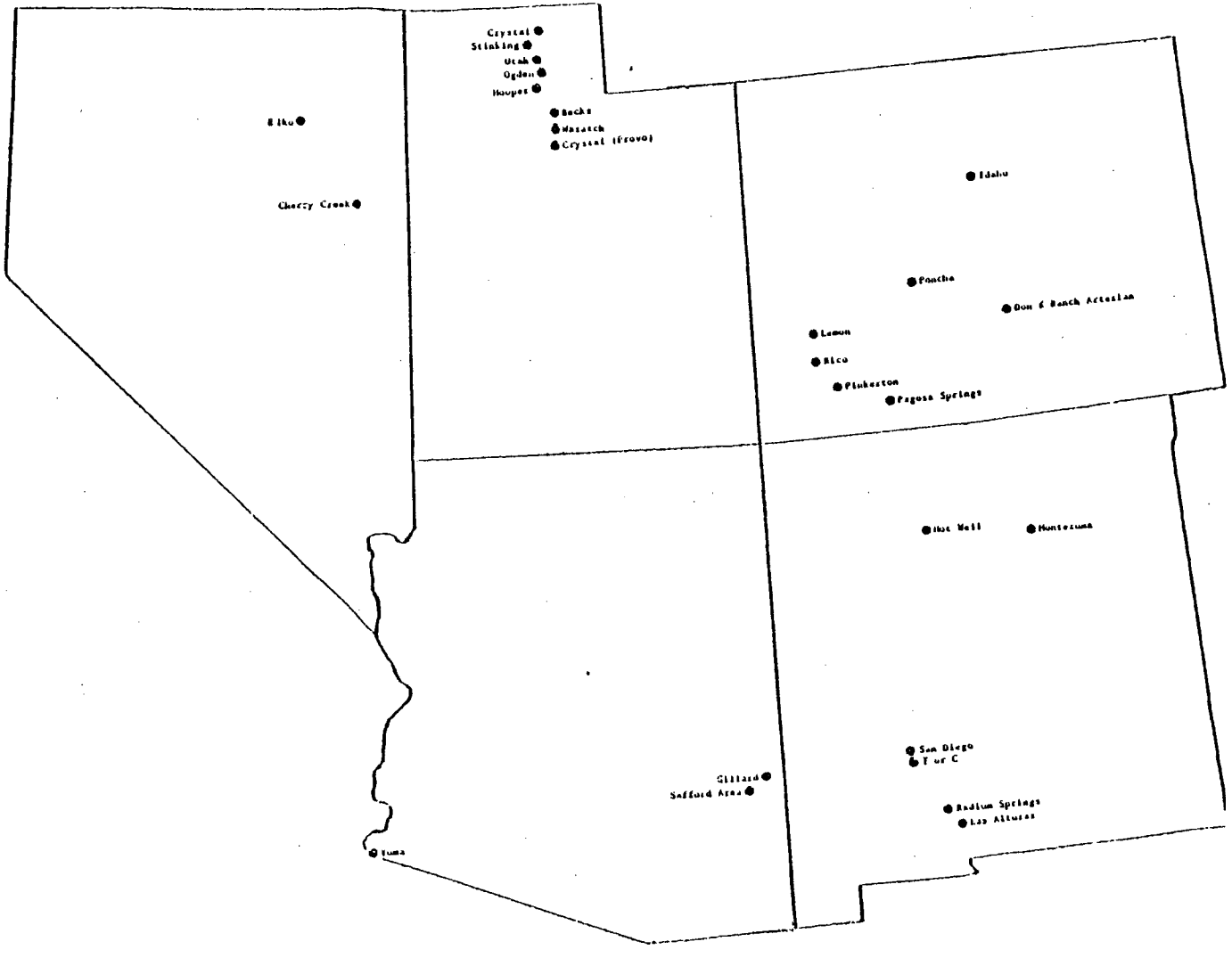


Figure 5.15 Economically Feasible Low Temperature Sites in the Southwestern Region

Table 5.7

Summary Table of Technological and Economic Feasibility of Low Temperature Geothermal Resources in the Southwest

State	Total		Technological Feasibility		Economic Feasibility	
	No. of Sites	Available Heat MBtuh	No. of Sites	Heat MBtuh	No. of Sites	Heat MBtuh
Arizona	40	1892	12	1045	6	364
Colorado	45	1460	24	588	7	234
Nevada	328	30423	14	672	3	186
New Mexico	46	2969	19	1724	6	383
Utah	45	2201	13	1573	8	904
Total	504	38945	88	5602	30	2071

Technological Feasibility:

Temperature: $65° C \leq T < 150° C$

Population: 1000

Distance: 50 miles for single population center

Economic Feasibility:

Rate of Return $\geq$ 12% from GIRORA

CHAPTER VI

DATA BASE AND REGIONAL PROGRAM PROGRESS MONITOR

The computing support described here has been provided by the Regional Program Progress Monitor (RPPM) Group of the Physical Science Laboratory (PSL) of New Mexico State University (NMSU). This support falls into two categories. The first includes the work connected with design, development, implementation, and validation of the geothermal data base, which is the first phase in achieving the goal of a computerized Regional Program Progress Monitor for the project. The second category encompasses the computing required for various economic and scientific investigations conducted by the Core Team.

Soon after the project was started, the state teams were requested to gather information about their resources and send it to the Core Team. To aid in recording the data, a Resource Area Data Sheet (Figure 6.1) and a Drilling Data Sheet (Figure 6.2) were distributed to the state teams. While data were being gathered by the state teams, the core team was considering the question of data storage. It was decided that geothermal data which would be used regularly in calculations and reports should be put in computer storage. The remaining data would be kept on file until the demand for it increased to a point that would justify electronic storage. By mid-1977 interactive (conversational) terminals, such as the IBM 2741, were available in some work areas at NMSU. These allowed quick computer response in jobs which could be processed using the APL computer language. Consequently, this particular language was adopted as standard for use on short geothermal data processing jobs.

6.1 Market Area Determination

In November and December 1977, the accomplishment of market studies required that the number of people living within 50 miles of certain geothermal sites be determined. A computer file was created which contained population center information consisting of city name, county, state, population, latitude, and longitude. Most of the data were obtained from U. S. Census reports; some position information was obtained from atlases. Distance were calculated using the APL functions shown in Appendix 3 of this report.

Thus, the approximate number of people living within a specified distance of a site could be calculated. Repeated studies were made using various distances. The recurring demand for such information established the need to keep the 'city and population" tables in computer storage.

SOUTHWEST REGIONAL
GEOTHERMAL O/R PROJECT

Classification:
Open _____

RESOURCE AREA DATA SHEET

Common Name: _____ Project I.D. No. _____

County _____ State _____

Location: _____ Township/Section _____

Lat./Long _____

Nearest Community _____ Population _____ Distance _____

Nearest Metro Area _____ Population _____ Distance _____

Designated KGRA? _____ by (Agency) _____ Date _____

Leasing Status:

Location:	Surface Ownership:	Lessor:	Lessee:	Access:	Cost:	Terms.

Information Source _____

Person Compiling _____ Date _____ Revision _____

Agency _____ Page _____ of _____

Information Source: _____

Reliability Assessment: _____

Figure 6.1 Resource Area Data Sheet

Drilling Data Sheet No.'s: _____

Environmental Aspects:

Effluent Gases: _____

Effluent Solubles: _____

Subsidence: _____

Reinjection: _____

Other seismic: _____

Disturbance of Terrain: _____

Co-Use With: _____

Resource Quantification: _____

_____

_____

_____

_____

_____

_____

_____

_____

Probable Available Energy:

Rate: _____ MWe ± _____ MWe _____

Expected Life _____ Years ± _____ Years _____

CUM Energy _____ MWe Years ± _____ MWe Years _____

Distance to:

Nearest Power Transmission Line _____

Nearest Use Point: _____

Development Status/Schedule:

_____

_____

_____

Figure 6.1 Resource Area Data Sheet (Continued)

SOUTHWEST REGIONAL
GEOTHERMAL O/R PROJECT

Classification:
Open _____

DRILLING DATA SHEET

Well Name/No. _____ Project I.D. No. _____

Resource Area Name/No. _____

Location _____ Township/Section _____

County _____ State _____

Operator _____

Drilling: _____ Diam, _____ deep, through downhole conditions of: _____

_____

_____

_____

_____

Finds: _____

_____

_____

_____

Energy Quality: Temp _____ ± _____ Flow Rate _____ ± _____ Pressure _____ ± _____

By Test _____

By Calc _____

Estimated Lifetime: _____

Effluent Quality:

Gases (Composition, %): _____ ± _____ (cc's/kw _____ ± _____)

_____ ± _____ _____ ± _____

_____ ± _____ _____ ± _____)

Solubles Suspended Solids (Composition or PPM , %): _____ (kg/kw) _____

_____ _____

_____ _____

Figure 6.2 Drilling Data Sheet

Status: Drilling in Progress ☐ Completed _____ (Date)

Producible ☐ In production _____ (Date) ± Suspended ☐ Abandoned ☐ Observation ☐ Injection ☐

From (Source) _____

Drilling Contractor/address _____

Cost of drilling: _____

Adjacent Drilling:

Name/No. _____ Project I. D. No. _____

Notes:

Information Source

Person Compiling _____ Date _____ Revision _____

Agency _____ Page _____ of _____

Information Source: _____

Reliability Assessment: _____

Figure 6.2 Drilling Data Sheet (Continued)

6.2 Data Base Design

Also in November and December a tentative format for geothermal site information was adopted and data were entered as APL files into computer storage through the terminals. The format included basic site information such as name, location, reservoir volume, and temperature. Using APL commands and functions it was easy to manipulate the data and make useful calculations. Current demand was the primary factor in determining what should go into the data base. In January, estimates of recoverable energy were calculated for each hydrothermal site and results, which indicated sites with good potential for development, were sent to state teams to help them in writing site scenarios. This job utilized practically all of the data in the geothermal site file. The equations for calculation of stored heat, electric potential, and thermal potential (recoverable energy) were obtained from the U. S. Geological Survey Circular 726. The formatting of the report was done with APL and typing took place at the terminal under computer control.

The geothermal data base is relatively small. The SITE relation, which contains all of the geothermal site information, consisted of approximately 250 geothermal sites and about a dozen domains (data fields) for each site in January. In March at the quarterly meeting in Reno, Nevada, an explanation of of the data base structure was made to the state teams and consultants, and samples of the data base were displayed. Later in March new data provided by the state teams were entered in the data base. Then the entire geothermal site portion of the data base was arranged into tables, reproduced, and copies were sent to state teams and Core Team investigators for comments and verification. As a consequence, the state teams sent in additional data which enabled correction of the entries already in the data base.

A complete description of the entire data base was begun in April, continued into May and was published as a 62 page volume called the RPPM Data base. This report lists all of the data in the three divisions of the data base. The report also explains how information may be retrieved from the data base using a terminal connected to the New Mexico State University computer. The report was distributed to the state and core teams during the fourth quarterly meeting of the project in Las Cruces, NM, on May 31 and June 1, 1978. A copy of the report is included as Appendix 3 in this report.

6.3 The Data Base Management System

In 1977 a data base management system called Educational Data Base System (EDBS) was obtained by the NMSU Computing Center from the University of Toronto.

EDBS used the APL language and files so it appeared to be well suited for geothermal data base management. However, EDBS proved to be too slow in retrieving information from the data base. It was not possible at that time to determine whether the computer system or EDBS was responsible for the delays. The use of EDBS for the geothermal data base was postponed. Instead, some APL functions such as 'GET', which is described in Appendix 3, were used for retrieval and update purposes.

6.4 Leasing and Drilling Information

Since leasing and drilling information is of great importance in estimating future sites development, it should be incorporated into the data base. To put all such data into a data base would require a substantial amount of manpower, which would be justified only if the data were used frequently in development scenarios. Detailed leasing data has not been needed thus far by project analysts and as a consequence it has not yet been entered into computer storage. Alternate designs for including lease data are now being considered. One approach is to create a new relation, based on townships, giving detailed information about leases near each geothermal site. Similar methods are being considered for drilling data.

6.5 Data Base Functions

Many APL functions have been developed especially for the geothermal project. The following pages in this chapter contain listings of these functions together with explanations of how they work, their input and output, and their limitations. More information about the functions can be obtained from the Gore Team.

Group Name: UTILITYGROUP

WS Name: 310733401 PJLIB

Group Description: These functions are designed to assist in many applications. They are of two types, those written expressly for the project and those found in edit packages in public workspaces at the UCC (indicated by an asterisk).

Functions Used: TIE∆FILE, CHECK∆LIB, ST∆NAMES, ST∆ABBRV, CNTY∆NAMES, SUBMIT*, STATUS*, JOB*, AI, DUMP, RESHAPE, RAVEL, DATE, SORT.

Variables Used: FILEPRT

Function Name: TIE∆FILE

Global Variables Used: none

Global Variables Created: none

Local Variables: FN (input as described below)
TN (output as described below)

Input: A right argument, FN, containing the library number and name of file to be tied. This argument (a vector) must resemble a row in the explicit result of system function □FLIB, ie:

column	description
1	blank
2-10	library number
11	blank
12-22	file name

Output: An explicit result, TN, a scalar. Z is a 0 if the file could not be tied; if the file was tied, Z is the tie number.

Subroutines: CHECKALIB

Calling Routines: MARKET

Function Name: CHECKALIB

Global Variables Used: none

Global Variables Created: none

Local Variables: FN (input as described below)
X (output as described below)

Input: See input description for function TIE▲FILE in this group.

Output: An explicit result, X, a scalar. X is a -1 if the file doesn't exist. X is a 0 if the file exists, but is not tied. X is the file tie number if the file is tied.

Subroutines: none

Calling Routines: TIE▲FILE

Special Coding:

line	coding comments
2	If file exists, X will be 0; otherwise, X will be -1.
4	X is assigned the file tie number.
5	If file was not tied, X will be an empty vector or a result of line 4.
6	File not tied, so reassign X to be 0.

Function Name: ST▲NAMES

Global Variables Used: Codes

Global Variables Created: Z

Local Variables: none

Input: A matrix of numbers; for one state name it could be used as follows: ST▲NAMES 1 1⌷'4' which gives Arizona. To get the entire matrix of state names the following will do it: ST▲NAMES 13 2⍴'4 5 6 7 8 9101112131415 16'.

Output: Will be one or however many the first dimension of the matrix is.

Subroutines Used: none.

Special Coding: none.

Function Name: SUBMIT*

Input: A right argument, X, a vector containing card images (they needn't be 80 characters) separated by carriage returns, representing a job deck.

Output: An explicit result, R, containing the name of the job submitted.

Function Name: STΔABBRV

Global Variables Used: CODES

Global Variables Created: Z

Local Variables: none

Input: A matrix of numbers. For New Mexico the function could be used as follows: STΔABBRV 1 1⍵'7'. To get the entire matrix of state abbreviations: STΔABBRV 13 2⍵' 4 5 6 7 8 910111213141516'.

Output: Will be one or however many the first dimension of the matrix is.

Subroutines Used: none

Special Coding: none

Group Name: MARKETGROUP

WS Name: 310733401 PJLIB

Group Description: For user documentation, refer to the variable MARKETHOW in this group. The user routines are MARKET and MARKETSTATUS. The group can be divided into two subsets: those routines written specifically for the O/R project effort and those routines available from various editing packages (notably, 501 EEEDIT) in public workspaces at the UCC (These are noted below with an asterisk).

Functions Used: MARKET TIE▲FILE CHECK▲LIB ST▲ABBRV CNTY▲NAMES SUBMIT* MARKETSTATUS STATUS* JOB*.

Variables Used: MARKETHOW, MKTMSG MKTDMP

FUNCTION NAME: MARKET

Input: Refer to user documentation variable, MARKETHOW, in this group.

Output: Either a summary of output directed to terminal or a detail of output directed to the line printer at UCC. This detail is dumped through an APL file called 'MKTOUT' which must contain approximately 100,000 bytes of unused file space.

Subroutines: TIE▲FILE, CHECK▲LIB, ST▲ABBRV, CNTY▲NAMES, SUBMIT, STATUS.

Calling routines: none.

Special Coding:

line	coding comments
9	If user doesn't request a detail dump, the next few operations are unnecessary.
13	If the MKTOUT file is not empty, request instructions.
15	If the user requests the file to be erased, fall through and drop all components.
18-19	If the user requests the file be left as is, change DMP condition to false and PRTSUM to true.
20	Reserve a component for the job summary.
25	Since we have 2 temp domains ETEMP and MTEMP, we must combine them into 1.
26-27	Eliminate from input those sites and temps which don't meet input criteria.

line	coding comments
29	If no sites result skip processing.
30-36	format summary
37-38	Read appropriate site latitude and longitude.
39	Construct a rectangular boundary around the site.
40-50	Construct a file of cities within this rectangular boundary.
47	If no cities found within boundaries in the state, don't try and change pop. to numeric form.
51	If no cities are found within this rectangular boundary, skip ahead.
52-65	Intermediate results of the calculations to determine the straight line distance between the site and each city within the rectangular boundary.
66	MI is that distance rounded to the nearest mile.
67-68	Eliminate those cities not within the specified radius.
70	If no cities within radius, skip ahead.
71-74	format summary
75	If no dump requested, skip ahead.
79-80	If there is more than one county name in CST, skip ahead; else, reshape a single name into a matrix.
81-93	format detail
94	Append format detail.
96-97	Compress the last processed site and its temp from the input.
98	If sites remain, go back; else,
99	If no dump requested, skip ahead.
100	Replace reserved component with summary.
101	Submit the program to dump the detail output.
102	Append job number of dump onto end of file.

line	coding comments
103	Check dump job status.
104	If no summary, skip ahead.

Function Name: MARKETSTATUS

Global Variables Used: JOB (contains job name)

Global Variables Created: none.

Local Variables: TN (tie number of output file)

Function Description: This function is used to report the current status of the job which prints the detail output at the UCC.

Input: No arguments.

Output: A status message.

Subroutines: TIEFILE, STATUS

Calling Routines: none

Special Coding:

line	coding comments
3	Assign JOB the job name as previously stored in output file.
4	Check status.
5	Untie file.

Group Name: MARKETGROUP and UTILITYGROUP

Function Name: CHECK∆LIB

Refer to documentation in UTILITYGROUP.

Function Name: TIE∆FILE

Refer to documentation in UTILITYGROUP.

Function Name: ST∆AB∃RV

Refer to documentation in UTILITYGROUP.

Function Name: CNTY∆NAMES

Refer to documentation in UTILITYGROUP.

Note: Although this routine actually does nothing once county codes are substituted for names in the file NCITY (if ever), the program needn't be rewritten; simply modify this routine to make the conversion from code to name.

Function Name: SUBMIT

Refer to documentation in UTILITYGROUP.

Function Name: STATUS

Refer to documentation in UTILITYGROUP.

Function Name: JOB

Refer to documentation in UTILITYGROUP.

```
    ∇ CITYS STN
[1]   OPEN 'CITY' ⋄ →(ERROR=1)/L0
[2]   G←⍉1 8 7 6 2 3 4 5 GET 1,0,(1000×STN),(((STN+1)×1000)-1)
[3]   G←G[;(G[1;]≠',')/⍳(⍴G)[2]]
[4]   G←ABC G
[5]   G2←⍴G ⋄ MAX←MAX1←MAX2←MAX3←MAX4←MAX5←MAX6←0 ⋄ I←COUNT←1 ⋄ SZ←⍴(⍬,STN) ⋄ →(SZ=2)/NXT ⋄ NAME←ST∆NAMES 1 1 ⍴(⍬,STN) ⋄ →N
[6]  NXT:NAME←ST∆NAMES 1 2 ⍴(⍬,STN)
[7]  NXT2:→((G2[1]>50)∧(G2[1]≤100))/CK1
[8]   →((G2[1]>100)∧(G2[1]≤150))/CK2
[9]   →((G2[1]>150)∧(G2[1]≤200))/CK3
[10]  →((G2[1]>200)∧(G2[1]≤250))/CK4
[11]  →((G2[1]>250)∧(G2[1]≤300))/CK5
[12]  MAX←G2[1]
[13] ∆L1:Z1←1 70 ⍴((30⍴' '),NAME,(10⍴' '))
[14]  Z1←Z1,[1] 1 70 ⍴('CITY',(10⍴' '),'CITY NAME',(9⍴' '),'COUNTY NAME  POPULATION  LAT     LONG ')
[15]  Z1←Z1,[1] 1 70 ⍴('ID',(68⍴' '))
[16] CONT:A1←1 5 ⍴G[I;⍳5] ⋄ A2←1 24 ⍴G[I;5+⍳24] ⋄ A3←1 12 ⍴G[I;29+⍳12] ⋄ A4←1 6 ⍴G[I;41+⍳6] ⋄ A5←1 2 ⍴G[I; 48 49]
[17]  A6←1 2 ⍴G[I; 50 51] ⋄ A7←1 3 ⍴G[I;51+⍳3] ⋄ A8←1 2 ⍴G[I; 55 56] ⋄ ARRAY←A1,A2,A3,A4,A5,A6,A7,A8
[18]  FMT←'5A1,X1,24A1,X2,12A1,X1,6A1,X5,2A1,X1,2A1,X3,3A1,X1,2A1'
[19]  Z1←Z1,[1] 1 70 ⍴(FMT ⍕FMT ARRAY)
[20]  I←I+1
[21]  →(I≤MAX)/CONT
[22]  Z1←Z1,[1] 2 70 ⍴' '
[23]  Z1←Z1,[1] 1 70 ⍴('TABLE 8. CITY ID, CITY NAME, COUNTY NAME, POPULATION, LATITUDE',(8⍴' '))
[24]  Z1←Z1,[1] 1 70 ⍴(9⍴' '),'AND LONGITUDE',(39⍴' ') ⋄ LL←⍞ ⋄ Z1 ⋄ LL←⍞
[25]  →(MAX2=0)/L0 ⋄ →MAX3=0)/C1 ⋄ →(MAX4=0)/C2 ⋄ →(MAX5=0)/C3 ⋄ →(MAX6=0)/C4 ⋄ →C5
[26] C1:MAX←MAX1↑MAX2 ⋄ COUNT←COUNT+1 ⋄ →(COUNT<3)/∆L1 ⋄ →L0
[27] C2:MAX←MAX1↑MAX2 ⋄ COUNT←COUNT+1 ⋄ →(COUNT<3)/∆L1 ⋄ MAX←MAX1↑MAX2↑MAX3 ⋄ →(COUNT<4)/∆L1 ⋄ →L0
[28] C3:MAX←MAX1↑MAX2 ⋄ COUNT←COUNT+1 ⋄ →(COUNT<3)/∆L1 ⋄ MAX←MAX1↑MAX2↑MAX3 ⋄ →(COUNT<4)/∆L1 ⋄ MAX←MAX1↑MAX2↑MAX3↑MAX4
[29]  →(COUNT<5)/∆L1 ⋄ →L0
[30] C4:MAX←MAX1↑MAX2 ⋄ COUNT←COUNT+1 ⋄ →(COUNT<3)/∆L1 ⋄ MAX←MAX1↑MAX2↑MAX3 ⋄ →(COUNT<4)/∆L1 ⋄ MAX←MAX1↑MAX2↑MAX3↑MAX4
[31]  →(COUNT<5)/∆L1 ⋄ MAX←MAX1↑MAX2↑MAX3↑MAX4↑MAX5 ⋄ →(COUNT<6)/∆L1 ⋄ →L0
```

310733401 PJLIB MARKETHOW

THE FUNCTION 'MARKET' IS DESIGNED TO ASSIST IN DETERMINING THE MARKET POTENTIAL FOR LOW TEMPERATURE GEOTHERMAL APPLICATIONS.

THE FUNCTION ACCEPTS AS INPUT A LEFT AND RIGHT ARGUMENT. THE LEFT ARGUMENT IS A SCALAR SPECIFYING THE STATE WITHIN WHICH THE GEOTHERMAL SITES ARE LOCATED. ONLY THE FOLLOWING VALUES ARE VALID.

4 ARIZONA
5 COLORADO
6 NEVADA
7 NEW MEXICO
8 UTAH

THE RIGHT ARGUMENT IS A THREE ELEMENT VECTOR INDICATING

1 RADIUS OF MARKET AREA IN MILES
2 MINIMUM SUBSURFACE TEMPERATURE IN DEGREES C
3 MINIMUM POPULATION.

THE FOLLOWING COMMAND INITIATES EXECUTION FOR THE STATE OF ARIZONA. THE RADIUS OF THE MARKET AREA IS 50 MILES, THE MINIMUM TEMPERATURE IS 150 DEGREES CENTIGRADE, AND THE MINIMUM POPULATION IS 1000.

4 RADIUS 50 150 1000

AFTER INITIATING EXECUTION, THE USER WILL BE PROMPTED FOR OUTPUT INSTRUCTIONS. EACH QUESTION SHOULD BE ANSWERED Y (YES) OR N (NO). OUTPUT OPTIONS INCLUDE

(1) A SUMMARY OF OUTPUT DIRECTED TO THE USER'S TERMINAL
(2) A SUMMARY AND DETAILED OUTPUT DIRECTED TO THE LINE PRINTER AT THE UNIVERSITY COMPUTER CENTER.

IF OPTION (2) IS SELECTED, THE SUMMARY AND DETAILED OUTPUT ARE 'DUMPED' TO THE UNIVERSITY COMPUTER IN A BATCH MODE, AND MAY NOT BE PRINTED IMMEDIATELY. TO CHECK THE STATUS OF THE 'DUMP', ENTER THE COMMAND MARKETSTATUS . THE SYSTEM WILL RESPOND WITH A TIME ESTIMATE IF THE JOB HAS NOT YET BEEN PRINTED. IF THE RESPONSE IS 'NMS053 JOB NOT FOUND', YOU WILL FIND YOUR LISTING IN THE OUTPUT BOX MARKED 29 IN THE USER AREA OF THE UCC. THE LISTING WILL HAVE THE NUMBERS 2429 AT THE TOP, BUT TO BE CERTAIN IT IS YOURS, LOOK FOR THE WORD 'MARKET' JUST BELOW THE NUMBERS

```
    ∇ STATE MARKET LIMITS
[1]   →(1=+/STATE= 4 5 6 7 8)/ΔL10
[2]   'INVALID STATE CODE'
[3]   →0
[4]  ΔL10:TNS←STN←TIEΔFILE ' 310733401 NSITE'
[5]   TNS←TNS,CTN←TIEΔFILE ' 310733401 NCITY'
[6]   →(3>STN+CTN)/0
[7]   'PRINT SUMMARY ?' ⋄ PRTSUM←'Y'=1↑⍞,' '
[8]   'DUMP ?' ⋄ DMP←'Y'=1↑⍞,' '
[9]   →(DMP=0)/ΔL30
[10]  OTN←TIEΔFILE ' 310733401 MKTOUT'
[11]  →(0≥OTN)/ΔL100
[12]  TNS←TNS,OTN
[13]  →(0=SOTN[2]-(SOTN←⎕FSIZE OTN)[1])/ΔL25
[14]  MKTMSG
[15]  →('E'≠1↑FLAG←⍞,' ')/ΔL12
[16]  ⎕FDROP OTN,-SOTN[2]-SOTN[1]
[17]  →ΔL25
[18] ΔL12:→('C'≠1↑FLAG)/ΔL100
[19]  DMP←0 ⋄ PRTSUM←1 ⋄ →ΔL30
[20] ΔL25:(0ρ0) ⎕FAPPEND OTN
[21] ΔL30:RLIM←LIMITS[1] ⋄ TLIM←LIMITS[2] ⋄ PLIM←LIMITS[3]
[22]  SITES←⎕FREAD STN,STATE
[23]  ETEMP←⍪SITES[;73 74 75 76]
[24]  MTEMP←⍪SITES[;77 78 79 80]
[25]  ETEMP[CTEMP]←MTEMP[CTEMP←(ETEMP=0)/⍳ρETEMP]
[26]  SITES←(ETEMP≥TLIM)⌿SITES
[27]  ETEMP←(ETEMP≥TLIM)/ETEMP
[28]  (ρSITES)[1];' SITES'
[29]  →(0=(ρSITES)[1])/ΔL100
[30]  SUMMARY← 2 73 ρ'          INPUT PARAMETERS',146ρ' '
[31]  ST←STΔABBRV SITES[1;1],' '
[32]  SUMMARY←SUMMARY,[1] 1 73 ρ'STATE',(20ρ' '),ST,73ρ' '
[33]  SUMMARY←SUMMARY,[1] 1 73 ρ'MARKET AREA RADIUS       ',(⍕RLIM),'
      MILES',73ρ' '
[34]  SUMMARY←SUMMARY,[1] 1 73 ρ'MINIMUM TEMPERATURE      ',(⍕TLIM),'
      DEGREES C',73ρ' '
[35]  SUMMARY←SUMMARY,[1] 4 73 ρ'MINIMUM POPULATION       ',(⍕PLIM),((
      47-ρ⍕PLIM)ρ' '),(206ρ' '),'AREA   ',9ρ' '
```

```
[36]  SUMMARY←SUMMARY,[1] 2 73 ρ'ID       NAME',(21ρ' '),'   LAT
        LONG    POPULATION   TEMP',146ρ' '
[37] ΔL40:SLA←(⍎,SITES[1; 31 32 33])+(⍎,SITES[1; 34 35 36])÷60
[38]  SLO←(⍎,SITES[1; 37 38 39 40])+(⍎,SITES[1; 41 42 43])÷60
[39]  BOUND←(SLA+RLIM÷60),(SLA-RLIM÷60),(SLO+(RLIM×1.2)÷60),(SLO-(RLIM
      ×1.2)÷60)
[40]  CITIES← 0 64 ρ' ' ⍝ CN←4
[41] ΔL50:X←⎕FREAD CTN,CN
[2]  LA←(⍎,X[; 6 7 8])+(⍎,X[; 9 10 11])÷60
[43]  LO←(⍎,X[; 12 13 14 15])+(⍎,X[; 16 17 18])÷60
[44]  LALOC←(LA≤BOUND[1])∧(LA≥BOUND[2])
[45]  LOLOC←(LO≤BOUND[3])∧(LO>BOUND[4])
[46]  CITIES←CITIES,[1](LALOC∧LOLOC)⌿X
[47]  →(0=(ρCITIES)[1])/ΔL55
[48]  CITIES←(PLIM≤⍎,CITIES[;19+⍳7])⌿CITIES
[49] ΔL55:CN←CN+1
[50]  →(CN≤16)/ΔL50
[51]  →(0=(ρCITIES)[1])/ΔL70
[52]  SLA←SLA÷57.29578
[53]  SLO←SLO÷57.29578
[54]  CLA←((⍎,CITIES[; 6 7 8])+(⍎,CITIES[; 9 10 11])÷60)÷57.29578
[55]  CLO←((⍎,CITIES[; 12 13 14 15])+(⍎,CITIES[; 16 17 18])÷60)÷57.295
      78
[56]  A←20925831 ⍝ B←20854891 ⍝ C←0.006768658
[57]  SN←A÷(1-(C×10SLA)*2)*0.5
[58]  CN←A÷(1-(C×10CLA)*2)*0.5
[59]  SX←(20SLA)×(20SLO)×SN
[60]  CX←(20CLA)×(20CLO)×CN
[61]  SY←(20SLA)×(10SLO)×SN
[62]  CY←(20CLA)×(10CLO)×CN
[63]  SZ←(10SLA)×SN×(B*2)÷A*2
[64]  CZ←(10CLA)×CN×(B*2)÷A*2
[65]  Δ←(((SX-CX)*2)+((SY-CY)*2)+(SZ-CZ)*2)*0.5
[66]  MI←⌈3957.7719×¯30Δ÷20897037
[67]  CITIES←(MI≤RLIM)⌿CITIES
[68]  MI←(MI≤RLIM)⌿MI
[69] ΔL70:POP←0
[70]  →(0=(ρCITIES)[1])/ΔL80
[71]  POP←⍎,CITIES[;19+⍳7]
```

```
[72] ΔL80:LINE←SITES[1;⍳4],(5ρ' '),SITES[1;5+⍳20],(5ρ' '),SITES[1;30+⍳
     5]
[73]  LINE←LINE,' N',(5ρ' '),SITES[1;36+⍳6],' W',(3ρ' '),((2ρ 7 0)⍕+/P
     OP),(2ρ 9 0)⍕1↑ETEMP
[74]  SUMMARY←SUMMARY,[1] LINE
[75]  →(DMP=0)/ΔL90
[76]  →(0=(ρCITIES)[1])/ΔL87
[77]  NAMES←CITIES[;39+⍳25]
[78]  CST←STΔABBRV CITIES[;⍳2]
[79]  →(2=ρρCST)/ΔL85
[80]  CST← 1 2 ρCST
[81] ΔL85:COUNTY←CNTYΔNAMES CITIES[;26+⍳12]
[82]  MI←(2ρ 3 0)⍕((ρMI),1)ρMI
[83] ΔL87:DETAIL← 1 73 ρ'PROJECT ID NO.     ',SITES[1;⍳4],51ρ' '
[84]  ST←,STΔABBRV SITES[1;1],' '
[85]  DETAIL←DETAIL,[1] 1 73 ρ'SITE NAME          ',SITES[1;5+⍳20],'  '
     ,ST,31ρ' '
[86]  DETAIL←DETAIL,[1] 1 73 ρ'LOCATION           ',SITES[1;30+⍳5],' N
          ',SITES[1;36+⍳6],' W',35ρ' '
[87]  DETAIL←DETAIL,[1] 1 73 ρ'TEMPERATURE        ',((2ρ 3 0)⍕1↑ETEMP),
     ' DEGREES C',70ρ' '
[88]  DETAIL←DETAIL,[1] 1 73 ρ'AREA POPULATION    ',((2ρ 7 0)⍕+/POP),55
     ρ' '
[89]  →(0=(ρCITIES)[1])/ΔL89
[90]  DETAIL←DETAIL,[1] 2 73 ρ' '
[91]  DETAIL←DETAIL,[1] 2 73 ρ(10ρ' '),'CITY',(14ρ' '),'STATE',(7ρ' ')
     ,'COUNTY',(6ρ' '),'POPULATION   DISTANCE',73ρ' '
[92]  POP←(2ρ 7 0)⍕((ρCITIES)[1],1)ρPOP
[93]  DETAIL←DETAIL,[1] NAMES,SP,CST,SP,COUNTY,SP,POP,(SP←((ρMI)[1],5)
     ρ' '),MI,((ρMI)[1],4)ρ' '
[94] ΔL89:DETAIL ⎕FAPPEND OTN
[95] ΔL90:'END SITE ',SITES[1;⍳4]
[96]  ETEMP←(0,((ρETEMP)-1)ρ1)/ETEMP
[97]  SITES←(0,((ρSITES)[1]-1)ρ1)⌿SITES
[98]  →(0<(ρSITES)[1])/ΔL40
[99]  →(~DMP)/ΔL95
[100] SUMMARY ⎕FREPLACE OTN,(⎕FSIZE OTN)[1]
[101] DUMMY←SUBMIT MKTDMP
[102] DUMMY ⎕FAPPEND OTN
[103] STATUS
[104] ΔL95:→(PRTSUM=0)/ΔL100
[105] 'POSITION PAPER, THEN RETURN CARRIAGE TO RECEIVE SUMMARY' ⋆ DUMM
     Y←⍞
[106] SUMMARY
[107] ΔL100:⎕FUNTIE TNS

      ∇
```

```
    ∇ X←CHECKΔLIB FN
[1]   FN←FN,(22-ρFN)ρ' '
[2]   X←¯1++/(⎕FLIB 310733401)∧.=FN
[3]   →(X=-1)/0
[4]   X←(⎕FNAMES∧.=FN)/⎕FNUMS
[5]   →(1=ρX)/0
[6]   X←0
    ∇
```

```
    ∇ TN←TIEΔFILE FN
[1]   TN←0
[2]   →(¯1 0 =CHECKΔLIB FN)/ΔL1,ΔL2
[3]   'FILE ',FN,' MUST NOT BE TIED' ⋄ →0
[4]  ΔL1:'FILE ',FN,' DOESN''T EXIST' ⋄ →0
[5]  ΔL2:FN ⎕FSTIE TN←1+⌈/0,⎕FNUMS
    ∇
```

```
    ∇ Z←CNTYΔNAMES CODES
[1]   Z←CODES
    ∇
```

```
     MKTMSG
OUTPUT FILE CONTAINS DATA FROM A PREVIOUS RUN.
ENTER   E   TO ERASE EXISTING DATA,
        C   TO CONTINUE WITH ONLY A PRINTED SUMMARY, OR
            RETURN CARRIAGE TO END EXECUTION.
```

```
    ∇ R←SUBMIT X
[1]   R←JOB←⎕SUBMIT X
    ∇
```

```
    ∇ Z←STATUS
[1]   Z←⎕HASPIW('I';12↑'$D''',JOB)
    ∇
```

```
      MKTDMP

//**GPN0001L,585-66-2429-0,MARKET
// EXEC FILEPRT
_ FILE 310733401 MKTOUT
_ CEJECT
_ SELECT ALL
```

```
    ∇ MARKETSTATUS;TN
[1]   TN←TIE∆FILE ' 310733401 MKTOUT'
[2]   →(TN≤0)/0
[3]   JCB←□FREAD TN,(□FSIZE TN)[2]-1
[4]   STATUS
[5]   □FUNTIE TN
    ∇
```

```
    ∇ Z←JOB;□RX
[1]   □RX←'□RM ¤ →'
[2]   →(2≠□NC 'JOB')ρNG
[3]   →(~(ρρJOB)∈ 0 1)ρNG
[4]   →(~∧/JOB∈□AV)ρNG
[5]   →(∧/' '=JOB)ρNG
[6]   Z←JOB ¤ →0
[7]  NG:'JOBNAME ERROR' ¤ →
    ∇
```

```
    ∇ Z←ST∆ABBRV CODES
[1]   Z← 16 2 ρ'      AZCONVNMCAIDKANBOKORTXWY'
[2]   Z←Z[(⍳,(((ρCODES)[1],1)ρ' '),CODES);]
    ∇
```

```
Group Name:  DBGROUP
WS Name:  310733401  PJLIB

This group  allows simple retrieval of data  from the RPPM Database.
Using the GET function a retrieval  may search a maximum of two domains,
(provided one domain is ID as specified  by the second element of Arg2
of the GET function. Refer to user documentation for that function.)

For detained examples of the use of these functions, refer to the user
manual.

User functions are OPEN, CLOSE. GET.

)FNS:  OPEN CLOSE GET EDITRELNAME VERIFYACCESS

)VARS:  RELATION  contains a valid relation name for use by other functions.
        ERROR     a variable which should be checked after each database
                  operation performed within a user's function.  If a
                  database function terminates normally with a database
                  error message, execution of the user function should be
                  halted as  results are unpredictable.
                  ERROR = 1 if an error was detected.
                  ERROR = 0 if no error was detected.
              - - - - - - - - - - - - - - - - - - - - - - - -

Function Name: OPEN
Group Name:    DBGROUP

Input: a right argument RELNAME containing the name of the relation
to be accessed.

Output: none

Global vars used:  ERROR, RELATION
Global vars created: none
Local vars:  TIES a vector (or scalar) of tie numbers

Subroutines:  EDITRELNAME
              VERIFYACCESS

Calling  routines: none

Coding comments
Line
1         set ERROR condition to true; if execution is terminated before the
          end of program then ERROR condition will be true.
2-4       if user hasn't been given access to the data element dictionary,
          end.
5-7       if tie numbers 99 or 100 are in use, end.
9         check for valid relation name
10        check for proper access rights (type 0 access is read only)
11-12     (if invalid relation name or access rights not granted) untie
          data element dictionary and end
15        no error has been detected thru this point, so ERROR condition
          is false
```

Function name: CLOSE Group name: DBGROUP
Input: none Output: none
Global vars used: none Global vars created: none
Local vars: none Subroutines: none
Calling routines: none

Line	Comments
1-3	if file tie numbers 99 and 100 are not in use it is assumed no relation is open, and execution ends, else
4	files untied.

Function name: GET Group name: DBGROUP
Input: see users documentation
Output: an explicit result, Z, which contains the domains specified for every tuple meeting the input specifications. If no tuples meet the specs, Z is a matrix of shape 0 rows and 0 columns. Each domain is separated by a comma.
Global vars used; RELATION, ERROR
Global vars created: none

Local vars:

D	the qualifying domain
DX	the domain directory
ID	the primary key of the open relation
L	vector of 1's and 0's, where 1's represent those tuples in a domain which meet the specified restrictions.
Z	the output, as described above
ARG1, ARG2	input as described above.
LOC	ordinal position of info relating to their relation in the dictionary.

Subroutines: VERIFYACCESS
Calling routines: none

Function name: GET (continued)

Line	Coding comment
1	initialize result
2	set ERROR condition to true so that if execution terminates during editing, an ERROR condition will be indicated.
3	if read only access is not approved, end; if LOC is greater than zero, it represents the ordinal location of info relating to this relation in the dictionary.
4-5	reshape the left argument into a vector if it isn't already.
6	read domain information of the open relation
7-9	if an invalid domain was included in the left argument, end.
10-12	if an invalid state code or not enough elements included in right argument,end.
13-15	if the qualifying domain is not valid, end.
16	if execution has reached this point, it is assumed no error condition will occur, so ERROR is set to false (actually a workspace full condition may occur during further processing, but this error cannot go undetected and the user will not benefit from setting the ERROR flag to true if the condition did occur).
17	read and convert qualifying domain to numeric data.
18	L is assigned a logical vector, where ones indicate ID's meeting specified requirements.
19	if no tuples meet qualifications, end.
20	if no restrictions by state, skip the next section.
21	read ID domain, convert to numeric data.
22	L is reassigned to be one only where originally one and where ID's also meet specified restrictions.
23	initialize result.
26	assign result
27	remove trailing commas

Function name: EDITRELNAME Group name: DBGROUP
Input: none
Output: 1 if RELNAME is a valid relation name, 0 if not;
Z is an explicit result containing this value.
Global vars used: RELNAME
Global vars created: none
Local vars: none
Subroutines: none
Calling routines: OPEN

Line	Coding comments
3	reassign RELNAME to include library number and reassemble the results of DFNAME and DFLIB system functions.
4	if name is valid,end.

RPPMDED PASSNUMBER 924266585

Component	Contents
1	valid relation names, one per line of the matrix. The location of each relation in the matrix determines the location of other info in the DED.
2	a vector of ones and zeros corresponding ordinally to the relation names in component 1. 1 represents availability 0 represents unavailability
3-20	empty
21	(20 + LOC) access matrix for relation CITY.
22	(20 + LOC) access matrix for relation COUNTY.
23	(20 + LOC) access matrix for relation SITE. 0 is read only access 1 is read and update access
24-40	empty
41	(40 + LOC) domain description for relation CITY
42	" " " " COUNTY
43	" " " " SITE

column	description
1	valid domain numbers
2	1 is numeric and 0 is character data
3	domain size (length)

Function name: VERIFYACCESS Group name: DBGROUP
Input: left argument, RELNAME, containing a valid relation name and library number.
right argument, TYPE, containing access type. See RPPMDED structure for discussion of access types.
Output: an explicit result, Z, which is zero if access is not approved. If access is approved, Z contains a positive integer used to locate data regarding the open relation in the RPPMDED.
Global vars used: none
Global vars created: none

Local vars:

RELNAME	input as described above	
TYPE	input	" "
Z	output	" "
AM	the relation access matrix (not to be confused with the APL access matrix) for the specified relation.	
ACCESS	a matrix containing all possible access types, one per row.	
LOC	the ordinal location of data in the RPPMDED for a particular relation.	
NAMES	a matrix of tied file names.	

Subroutines: none
Calling routines: OPEN GET

Line	Coding comments
1	assign result to indicate no access.
2	determine position of relation name, which will later be used to locate data in the RPPMDED
3	read RPPMDED access matrix for the specified relation
4-7	if requested access not approved, print message and end.
8,11,12	if the specified relation is not available for use, print message and end, else
13	return an ordinal position (indicating access verified) as described in 2 above.
9,10	if these lines are executed the data in the components read in line 8 are not ones and zeros. 0 indicates unavailability of relation 1 indicates availability "

```
    ∇ OPEN RELNAME;TIES
[1]   ERROR←1
[2]   →(1=+/(⎕FLIB 310733401)∧.=' 310733401 RPPMDED    ')/ΔL10
[3]   'NO, ACCESS NOT APPROVED'
[4]   →0
[5]  ΔL10:→(0=+/ 99 100 ∈TIES←⎕FNUMS)/ΔL20
[6]   'NO, IMPROPER USE OF TIE NUMBER 99, 100 OR A RELATION IS ALREADY OPEN'
[7]   →0
[8]  ΔL20:'310733401 RPPMDED' ⎕FSTIE 99 924266585
[9]   →(0=EDITRELNAME)/ΔL25
[10]  →(0<RELNAME VERIFYACCESS 0)/ΔL30
[11] ΔL25:⎕FUNTIE 99
[12]  →0
[13] ΔL30:RELNAME ⎕FSTIE 100,924266585
[14]  RELATION←RELNAME
[15]  ERROR←0
    ∇


     ∇ CLOSE
[1]   →(2=+/ 99 100 ∈⎕FNUMS)/ΔL10
[2]   'NO RELATION OPEN'
[3]   →0
[4]  ΔL10:⎕FUNTIE 99 100
    ∇


    ∇ Z←EDITRELNAME
[1]  ⍝RETURNS 1 IF RELNAME IS A VALID RELATION NAME
[2]  ⍝        0 IF INVALID
[3]   RELNAME←22↑' 310733401 ',11↑RELNAME,11⍴' '
[4]   →(1=Z←+/(⎕FREAD 99 1 924266585)∧.=RELNAME[11+⍳11])/0
[5]   'NOT A VALID RELATION NAME'
    ∇
```

```
      ∇GET[□]∇

    ∇ Z←ARG1 GET ARG2;D;DX;ID;L;LOC
[1]   Z←0 0 ⍴' '
[2]   ERROR←1
[3]   →(0≥LOC←RELATION VERIFYACCESS 0)/0
[4]  ΔL5:→(0<⍴⍴ARG1)/ΔL10
[5]   ARG1←1⍴ARG1
[6]  ΔL10:DX←□FREAD 99,(40+LOC),924266585
[7]   →((⍴ARG1)=+/ARG1∈DX[;1])/ΔL20
[8]   'INVALID DOMAIN IN LEFT ARGUMENT'
[9]   →0
[10] ΔL20:→((4=⍴ARG2)∧(ARG2[2]∈ 0 4 5 6 7 8))/ΔL30
[11]  'INVALID RIGHT ARGUMENT'
[12]  →0
[13] ΔL30:→(DX[ARG2[1];2]>0)/ΔL40
[14]  'INVALID QUALIFYING DOMAIN'
[15]  →0
[16] ΔL40:ERROR←0
[17]  D←⍉,(((⍴D)[1],1)⍴' '),D←□FREAD 100,ARG2[1],924266585
[18]  L←(D≥ARG2[3])∧(D≤ARG2[4])
[19]  →(1>+/L)/0
[20]  →(0=ARG2[2])/ΔL55
[21]  ID←⍉,(((⍴ID)[1],1)⍴' '),ID←□FREAD 100,1,924266585
[22]  L←L∧((ID>ARG2[2]×1000)∧(ID<1000+ARG2[2]×1000))
[23] ΔL55:Z←((+/L),0)⍴' '
[24] ΔL60:Z←Z,(L/□FREAD 100,(1+ARG1),924266585),(+/L)⍴','
[25]  ARG1←1↓ARG1
[26]  →(1≤⍴ARG1)/ΔL60
[27]  Z←Z[;⍳(⍴Z)[2]-1]
    ∇
```

```
      ∇VERIFYACCESS[□]∇

    ∇ Z←RELNAME VERIFYACCESS TYPE;AM;ACCESS;LOC;NAMES
[1]   Z←0
[2]   LOC←(NAMES∧.=RELNAME[11+⍳11])/⍳(⍴NAMES←□FREAD 99,1,924266585)[1]
[3]   AM←□FREAD 99,(20+LOC),924266585
[4]   →(TYPE≤AM[(AM[;1]=□AI[1])/⍳(⍴AM)[1];2])/ΔL20
[5]   ACCESS← 2 6 ⍴'READ  UPDATE'
[6]   'NO, ',ACCESS[TYPE+1;],' ACCESS NOT APPROVED'
[7]   →0
[8]  ΔL20:→(0 1 =(□FREAD 99,2,924266585)[LOC])/ΔL30,ΔL40
[9]   '*****SYSTEM ERROR AT ΔL20 IN FUNCTION VERIFYACCESS,',□AV[
      157],'     NOTIFY DATABASE ADMINISTRATOR'
[10]  →0
[11] ΔL30:'RELATION UNAVAILABLE, TRY AGAIN LATER'
[12]  →0
[13] ΔL40:Z←LOC
    ∇
```

Group name: ENPGROUP
Ws name: 310733401 PJLIB

This group of routines is used to estimate the electric and nonelectric potential of geothermal sites. Output produced by this group is used as input to the SCENARIO GROUP.

The two user functions are EP (electric potential), which processes data for sites with a temperature greater than 150 degrees celsius, and NP (non-electric potential), which processes data for sites with a temperature less than 150 degrees celsius.

)FNS EP NP EDITΔENP FORMATΔEP FORMATΔNP MWPESS MWOPT

)VARS (none)

Refer to instructions from DR. RAO for program specifications.

Function name: EP
Group name: ENPGROUP
Input: requires a right argument ,X, which is a character matrix of at least one row and 36 columns.

columns	field name
1-4	site id
5	filler
6-25	site name
26	filler
27-32	reservoir volume in cubic kilometers
33	filler
34-36	temperature in degrees celsius

Output: produces an explicit result in character matrix form which may be assigned to a variable name. This result is a table containing site id, site name, temperature, reservoir volume, megawatt equivalent (MWE) for 30 years, MWE pessimistic estimate, MWE optimistic estimate. The optimistic and pessimistic estimate for MWE are used as input to functions in the SCENARIO GROUP.

For information reguarding source formulas, refer to program specifications from Dr. Rao.

Global variables used: none
Global variables created: none

Local variables:

X	input as described above
Z	output as described above
SID	site id
SNAME	site name
T	temperature in degrees celsius
RV	reservoir volume- if not known,use default value of 2.25 cubic kilometers.
ER	recovery factor.
ERI	recovery factor index
Q	calories
MWE100	megawatt centuries
MW30	megawatts for 30 years
S	number of sites in input
MWO	megawatt estimate optimistic
MWP	megawatt estimate pessimistic

Subroutines:

EDITAENP	edits input
FORMATAEP	formats output
MWOPT	calculates optimistic MWE estimate
MWPESS	calculates pessimistic MWE estimate

Calling roucines: none

Function name: NP
Group name: ENPGROUP

Input: requires a right argument,X, which is a character matrix of at least one row and 36 columns.

Columns	Field name
1-4	site ID
5	filler
6-25	site name
26	filler
27-32	reservoir volume in cu km
33	filler
34-36	temperature, deg C

Output: produces an explicit result in character matrix form which may be assigned to a variable name. This result is a table containing site ID, site name, temperature, reservoir volume and megawatt equivalent for 30 yrs.

Local vars

X	input as described above
Z	output " "
SID	site ID
SNAME	site name
T	temp in deg C
RV	reservoir vol
Q	thermal potential
MWTH30	megawatt thermal potential for 30 yrs
S	number of sites in input

Subroutines: EDIT∆ENP edits input
FORMAT∆NP formats output

Calling routines: none
Global vars: none

Function name: EDIT∆ENP Group name: ENPGROUP
This function edits the input to the EP and NP routines; however, no error checking is performed.

Input: requires a right argument, X. Refer to input description for functions EP and NP.
Output: none
Global vars used: none
Global vars created:

SID	site ID
SNAME	site name
RV	reservoir volume
T	temperature

Subroutines: none
Calling routines: EP, NP

Function name: MWOPT Group name: ENPGROUP
This function calculates the optimistic megawatt equivalent estimate.

Input: requires a right argument, MW30, which is a numeric vector of megawatt equivalent for 30 years estimated. It contains one element for each site being processed.
Output: an explicit result in numeric vector form, containing an optimistic estimate of megawatt equivalent for each MW30 value input.

Global vars used or created: none
Local vars: none
Subroutines: none
Calling routines: EP
Coding comments: Line 1. Each element of MW30≠0 is reassigned the value -1 so that when adjusted to the next highest 30MW those values will remain zero.

Function name: FORMATAEP Group name: ENPGROUP
This function formats the output of the EP function.

Input requires a right argument, X, a numeric matrix of at least one row and 5 columns.

Column	Description
1	T temperature
2	RV, reservoir vol
3	MW30, megawatt estimate for 30 yrs
4	MWO, optimistic MW estimate
5	MWP, pessimistic MW estimate

Output: an explicit result in character matrix form containing site ID , site name, temp, reservoir vol, MW30, MWO, MWP.

Global vars used: SID site ID
SNAME site name
Global vars created: none
Local vars: none
Subroutines: none
Calling routines: EP

Function Name: FORMAT∆NP

Group Name: ENPGROUP

Function Description: This function formats the output of the NP function.

Input: Requires a right argument, X, a numeric matrix of at least one row and 3 columns.

column	description
1	T (temperature)
2	RV (reservior volume)
3	MWTH30 (megawatt thermal potential for 30 years)

Output: An explicit result in character matrix form containing site id, site name, temperature, reservoir volume, and MW thermal potential estimates for 30 years.

Function Name: FORMAT∆NP

Group Name: Endgroup

Global Variables Created: none

Local Variables: none

Subroutines: none

Calling Routines: NP

Function name: MWPESS Group name: ENPGROUP
This function calculates the pessimistic megawatt equivalent estimate.
Input: requires a right argument, MW30, which is a numeric vector of megawatt equivalent for 30 yrs estimates. It contains one element for each site being processed.
Output: an explicit result in numeric vector form containing an optimistic estimate of megawatt equivalent for each MW30 value input.
Global vars used or created: none
Local vars: MWP an intermediate result
Subroutines: none
Calling routines: EP
Coding comments.

Line 2	each element of MWP≠0 is reassigned the value -1 so that when adjusted to the next highest 50 MW, those values will remain zero.
Line 3	same as line 2, but for those sites with temperatures less than 200 deg C.

```
)GRP ENP∆GROUP
EP      NP      EDIT∆ENP        FORMAT∆EP       FORMAT∆NP       MWPESS  MWOPT

      ∇EP[⎕]∇
    ∇ Z←EP X;SID;SNAME;T;RV;ER;ERI;Q;MW100;MW30;S;MWO;MWP
[1]   EDIT∆ENP X
[2]   ER← 0.03 0.025 0.02
[3]   ERI←(T≤200)+(T≤300)+T≤300
[4]   Q←0.6×RV×T-15
[5]   MW100←(Q×ER[ERI])÷0.753
[6]   MW30←MW100÷0.3
[7]   MWO←MWOPT MW30
[8]   MWP←MWPESS MWO
[9]   X←(S⍴T),(S⍴RV),(S⍴MW30),(S⍴MWO),((S←(⍴T),1)⍴MWP)
[10]  Z←FORMAT∆EP X
    ∇

      ∇NP[⎕]∇
    ∇ Z←NP X;SID;SNAMES;T;RV;Q;MWTH30;S
[1]   EDIT∆ENP X
[2]   Q←0.06×RV×T-15
[3]   MWTH30←(Q×0.25×0.24×1327÷100)÷0.3
[4]   X←(S⍴T),(S⍴RV),((S←(⍴T),1)⍴MWTH30)
[5]   Z←FORMAT∆NP X
    ∇

      ∇EDIT∆ENP[⎕]∇
    ∇ EDIT∆ENP X
[1]   SID←X[;⍳4] ⋄ SNAME←X[;5+⍳20]
[2]   RV←⍬,X[;26+⍳6],((⍴X)[1],1)⍴' '
[3]   T←⍬,X[;33+⍳3],((⍴X)[1],1)⍴' '
    ∇
```

```
      ∇FORMAT∆EP[□]∇
    ∇ Z←FORMAT∆EP X
[1]   Z← 1 61 ρ'SITE',(30ρ' '),'RSVR      MWE       MWE  MWE '
 2]   Z←Z,[1] 1 61 ρ'ID     SITE NAME',(13ρ' '),'TEMP  VOLUME   30 YRS   OPT  PESS'
[3]   Z←Z,[1] 1 61 ρ' '
[4]   X←'I5,2F9.2,2I6' □FMT X
[5]   X←('4A1,X2,20A1' □FMT SID,SNAME),X
[6]   Z←Z,[1] X
    ∇


      ∇FORMAT∆NP[□]∇
    ∇ Z←FORMAT∆NP X
[1]   Z← 1 48 ρ'SITE',(29ρ' '),'RSVR      MWE    '
[2]   Z←Z,[1] 1 48 ρ'ID     SITE NAME',(12ρ' '),'TEMP  VOLUME   30 YRS'
[3]   Z←Z,[1] 1 48 ρ' '
[4]   X←'I4,2F9.2' □FMT X
[5]   X←('4A1,X2,20A1' □FMT SID,SNAME),X
[6]   Z←Z,[1] X
    ∇


      ∇MWOPT[□]∇
    ∇ Z←MWOPT MW30
[1]   MW30[(MW30≤0)/ι ρMW30]←¯0.1
[2]   Z←50×1+⌊MW30÷50
    ∇


      ∇MWPESS[□]∇
    ∇ Z←MWPESS MWO ; MWP
[1]   MWP←¯117.762+1.01×MWO
[2]   MWP[(MWP≤0)/ι ρMWP]←¯0.1
[3]   MWP[(T< 200)/ι ρT]←¯0.1
[4]   Z←50×1+⌊MWP÷50
    ∇
```

Sample Input to EP Function

```
4001,POWER RANCH AREAS    ,  2.50,184
4002,CLIFTON HOT SPRINGS  ,  2.25,160
4003,VERDE HOT SPRINGS    ,  2.25,150
5020,COTTONWOOD CREEK JUM,  1.09,170
5021,CHALK CR MT PRINCETN,  2.48,200
5022,CHALK CREEK WRIGHT H,  2.25,170
5023,CHALK CREEK HORTENSE,  2.25,170
5024,CHALK CREEK WOOLMING,  2.25,170
6001,BEOWAWE H S          , 42.00,240
6002,BRADY HOT SP         , 30.00,214
6003,STEAMBOAT SP         , 16.00,210
6004,SAN EMIDIO           ,  2.25,200
6005,SULPHUR HS           , 10.00,190
6006,KYLE H S             ,  2.25,190
6007,JERSEY VALLEY HS     ,  2.25,185
6008,HOT SULPHUR SP       ,  2.25,180
6009,HOT SP NEAR WELLS    ,  2.25,180
6010,HOT SP RANCH         ,  2.25,180
6011,LEE H S              ,  2.25,175
6012,PINTO H S            ,  7.50,175
6013,GREAT BOILING H S    , 25.00,170
6014,LEACH HS             , 10.00,170
6015,FERNLEY HS           ,  2.25,170
6016,BALTAZOR HS          ,  3.00,170
6017,SODA LAKE            , 12.50,165
6018,STILLWATER           , 25.00,165
6019,SMITH CREEK VALLEY   ,  2.25,160
6020,WABUSKA HS           ,  2.25,155
6021,NEEDLE ROCKS         ,  3.00,150
6022,BLACK ROCK DESERT    ,  2.25,150
6023,DIXIE VALLEY HS      ,  3.00,150
7001,VALLES CALDERA       ,130.00,240
7002,LIGHTNING DOCK       ,  2.25,170
7003,LWR SAN FRANCISCO HS,  2.25,150
7004,KILBOURNE HOLE       ,  2.25,155
8001,ROOSEVELT HS         ,  8.00,250
8002,COVE FORT-SULPHURDAL, 22.50,200
8003,THERMO HS            ,  2.25,185
```

Sample Output of EP Function

SITE ID	SITE NAME	TEMP	RSVR VOLUME	MWE 30 YRS	MWE OPT	MWE PESS
4001	POWER RANCH AREAS	184	2.50	22.44	50	0
4002	CLIFTON HOT SPRINGS	160	2.25	17.33	50	0
4003	VERDE HOT SPRINGS	150	2.25	16.14	50	0
5020	COTTONWOOD CREEK JUM	170	1.09	8.97	50	0
5021	CHALK CR MT PRINCETN	200	2.48	24.37	50	0
5022	CHALK CREEK WRIGHT H	170	2.25	18.53	50	0
5023	CHALK CREEK HORTENSE	170	2.25	18.53	50	0
5024	CHALK CREEK WOOLMING	170	2.25	18.53	50	0
6001	BEOWAWE H S	240	42.00	627.49	650	550
6002	BRADY HOT SP	214	30.00	396.41	400	300
6003	STEAMBOAT SP	210	16.00	207.17	250	150
6004	SAN EMIDIO	200	2.25	22.11	50	0
6005	SULPHUR HS	190	10.00	92.96	100	0
6006	KYLE H S	190	2.25	20.92	50	0
6007	JERSEY VALLEY HS	185	2.25	20.32	50	0
6008	HOT SULPHUR SP	180	2.25	19.72	50	0
6009	HOT SP NEAR WELLS	180	2.25	19.72	50	0
6010	HOT SP RANCH	180	2.25	19.72	50	0
6011	LEE H S	175	2.25	19.12	50	0
6012	PINTO H S	175	7.50	63.75	100	0
6013	GREAT BOILING H S	170	25.00	205.84	250	0
6014	LEACH HS	170	10.00	82.34	100	0
6015	FERNLEY HS	170	2.25	18.53	50	0
6016	BALTAZOR HS	170	3.00	24.70	50	0
6017	SODA LAKE	165	12.50	99.60	100	0
6018	STILLWATER	165	25.00	199.20	200	0
6019	SMITH CREEK VALLEY	160	2.25	17.33	50	0
6020	WABUSKA HS	155	2.25	16.73	50	0
6021	NEEDLE ROCKS	150	3.00	21.51	50	0
6022	BLACK ROCK DESERT	150	2.25	16.14	50	0
6023	DIXIE VALLEY HS	150	3.00	21.51	50	0
7001	VALLES CALDERA	240	130.00	1942.23	1950	1900
7002	LIGHTNING DOCK	170	2.25	18.53	50	0
7003	LWR SAN FRANCISCO HS	150	2.25	16.14	50	0
7004	KILBOURNE HOLE	155	2.25	16.73	50	0
8001	ROOSEVELT HS	250	8.00	124.83	150	50
8002	COVE FORT-SULPHURDAL	200	22.50	221.12	250	150
8003	THERMO HS	185	2.25	20.32	50	0

Group Name: SCENARIOGROUP

WS Name: 310733401 PJLIB

Group Description: This group of routines provides a graphical representation of megawatts on line for each year, 1982 through 2021, for a single site or for a group of sites. The user functions are SCENARIO, which accepts only a single site as input, and AGGREGATE, which processes a group of sites. All 5 states are required. AGGREGATE also calculates annual totals of megawatts on line for each state included in input and a grand total.

Functions Used: AGGREGATE, GRAPH, READSITE, SCENARIO, STANAMES, SITETIMELINE, SPREAD, SCENARIOHEADER, FORMAT.

Variables Used: none

Function Name: AGGREGATE

Input: Requires a left argument, TYPE, containing either the characters 'OPTIMISTIC' or 'PESSIMISTIC'. It also requires a right argument, X, which is a character matrix of at least two rows, and 33 columns. Refer to documentation for function READSITE in this group for input description. Input must be sorted by state, though it needn't be in ascending or descending order; input must also contain sites in more than one state.

Output: Produces a character matrix containing a report of processing which is appended to an APL file tied with the tie number 1. This file should contain at least 75,000 bytes for an input data set containing 40 sites. Each page of the report contains 135 columns and a maximum of 51 lines. and is appended as a separate component of the file. When the printed report is reduced to 74% of original size, it is suitable for 8 1/2 by 11 inch paper.

Global Variables Used: none

Global Variables Created: none

Local Variables:

TYPE	Input as described above.
X	Input as described above.
Z	Output as described above.
STAT	State annual total of megawatts on line (MWOL) as a 40 element vector.
STT	State total MWOL as a scalar.
RAT	Region annual total MWOL as a 40 element vector.

RT	Region total as a scalar.
STTS	State totals MWOL as a 5 element vector, one for each state.
SAT	Site annual total MWOL as a 40 element vector.
SID	Site ID currently being processed.
OLDSID	Last site ID processed.
LINE	Last line on current page of output.
MW	Megawatt equivalent estimate for current site.
START	
SNAME	

Subroutines: FORMAT, READSITE, SITETIMELINE

Calling Routines: none

Special Coding:

line	coding comments
1-6	Initialization
7	Read site data.
8	Process site data.
9-10	Accummulate totals.
11	Read next site data.
12	If next site is in same state as last site repeat 8-11, else
13	Format state totals.
14-17	Accumulate region totals, and reinitialize state totals.
18	If last site has been processed, begin final formatting operations, else
19	If the current page of output contains only the header, do not print the next state name, as it has already been printed, but repeat 8-18.
20	Print next state name.

line	coding comments
21	Repeat 8-18.
22-24	Begin final format operations.
25	Append final page.
26	Indicate to user normal termination of execution.

Function Name: SCENARIO

Global Variable Used: none

Global Variables Created: none

Local Variables:

X	Input as described above.
Z	Output as described above.
SID	Site ID
SNAME	Site name
MW	Megawatt equivalent estimate.

Input: Requires a right argument, X, which is a character matrix of exactly one row and 33 columns. Refer to documentation of function READSITE in this group for input descriptions.

Output: An explicit result, Z, which is a character matrix containing a report of processing.

Subroutines: SITETIMELINE

Calling Routines: none

Function Name: GRAPH

Global Variables Used: none

Global Variables Created: none

Local Variables:

N	Input as described below.
M	Input as described below.
Z	Output as described below.

W	Contains the number of rows in the output to which a row in the input is to be expanded.
X	The number of rows in the input.
Y	index

Input: A right argument, X, which is a matrix of ones and zeros, having at least one row, and 40 columns. Each column represents a year between 1982 and 2021. Each row represents a 50 megawatt geothermal plant; each 1 in a row indicates a year in which that plant is generating electricity, a zero, a year in which it is not. A left argument, N, which is a single character. This character will replace each one in the matrix, X, while a blank will replace each zero.

Output: An explicit result, Z, containing a graphical representation of megawatts on line and where during the 40 year period, 1982-2021. The output is a character matrix of any number of rows and 100 columns.

Subroutines: none

Calling Routines: SITETIMELINE

Function Name: READSITE

Global Variables Used: SID, OLDSID

Global Variables Created: SNAME, MW, START

Local Variables: none

Input: No arguments.

Output: No explicit result, or printed output. The function operates on a global variable, X, a matrix of at least two rows, and 33 columns.

column	description
1-4	SID (site ID)
5	filler
6-25	SNAME (site name)
26	filler
27-30	MW (megawatt equivalent estimate)
31	filler
32-33	START (starting date; if no date available, default is 0)

Subroutines: none

Calling Routines: AGGREGATE

Function Name: STANAMES

Global Variables Used: none

Global Variables Created: none

Local Variables:

CODES	input as described below
Z	output as described below

Input: A right argument, CODES, a character matrix of at least one row, and exactly 1 column. Each element of codes must be one of the characters 4, 5, 6, 7, 8. No error checking is performed.

Output: An explicit result, Z, in character matrix form, of at least one row and exactly 10 columns with as many rows as the input. Each row contains an underscored name of a state in the Southwest Region corresponding to the appropriate state code in the input.

Subroutines: none

Calling routines: AGGREGATE, SCENARIOHEADER

Function Name: SITETIMELINE

Global Variables Used: SNAME

Global Variables Created: SAT (site annual total)

Local Variables:

Z1	A matrix of ones and zeros; refer to input description of the right argument of the function GRAPH in this group.
MW	Input as described below.
Z	Output as described below.
Y	Graphical representation of megawatts on line; refer to output description of function GRAPH in this group.

Subroutines: SPREAD, GRAPH

Calling Routines: SCENARIO, AGGREGATE

Input: A right argument, MW, a scalar estimate of megawatt equivalent.

Output: An explicit result, Z, in character matrix form, which includes site name, a graphic representation of megawatts on line during the 40 year period 1982 through 2021, and an annual total of megawatts on line.

Special Coding:

line	coding comments
2	Site annual total is assigned the value of the odd subscripts of Z1 summed through the columns (the odd subscripts represent the even numbered years from 1982 through 2021).
3-4	Formal site name and graph.
5	If MW is less than or equal to 0, there is no need to print a site annual total line, so, end, else.
6	Formal site annual total.

Function Name: SPREAD

Global Variables used: START

Global Variables Created: none

Local Variables:

MWE	Input as described below.
Z	Output as described below.
PLN	No. of 50 megawatt plants needed, given input.
PLNY	No. of 50 MW plants needed per year.
DELAY	No. of years from 1982 until a plants begins production.
APL	Actual plants producing.
APLY	Actual plants producing during the current year.
SCHED	A vector indicating delay between plants, after the first begins producing.

Input: A right argument, MWE, a scalar to estimate megawatt equivalent.

Output: An explicit result, Z, a matrix of ones and zeros representing megawatts on line. Refer to input description for function GRAPH in this group.

Subroutines: none

Calling Routines: SITETIMELINE

Special Coding:

line	coding comments
1	Megawatt equivalent divided by 30 megawatts is number of plants needed.
2	If start date not specified, generate
3	A random number and calculate a start date.
8	If plants needed is less than 1, end.
12	If actual plants equal plants needed or if the delay is greater than 40 years (in which case it won't appear in output), end; else
13	If actual plants for the current year is less than plants needed for the current year, add another, else
15	Increase the delay, and add another plant.

Function Name: SCENARIOHEADER

Global Variabls used: SID, TYPE

Global Variables Created: none

Local Variables: Z (output as described below)

Input: none

Output: An explicit result, Z, a matrix of 8 rows, 135 columns containing the report header.

Subroutines: STANAMES

Calling Routines: AGGREGATE, FORMAT

Function Name: FORMAT

Global Variables used:

LINE	Last line on current page.
Z	Current page.
SID	
OLDSID	

Global Variables Created: none

Local Variables: none

Input: A right argument, X, a character matrix of at least one row and exactly 135 columns. The matrix may contain any portion of the output report.

Output: Adds the input to the current page unless the page will the have more than 50 lines. In this case, the current page is appended. A new page complete with header, is begun and the input is added to the new current page.

Subroutines: SCENARIOHEADER

Calling Routines: AGGREGATE

Special Coding:

line	coding comments
1	If adding input to current page would push the current page over 50 lines, fall through.
2	Append current page.
3	If last site has been processed, prepare report header for final summary, else,
4	Replace current page with header.
6	If next site is not in same state, don't add CONT'D to header.
12	Add input to current page.

```
      ∇AGGREGATE[⎕]∇

    ∇ TYPE AGGREGATE X;STAT;STT;RAT;RT;STTS;SID;OLDSID;LINE;Z;MW;SNAME
      ;SAT;START
[1]   STAT←STT←RT←0
[2]   STTS←⍳0
[3]   RAT← 0 20 ⍴0 ⍝ SID←X[1;⍳4]
[4]   LINE←0
[5]   Z← 0 135 ⍴' ' ⍝ OLDSID←'0000'
[6]   FORMAT SCENARIOHEADER
[7]   READSITE
[8]  ΔL10:FORMAT SITETIMELINE MW
[9]   STT←STT+MW
[10]  STAT←STAT+SAT
[11]  READSITE
[12]  →((1↑OLDSID)=1↑SID)/ΔL10
[13]  FORMAT 4 135 ⍴(35⍴' '),(100⍴'_'),(8⍴' '),'STATE TOTALS',(
      8 0 ▼STT),(6⍴' '),(5 0 ▼STAT),' ',(135⍴'_'),135⍴' '
[14]  RT←RT+STT
[15]  RAT←RAT,[1] STAT
[16]  STTS←STTS,STT
[17]  STAT←STT←0
[18]  →(4=+/SID='0000')/ΔL20
[19]  →((⍴Z)[1]≤8)\ΔL10
[20]  FORMAT 3 135 ⍴(135⍴' '),(STΔNAMES 1 1 ⍴1↑SID),135⍴' '
[21]  →ΔL10
[22] ΔL20:FORMAT((51-LINE),135)⍴' '
[23]  FORMAT(10⍴ 1 0)\(STΔNAMES 5 1 ⍴'45678'),(18 0 ▼ 5 1 ⍴STTS),(
      5 7 ⍴' '), 5 0 ▼RAT
[24]  FORMAT 2 135 ⍴(35⍴' '),(100⍴'_'),(7⍴' '),'REGION TOTALS',(
      8 0 ▼RT),(6⍴' '),(5 0 ▼+/RAT)
[25]  Z ⎕FAPPEND 1
[26]  'DONE'
    ∇
```

Sample Input to AGGREGATE Function

```
4001,POWER RANCH AREAS    ,  50, 0
4002,CLIFTON HOT SPRINGS  ,  50, 0
4003,VERDE HOT SPRINGS    ,  50, 0
5020,COTTONWOOD CREEK JUM,   50, 0
5021,CHALK CR MT PRINCETN,   50, 0
5022,CHALK CREEK WRIGHT H,   50, 0
5023,CHALK CREEK HORTENSE,   50, 0
5024,CHALK CREEK WOOLMING,   50, 0
6001,BEOWAWE H S          , 650,84
6002,BRADY HOT SP         , 400,82
6003,STEAMBOAT SP         , 250, 0
6004,SAN EMIDIO           ,  50, 0
6005,SULPHUR HS           , 100, 0
6006,KYLE H S             ,  50, 0
6007,JERSEY VALLEY HS     ,  50, 0
6008,HOT SULPHUR SP       ,  50, 0
6009,HOT SP NEAR WELLS    ,  50, 0
6010,HOT SP RANCH         ,  50, 0
6011,LEE H S              ,  50, 0
6012,PINTO H S            , 100, 0
6013,GREAT BOILING H S    , 250, 0
6014,LEACH HS             , 100, 0
6015,FERNLEY HS           ,  50, 0
6016,BALTAZOR HS          ,  50, 0
6017,SODA LAKE            , 100, 0
6018,STILLWATER           , 200, 0
6019,SMITH CREEK VALLEY   ,  50, 0
6020,WABUSKA HS           ,  50, 0
6021,NEEDLE ROCKS         ,  50, 0
6022,BLACK ROCK DESERT    ,  50, 0
6023,DIXIE VALLEY HS      ,  50, 0
7001,VALLES CALDERA       ,1950,82
7002,LIGHTNING DOCK       ,  50, 0
7003,LWR SAN FRANCISCO HS,   50, 0
7004,KILBOURNE HOLE       ,  50, 0
8001,ROOSEVELT HS         , 150,82
8002,COVE FORT-SULPHURDAL,   250, 0
8003,THERMO HS            ,  50, 0
```

```
      ∇SCENARIO[□]∇

    ∇ Z←SCENARIO X;SID;SNAME;MW
[1]   SID←X[⍳4] ⋄ SNAME←X[5+⍳20] ⋄ MW←⍎X[26+⍳4]
[2]   Z←SCENARIOHEADER
[3]   Z←Z,[1] SITETIMELINE MW
      ∇

      ∇GRAPH[□]∇

    ∇ Z←N GRAPH M;W;X;Y
[1]   Z←(0,X←(⍴M)[1])⍴' ' ⋄ Y←1
[2]  ΔL10:W← 3 2[1+Y=2×⌊Y÷2]
[3]   Z←Z,[1](W,X)⍴M[;Y]
[4]   Y←Y+1
[5]   →(Y≤(⍴M)[2])/ΔL10
[6]   Z←(' ',N)[1+1=⊖Z]
      ∇


      ∇READSITE[□]∇

    ∇ READSITE
[1]   →((⍴X)[1]>0)/ΔL10
[2]   SID←'0000'
[3]   →0
[4]  ΔL10:OLDSID←SID ⋄ SID←X[1;⍳4]
[5]   SNAME←X[1;5+⍳20] ⋄ MW←⍎X[1;26+⍳4]
[6]   START←⍎X[1; 32 33]
[7]   X←(0,((⍴X)[1]-1)⍴1)⌿X
      ∇


      ∇STΔNAMES[□]∇

    ∇ Z←STΔNAMES CODES
[1]   Z← 8 10 ⍴(30⍴' '),'ARIZONA   COLORADO  NEVADA    NEW MEXICOUTAH
                                                        '
[2]   Z←Z[(⍋,(((⍴CODES)[1],1)⍴' '),CODES);]
      ∇
```

```
    ∇ FORMAT X
[1]   →((ρX)[1]≤51-LINE)/ΔL10
[2]   Z □FAPPEND 1
[3]   →(4=+/SID='0000')/ΔL5
[4]   Z←SCENARIOHEADER
[5]   LINE←(ρZ)[1]
[6]   →((1↑OLDSID)≠1↑SID)/ΔL10
[7]   Z[7;12+⍳8]←'(CONT''D)'
[8]   →ΔL10
[9]  ΔL5:Z←Z[⍳6;]
[10]  Z[4;5+⍳9]←' '
[11]  LINE←6
[12] ΔL10:Z←Z,[1] X
[13]  LINE←LINE+(ρX)[1]
    ∇
```

```
    ∇ Z←SPREAD MWE;PLN;PLNY;DELAY;APL;APLY;SCHED
[1]   PLN←MWE÷50
[2]   →(START≠0)/ΔL5
[3]   START←83+?4
[4]  ΔL5:DELAY←START-82
[5]   PLNY←⌈PLN÷40-DELAY
[6]   Z← 0 40 ρ0
[7]   SCHED← 3 4 ,27ρ3
[8]   →(PLN<1)/0
[9]   APL←APLY←0
[10] ΔL10:Z←Z,[1] 1 40 ρ(DELAYρ0),(30ρ1),10ρ0
[11]  APL←APL+1 ⋆ APLY←APLY+1
[12]  →((APL=PLN)∨(DELAY≥40))/0
[13]  →(APLY<PLNY)/ΔL10
[14]  APLY←0
[15]  DELAY←DELAY+1↑SCHED←1⌽SCHED
[16]  →ΔL10
    ∇
```

```
    ∇ Z←SITETIMELINE MW;Z1;Y
[1]   Z1←SPREAD MW
[2]   SAT←50×(+⌿Z1)[(2×⍳20)-1]
[3]   Z←(((⍴Y)[1],35)⍴SNAME,(8 0 ⍕MW),((⍴Y)[1]×35)⍴' '),Y←'>' GRAPH Z1
[4]   Z←Z,[1] 1 135 ⍴' '
[5]   →(MW≤50)/0
[6]   Z←Z,[1] 3 135 ⍴'   SITE ANNUAL TOTAL',(14⍴' '),(, 5 0 ⍕ 20 1 ⍴SAT),270⍴' '
    ∇
```

```
    ∇ Z←SCENARIOHEADER
[1]   Z← 2 135 ⍴(50⍴' '),'POWER ON LINE ESTIMATE (',TYPE,')',195⍴' '
[2]   Z←Z,[1] 1 135 ⍴(24⍴' '),'TOTAL',(135⍴' ')
[3]   Z←Z,[1] 1 135 ⍴'STATE AND SITE',(11⍴' '),'MW',(8⍴' '),(100↑⍕1980+2×⍳20)
[4]   Z←Z,[1] 2 135 ⍴(135⍴'_'),135⍴' '
[5]   Z←Z,[1] 2 135 ⍴(STΔNAMES 1 1 ⍴1↑SID),270⍴' '
    ∇
```

The five functions: TABLE5,TABLE6,TABLE7,CITYS and COUNTYS are so very similar that they will all be explained here.

Input: A right argument, 'STN', contains the state number on which the searching is to be done in the files to get the desired output. The files that are used for the searching are: SITE,CITY and COUNTY . The first three functions use the SITE file and the fourth function uses the CITY file and the last function uses the COUNTY file.

output: The output is listed out in equivalent portions such that each page has an equivalent number of lines. The output is formatted in columns containing information depending on the function used. TABLE5 gives GEOTHERMAL SITE LOCATIONS. TABLE6 gives GEOTHERMAL SITE TEMPERATURES. TABLE7 gives RESERVOIR VOLUME, THERMAL GRADIENT, DISSOLVED SOLIDS and FLOWRATE. CITYS gives CITY ID, CITY NAME, COUNTY NAME, POPULATION, LATITUDE and LONGITUDE. COUNTYS gives COUNTY ID and COUNTY NAME.

SUBROUTINES USED: ABC, EDITRELNAME, GET, OPEN, STANAMES, VERIFYACCESS.

VARIABLES USED: RELATION

```
    ∇ Z1←TABLE5 STN
[1]   OPEN 'SITE'
[2]   G←(⍳10) GET 1,STN,(1000×STN),((STN+1)×1000)-1
[3]   G←ABC G
[4]   S5←5⍴' ' ⋄ S3←3⍴' ' ⋄ G2←⍴G ⋄ MAX←MAX1←MAX2←MAX3←MAX4←0 ⋄ I←COUNT←1 ⋄ NAME←STANAMES 1 1 ⍴(⍬,STN)
[5]   →((G2[1]>50)∧(G2[1]≤100))/CK1
[6]   →((G2[1]>100)∧(G2[1]≤150))/CK2
[7]   →((G2[1]>150)∧(G2[1]≤200))/CK3
[8]   MAX←G2[1]
[9]  AL1:Z1← 1 70 ⍴((3⍴' '),NAME,(10⍴' '))
[10]  Z1←Z1,[1] 1 70 ⍴((5⍴' '),'TOWN',(11⍴' '))
[11]  Z1←Z1,[1] 1 70 ⍴(' ID',(4⍴' '),'SITE NAME',(13⍴' '),'COUNTY',(4⍴' '),'LAT',(4⍴' '),'LONG',(5⍴' '),'SHIP RANGE SEC ')
[12] CONT:A1←G[I;1 4] ⋄ A2←G[I;5+⍳20] ⋄ A3←G[I;26+⍳3] ⋄ A4←G[I; 31 32] ⋄ A5←G[I; 34 35] ⋄ A6←G[I;36+⍳3]
[13]  A7←G[I; 41 42] ⋄ A8←G[I;43+⍳4] ⋄ A9←G[I;48+⍳4] ⋄ A10←G[I; 54 55]
[14]  Z1←Z1,[1], 1 70 ⍴(A1,' ',A2,S5,A3,S5,A4,' ',A5,'  ',A6,' ',A7,S3,A8,'  ',A9,S3,A10,' ')
[15]  I←I+1 ⋄ →(I≤MAX)/CONT
[16]  Z1←Z1,[1] 2 70 ⍴' '
[17]  Z1←Z1,[1] 1 70 ⍴('TABLE 5.  GEOTHERMAL SITE LOCATIONS.',(34⍴' ')) ⋄ Z1 ⋄ LA←⎕
[18]  →(MAX2=0)/L0 ⋄ →(MAX3=0)/C1 ⋄ →(MAX4=0)/C2 ⋄ →C3
[19] C1:MAX←MAX1←MAX2 ⋄ COUNT←COUNT+1 ⋄ →(COUNT<3)/AL1 ⋄ →L0
[20] C2:MAX←MAX1←MAX2 ⋄ COUNT←COUNT+1 ⋄ →(COUNT<3)/AL1 ⋄ MAX←MAX1←MAX2←MAX3 ⋄ →(COUNT<4)/AL1 ⋄ →L0
[21] C3:MAX←MAX1←MAX2 ⋄ COUNT←COUNT+1 ⋄ →(COUNT<3)/AL1 ⋄ MAX←MAX1←MAX2←MAX3 ⋄ →(COUNT<4)/AL1
[22]  MAX←MAX1←MAX2←MAX3←MAX4 ⋄ →(COUNT<5)/AL1 ⋄ →L0
[23] CK1:MAX←MAX1←(⌈(G2[1]÷2)) ⋄ →(MAX1=(⌊(G2[1]÷2)))/CH1 ⋄ MAX2←MAX1-1 ⋄ →AL1
[24] CH1:MAX2←MAX1 ⋄ →AL1
[25] CK2:MAX←MAX1←(⌈(G2[1]÷3)) ⋄ →(MAX1=(⌊(G2[1]÷3)))/CH2
[26]  →((MAX1-(G2[1]÷3))>0.4)/CH3 ⋄ MAX2←MAX1 ⋄ MAX3←MAX1-1 ⋄ →AL1
[27] CH2:MAX2←MAX3←MAX1 ⋄ →AL1
[28] CH3:MAX2←MAX3←MAX1-1 ⋄ →AL1
[29] CK3:MAX←MAX1←(⌈(G2[1]÷4)) ⋄ →(MAX1=(⌊(G2[1]÷4)))/CH4
[30]  →(((MAX1-(G2[1]÷4))=0.75),((MAX1-(G2[1]÷4))=0.5))/K1,K2 ⋄ MAX2←MAX1 ⋄ MAX3←MAX4←MAX2-1 ⋄ →AL1
[31] K1:MAX4←MAX3←MAX2←MAX1-1 ⋄ →AL1
[32] K2:MAX3←MAX2←MAX1 ⋄ MAX4←MAX1-1 ⋄ →AL1
[33] CH4:MAX4←MAX3←MAX2←MAX1 ⋄ →AL1
[34] L0:⎕FUNTIE 100
    ∇
```

```
    ∇ Z1←TABLE6 STN
[1]   OPEN 'SITE'
[2]   G← 1 2 11 12 13 14 15 16 17 18 GET 1,STN,(1000×STN),((STN+1)×1000)-1
[3]   G←ABC G
[4]   G←G[;(G[1;]≠',')/⍳(⍴G)[2]]
[5]   G2←⍴G ⋄ MAX←MAX1←MAX2←MAX3←MAX4←0 ⋄ I←COUNT←1 ⋄ NAME←ST∆NAMES 1 1 ⍴(⍬,STN)
[6]   →((G2[1]>50)∧(G2[1]≤100))/CK1
[7]   →((G2[1]>100)∧(G2[1]≤150))/CK2
[8]   →((G2[1]>150)∧(G2[1]≤200))/CK3
[9]   MAX←G2[1]
[10] ∆L1:Z1← 1 70 ⍴((30⍴' '),NAME,(10⍴' '))
[11]  Z1←Z1,[1] 1 70 ⍴((27⍴' '),'------TEMPERATURE IN DEGREES CELSIUS--------')
[12]  Z1←Z1,[1] 1 70 ⍴('SITE','    ','SITE NAME',(10⍴' '),'SUBSUR- SOU-    SURFACE SOU-    CS     CS  ')
[13]  Z1←Z1,[1] 1 70 ⍴('ID',(25⍴' '),'FACE    RCE              RCE     EST    MEAS')
[14] CONT:A1← 1 4 ⍴G[I;⍳4] ⋄ A2← 1 20 ⍴G[I;4+⍳20] ⋄ A3← 1 6 ⍴G[I;24+⍳6] ⋄ A4← 1 2 ⍴G[I; 31 32] ⋄ A5← 1 3 ⍴G[I;32+⍳3]
[15]  A6← 1 2 ⍴G[I; 36 37] ⋄ A7← 1 3 ⍴G[I;37+⍳3] ⋄ A8← 1 2 ⍴G[I; 41 42] ⋄ A9← 1 3 ⍴G[I;42+⍳3] ⋄ A0← 1 3 ⍴G[I;45+⍳3]
[16]  Z1←Z1,[1] 1 70 ⍴('4A1,X1,2A1,X2,3A1,X5,2A1,X6,3A1,X5,2A1,X6,3A1,X4,3A1,X1' ⎕FMT(A1;A2;A5;A6;A7;A8;A9;A0))
[17]  I←I+1 ⋄ →(I≤MAX)/CONT
[18]  Z1←Z1,[1] 2 70 ⍴' '
[19]  Z1←Z1,[1] 1 70 ⍴('TABLE 6.  GEOTHERMAL SITE TEMPERATURES.',(30⍴' ')) ⋄ Z1 ⋄ L∆←⎕
[20]  →(MAX2=0)/LO ⋄ →(MAX3=0)/C1 ⋄ →(MAX4=0)/C2 ⋄ →C3
[21] C1:MAX←MAX1+MAX2 ⋄ COUNT←COUNT+1 ⋄ →(COUNT<3)/∆L1 ⋄ →L0
[22] C2:MAX←MAX1+MAX2 ⋄ COUNT←COUNT+1 ⋄ →(COUNT<3)/∆L1 ⋄ MAX←MAX1+MAX2+MAX3 ⋄ →(COUNT<4)/∆L1 ⋄ →L0
[23] C3:MAX←MAX1+MAX2 ⋄ COUNT←COUNT+1 ⋄ →(COUNT<3)/∆L1 ⋄ MAX←MAX1+MAX2+MAX3 ⋄ →(COUNT<4)/∆L1 ⋄ MAX←MAX1+MAX2+MAX3+MAX4
[24]  →(COUNT<5)/∆L1 ⋄ →L0
[25] CK1:MAX←MAX1←(⌈(G2[1]÷2)) ⋄ →(MAX1=(⌊(G2[1]÷2)))/CH1 ⋄ MAX2←MAX1-1 ⋄ →∆L1
[26] CH1:MAX2←MAX1 ⋄ →∆L1
[27] CK2:MAX←MAX1←(⌈(G2[1]÷3)) ⋄ →(MAX1=(⌊(G2[1]÷3)))/CH2
[28]  →((MAX1-(G2[1]÷3))>0.4)/CH3 ⋄ MAX2←MAX1 ⋄ MAX3←MAX1-1 ⋄ →∆L1
[29] CH2:MAX2←MAX3←MAX1 ⋄ →∆L1
[30] CH3:MAX2←MAX3←MAX1-1 ⋄ →∆L1
[31] CK3:MAX←MAX1←(⌈(G2[1]÷4)) ⋄ →(MAX1=(⌊(G2[1]÷4)))/CH4
[32]  →(((MAX1-(G2[1]÷4))=0.75),((MAX1-(G2[1]÷4))=0.5))/K1,K2 ⋄ MAX2←MAX1 ⋄ MAX3←MAX4←MAX2-1 ⋄ →∆L1
[33] K1:MAX4←MAX3←MAX2←MAX1-1 ⋄ →∆L1
[34] K2:MAX3←MAX2←MAX1 ⋄ MAX4←MAX1-1 ⋄ →∆L1
[35] CH4:MAX4←MAX3←MAX2←MAX1 ⋄ →∆L1
[36] L0:⎕WUNTIE 100
    ∇
```

```
    ∇ Z1←TABLE7 STN
[1]   OPEN 'SITE'
[2]   G← 1 2 11 12 19 20 21 22 23 24 GET 1,STN,(1000×STN),((STN+1)×1000)-1
[3]   G←ABC G
[4]   G←G[;(G[1;]≠',')/⍳(⍴G)[2]]
[5]   G2←⍴G ⋄ MAX←MAX1←MAX2←MAX3←MAX4←0 ⋄ I←COUNT←1 ⋄ NAME←STΔNAMES 1 1 ρ(⍬,STN)
[6]   →((G2[1]>50)∧(G2[1]≤100))/CK1
[7]   →((G2[1]>100)∧(G2[1]≤150))/CK2
[8]   →((G2[1]>150)∧(G2[1]≤200))/CK3
[9]   MAX←G2[1]
[10] ΔL1:Z1← 1 70 ρ((30ρ' '),NAME,(10ρ' '))
[11]  Z1←Z1,[1] 1 70 ρ('SITE','    ','SITE NAME',(9ρ' '),'RSVR  SOU  THRM SOU-  DISS SOU-  FLOW  SOU-')
[12]  Z1←Z1,[1] 1 70 ρ('ID',(24ρ' '),'VOLUME RCE  GRAD RCE  SLDS RCE  RATE  RCE ')
[13]  Z1←Z1,[1] 1 70 ρ((26ρ' '),'CU KM',(7ρ' '),'C/KM',(7ρ' '),'PIT',(8ρ' '),'L/SEC',(5ρ' '))
[14] CONT:A1← 1 4 ρG[I;1 4] ⋄ A2← 1 20 ρG[I;4+⍳20] ⋄ A3← 1 6 ρG[I;24+⍳6] ⋄ A4← 1 2 ρG[I; 31 32] ⋄ A5← 1 3 ρG[I;32+⍳3]
[15]  A6← 1 2 ρG[I; 36 37] ⋄ A7← 1 3 ρG[I;37+⍳3] ⋄ A8← 1 2 ρG[I; 41 42] ⋄ A9← 1 3 ρG[I;42+⍳3] ⋄ A0← 1 2 ρG[I; 46 47]
[16]  ARRAY←A1,A2,A3,A4,A5,A6,A7,A8,A9,A0
[17]  FMT←'4A1,X1,20A1,X1,6A1,X1,2A1,X3,3A1,X2,2A1,X4,3A1,X2,2A1,X4,3A1,X3,2A1,X2'
[18]  Z1←Z1,[1] 1 70 ρ(FMT ⎕FMT ARRAY)
[19]  I←I+1
[20]  →(I≤MAX)/CONT
[21]  Z1←Z1,[1] 2 70 ρ' '
[22]  Z1←Z1,[1] 1 70 ρ('TABLE 7. RESERVOIR VOLUME, THERMAL GRADIENT, DISSOLVED SOLIDS',(9ρ' '))
[23]  Z1←Z1,[1] 1 70 ρ((10ρ' '),'AND FLOW RATE',(47ρ' ')) ⋄ LΔ←⎕ ⋄ Z1 ⋄ LΔ←⎕
[24]  →(MAX2=0)/L0 ⋄ →(MAX3=0)/C1 ⋄ →(MAX4=0)/C2 ⋄ →C3
[25] C1:MAX←MAX1+MAX2 ⋄ COUNT←COUNT+1 ⋄ →(COUNT<3)/ΔL1 ⋄ →L0
[26] C2:MAX←MAX1+MAX2 ⋄ COUNT←COUNT+1 ⋄ →(COUNT<3)/ΔL1 ⋄ MAX←MAX1+MAX2+MAX3 ⋄ →(COUNT<4)/ΔL1 ⋄ →L0
[27] C3:MAX←MAX1+MAX2 ⋄ COUNT←COUNT+1 ⋄ →(COUNT<3)/ΔL1 ⋄ MAX←MAX1+MAX2+MAX3 ⋄ →(COUNT<4)/ΔL1 ⋄ MAX←MAX1+MAX2+MAX3+MAX4
[28]  →(COUNT<5)/ΔL1 ⋄ →L0
[29] CK1:MAX←MAX1←(⌈(G2[1]÷2)) ⋄ →(MAX1=(⌊(G2[1]÷2)))/CH1 ⋄ MAX2←MAX1-1 ⋄ →ΔL1
[30] CH1:MAX2←MAX1 ⋄ →ΔL1
[31] CK2:MAX←MAX1←(⌈(G2[1]÷3)) ⋄ →(MAX1=(⌊(G2[1]÷3)))/CH2
[32]  →((MAX1-(G2[1]÷3))>0.4)/CH3 ⋄ MAX2←MAX1 ⋄ MAX3←MAX1-1 ⋄ →ΔL1
[33] CH2:MAX2←MAX3←MAX1 ⋄ →ΔL1
[34] CH3:MAX2←MAX3←MAX1-1 ⋄ →ΔL1
[35] CK3:MAX←MAX1←(⌈(G2[1]÷4)) ⋄ →(MAX1=(⌊(G2[1]÷4)))/CH4
[36]  →(((MAX1-(G2[1]÷4))=0.75),((MAX1-(G2[1]÷4))=0.5))/K1,K2 ⋄ MAX2←MAX1 ⋄ MAX3←MAX4←MAX2-1 ⋄ →ΔL1
[37] K1:MAX4←MAX3←MAX2←MAX1-1 ⋄ →ΔL1
[38] K2:MAX3←MAX2←MAX1 ⋄ MAX4←MAX1-1 ⋄ →ΔL1
[39] CH4:MAX4←MAX3←MAX2←MAX1 ⋄ →ΔL1
[40] L0:⎕FUNTIE 100
    ∇
```

```
    ∇ CITYS STN
[1]   OPEN 'CITY' ⋄ →(ERROR=1)/L0
[2]   G←⍉1 8 7 6 2 3 4 5 GET 1,0,(1000×STN),(((STN+1)×1000)-1)
[3]   G←G[;(G[1;]≠',')/⍳(⍴G)[2]]
[4]   G←ARC G
[5]   G2←⍴G ⋄ MAX←MAX1←MAX2←MAX3←MAX4←MAX5←MAX6←0 ⋄ I←COUNT←1 ⋄ SZ←⍴(⍴,STN) ⋄ →(SZ=2)/NXT ⋄ NAME←STNAMES 1 1 ⍴(⍴,STN) ⋄ →N
[6]   NXT:NAME←STNAMES[;⍳2⍴(⍴,STN)]
[7]   NXT2:→((G2[1]>50)∧(G2[1]≤100))/CK1
[8]    →((G2[1]>100)∧(G2[1]≤150))/CK2
[9]    →((G2[1]>150)∧(G2[1]≤200))/CK3
[10]   →((G2[1]>200)∧(G2[1]≤250))/CK4
[11]   →((G2[1]>250)∧(G2[1]≤300))/CK5
[12]   MAX←G2[1]
[13]  AL1:Z1←⍬1 70⍴(30⍴' '),NAME,(10⍴' ')
[14]   Z1←Z1,[1]⍬1 70⍴('CITY',(10⍴' '),'CITY NAME',(9⍴' '),'COUNTY NAME  POPULATION  LAT     LONG ')
[15]   Z1←Z1,[1]⍬1 70⍴('ID',(68⍴' '))
[16]  CONT:A1←⍬1 5⍴G[I;⍳5] ⋄ A2←⍬1 24⍴G[I;51+⍳24] ⋄ A3←⍬1 12⍴G[I;29+⍳12] ⋄ A4←⍬1 6⍴G[I;41+⍳6] ⋄ A5←⍬1 2⍴G[I;48 49]
[17]   A6←⍬1 2⍴G[I;50 51] ⋄ A7←⍬1 3⍴G[I;51+⍳3] ⋄ A8←⍬1 2⍴G[I;55 56] ⋄ ARRAY←A1,A2,A3,A4,A5,A6,A7,A8
[18]   FMT←'5A1,X1,2⍕A1,X2,12A1,X1,6A1,X5,2A1,X1,2A1,X3,3A1,X1,2A1'
[19]   Z1←Z1,[1]⍬1 70⍴(FMT (FMT ARRAY)
[20]   I←I+1
[21]   →(I≤MAX)/CONT
[22]   Z1←Z1,[1]⍬2 70⍴' '
[23]   Z1←Z1,[1]⍬1 70⍴'TABLE 8. CITY ID, CITY NAME, COUNTY NAME, POPULATION, LATITUDE',(8⍴' '))
[24]   Z1←Z1,[1]⍬1 70⍴'9⍴' '),'AND LONGITUDE',(39⍴' ') ⋄ LL←⎕ ⋄ Z1 ⋄ LL←⎕
[25]   →(MAX2=0)/L0 ⋄ →(MAX3=0)/C1 ⋄ →(MAX4=0)/C2 ⋄ →(MAX5=0)/C3 ⋄ →(MAX6=0)/C4 ⋄ →C5
[26]   C1:MAX←MAX1↑MAX2 ⋄ COUNT←COUNT+1 ⋄ →(COUNT<3)/AL1 ⋄ →L0
[27]   C2:MAX←MAX1↑MAX2 ⋄ COUNT←COUNT+1 ⋄ →(COUNT<3)/AL1 ⋄ MAX←MAX1↑MAX2↑MAX3 ⋄ →(COUNT<4)/AL1 ⋄ →L0
[28]   C3:MAX←MAX1↑MAX2 ⋄ COUNT←COUNT+1 ⋄ →(COUNT<3)/AL1 ⋄ MAX←MAX1↑MAX2↑MAX3 ⋄ →(COUNT<4)/AL1 ⋄ MAX←MAX1↑MAX2↑MAX3↑MAX4
[29]   →(COUNT<5)/AL1 ⋄ →L0
[30]   C4:MAX←MAX1↑MAX2 ⋄ COUNT←COUNT+1 ⋄ →(COUNT<3)/AL1 ⋄ MAX←MAX1↑MAX2↑MAX3 ⋄ →(COUNT<4)/AL1 ⋄ MAX←MAX1↑MAX2↑MAX3↑MAX4
[31]   →(COUNT<5)/AL1 ⋄ MAX←MAX1↑MAX2↑MAX3↑MAX4↑MAX5 ⋄ →(COUNT<6)/AL1 ⋄ →L0
```

```
[32] C5:MAX←MAX1+MAX2 ⋆ COUNT←COUNT+1 ⋆ →(COUNT<3)/ΔL1 ⋆ MAX←MAX1+MAX2+MAX3 ⋆ →(COUNT<4)/ΔL1 ⋆ MAX←MAX1+MAX2+MAX3+MAX4
[33]  →(COUNT<5)/ΔL1 ⋆ MAX←MAX1+MAX2+MAX3+MAX4+MAX5 ⋆ →(COUNT<6)/ΔL1 ⋆ MAX←MAX1+MAX2+MAX3+MAX4+MAX5+MAX6 ⋆ →(COUNT<7)/ΔL1
[34]  →L0
[35] CK1:MAX←MAX1←(⌈(G2[1]÷2)) ⋆ →(MAX1=(⌊(G2[1]÷2)))/CH1 ⋆ MAX2←MAX1-1 ⋆ →ΔL1
[36] CH1:MAX2←MAX1 ⋆ →ΔL1
[37] CK2:MAX←MAX1←(⌈(G2[1]÷3)) ⋆ →(MAX1=(⌊(G2[1]÷3)))/CH2
[38]  →((MAX1-(G2[1]÷3))>0.4)/CH3 ⋆ MAX2←MAX1 ⋆ MAX3←MAX1-1 ⋆ →ΔL1
[39] CH2:MAX2←MAX3←MAX1 ⋆ →ΔL1
[40] CH3:MAX2←MAX3←MAX1-1 ⋆ →ΔL1
[41] CK3:MAX←MAX1←(⌈(G2[1]÷4)) ⋆ →(MAX1=(⌊(G2[1]÷4)))/CH4
[42]  →(((MAX1-(G2[1]÷4))=0.75),((MAX1-(G2[1]÷4))=0.5))/K1,K2 ⋆ MAX2←MAX1 ⋆ MAX3←MAX4←MAX2-1 ⋆ →ΔL1
[43] K1:MAX4←MAX3←MAX2←MAX1-1 ⋆ →ΔL1
[44] K2:MAX3←MAX2←MAX1 ⋆ MAX4←MAX1-1 ⋆ →ΔL1
[45] CH4:MAX4←MAX3←MAX2←MAX1 ⋆ →ΔL1
[46] CK4:TEM←G2[1]÷5 ⋆ →((((⌈TEM)-TEM)=0.2),(((⌈TEM)-TEM)=0.4),(((⌈TEM)-TEM)=0.6),(((⌈TEM)-TEM)=0.8))/Δ1,Δ2,Δ3,Δ4
[47]  MAX←MAX1←MAX2←MAX3←MAX4←MAX5←TEM ⋆ →ΔL1
[48] Δ1:MAX←MAX1←MAX2←MAX3←MAX4←⌈TEM ⋆ MAX5←⌊TEM ⋆ →ΔL1
[49] Δ2:MAX←MAX1←MAX2←MAX3←⌈TEM ⋆ MAX4←MAX5←⌊TEM ⋆ →ΔL1
[50] Δ3:MAX←MAX1←MAX2←⌈TEM ⋆ MAX3←MAX4←MAX5←⌊TEM ⋆ →ΔL1
[51] Δ4:MAX←MAX1←⌈TEM ⋆ MAX2←MAX3←MAX4←MAX5←⌊TEM ⋆ →ΔL1
[52] CK5:TEM←G2[1]÷6 ⋆ →((((⌈TEM)-TEM)<0),(((⌈TEM)-TEM)=0.5))/A,B
[53]  →(((((⌈TEM)-TEM)<0.5)∧(((⌈TEM)-TEM)<0.2)),((((⌈TEM)-TEM)>0.5)∧(((⌈TEM)-TEM)>0.7)))/C,D
[54]  →((((⌈TEM)-TEM)<0.5),(((⌈TEM)-TEM)>0.5))/LΔ1,LΔ2
[55] A:MAX←MAX1←MAX2←MAX3←MAX4←MAX5←MAX6←TEM ⋆ →ΔL1
[56] B:MAX←MAX1←MAX2←MAX3←⌈TEM ⋆ MAX4←MAX5←MAX6←⌊TEM ⋆ →ΔL1
[57] C:MAX←MAX1←MAX2←MAX3←MAX4←MAX5←⌈TEM ⋆ MAX6←⌊TEM ⋆ →ΔL1
[58] D:MAX←MAX1←⌈TEM ⋆ MAX2←MAX3←MAX4←MAX5←MAX6←⌊TEM ⋆ →ΔL1
[59] LΔ1:MAX←MAX1←MAX2←MAX3←MAX4←⌈TEM ⋆ MAX5←MAX6←⌊TEM ⋆ →ΔL1
[60] LΔ2:MAX←MAX1←MAX2←⌈TEM ⋆ MAX3←MAX4←MAX5←MAX6←⌊TEM ⋆ →ΔL1
[61] L0:⎕FUNTIE ⎕FNUMS
    ∇
```

```
    ∇ COUNTYS STN
[1]   OPEN 'COUNTY' ⋄ →(ERROR=1)/LO
[2]   G←1 2 GET 1,0,(100×STN),(((STN+1)×100)-1)
[3]   G←G[;(G[1;]≠',')/⍳(ρG)[2]]
[4]   G2←ρG ⋄ MAX←MAX1←MAX2←MAX3←MAX4←MAX5←MAX6←0 ⋄ I←COUNT←1 ⋄ →((ρ(⍕,STN))=2)/NXT ⋄ NAME←STΔNAMES 1 1 ρ(⍕,STN) ⋄ →NXT2
[5]   NXT:NAME←STΔNAMES 1 2 ρ(⍕,STN)
[6]   NXT2:DUMM←G2[1]÷3 ⋄ DUMM2←(⌈DUMM)×2 ⋄ →((((⌈DUMM)-DUMM)>0.5)/FIX1 ⋄ G←G,[1] 1 16 ρ' ' ⋄ →FIX2
[7]   FIX1:G←G,[1] 2 16 ρ' '
[8]   FIX2:→((G2[1]>150)∧(G2[1]≤300))/CK1
[9]    →((G2[1]>300)∧(G2[1]≤450))/CK2
[10]  →((G2[1]>450)∧(G2[1]≤600))/CK3
[11]  →((G2[1]≥600)∧(G2[1]≤750))/CK4
[12]  →((G2[1]>750)∧(G2[1]≤900))/CK5
[13]  MAX←⌈DUMM
[14] ΔL1:Z1←1 70 ρ((30ρ' '),NAME,(10ρ' '))
[15]  Z1←Z1,[1] 1 70 ρ('COUNTY  COUNTY NAME    |  ')
[16]  Z1←Z1,[1] 1 70 ρ('ID',20ρ' '),'|  '
[17] CONT:A1←1 4 ρG[I;1+⍳4] ⋄ A2←1 12 ρG[I;5+⍳12] ⋄ A3←1 4 ρG[(⌈DUMM)+I;⍳4] ⋄ A4←1 12 ρG[(⌈DUMM)+I;5+⍳12]
[18]  A5←1 4 ρG[I+DUMM2;⍳4] ⋄ A6←1 12 ρG[I+DUMM2;5+⍳12] ⋄ A7←'|' ⋄ ARRAY←A1,A2,A7,A3,A4,A7,A5,A6
[19]  FMT←'4A1,X4,12A1,X2,1A1,X2,4A1,X4,12A1,X2,1A1,X2,4A1,X4,12A1'
[20]  Z1←Z1,[1] 1 70 ρ(FMT ⍕FMT ARRAY)
[21]  I←I+1
[22]  →(I≤MAX)/CONT
[23]  Z1←Z1,[1] 2 70 ρ' '
[24]  Z1←Z1,[1] 1 70 ρ('TABLE 9. COUNTY ID AND COUNTY NAME',(39ρ' ')) ⋄ LL←⎕ ⋄ Z1 ⋄ LL←⎕
[25]  →(MAX2=0)/LO ⋄ →(MAX3=0)/C1 ⋄ →(MAX4=0)/C2 ⋄ →(MAX5=0)/C3 ⋄ →(MAX6=0)/C4 ⋄ →C5
[26] C1:MAX←MAX1←MAX2 ⋄ COUNT←COUNT+1 ⋄ →(COUNT<3)/ΔL1 ⋄ →LO
[27] C2:MAX←MAX1+MAX2 ⋄ COUNT←COUNT+1 ⋄ →(COUNT<3)/ΔL1 ⋄ MAX←MAX1+MAX2+MAX3 ⋄ →(COUNT<4)/ΔL1 ⋄ →LO
[28] C3:MAX←MAX1+MAX2 ⋄ COUNT←COUNT+1 ⋄ →(COUNT<3)/ΔL1 ⋄ MAX←MAX1+MAX2+MAX3 ⋄ →(COUNT<4)/ΔL1 ⋄ MAX←MAX1+MAX2+MAX3+MAX4
[29]  →(COUNT<5)/ΔL1 ⋄ →LO
[30] C4:MAX←MAX1+MAX2 ⋄ COUNT←COUNT+1 ⋄ →(COUNT<3)/ΔL1 ⋄ MAX←MAX1+MAX2+MAX3 ⋄ →(COUNT<4)/ΔL1 ⋄ MAX←MAX1+MAX2+MAX3+MAX4
[31]  →(COUNT<5)/ΔL1 ⋄ MAX←MAX1+MAX2+MAX3+MAX4+MAX5 ⋄ →(COUNT<6)/ΔL1 ⋄ →LO
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[32] C5:MAX←MAX1+MAX2 ⋇ COUNT←COUNT+1 ⋇ →(COUNT<3)/ΔL1 ⋇ MAX←MAX1+MAX2+MAX3 ⋇ →(COUNT<4)/ΔL1 ⋇ MAX←MAX1+MAX2+MAX3+MAX4
[33]  →(COUNT<5)/ΔL1 ⋇ MAX←MAX1+MAX2+MAX3+MAX4+MAX5 ⋇ →(COUNT<6)/ΔL1 ⋇ MAX←MAX1+MAX2+MAX3+MAX4+MAX5+MAX6 ⋇ →(COUNT<7)/ΔL1
[34]  →L0
[35] CK1:MAX←MAX1←(⌈(G2[1]÷2)) ⋇ →(MAX1=(⌊(G2[1]÷2)))/CH1 ⋇ MAX2←MAX1-1 ⋇ →ΔL1
[36] CH1:MAX2←MAX1 ⋇ →ΔL1
[37] CK2:MAX←MAX1←(⌈(G2[1]÷3)) ⋇ →(MAX1=(⌊(G2[1]÷3)))/CH2
[38]  →((MAX1-(G2[1]÷3))>0.4)/CH3 ⋇ MAX2←MAX1 ⋇ MAX3←MAX1-1 ⋇ →ΔL1
[39] CH2:MAX2←MAX3←MAX1 ⋇ →ΔL1
[40] CH3:MAX2←MAX3←MAX1-1 ⋇ →ΔL1
[41] CK3:MAX←MAX1←(⌈(G2[1]÷4)) ⋇ →(MAX1=(⌊(G2[1]÷4)))/CH4
[42]  →(((MAX1-(G2[1]÷4))=0.75),((MAX1-(G2[1]÷4))=0.5))/K1,K2 ⋇ MAX2←MAX1 ⋇ MAX3←MAX4←MAX2-1 ⋇ →ΔL1
[43] K1:MAX4←MAX3←MAX2←MAX1-1 ⋇ →ΔL1
[44] K2:MAX3←MAX2←MAX1 ⋇ MAX4←MAX1-1 ⋇ →ΔL1
[45] CH4:MAX4←MAX3←MAX2←MAX1 ⋇ →ΔL1
[46] CK4:TEM←G2[1]÷5 ⋇ →((((⌈TEM)-TEM)=0.2),(((⌈TEM)-TEM)=0.4),(((⌈TEM)-TEM)=0.6),(((⌈TEM)-TEM)=0.8))/Δ1,Δ2,Δ3,Δ4
[47]  MAX←MAX1←MAX2←MAX3←MAX4←MAX5←TEM ⋇ →ΔL1
[48] Δ1:MAX←MAX1←MAX2←MAX3←MAX4←⌈TEM ⋇ MAX5←⌊TEM ⋇ →ΔL1
[49] Δ2:MAX←MAX1←MAX2←MAX3←⌈TEM ⋇ MAX4←MAX5←⌊TEM ⋇ →ΔL1
[50] Δ3:MAX←MAX1←MAX2←⌈TEM ⋇ MAX3←MAX4←MAX5←⌊TEM ⋇ →ΔL1
[51] Δ4:MAX←MAX1←⌈TEM ⋇ MAX2←MAX3←MAX4←MAX5←⌊TEM ⋇ →ΔL1
[52] CK5:TEM←G2[1]÷6 ⋇ →((((⌈TEM)-TEM)<0),(((⌈TEM)-TEM)=0.5))/A,B
[53]  →(((((⌈TEM)-TEM)<0.5)∧(((⌈TEM)-TEM)<0.2)),((((⌈TEM)-TEM)>0.5)∧(((⌈TEM)-TEM)>0.7)))/C,D
[54]  →((((⌈TEM)-TEM)<0.5),(((⌈TEM)-TEM)>0.5))/LΔ1,LΔ2
[55] A:MAX←MAX1←MAX2←MAX3←MAX4←MAX5←MAX6←TEM ⋇ →ΔL1
[56] B:MAX←MAX1←MAX2←MAX3←⌈TEM ⋇ MAX4←MAX5←MAX6←⌊TEM ⋇ →ΔL1
[57] C:MAX←MAX1←MAX2←MAX3←MAX4←MAX5←⌈TEM ⋇ MAX6←⌊TEM ⋇ →ΔL1
[58] D:MAX←MAX1←⌈TEM ⋇ MAX2←MAX3←MAX4←MAX5←MAX6←⌊TEM ⋇ →ΔL1
[59] LΔ1:MAX←MAX1←MAX2←MAX3←MAX4←⌈TEM ⋇ MAX5←MAX6←⌊TEM ⋇ →ΔL1
[60] LΔ2:MAX←MAX1←MAX2←⌈TEM ⋇ MAX3←MAX4←MAX5←MAX6←⌊TEM ⋇ →ΔL1
[61] L0:⎕FUNTIE ⎕FNUMS
     V
```

```
    ∇ CHNG B1
[1]   A←⍴B1
[2]   IN←1
[3]   AA←B1[IN;],[1] ⎕TCNL
[4]  NXT:IN←IN+1
[5]   AA←AA,[1] B1[IN;],[1] ⎕TCNL
[6]   →(IN<A[1])/NXT
    ∇
```

Function name: CHNG

input: A variable in matrix form which this function will change into a vector so that it can be submitted to the high speed printer.
output: a vector of whatever length it is needed to be, the variable name is AA.

SUBROUTINES: none

VARIABLES: AA

```
    ∇ M3←REMOVE MC
[1]   QR←⍴MC
[2]   QM←,MC
[3]   M2←(QM='(')∨(QM=')')∨(QM='-')
[4]   QM[M2/⍳⍴QM]←' '
[5]   M3←QR⍴QM
    ∇
```

Function name: REMOVE

input: A matrix that has hyphens, or parenthesis in its contents which are to be removed.

output: a matrix without hyphens, or parenthesis.

SUBROUTINES: none

VARIABLES: none

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University of Wyoming	Laramie, WY	E. Meyer	2
South Dakota Office of Energy Policy	Pierre, SD	M. Hohmann	2
North Dakota Energy Office	Bismarck, ND	D. Connor	2

APPENDIX 1

SUMMARY OF GEOTHERMAL ALGORITHM - ELECTRIC USES (GIRORA-ELECTRIC)

The model which follows posits the very simple economic idea that an investment should be made if the present value of all net income streams is equal to the investment required to generate them when discounted at an interest rate appropriately high.[1] If the amount of an investment is known, and the net income streams are known, the rate-of-return can be calculated. This model attempts to calculate the internal rate-of-return to a producer from a geothermal field for which electricity production is planned. This model can easily be modified to fit any type of energy production from a geothermal field.

The basic equation is of the simple form for discounting cash flows:

$$\text{Investment} = \sum_{t=1}^{T} (\text{Net Income}_t)\ (1 + R)^{-t} \qquad (1.1)$$

where Net Income = (Total Revenues) - (Total Operating Cost) - (Taxes)

Total Revenues = (Price) (Quantity Output)

Total Operating Cost = A Percentage of Investment

R: Rate-of-Return

t: Each year, t = 1,2,...,T.

T: Expected life span of the Investment

However, this rather fundamental notion is modified somewhat in GIRORA-Electric due to the fact that some investments are made throughout the life of the project and thus must also be discounted to the present for proper evaluation. This yields the equation,

$$\sum_{t=1}^{T} (\text{Investment}_t)\ (1 + R)^{-t} = \sum_{t=1}^{T} (\text{Net Income}_t)\ (1 + R)^{-t} \qquad (1.2)$$

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[1] For a discussion of this principal, see Fred R. Glahe Macroeconomics (New York Harcourt, Brace, Jovanich, Inc., 1973), pp. 91-95

which reduces to

$$\sum_{t=1}^{T} (\text{Investment}_t)\ (1 + R)^{-t} = 0 \qquad (1.3)$$

If we set $(1 + R)^{-1} = b$, then

$$\sum_{t=1}^{T} (\text{Investment}_t - \text{Net Income}_t)\ b^t = 0 \qquad (1.4)$$

Equation (1.4) is a polynomial with T roots. Assuming a monotonic function there will be one real (non-imaginary) root (b) which permits a solution for the equation. This root can be found iteratively by Newton's technique.[2] Fortunately, GIRORA-Electric has generated only monotonic functions.

GIRORA-Electric simulates all investment, revenue, and cost flows for a specified resource site, and inputs the flows to equation (1.3) and solves for R.

Investment, revenue and cost flows are divided into two sectors, a geothermal developer sector, and an electric utility sector. The geothermal developer's revenues are operating costs as perceived by the electric utility. The electric utility demand for geothermal fluid (or steam) is derived from the demand for electricity. Once a quantity of electricity has been specified, given resource characteristics, the quantity of fluid or steam is automatically specified. The price of the geothermal energy is the highest price consistent with the competitive price of electricity and the electric utility's regulated rate-of-return (both which are assumed to be known). The description of GIRORA-Electric begins with a description of the Electric Utility Sector.

Electric Utility Sector

The model first identifies the principal components of cost to the electric utility for each year (t) of electricity production: capital costs (CC_t),

[2] For a description of the mathematical technique involved, see C. C. T. Baker, Dictionary of Mathematics, (New York City, Hart Publishing Co., 1966), p. 206.

operating costs (OMC_t), income taxes (ITX_t), property taxes (PTX_t), and energy costs (ENC_t).

Capital costs are a function the investment (K) required for a specified level of capacity in kilowatts (CAP).

$$K = (CAP)\ (CAPC) \tag{1.5}$$

CAPC: capacity cost in dollars per KW; an input parameter

Capital costs are also a function of the regulated return to equity (ER), the bond rate (BR), the debt to equity ratio, and depreciation ($DEPR_t$).

$$E = (EK)\ (K)\ (ER),\ \text{(equity costs)}, \tag{1.6}$$

$$D = (DK)\ (K)\ (BR),\ \text{(debt costs)}, \tag{1.7}$$

$$DEPR_t = (DEP_t)\ (K),\ \text{(depreciation)}, \tag{1.8}$$

and therefore

$$CC_t = E + D + DEPR_t \tag{1.9}$$

where, EK: equity share of capital; an input parameter,

DK: debt share of capital; an input parameter

(EK = 1-DK)

DEP_t: depreciation rate in year t;

$$DEP_t\ \ (T + 1 - t)/\sum_{t=1}^{T} t\ , \tag{1.10}$$

where T is the length of time for electricity production. The model provides for a fast write-off option.

Operating costs are a function of total investment and escalate through time.

$$OMC_t = (OC_t)\ (K) \tag{1.11}$$

$$OC_t = (OCB)\ (1. + \dot{OC})^t \tag{1.12}$$

OC_t: operating percent of investment in year t; input variable

OCB: base rate; input variable,

$\dot{OC}$: escalation rate; input variable

Likewise, property taxes are a function of investment.

$$PTX = (PTP)\ (K). \tag{1.13}$$

PTP: property tax rate; input variable

Before income taxes are calculated, total revenues must be known. They are, of course, a function of the price of electricity (PE_t) and the quantity of electricity (QE), which is a function of plant capacity. PE_t is specified as an exogenous busbar price of electricity which is determined by the market and escalates over time.

$$PE_t = (PB)\ (1 + \dot{P})^t \tag{1.14}$$

PB: Base busbar price of electricity; input variable.

$\dot{P}$: escalation factor; input variable

$$QE = (CAP)\ (8760)\ (LF)\ (1\text{-}UF) \tag{1.15}$$

LF: Plant factor; an input variable,

UF: Plant use of power; an input variable.

Income taxes and energy costs must be determined simultaneously, because the price of the geothermal energy (PHW_t) is an element of both and moreover, PHW_t is the output of the utility sector for the model. The quantity of geothermal energy is determined by electricity plant requirements.

$$QHW = (CAP)\ (8760)\ (LF) \tag{1.16}$$

$$ENC_t = (PHW_t)\ (QHW) \tag{1.17}$$

$$ITX_t = \{TXRT\}\{[(PE_t)\ (QE)] - [OMC_t] - [PTX] - [ENC_t] - [D] - [DEPR_t]\} - \{[CRRT]\ [K_{t=1,t=2,\ t=3,}]\} \tag{1.18}$$

TXRT: income tax rate; input variable

CRRT; investment tax credit rate; input variable

Therefore,

$$PHW_t = \frac{(TXRT)(DEPR_t)+(CRRT)(K_{t=1,t=2,t=3,})-(CC_t)}{(QHW)\ (1\text{-}TXRT)} + \frac{(PE_t)(QE)-(OMC_t)-(PTX)}{(QHW)} \tag{1.19}$$

The price of energy in year (t) from (15) and the quantity of energy from (12), that is, ENC_t (equation 1.17), become total revenue for the geothermal energy producer.

Geothermal Energy Producer Sector

We will recall equation (1.17) ENC_t for the producer, REV_j, or total revenues.

$$REV_j = ENC_t \tag{1.20}$$

First, a discussion of the time period involved is necessary. The producer's time horizon is different from that of the electric utility. The years t are elements of T, while the years j are elements of J. J - T = PPY, the "pre-production years." PPY is composed of two periods. The exploration period (EXP) and the development period (DVP), and thus EXP+DVP=PPY. Thus, the determinative direction is EXP+DVP+T=J. EXP is the period during which only exploratory wells are drilled. The development period begins with the drilling of the first production well.

The producer's activity is modeled somewhat differently from the utilities because the output of the simulation is a rate of return on the producer's equity. Thus, the first order of business is to determine what the level of the investment is in each year of the project. The producer's investment (PNV_j) is a share of the total investment in year J (PPK_j).

$$PNV_j = (EPK)(PKK_j) \tag{1.21}$$

$$PKK_j = (LNV_j) + (DNV_j) + (IDC_j) + (OPNV_j) \tag{1.22}$$

EPK: Equity portion of capital; an input variable,

LNV_j: Leasing investment in year j, in $,

DNV_j: Drilling investment in year j, in $,

IDC_j: Interest cost during construction in year j, in $,

$OPNV_j$: Other producer investments in year j, in $,

Total investment by the producer, cumulative to year j is

$$PK_j = \sum_{i=0}^{j} PKK_i \qquad (1.23)$$

We will first describe the calculation of each element of PKK_j, beginning with DNV_j.

$$DNV_j = \left[\left(\frac{NPW_j}{PSS}\right)(ADDP)(CPFP)\right] + \left[\left(\frac{NIW_j}{ISS}\right)(ADDI)(CPFI)\right] \qquad (1.24)$$

NPW_j: New producing wells in year j.

PSS: Production Well Success ratio,

CPFP: Cost per foot, producing wells,

NIW_j: New injection wells in year j,

ISS: Injection well success ratio (= 1 usually),

ADDI: Average depth of injection wells,

CPFI: Cost per foot of injection wells.

The calculation of the elements of DNV_j is shown below.

$$NPW_j = RPW_j - RPW_{j-1} \qquad (1.25)$$

RPW_j: required producing wells, $RPW_j = 0$ when $j < EXP+1$.

$$RPW_j = \frac{RFR_{CAP}}{FR} \qquad (1.26)$$

FR: Flowrate in lb/hr per producing well,

RFR_{CAP}: required flowrate for rated capacity in lb/hr.[3]
(CAP is stated here in MW, not KW, and is net of UF.)

$$RFR_{50} = 1374.912e^{-0.01379\ (TEMP)} \qquad (1.27a)$$

$$RFR_{100} = 2667.012e^{-0.01372\ (TEMP)} \qquad (1.27b)$$

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[3] Bechtel Corporation, Advanced Design and Economic Considerations for Commercial Geothermal Power Plants at Heber and Niland, California. SAN-1124-2, San Francisco, California, 1977.

$$RFR_{150} = 3959.226\ e^{-0.013655\ (TEMP)} \quad (1.27c)$$

$$RFR_{200} = 5251.44\ e^{-0.01359\ (TEMP)} \quad (1.27d)$$

Temperature decline is estimated, and resulting need for increased flow rate, thus producing wells, is modeled in the following way:

$$Temp = \frac{T_0}{360}\ [358.344\ e^{-0.00144(Time)}],\ \text{for CAP = 50MW} \quad (1.28a)$$

$$Temp = \frac{T_0}{360}\ [357.474\ e^{-0.00233(Time)}],\ \text{for CAP = 100 MW} \quad (1.28b)$$

$$Temp = \frac{T_0}{360}\ [357.12\ e^{-0.00322(Time)}],\ \text{for CAP = 150 MW} \quad (1.28c)$$

$$Temp = \frac{T_0}{360}\ [357.769\ e^{-0.00411(Time)}],\ \text{for CAP = 200MW} \quad (1.28d)$$

T_0: downhole temperature of brine in °F, an input variable.

$$NIW_j = RIW_j - RIW_{j-1} \quad (1.29)$$

RIW_j : required injection wells in year j.

$$RIW_j = RPW_j\ (PIR)^{-1} \quad (1.30)$$

PIR: required ratio of producing wells to injection wells, in year j, an input variable.

After initiation of power generation, NPW_j and NIW_j will generally take on a value of 0 or 1, but are arbitrarily allocated during DVP.

The remaining elements of PKK_j are discussed below:

$$LNV_j = [(DPAC)(ACPW)(NPW_j)] + [DPAC)(ACIW)(NIW_j)] \quad (1.31)$$

DPAC: dollars per acre leasing cost; input variable,

ACPW: acres per producing well; input variable,

ACIW: acres per injection well; input variable.

$$OPNV_j = EXPN_n + PIPN_j + ONV_j \quad (1.32)$$

$EXPN_j$: exploration investments, year j,

$PIPN_j$: piping investments, year j,

ONV_j: other investments, year j.

$$EXPN_j = f(EXPN) \tag{1.33}$$

$$EXPN = (EXD)(CAP) \tag{1.34}$$

EXD: dollars per unit of capacity (electric needed for exploration, on average; input variable.

$j > EXP$, $EXPN_j = 0$

EXPN: total exploration investment in $

(Note: $EXPN = \sum_{j=0}^{EXP} EXPN_j$, where the distribution function is chosen arbitrarily)

$$PIPN_j = (PIP)(DNV_j) \tag{1.35}$$

PIP: average percentage of drilling investment required for piping and similar field developments.

$$ONV_j = (OPE_j)(DNV_j) \tag{1.36}$$

$$OPE_j = (OPEB)(1+\dot{OP})^j \tag{1.37}$$

Equations (1.37) and (1.38) calculate estimate additional investments in field development which are related to drilling expenses.

$$IDC_j = [BR][DPK]\left[\sum_{i=0}^{j} LNV_i + \sum_{i=0}^{j} DNV_i + \sum_{i=0}^{j} OPNV_i\right] \tag{1.38}$$

$IDC_j = 0$ for $j > PPY$.

DPK: debt portion of capital; DPK = 1 - EPK.

Thus, total revenues and all elements of investment have been calculated. What remain are uncapitalized elements of cost. $OMCP_j$ are operating and other current outlays.

$$OMCP_j = [(OCP_j)(PK_j)] + [(BR)(PK_j)(DPK)] + [PTXP_j] \tag{1.39}$$

$$OCP_j = (OCPB)(1+\dot{OCP})^j \tag{1.40}$$

OCP_j: operating percentage of investment outlay,

OCPB: base percentage; input variable,

$\dot{OCP}$: escalation factor.

$PTXP_j$: property taxes.

$$PTXP_j: \quad (PTPP)(PK_j) \tag{1.41}$$

PTPP: property tax rate; input variable.

Income taxes are as follows:

$$ITXP_j = \{TXRT\}\{[(REV_j)(1-\lambda)(1-Z)] - OMCP_j - [(Y)(DNVD_j)]\} - \{[CRRT][(1-Y)\left(\sum_{i=j-2}^{j} DNV_i\right)]\} \tag{1.42}$$

$$DNVD_j = \sum_{i=1}^{j} DNV_i \; (DEPRP_{j-i+1}) \tag{1.43}$$

$$DEPRP_j = (D + 1 - j) / \sum_{j=1}^{D} j \tag{1.44}$$

D: period chosen for depreciation; input variable

λ: royalty rate, input variable,

Y: percentage tangible investment, input variable,

Z: depletion allowance, input variable,

$DNVD_j$: depreciation allowance in year j, $

$DEPRP_j$: depreciation rate in year j. Program contains fast write-off option.

Finally, the model solves for R, the rate of return to equity for the geothermal energy producer from the Jth degree polynomial given by

$$\sum_{j=i}^{J} \{[(REV_j)(1-\lambda) - (OMCP_j) - (ITXP_j)]\}e^{-Rj} = 0 \tag{1.45}$$

The R thus solved is one criterion for ranking geothermal resource sites and for comparing the outcomes of policy variable changes.

APPENDIX 2

A DISTRICT SPACE HEATING MODEL - GIRORA: NONELECTRIC

To find the commercial feasibility of a geothermal resource for district heating, an internal rate of return model is developed, which is labeled as GIRORA-NONELECTRIC.

GIRORA NON-ELECTRIC is a simple but powerful simulation model which evaluates the economic potential of low temperature hydrothermal geothermal resources for district space heating. The model also provides a means for measuring the estimated economic impacts of variations in a number of policy variables and site specific geophysical variables. In composite, these findings present an empirical collage which proves richly productive in evaluating the potential of low temperature geothermal energy.

GIRORA NON-ELECTRIC will be considered in detail below. The primary output of the model is an estimated measure of profitability for a geothermal producer developing a given geothermal resource site. On this basis, an ordinal ranking of low temperature sites in Region 4 can be compiled with respect to expected profitability. Such a ranking provides a best guess listing, ceteris paribus, of which sites might be expected to come "on line" and in what order they will be developed.

While a number of analytical models similar to the model described herein are being developed, each of the current generation is dependent upon the original GEOCITY model developed by Bloomster, et. al., at Batelle Pacific Northwest Laboratories[1]. Unfortunately for most analysts interested in broad regional study, GEOCITY may be too elegant. "GEOCITY is an offshoot of the GEOCOST program. . .," a highly technical and extremely detailed

[1]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. Battelle Pacific Northwest Laboratories, Richland, Washington, August 1977.

simulation model which describes the development of high temperature resources for generating electricity[2]. As a result, GEOCITY might be more appropriately described as an engineering description of a district heating model than as a financial feasibility model.

For a broader research thrust with which little proprietary data or detailed district heating plans are available, many properties of GEOCITY are redundant. Given the objectives of the present analysis, therefore, a simpler more functional model is necessary. Accordingly, Geothermal Internal Rate of Return Algorithm (GIRORA) has been developed.

From an analytical perspective, GIRORA NON-ELECTRIC is a discounted cash flow model which simulates required investments, revenues, and operating outlays for each year of the investment life of a geothermal anomaly. The model iterates for the internal rate of return which equates the sums of investment costs incurred with net revenues, discounted to the present. In simple terms, the model calculates R (internal rate of return) from

$$\sum_{t=1}^{T} \text{Investments} \; (1+R)^{-t} = \sum_{t=1}^{T} \text{Net Revenues}_t \; (1+R)^{-t} \qquad (2.1)$$

T: Each year of the period, t=1,...T

Simulating the life of an investment through T years results in a T-th order polynomial which is solved iteratively by Newton's method of approximation for a unique real root, R. This root is a measure of the expected profitability of an investment. Ceteris Paribus, the greater the present value of all net revenues or the lowest cost of all investments throughout the productive life of a resource, the higher is R, and vice versa.

[2] Bloomster, C. H., Huber, H. D. and Walter, R. A. User Manual for GEOCOST: A Computer Model for Geothermal Cost Analysis; Vols. 1 & 2, Battelle Pacific Northwest Laboratories, Richland, Washington, 1975-1976.

The heart of the simulation model is an expanded version of equation (2.1).

$$\sum_{t=1}^{T} INV(1+R)^{-t} = \sum_{t=1}^{T} (REV_t - TC_t - TX_t)(1+R)^{-t} \qquad (2.2)$$

INV: Equity Investment by project developers

REV_t: Total revenues in year t.

TC_t: Variable costs in year t.

TX_t: Taxes in year t.

R: Discount rate of internal rate of return.

t: Each year of project, t=1,...T.

The remainder of the model identifies explicitly each element of equation (2.2). Beginning on the left side of the equation and working to the right,

$$INV = (EK)(TNV) \qquad (2.3)$$

EK: Equity portion of capital.

TNV: Total Investment.

Equation (2.3) indicates that the return to <u>risk</u> capital is of primary concern, since the return on debt capital will be specified by a bond rate.

Total investment costs include drilling investment, leasing costs, plant investment, and interest paid during construction. During the early years of a geothermal resource investment, i.e. during the period of resevoir exploration and development and plant construction, investment cost is the sum of all of the four components above. Thereafter, during the actual operation of the space heating system, total investment is the sum of drilling, leasing, and interest expenses. Thus,

$$TNV_t = DNV_t + LNV_t + IDC_t + PLV_t, \quad t = EXP + DVP + CON \qquad (2.4a)$$

$$TNV_t = DNV_t + LNV_t + IDC_t, \quad t \neq EXP + DVP + CON \qquad (2.4b)$$

DNV_t = Drilling investment costs in year t, $

LNV_t = Leasing investment cost in year t, $

PLV = Plant investment cost for transmission and distribution system, $

IDC_t = Interest during construction in year t, $

EXP = Exploration period in years, input variable

DVP = Development period in years, input variable

CON = Plant construction period in years, input variable

Each of the four components of the capital investment is estimated individually. The first is the drilling investment. Drilling investment is a function of the number of geothermal production and injection wells required, the average depth of production and injection wells, and the cost per unit depth of proudction and injection wells.

$$DNV_t = \left(\frac{NPW_t}{PSS}\right) \quad (ADDP) \quad (CPFP) + \left(\frac{NIW}{ISS}t\right) \quad (ADDI) \quad (CPFI) \qquad (2.5)$$

NPW_t = New production wells to be drilled in year t

PSS = Production well success ratio; input variable,

ADDP = Average depth of production well in feet; input variable,

CPFF = Drilling cost per foot of production well, $, input variable,

NIW_t = New injection wells to be drilled in year t,

ISS = Injection well success ratio; input variable,

ADDI = Average depth of injection well in feet; input variable,

CPFI = Drilling cost per foot of injection well, $, input variable.

The number of production wells required is dependent upon the amount of hot water required to meet the space heating system demand and the flow rate of each production well.

$$RPW = HWLBH/FR \quad (2.6)$$

RPW = Required number of production wells to be drilled,

HWLBH = Hot water required to meet system demand, lbs/hr,

FR = Flow rate of the production well, lbs/hr; input variable.

In return, the amount of hot water that is required to meet the demand of the space heating system is jointly dependent upon the estimated peak heat demand (PHD) of the user and the usable heat (TD) from the available water. In the case of the former, the hot water required is assumed to be 75 percent of the amount necessary to supply peak heat demand, with the remaining 25 percent supplied by conventionally fueled backup units. Thus[3]

$$HWLBH = 0.75\ [PHD/TD] \quad (2.7)$$

When estimating peak heat demand, the user mix or the percent of the population residing in single family dwelling units versus multiple family dwelling units is specified. In addition, the non-residential demand is assumed to be 50 percent of residential demand.

$$PHD = 1.5\ [2.016\ (\Omega) + 0.914\ (1-\Omega)]\ [POP/3]\ [DEGD] \quad (2.8)$$

DEGD = Heating degree days (°F) of the community

POP = Population of the community; input

Ω = User mix ($0.0 < \Omega < 1.0$)

TD = Usable temperature from the available hot water

As the hot water is transported from the resource site to the demand site, there will be a decline in temperature of hot water proportional to the distance. In addition, the usable temperature also depends on the downhole temperature of the hot water at the source.[4]

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[3] E. F. Wehlage, The Basics of Applied Geothermal Engineering, Geothermal Information Services, California, 1976.

[4] E G & G Idaho Inc., The Potential for Utilizing Geothermal Energy in Reconstructed Sugar City, Idaho, TREE-116, January 1977.

$$TD = -75.41 + 0.7142\ (TEMP - DIST) \quad (2.9)$$

TEMP = Downhole temperature of hot water at source, °F; input variable,

DIST = Distance from resource to the population center, miles; input variable.

Neither the temperature nor the flow rate is assumed to decline through time. Accordingly, once the production and injection wells are drilled at the beginning of the project, they are assumed adequate to support the estimated demand throughout the project life.

$$NPW_t = RPW \qquad t=1 \quad (2.10a)$$

$$NPW_t = 0 \qquad t>1 \quad (2.10b)$$

$$NIW_t = NPW_t \ /PIR \quad (2.11)$$

PIR = Necessary production well to injection well ratio; input variable.

The second component of investment expenditures is the leasing investment. Leasing investment is a joint function of the acreage required for production and injection wells and the leasing cost per acre.

$$LNV_t = (DPAC)\ (ACPW)\ (NPW_t) + (DPAC)\ (ACIW)\ (NIW_t) \quad (2.12)$$

DPAC = Leasing cost, $ per acre; input variable,

ACPW = Required acreage per production well; input variable,

ACIW = Required acreage per injection well; input variable.

The third component of investment cost necessary for the development of a low temperature geothermal resource is the plant investment cost. Plant investment consists of two components. The first is transmission investment, the costs incurred in transporting geothermal hot water from the supply site to the point of demand. The second component is distribution investment, which consists of costs incurred in distributing geothermal water to individual demand units.

$$PLV = TRNV + DINV \quad (2\text{-}13)$$

TRNV = Transmission costs, $

DINV = Distribution costs, $

Each of these two investment expenses is individually explained below.

The transmission cost is a dual function of the transmission line pipe diameter (which is itself directly related to the amount of hot water to be transported) and the distance from the geothermal resource to the population center. This cost includes the expense of schedule 10 international pipe, fittings and valves, 2.5" insulation, tin shield, labor and trenching, modified expansion loop and miscellaneous costs associated with transmission pipe installation[5,6]. More specifically,

$$TRNV = 7.2474 + 2.699\ (TPD) \times 5280 \times DIST \quad (2.14)$$

$$TPD = \text{Transmission line pipe diameter, inches} \quad (2.15)$$

$$TPD = 6.6 + 4.04 \times HWLBH \times 10^{-6}$$

The transmission line pipe diameter is in each case adjusted to the next highest integer.

The distribution investment is a function of the peak heat demand.[6]

$$DINV = 0.75\ (115{,}000 \times PHD/3.413) \quad (2.16)$$

The final component of investment cost is the interest expense incurred during construction.

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5 C. L. McDonald and C. H. Bloomster, The Geocity Model: Description and Application, Battelle Pacific Northwest Laboratories, Richland, Washington, June 1977.

6 S. S. Einarsson, Geothermal Space Heating and Cooling, Second U. N. Symposium on the Development and Use of Geothermal Resources, San Francisco, California, 1975.

$$IDC_t = [BR] \left[\sum_{j=1}^{t} (DNV_j + LNV_j)\right] [DK], \quad (2.17a)$$

$$t = EXP + DVP,$$

$$IDC_t = [BR] \left[\sum_{j=1}^{t} (DNV_j + LNV_j + PLV_j)\right] [DK], \quad (2.17b)$$

$$t = EXP + DVP + CON,$$

$$IDC_t = 0, \qquad t > EXP + DVP + CON \quad (2.17c)$$

where

The sum of the present values of all of these four investment costs, including drilling, leasing, plant investment and interest during construction is equated to the sum of the net revenues earned. Net revenue is defined as gross revenue (REV) less variable expenses (TC) and taxes (TX). Taking each of these items in order,

$$REV_t = (AHD)\ (8760)\ P\ (1 + i)^t\ (1 - \lambda) \quad (2.18)$$

AHD = Average heat demand of the population center, in million Btu/hr

P = Price of alternate fuel (natural gas), $ per million Btu equivalent; input variable,

i = rate of growth of alternate fuel price; input variable,

λ = Royalty rate; input variable

$$AHD = (PHD)\ (LF) \quad (2.19)$$

PHD = Peak heat demand of the population center in million Btu/hr

LF = Load factor; input variable

Gross revenue is directly related to the average heat demand placed upon the system. In theory, the demand for space heating is extremely variable, both as a diurnal and on an annual basis. As mentioned above, the space heating system is assumed to have installed capacity sufficient to fulfill 75 percent of estimated peak heat demand; the remaining demand is assumed to be supplied by an appropriate backup system. Over a period

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APPENDIX 5

This appendix is a collection of site specific scenarios compiled on state by state basis. These scenarios are extracted from the state team final reports.

TABLE OF CONTENTS

	Page
Site Scenarios for the State of Arizona	5 - 2
Site Scenarios for the State of Colorado	5 - 4
Site Scenarios for the State of Nevada	5 -93
Site Scenarios for the State of New Mexico	5-379
Site Scenarios for the State of Utah	5-386

SITE SCENARIOS FOR THE STATE OF ARIZONA

ARIZONA

ESTIMATED USEABLE GEOTHERMAL ENERGY AT VARIOUS AREAS IN ARIZONA

Electric Power Generation

	Area	Proven	Probable	Inferred
1.	San Bernardino Valley	0 MW	50 MW	500 MW
2.	Clifton-Morenci-Safford	0 MW	50 MW	500 MW
3.	Springerville	0 MW	100 MW	500 MW
4.	Flagstaff	0 MW	100 MW	1000 MW
5.	Kingman	0 MW	25 MW	100 MW
6.	Yuma	0 MW	50 MW	50 MW
7.	Hyder Valley	0 MW	50 MW	500 MW
8.	Tucson	0 MW	10 MW	50 MW
9.	Phoenix	0 MW	50 MW	500 MW
10.	Wilcox	0 MW	25 MW	100 MW
11.	Palo Verde	0 MW	25 MW	100 MW
12.	Pinacati Field	0 MW	100 MW	500 MW
	TOTAL	0 MW	635 MW	4450 MW

Non-electric power-space heating, cooling, agriculture is guestimate at 1.5 times total power generation for the state.

Non-Electric Power

	Proven	Probable	Inferred
Total electric power	0 MW	635 MW	4450 MW
x 1.5	0 MW	952.5 MW	6675 MW
Grand Total	0 MW	1587.5 MW	11,125 MW

SITE SCENARIOS FOR THE STATE OF COLORADO

SITE SCENARIO

Hartsel, Colorado

Summary of Relevant Milestones and Events/Calendar Year	1978	1979	1980	1981	1982	1983	1984	2020
Summary ● Power on Line				◆		◆	◆	Approx. 2.5×10^{12} Btu's Consumed
Developer ● Geophysical Exploration and Resource Assessment	—							
● Leasing	—							
● Exploratory Drilling		—						
● Reservoir Characterization		—						
● Field Development			—	—	—			
User/ Utility ● Plant Feasibility Studies	—							
● Plant Design/Construction		—	—					
● Site Activation/Start Up/ Power On-Line			—	◆ $.04 \times 10^{12}$ Btu's	— ◆ .06	Btu's $\times 10^{12}$	◆ $.08 \times 10^{12}$ Btu's	
Regulatory ● Environmental		— —	—					
● Land Use/Water Use/Drilling		— —		—		—		
● Pricing								
Financial ● Investment	—	—		—				
Detailed Project Schedule/Net Work								
1.0 Owner								
2.0 City/County	(1)	(2)		(3)		(4)		
3.0 State		(5)	(6)	(7)				
4.0 Developer/Provider 4.1 Exploration 4.2 Leasing 4.3 Drilling	(8)	(9)	(10)	(11)		(12)		
5.0 User/Utility	(13)	(14)	(15)	(16)	(17)	(18)		
6.0 U. S. Dept. of Interior 6.1 BLM 6.2 USGS 6.3 Drilling	(19)	(20)						
7.0 U. S. Dept. of Agriculture								
8.0 Environmental		(21)						
9.0 Pricing Reg.	(22)							
10.0 Financial Institutions	(23)	(24)		(25)	(26)			
11.0 DOE/DGE	(27)	(28)		(29)				
12.0								

LEGEND

1. Fairplay learns about potential for geothermal heating.
2. Issues permit for test well then production wells.
3. Issues permit for greenhouse.
4. Recreation development obtains permit for development.
5. Issues permit for test well, then for production wells, disposal wells.
6. State and regulatory economic development agencies promote resource for process use.
7. Approves right-of-way request.
8. Does preliminary exploration. Applies for BLM leases, drills shallow gradient holes.
9. Applies for permit to drill exploratory well. Drills May. Produces test well - applies for or buys water rights.
10. Drills production and disposal wells. Supplies to Fairplay utility. Has approval for further field development.
11. Drills more wells; production and disposal.
12. Drills another production well.
13. Does preliminary study for space heating. Conversion from propane and for process uses.
14. Promoter for Fairplay system. Applies for federal grant or loan guarantee. Does engineering. Gets Right-of-way, starts construction.
15. Pipeline constructed. Business and homeowners convert to geothermal heating systems. Greenhouse does evaluation, decides to build here Applies for permit.
16. Greenhouse applies for loan - Federally guaranteed. Starts engineering design and construction.
17. Greenhouse on line. Other users become interested. Feed lot will use waste heat. Tourist attraction at South Park. City begins planning for facilities.
18. Recreation Development with baths, swimming pool at South Park. City begins construction. Will use geothermal for all possible energy uses.
19. BLM does EAR, issues leases.
20. USGS issues permits for test well, then for production wells (After EAR), and for disposal wells, approves right-of-way request.

LEGEND - Hartsel, Colorado (Continued)

21. BLM does EAR for development. Developer for system.

22. Price of natural gas deregulation. Tax incentive for geothermal developer.

23. Financing obtained for exploration program.

24. Financing approved for field development.

25. Approves loan application for greenhouse.

26. Approves loan for new recreational development.

27. Works with BLM to get leases out.

28. EAR for funding approved. Approves grant or loan guarantee.

29. Approves loan guarantee.

SITE SCENARIO

Clenwood Springs, Colorado

Summary of Relevant Milestones and Events/Calendar Year	1978	1979	1980	1981	1982	1983	1984	2020
Summary ● Power on Line			◆	◆	◆			1.70 x 10^{12} Btu's Consumed
Developer ● Geophysical Exploration and Resource Assessment								
● Leasing								
● Exploratory Drilling								
● Reservoir Characterization								
● Field Development		No. 2						
User/Utility ● Plant Feasibility Studies								
● Plant Design/Construction		No. 1		No. 3				
● Site Activation/Start Up/Power On-Line		No. 2	No. 1 ◆ .03x10^{10}	No. 2 ◆	No. 3 6x10^{10}			
Regulatory ● Environmental								
● Land Use/Water Use/Drilling								
● Pricing								
Financial ● Investment								
Detailed Project Schedule/Net Work								
1.0 Owner								
2.0 City/County	(1)	(2)	(3)	(4)				
3.0 State	(5)	(6)	(7)					
4.0 Developer/Provider								
4.1 Exploration	(8)							
4.2 Leasing								
4.3 Drilling								
5.0 User/Utility	(9)	(10)	(11)	(12)				
6.0 U. S. Dept. of Interior								
6.1 BLM								
6.2 USGS								
6.3 Drilling								
7.0 U. S. Dept. of Agriculture								
8.0 Environmental		(13)						
9.0 Pricing Reg.								
10.0 Financial Institutions			(14)					
11.0 DOE/DGE	(15)	(16)						
12.0								

Glenwood Springs, Colorado

LEGEND

1. Permit for exploratory well.
2. Issues permits for well development.
3. Issues permits for well(s).
4. Issues permits for development.
5. State issues permits for exploratory well - O&GCC. State engineer, water quality and air pollution.
6. State issues permits for highway department to drill well.
7. Issues permits for city well(s).
8. State GS does perliminary assessment and drills exploratory well on city lease.
9. City submits proposal for funding for conversion of school to geothermal heat. State highway department assesses for snow melt on planned highway.
10. City has engineering design done, establishes heating district, starts development. Highway department does engineering, environmental assessment, drills well, obtains right-of-way. City does preliminary evaluation assessment for second phase.
11. City installs in school.
12. City drills well(s), does engineering design, obtains right-of-way, starts construction of second phase - - public buildings, stores, new subdivisions. Highway department installs on roadway.
13. Decides whether to use heat exchanger because of high TDS.
14. Voters approve city bond issue.
15. Approves request to fund system development, works with EPA to develop simplified procedure for obtaining permits for test wells.
16. Heat exchanger developed for efficient use in highway for snow melt.

SITE SCENARIO

San Luis Valley, Colorado

Summary of Relevant Milestones and Events/Calendar Year	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	2020[1]
Summary ● Power on Line											$43x10^{12}$ Btu's Consumed
Developer ● Geophysical Exploration and Resource Assessment	—	—									
● Leasing	—										
● Exploratory Drilling	—	— —	—								
● Reservoir Characterization	—										
● Field Development		—	—	—	—	—	—	—	—	—	—
User/ Utility ● Plant Feasibility Studies	— —										
● Plant Design/Construction		—	—	—							
● Site Activation/Start Up/ Power On-Line			.40x10^{12} Btu's	1.34x10^{12} Btu's	1.4x10^{12} Btu's	1.46x10^{12} Btu's/yr.	1.48x10^{12} Btu's/yr	1.5	1.52	1.54x10^{12}	Btu's
Regulatory ● Environmental		—	—								
● Land Use/Water Use/Drilling	—	—	—	—							
● Pricing	—			—							
Financial ● Investment	—	— —	—	—							
Detailed Project Schedule/Net Work											
1.0 Owner											
2.0 City/County	(1)	(2)	(3)								
3.0 State	(4)	(5)	(6)								
4.0 Developer/Provider 4.1 Exploration 4.2 Leasing 4.3 Drilling	(7)	(8)	(9)	(10)							
5.0 User/Utility	(11)	(12)	(13)	(14)							
6.0 U. S. Dept. of Interior 6.1 BLM 6.2 USGS 6.3 Drilling			(15)								
7.0 U. S. Dept. of Agriculture											
8.0 Environmental			(16)								
9.0 Pricing Reg.	(17)										
10.0 Financial Institutions	(18)	(19)		(20)							
11.0 DOE/DGE	(21)	(22)									
12.0		(23)									

LEGEND

1. Permits for test well at Splashland. Permits for Baca Grande system. Permits for development.

2. Permits for production wells at Splashland, sand dunes test, then production mineral.

3. Permits for test wells at Shaws, production, lumber kiln at Mineral.

4. Permits for test wells. Permits for system development at Baca Grande (including PUC), and right-of-way. Permits for development at Mineral.

5. Permits for production wells, Splashland, Sand Dunes, Test at Mineral, then for field development on state private land.

6. Permits for test wells at Shaws, production - permits for lumber kiln.

7. Major assigns lease to company with direct use interest. Promote Alamosa to use for space heating. Test well drilled. Decides to invest in Baca Grande. Drills test well. Starts program at Mineral. Applies for Federal Grant.

8. Drills production wells. Installs heat exchangers at Splashland and Sand Dunes. Drills thermal gradient at Shaws. Drills test at Mineral, evaluates and produces.

9. More power on line as development proceeds at Baca Grande. Drills test well at Shaws, produces. Drills more wells at Mineral.

10. Drills production wells on federal land.

11. Feasibility study for Alamosa space heating public buildings. City floats bond. Baca Grande decides to install alternate heat in development, Sand Dunes gets federal guaranteed loan - permits for system development, right-of-way, does design. Decides to malt barley at Mineral. Applies for grant. Feasibility study for vegetables dehydration.

12. Alamosa gets right-of-way leases, permits, establishes heating district, Does design, construction. Baca Grande Construction. Decision to build greenhouses at Shaws. Applies for grant. Decision to do potato flakes. Design for barley malt plant at Mineral, then construction. Design for vegerable dehydration, then construction. Lumber mill decides to use, gets permit.

13. Engineer construction of greenhouse at Shaws. Right-of-way for lumber kiln, pipelines, design, construction.

14. Town of Saquache decides to use for heating, floats bond, gets permit and right-of-way. Designs, constructs.

15. Permits to develop field from USGS after EIS.

16. EIS for field development at Mineral.

17. Price of natural gas rises, makes retrofitting at Alamosa economical.

18. Approves loan for Baca Grande and for well at Mineral.

19. Approves loan for lumber kiln.

20. Municipal bond for space heating.

21. Approves loan guarantee for Baca Grande.

22. Approves grant for greenhouse. Approves grant for barley malting.

23. Downhole heat exchangers improved.

SITE SCENARIO

Wannita, Colorado

Summary of Relevant Milestones and Events/Calendar Year	1978	1979	1980	1981	1982	1983	1984	2020[1]
Summary ● Power on Line			◆		◆			3.6 x 10^{12} Btu's consumed
Developer ● Geophysical Exploration and Resource Assessment	———							
● Leasing		——						
● Exploratory Drilling		——						
● Reservoir Characterization								
● Field Development				——				
User/ Utility ● Plant Feasibility Studies	——	———						
● Plant Design/Construction		No.1		No.2				
● Site Activation/Start Up/ Power On-Line			◆ .04x 10^{12} Btu's/.yr.		No.2 ◆ .12x10^{12} Btu's/yr			
Regulatory ● Environmental	———	———	———	——				
● Land Use/Water Use/Drilling	———	———	———	——				
● Pricing								
Financial ● Investment	——		——					
Detailed Project Schedule/Net Work								
1.0 Owner		(1)	(2)					
2.0 City/County	(3)	(4)	(5)					
3.0 State	(6)	(7)	(8)					
4.0 Developer/Provider (9) 4.1 Exploration 4.2 Leasing 4.3 Drilling	(10)	(11)		(12)				
5.0 User/Utility	(13)	(14)	(15)					
6.0 U. S. Dept. of Interior 6.1 BLM 6.2 USGS 6.3 Drilling	(16)	(17)		(18)				
7.0 U. S. Dept. of Agriculture USFS	(19)	(20)	(21)					
8.0 Environmental		(22)						
9.0 Pricing Reg.	(23)							
10.0 Financial Institutions	(24)		(25)					
11.0 DOE/DGE	(26)							
12.0								

LEGEND

1. Right-of-way for lumber kiln pipeline.
2. Leases right-of-way.
3. Permit for test well.
4. Permit for kiln.
5. Permit for district heating system in Gunnison.
6. Permits for test well.
7. Permit for water consumption for kiln.
8. Issues permit for production well.
9. Has state leases filed for NF leases in 1974.
10. Obtain leases on National Forest. Assigns all leases to direct use company. Company files application for permits for test well, obtains funds, promotes uses, drills thermal gradient holes.
11. Drills test well. Applies for permits for development and disposal including production of test well.
12. Drills wells for Gunnison space heating.
13. Does feasibility study for timber drying.
14. Starts design, construction of kiln. Feasibility studies for space heating at Gunnison.
15. Design, construction of space heating for Gunnison, pipeline from wells.
16. BLM issues leases after USFS review and USGS review.
17. USGS does EIS for development/disposal/utilization, including right-of-way.
18. Permits for Production/disposal/utilization.
19. Recommend leasing NF lands.
20. Input to EIS for development.
21. Approves right-of-way for pipeline to Gunnison.
22. Full EIS for development wells, primarily forest lands and for right-of-way.

LEGEND - Wannita, Colorado (Continued)

23. Natural gas prices higher. Incentives for geothermal development initiated.

24. Funds/exploration program available.

25. Town of Gunnison floats bond issue for space heating for schools, public buildings.

26. Assist with funding, exploration.

SITE SCENARIO

Pagosa Springs, Colorado

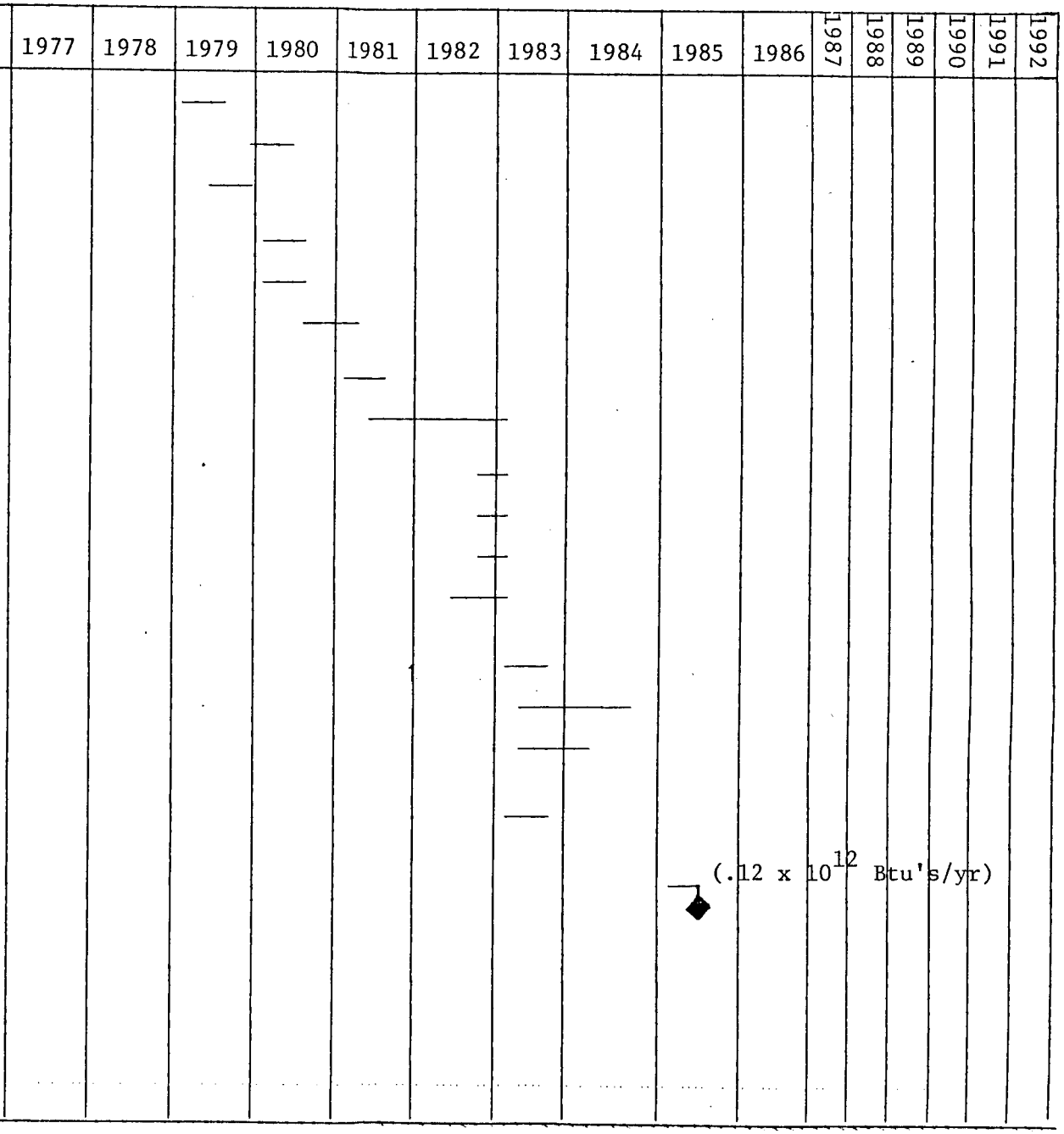
Summary of Relevant Milestones and Events/Calendar Year	1978	1979	1980	1981	1982	1983	1984	2020
Summary ● Power on Line			◆	◆				
Developer ● Geophysical Exploration and Resource Assessment								
● Leasing								
● Exploratory Drilling	No.1							
● Reservoir Characterization								
● Field Development		No.2	No.3					
User/Utility ● Plant Feasibility Studies	No.1 No.2		No.3					
● Plant Design/Construction		No.1	No.2	No.3				
● Site Activation/Start Up/ Power On-Line			.15x10^{12} Btu's ◆	.09 ◆	.10x10^{12} Btu's			2.9x10^{12} Btu's Consumed
Regulatory ● Environmental								
● Land Use/Water Use/Drilling								
● Pricing								
Financial ● Investment	No.1	No.2	No.3					
Detailed Project Schedule/Net Work								
1.0 Owner		(1)	(2)	(3)				
2.0 City/County								
3.0 State	(4)	(5)	(6)					
4.0 Developer/Provider	(7)	(8)	(9)					
4.1 Exploration								
4.2 Leasing								
4.3 Drilling								
5.0 User/Utility	(10)	(11)	(12)	(13)				
6.0 U. S. Dept. of Interior								
6.1 BLM								
6.2 USGS								
6.3 Drilling								
7.0 U. S. Dept. of Agriculture								
8.0 Environmental	(14)	(15)						
9.0 Pricing Reg.								
10.0 Financial Institutions		(16)	(17)					
11.0 DOE/DGE		(18)	(19)	(20)				
12.0								

LEGEND

1. Allows right-of-way for district heating system.
2. Issues leases for wells to town
3. Allows right-of-way for district lines.
4. Issues permits for exploratory well.
5. Issues permit for consumption of water by town utility. Issues permits for production well for lumber company, then for development of kiln.
6. Issues permits for well(s).
7. State GS drills exploratory well.
8. Lumber company obtains leases, drills well(s).
9. Town utility drills wells for residential heating system, first new, then converted structures.
10. Town establishes utility authority. Applies for federal funds for direct application. Lumber mill does feasibility study for kiln-drying with geothermal.
11. Contractor does design. Construction starts for district heating for commercial, senior citizens, schools, reconvert to geothermal heat. Lumber mill applies for insured loan.
12. Utility authority gets federal funds - does feasibility study for residential space heating. Applies for guaranteed loan. Lumber mill installs kiln.
13. Town utility converts old residences to geothermal, installs geothermal in new, up to limit of resource.
14. DOE approves environmental assessment.
15. Lumber co-op obtains EPA approval for geothermal kiln.
16. Federally insured loan granted to lumber company for kiln.
17. Federal guaranteed loan to town utility.
18. Approves grant application - town.
19. Helps lumber company loan application approval.
20. Funds feasibility study for residential use. Helps guaranteed loan approval.

JUNIPER/CRAIG NO, 1/2
SCENARIO FOR DEVELOPMENT

Operating Entity	Activity	Recipients
Developer	Preliminary Geophysics	
Developer	Gradient holes, eval.	
Utility	Feas. study for space heating	
Owners	Leases	
BLM	Leases	
USGS/State Co.and/orTown	Permits for test well	
Developer	Drill test well	
USGS/State Co.&orTown	Permit for field development/R.O.W.	
Utility	Water rights	
	R.O.W.	
Fin. Inst.	Loan or bond	
State/Co. & or Town	Permit to dev. system	
Utility	Design system	
Utility	Construction system	
Utility	Install in new structure, then retrofit existing	
Developer	Drill wells and/or produce test well	
	Heat on line	



ROUTT/STEAMBOAT HOT SPRINGS NO. 3/4

SITE DEVELOPMENT SCHEDULE

Operating Entity	Activity	Recipients	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Developer	Prelim. Geophysics																	
Developer	Drill Grad. holes, eval.																	
Developer	Feas. studies-Steam. Sprgs.																	
DOE/DGE	Grant for test well	Developer																
State,City	Permits for test well	Developer																
Developer	Drill test well, eval.																	
City	Establish heat. dist.																	
City	Obtain water rights																	
DOE/DGE	Guar. loan for system	City																
State/City	Permits-dev. test well	developer																
City	Right-of-way																	
City	Design																	
City	Constr. of system																	
City	Install. in approx. 225 dwell. units						(.02x10^{12} Btu's/hr.)											
Developer	Prod. test well																	
State/City	Permits for field dev.																	
Developer	Develop field																	
BLM-USFS	Leases on Natnl For.																	
USFS	Permit for grad. holes																	
Developer	Drill & eval. grad.																	
USGS, Co.	Permit for test wells																	
State																		
Developer	Drill test, eval.																	
USGS, Co.	Permits for field dev.																	
State																		
Developer	Field development																	
USFS-Priv.	Approve R.O.W.																	
Owners City	Expand system to 1000 homes. comm. & indust. Expanded as needed to .25 x 10^{12} Btu's By the year, 2012, 7.4 x 10^{12} Btu's consumed.								(.18 x 10^{12} Btu's/yr.)			(25 x 10^{12} Btu's)						

BRAND'S RANCH NO. 5
SCENARIO FOR DEVELOPMENT

Operating Entity	Activity	Recipients	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Developer	Preliminary Geophysics				—													
Developer	Gradient holes, eval.					—												
Utility	Feas. Studies for space heating'				—													
Owners	Leases					—												
State/Co/ and/or Town	Permits for test well						—											
Developer	Drill test well, eval.						—											
State/Co/ and/or Town	Permit to dev. system						—	—										
Utility	Water Rights						—											
	R.O.W.						—											
Fin. Inst.	Loan or bond						—											
Utility	Design system							—										
Utility	Construct System							—	—									
Utility	Install in new structures, then retrofit existing							—	—	—								
State/Co.	Permits to dev. well						—											
Developer	Develop test well							—										
	Heat on Line								—	(.007 x 10^{12} Btu's/yr.)								

HOT SULPHUR SPRINGS NO. 6
SITE DEVELOPMENT SCHEDULE

Operating Entity	Activity	Recipients	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Developer	Preliminary Geophysics			—														
Developer	Gradient holes, eval.				—													
City	Feas. Studies for Hot Sulphur Springs		—	—														
Owner	Leases				—													
DOE/DGE	Grant for test well				—													
State/Co.	Permits for test well				—													
Developer	Drill test well, eval.				—													
State/Co.	Permit to produce test well				—	—												
State/City	Permit to dev. system				—	—												
Developer	Water rights					—												
City	R.O.W.					—												
DOE/DGE	Guar. Loan for system					—	—											
City	Design					—	—											
City	Constr. of system						—											
City	Retro-homes, bus.						—											
City	Connect to 123 homes, plus business						◆	(.02 x 10^{12}	Btu's/yr.)									
City	Feas. studies for Kremmling/Granby					—	—											
BLM	Issue leases						—											
USGS	Permits for field development						—	—										
State/Co., Cities	Permits for system							—										
Cities	Design							—										
Cities	Construction								—									
Cities	Retrofit homes, bus.								—									
Cities	Connect to approx.	700 homes plus businesses							◆	(.14 x 10^{12}	Btu's/yr.)							

HAYSTACK BUTTE NO. 7

SCENARIO FOR DEVELOPMENT

Operating Entity	Activity	Recipients	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Developer	Preliminary Geophysics			—														
Developer	Gradient holes, eval.			—	—													
Town	Feas. Studies for space heating			—														
Owners	Leases																	
DOE/DGE	Grant for test well				—	—												
State/Co./ Town	Permits for test well					—												
Developer	Drill test well, eval.					—	—											
State/Town	Permit to dev. system						—											
Town	Water rights						—											
Town	R.O.W.						—											
DOE/DGE	Grant for system						—											
Town	Design						—											
Town	Constr. of system							—										
Town	Install-new homes, bus.							—	(.03 x 10^{12} Btu's/yr.)									

ELDORADO SPRINGS NO. 8
SCENARIO FOR DEVELOPMENT

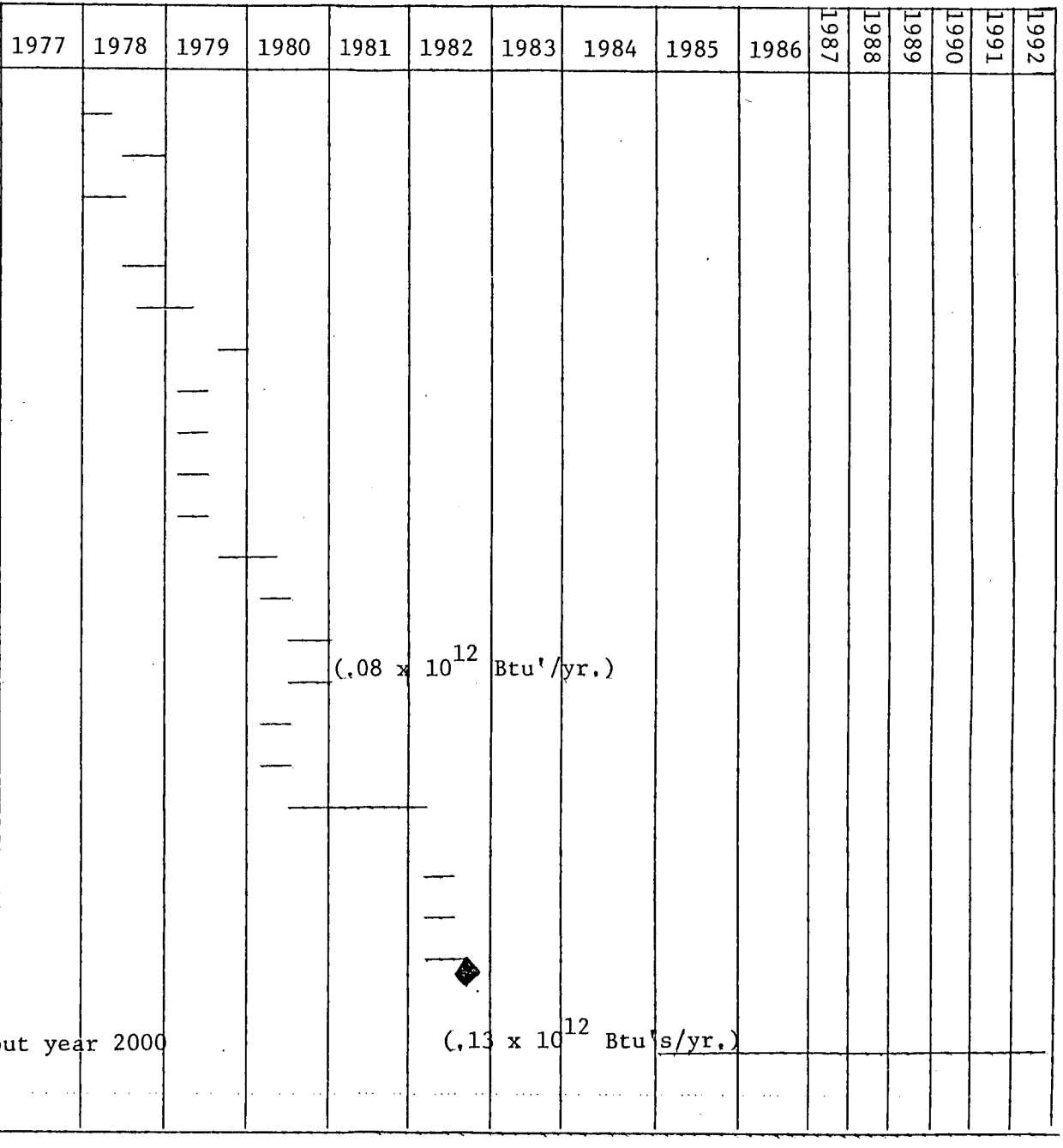
Operating Entity	Activity	Recipients
Developer	Preliminary Geophysics	
Developer	Gradient holes, eval	
Resort	Feas. Studies for space heating	
State/Co.	Permits for test well	
Developer	Drill test well	
State/Co. City	Permits to dev. system	
DOE/DGE	Guar. loan for system	
Resort	Design	
Resort	Construction	
Resort	Retrofit res. & comm. buildings	
	Connect	

1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992

(.02 x 10^{12} Btu's/yr)

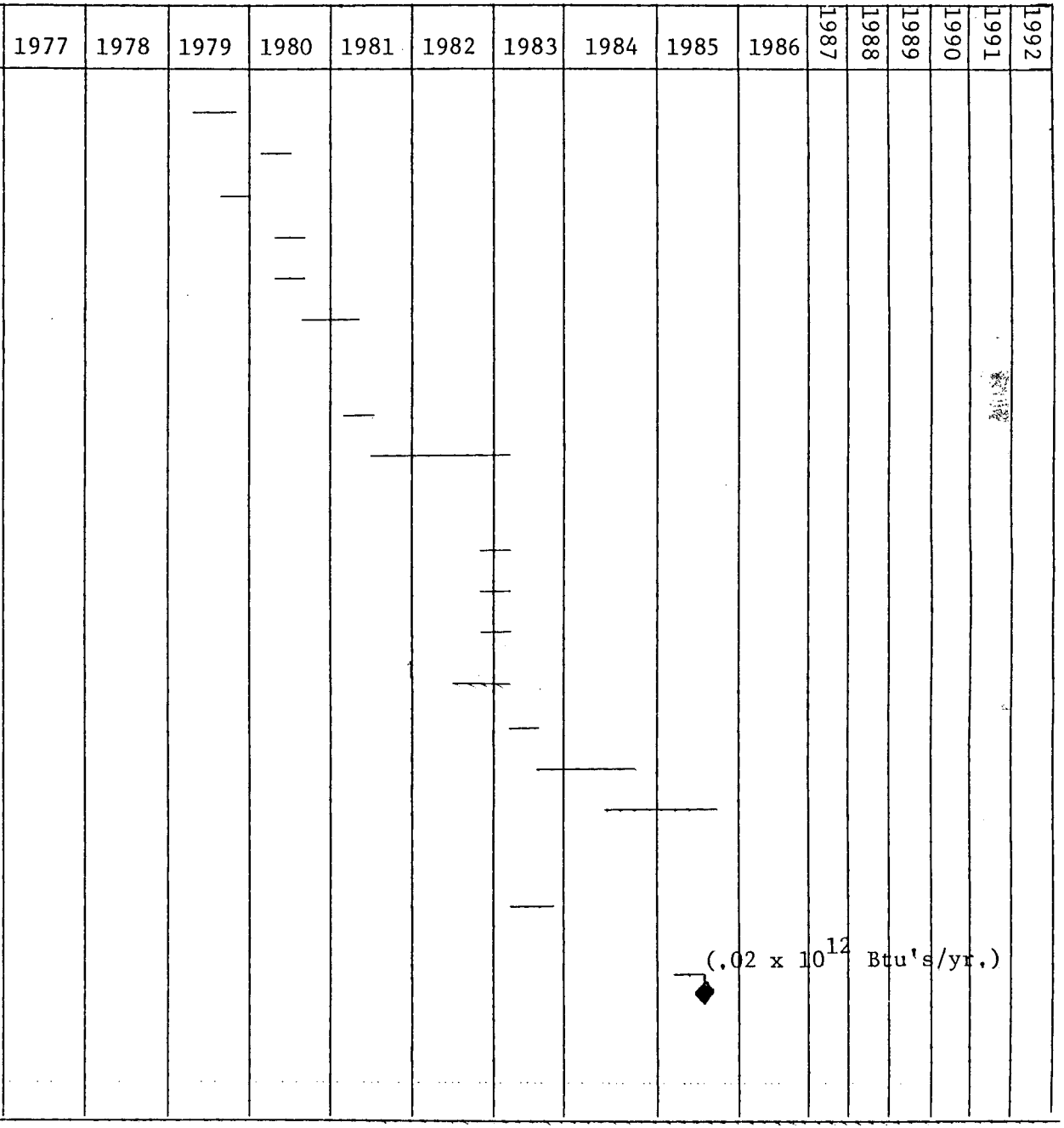
IDAHO HOT SPRINGS NO. 9
SITE DEVELOPMENT SCHEDULE

Operating Entity	Activity	Recipients
Developer	Preliminary Geophysics	
Developer	Gradient holes, eval.	
City	Feas. Studies for town space heating	
Owners	Leases	
DOE/DGE	Grant for test well	
Developer	Drill test well, eval.	
State/Co.	Permits to drill test well	
State/City	Permit to dev. system	
City	Water rights	
City	R.O.W.	
DOE/DGE	Guar. Loan for system	
City	Design	
City	Constr. of system	
City	Install. in homes, bus.	
City	Connect to homes, bus.	
BLM/USFS	Leases on Natl For.	
USGS/State County	Permit for field dev.	
Developer	Drill more wells	
USFS/Owners	Approve R.O.W.	
City	Expand system to as needed to existing structures.	
	Expand to .25 x 10^{12} Btu's - about year 2000	



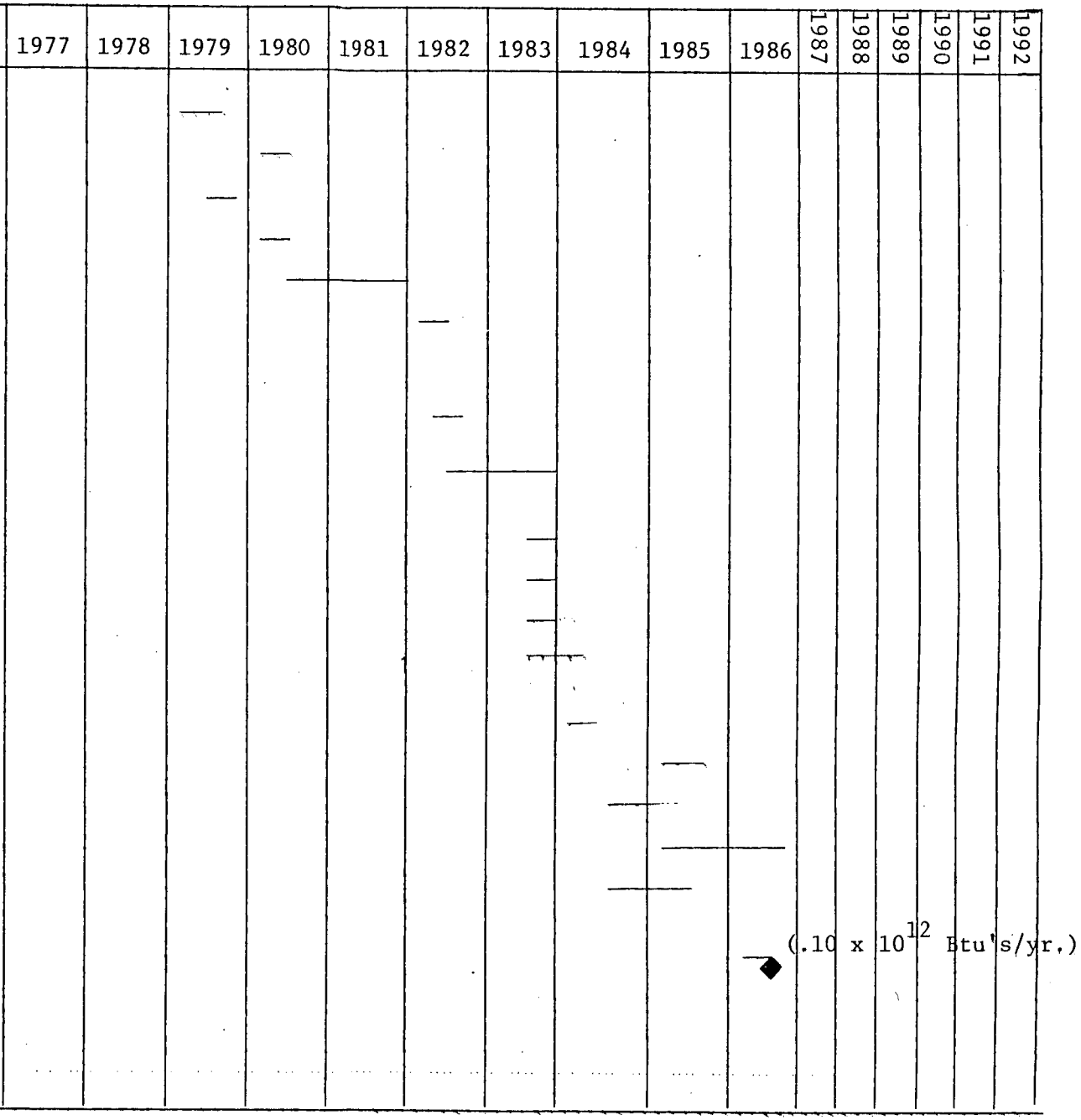
SOUTH CANYON NO. 12
SCENARIO FOR DEVELOPMENT

Operating Entity	Activity	Recipients
Developer	Preliminary Geophysics	
Developer	Gradient holes, eval	
Utility	Feas. study for space heating	
Owners	Leases	
BLM	Leases	
USGS/State/Co.and/or Town	Permits for test well	
Developer	Drill test well	
USGS/State Co.and/or town	Permit for field development/R.O.W.	
Utility	Water rights	
	R.O.W.	
Fin. Inst.	Loan or bond	
State/Co. and/or Town	Permit to dev. system	
Utility	Design system	
Utility	Construct system	
Utility	Install in new structures, then retrofit existing	
Developer	Drill wells and/or produce test well	
	Heat on line	



PENNEY NO. 13
SCENARIO FOR DEVELOPMENT

Operating Entity	Activity	Recipients
Developer	Preliminary Geophysics	
Developer	Gradient holes, eval.	
Utility	Feas. study for space heating	
Owners	Leases	
BLM/USFS	Leases	
USGS/State/Co.and/or town/FS	Permits for test well	
Developer	Drill test well	
USGS/State/Co. and/or Town/USFS	Permit for field development/R.O.W.	
Utility	Water rights	
	R.O.W.	
Fin.Inst.	Loan or bond	
State/Co. and/or town	Permit to dev. system	
Utility	Design system	
Utility	Construct system	
Utility	Install in new structure	
	then retrofit existing	
Developer	Drill wells and/or produce test well	
	Heat on line	



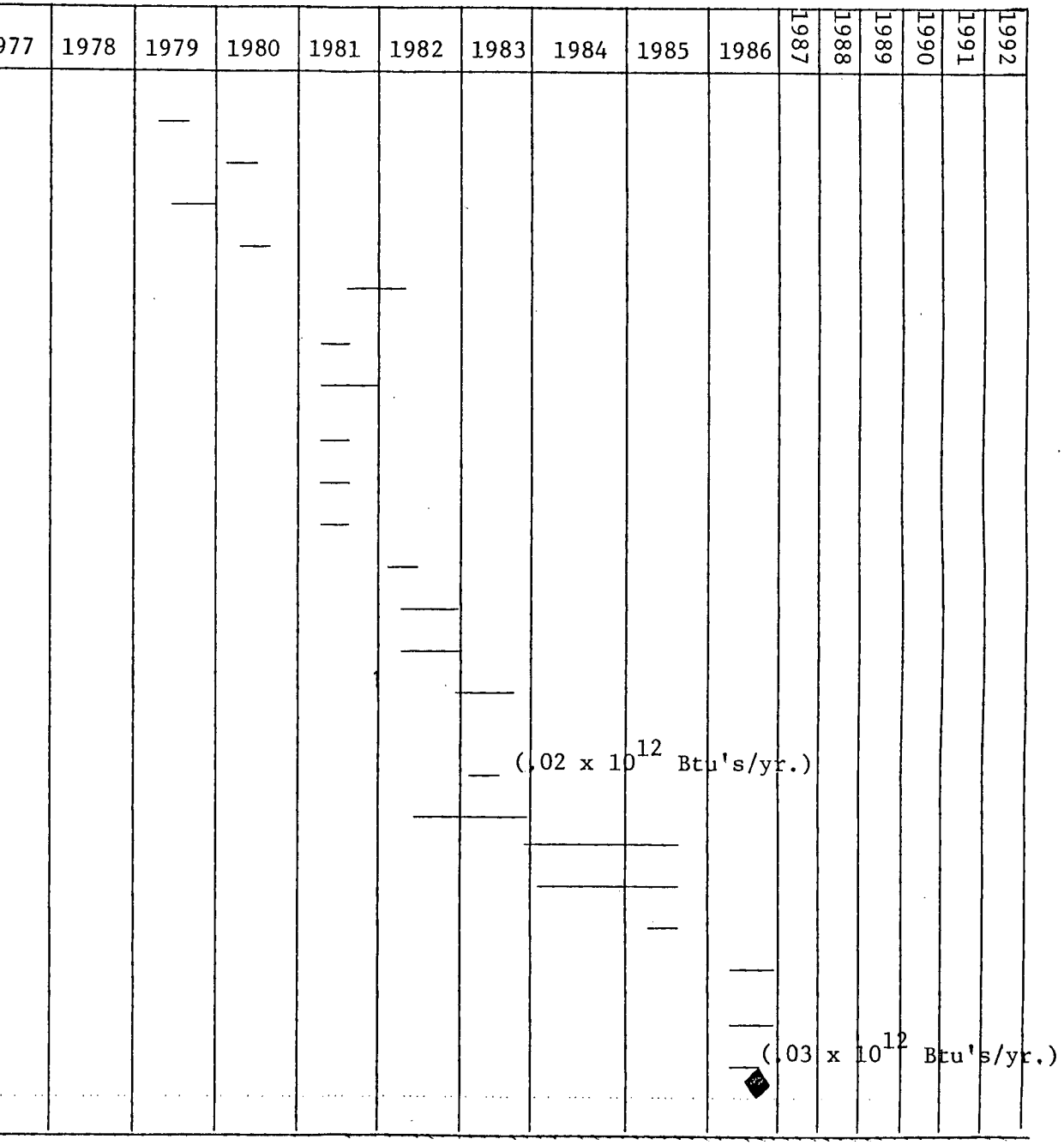
COL. CHINN NO. 14
SCENARIO FOR DEVELOPMENT

Operating Entity	Activity	Recipients	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Developer	Preliminary Geophysics				—													
Developer	Gradient holes, eval.					—												
Utility	Feas. Studies for space heating				—													
Owners	Leases					—												
State/Co. and/or Town	Permits for test well						—											
Developer	Drill test well, eval.						—											
State/Co./ and/or Town	Permit to dev. system						—	—										
Utility	Water rights						—											
	R.O.W.						—											
Fin. Inst.	Loan or bond						—											
Utility	Design System							—										
Utility	Construct system							—	—									
Utility	Install in new structures, then retrofit existing								—									
Developer	Permit to produce test well						—											
Developer	Produce test well							—										
	Heat on line								—	(.04 x 10^{12} Btu's/yr.)								

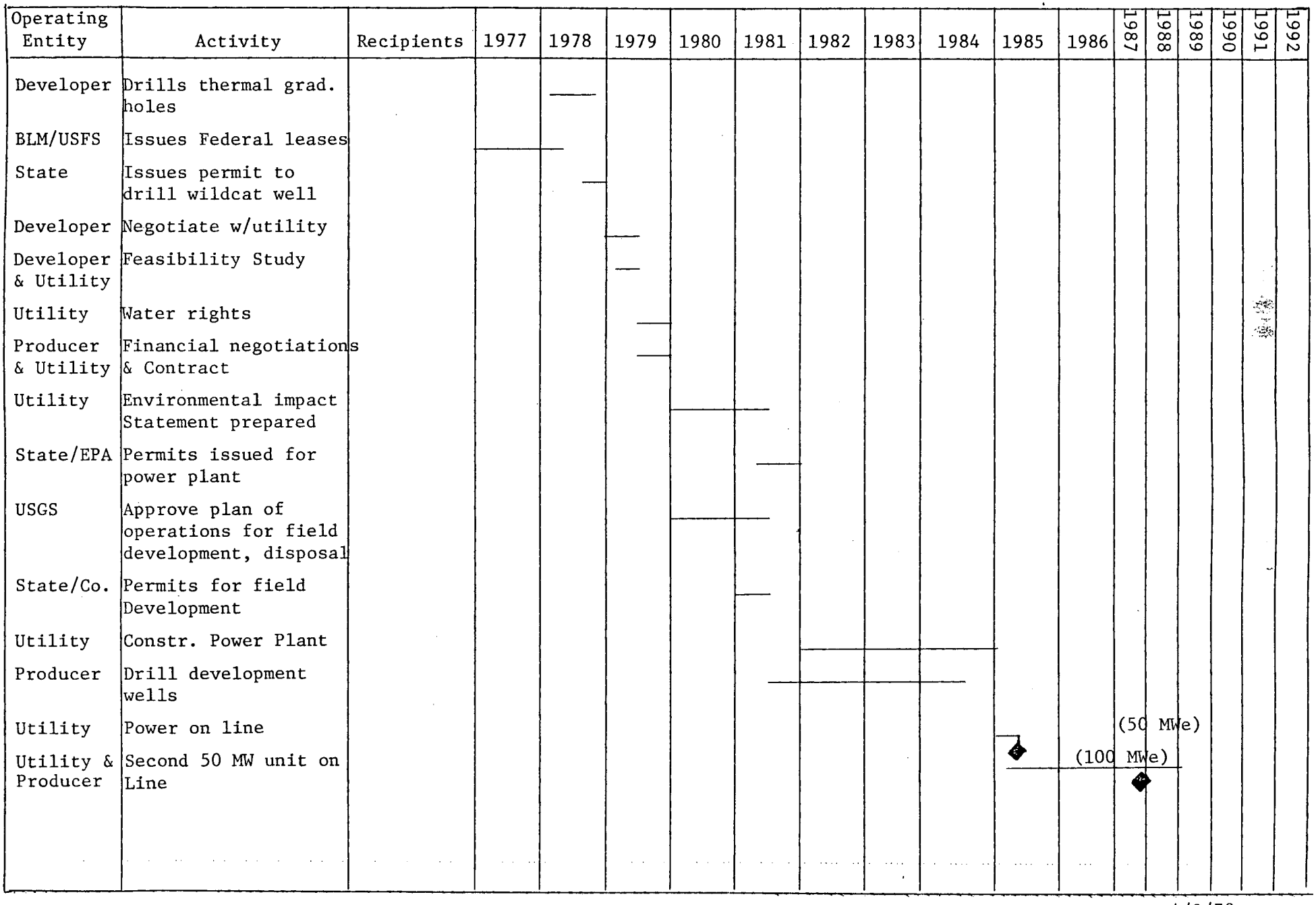
CEMENT CREEK/RANGER NO. 16/17

SCENARIO FOR DEVELOPMENT

Operating Entity	Activity	Recipients
Developer	Preliminary Geophysics	
Developer	Gradient holes, eval.	
Utility	Feas. Studies for space heating	
Owners	Leases	
State/Co./ and/or Town	Permits for test well	
Developer	Drill test well, eval.	
State/Co./ and/or Town	Permit to dev. system	
Utility	Water rights	
	R.O.W.	
Fin. Inst.	Loan or bond	
Utility	Design system	
Utility	Construct system	
Utility	Install in new structures	
State/Co.	Permit to develop well	
Developer	Develop test well	
	Heat on line	
BLM/USFS	Leases	
USGS/State/Co.	Permits to develop field	
USFS	R.O.W.	
Developer	Drill well at Cement Creek	
Utility	Construct pipeline from cement creek	
Utility	Retrofit existing Structures	
	Heat on line	



CHALK CREEK, MT, PRINCETON NO, 21A
SITE DEVELOPMENT SCHEDULE



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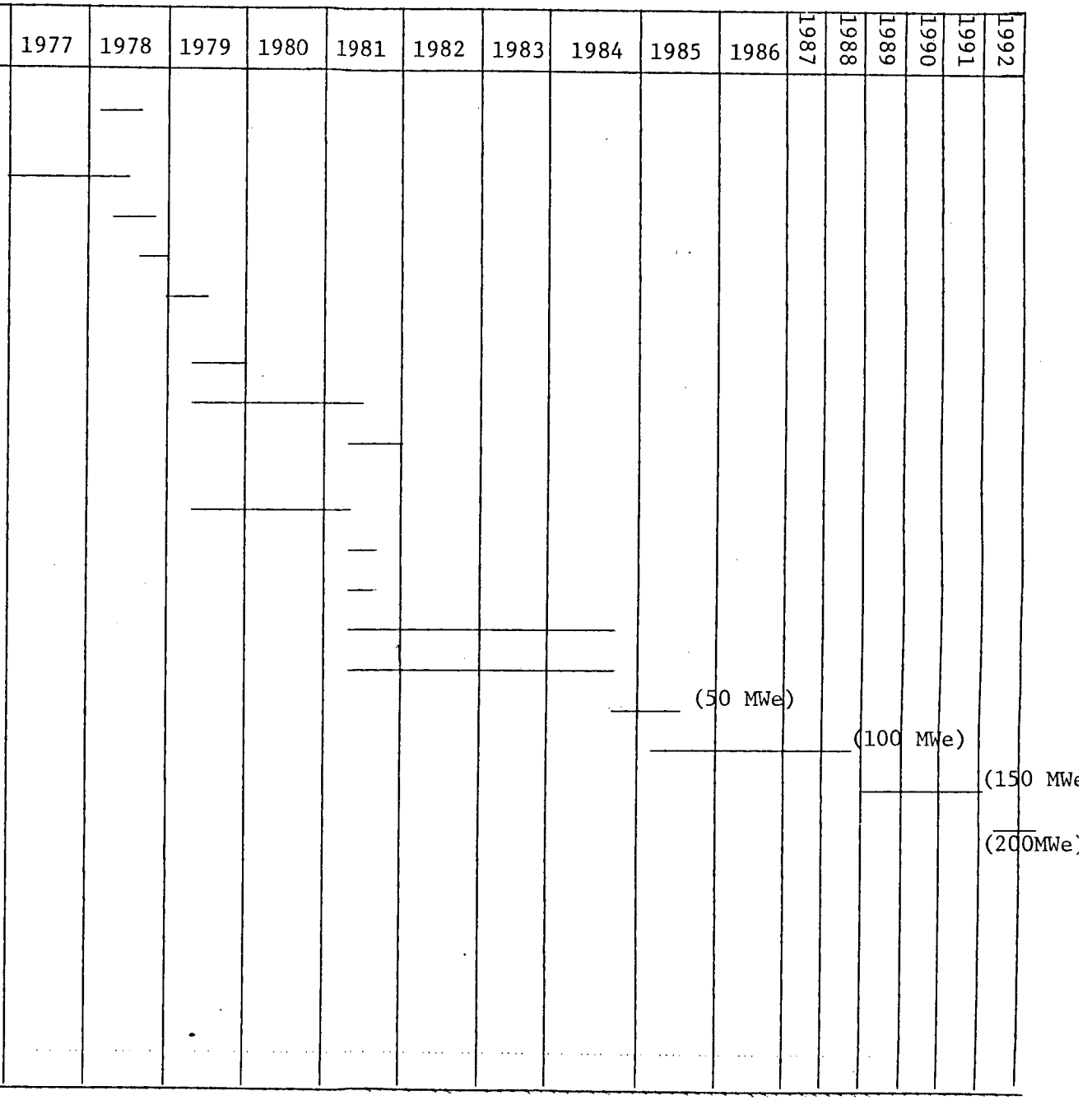
PONCHA SPRINGS NO. 23
SITE DEVELOPMENT SCHEDULE

Operating Entity	Activity	Recipients
Developer	Drills thermal grad hole	
BLM/USFS	Issues leases	
State/Co.	Issue permits for wells	
Developer	Drills slim holes	
Producer/ Utility	Negotiate contract	
Utility	Buys water rights	
Utility	EIS for power plant	
State/Co./ EPA	Issue permit for power plant	
USGS	EIS for field development	
USGS	Approves field development	
State/Co.	Permits for field dev.	
Utility	Constr. power plant	
Producer	Drills dev. wells	
Utility	50 MW power on line	
Utility	Adds 2nd unit (100 MW)	
Utility	Add 3rd unit (150 MW)	
Utility	Add 4th unit (200 MW)	



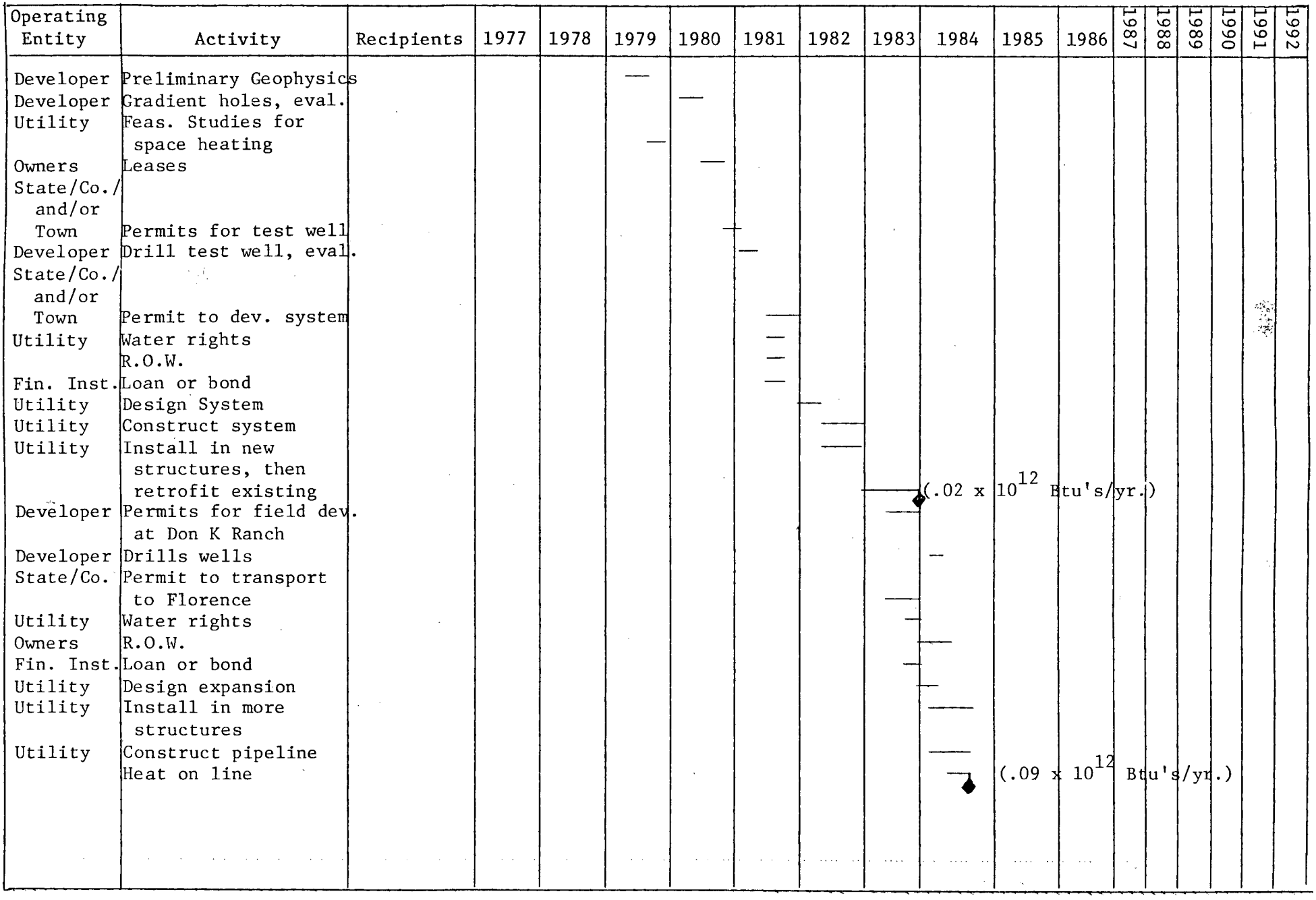
WELLSVILLE/SWISSVALE NO. 24/25
SCENARIO FOR DEVELOPMENT

Operating Entity	Activity	Recipients	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Developer	Preliminary Geophysics				—													
Developer	Gradient holes, eval.					—												
Utility	Feas. study for space heating				—													
Owners	Leases					—												
BLM	Leases					—												
USGS/State/ Co.and/ or town	Permits for test well						—											
Developer	Drill test well						—											
USGS/State/ Co. and/ or town	Permit for field development/R.O.W.							—	—									
Utility	Water rights								—									
	R.O.W.								—									
Fin. Inst.	Loan or bond								—									
State/Co. and/or Town	Permit to dev. system								—									
Utility	Design system								—									
Utility	Construct system									—	—							
Utility	Install in new structures, then retrofit existing									—	—							
Developer	Drill wells and/or produce test well								—									
	Heat on line										◆	(.02 x 10^{12} Btu's/yr.)						

CANON CITY/FREMONT NO. 26/27
SCENARIO FOR DEVELOPMENT

Operating Entity	Activity	Recipients	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Developer	Preliminary Geophysics				—													
Developer	Gradient holes, eval.					—												
Utility	Feas. Studies for Space Heating				—													
Owners State/Co. and/or Town	Leases					—												
	Permits for test well						—											
Developer State/Co./ and/or town	Drill test well, eval.						—											
	Permit to Dev. system						—											
Utility	Water rights						—											
	R.O.W.						—											
Fin. Inst.	Loan or bond						—											
Utility	Design System							—										
Utility	Construct system							—	—									
Utility	Install. in new structure then retrofit existing							—	—	—								
State/Co. Developer	Permit to Dev. well Develop test well Heat on line						—	—	—	◆ (.01 x 10^{12} Btu's/yr.								
State/Co.	Permit to dev. field at Fremont								—	—								
Utility	Water rights									—								
Owners	R.O.W.									—								
Utility	Design Extension									—								
Utility	Construct extension										—							
Utility	Retrofit more structures										—							
	Heat on Line										◆	(.03 x 10^{12} Btu's/Yr)						

DON K RANCH/FLORENCE NO. 28/29
SCENARIO FOR DEVELOPMENT



CLARK NO. 30

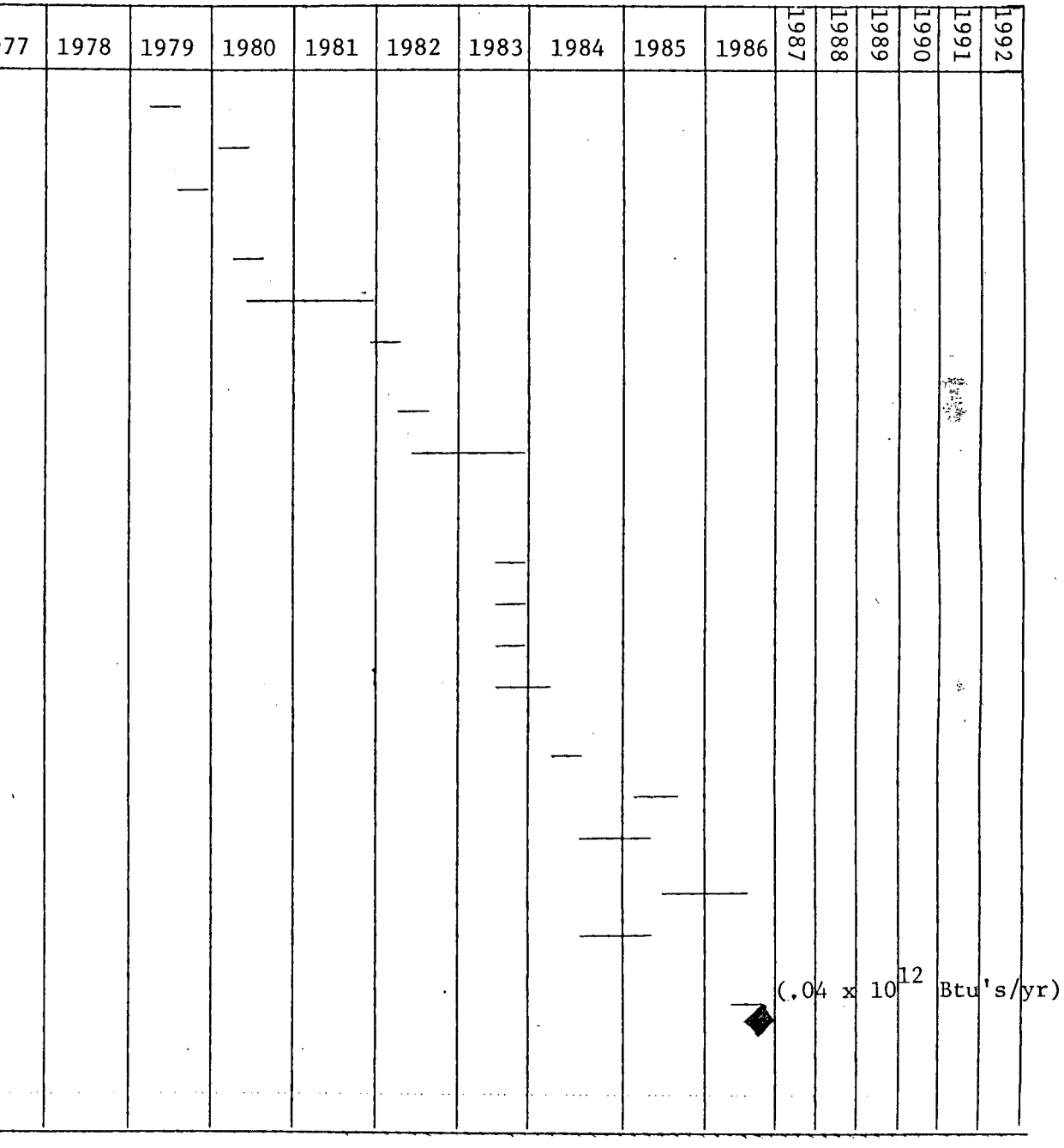
SCENARIO FOR DEVELOPMENT

Operating Entity	Activity	Recipients	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Developer	Preliminary Geophysics				—													
Developer	Gradient holes, eval.					—												
Utility	Feas. Studies for space heating at new	subdivision			—													
Owners	Leases					—												
State/Co. and/or Town	Permits for test well						—											
Developer	Drill Test well, eval.						—											
State/Co./ and/or Town	Permits to dev. system						—	—										
Utility	Water Rights						—											
	R.O.W.						—											
Fin. Inst.	Loan or bond						—											
Utility	Design system							—										
Utility	Construct system							—	—									
Utility	Install in new structures, then retrofit existing							—	—	—								
Developer	Permit to dev. test well						—											
Developer	Develop well							—										
	Heat on line								—									

(.02 x 10^{12} Btu's/yr.)

WAGON WHEEL GAP NO. 43
SCENARIO FOR DEVELOPMENT

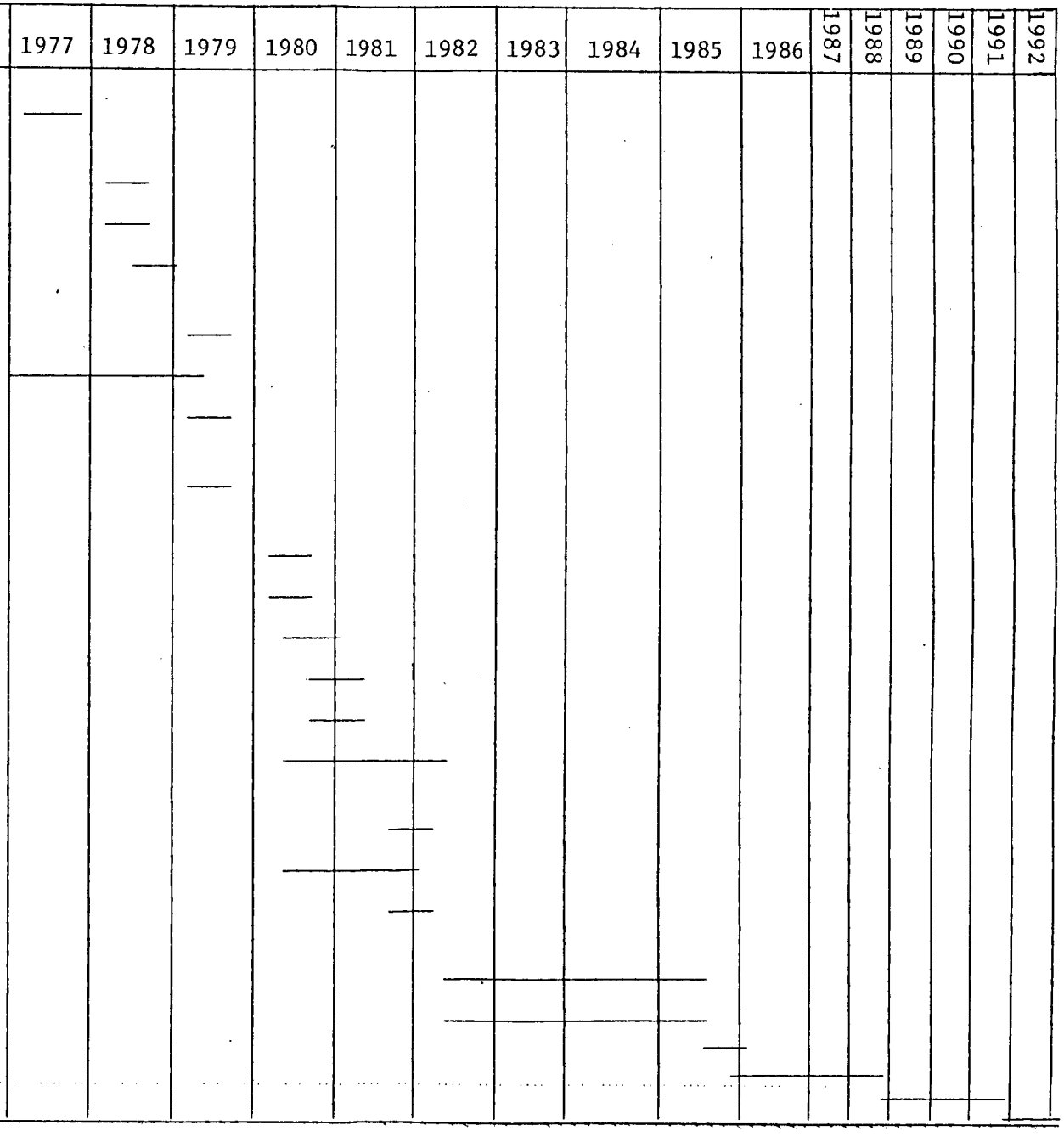
Operating Entity	Activity	Recipients
Developer	Preliminary Geophysics	
Developer	Gradient holes, eval.	
Utility	Feas. study for space heating	
Owners	Leases	
BLM/USFS	Leases	
USGS/State Co. and/or Town/FS	Permits for test well	
Developer	Drill test well	
USGS/State/ Co. and/or Town/USFS	Permit for field development/R.O.W.	
Utility	Water rights	
	R.O.W.	
Fin. Inst.	Loan or bond	
State/Co. and/or town	Permit to dev. system	
Utility	Design system	
Utility	Construct system	
Utility	Install in new structures, then retrofit existing	
Developer	Drill wells and/or produce test well	
	Heat on line	



CEBOLLA HOT SPRINGS NO, 47

SITE DEVELOPMENT SCHEDULE

Operating Entity	Activity	Recipients
USGE	Issue permits for thermal grad. holes	
Developer	Drill thermal grad	
USGS	Permit to deepen hole	
USGS/St./Co.	Permits for 3,000-5,000' holes	
Developer	Drills holes	
Owners	Issue Leases	
USGS	Approves plan of operation for test well	
State	Issues permits for test well	
Developer	Drills wildcat well	
Developer	Negotiate w/utility	
Dev./Util.	Feasibility study	
Utility	Buys water rights	
Prod./Util.	Fin. neg. & contract	
USGS	EIS/then approval of field development	
State/Co.	Permits for field dev.	
Utility	EIS for power plant	
State/Co/EPA	Permits for plant	
Utility	Constr. power plant	
Producer	Drills dev. wells	
Utility	Power on line (50 MWe)	
Utility	Add 2nd unit (100 MWe)	
Utility	Add 3rd unit (150 MWe)	
Utility	Add 4th unit (200 Mwe)	



ORVIS NO. 48
SCENARIO FOR DEVELOPMENT

Operating Entity	Activity	Recipients
Developer	Preliminary Geophysics	
Developer	Gradient holes, eval.	
Utility	Feas. Studies for space heating	
Owners	Leases	
State/Co./ and/or Town	Permits for test well	
Developer	Drill test well, eval.	
State/Co. and/or town	Permit to dev. system	
Utility	Water Rights	
	R.O.W.	
Fin. Inst.	Loan or bond	
Utility	Design system	
Utility	Construct system	
Utility	Install in new structures then retrofit existing	
State/Co.	Permits for development of test well	
Developer	Develop test well	
	Heat on line in Ridgeway	
Utility	Feas. study for Montrose	
Utility	R.O.W. for Montrose	
State/Co.	Permits for system	
Utility	Design system	
Utility	Construct system	
Utility	Retrofit or install in houses/businesses	
	In Montrose	
	Heat on line	

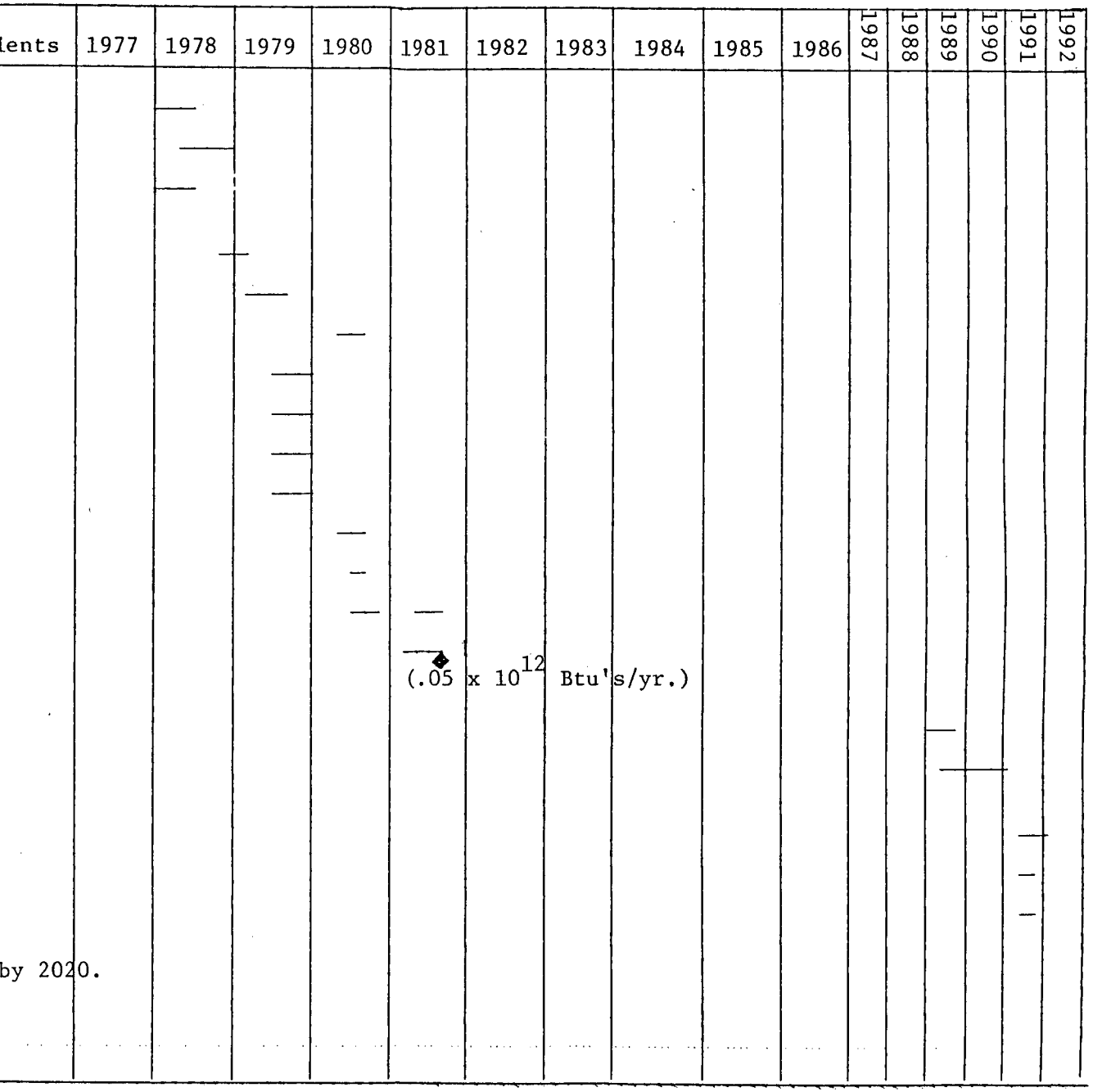
1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992

($.02 \times 10^{12}$ Btu's/yr.)

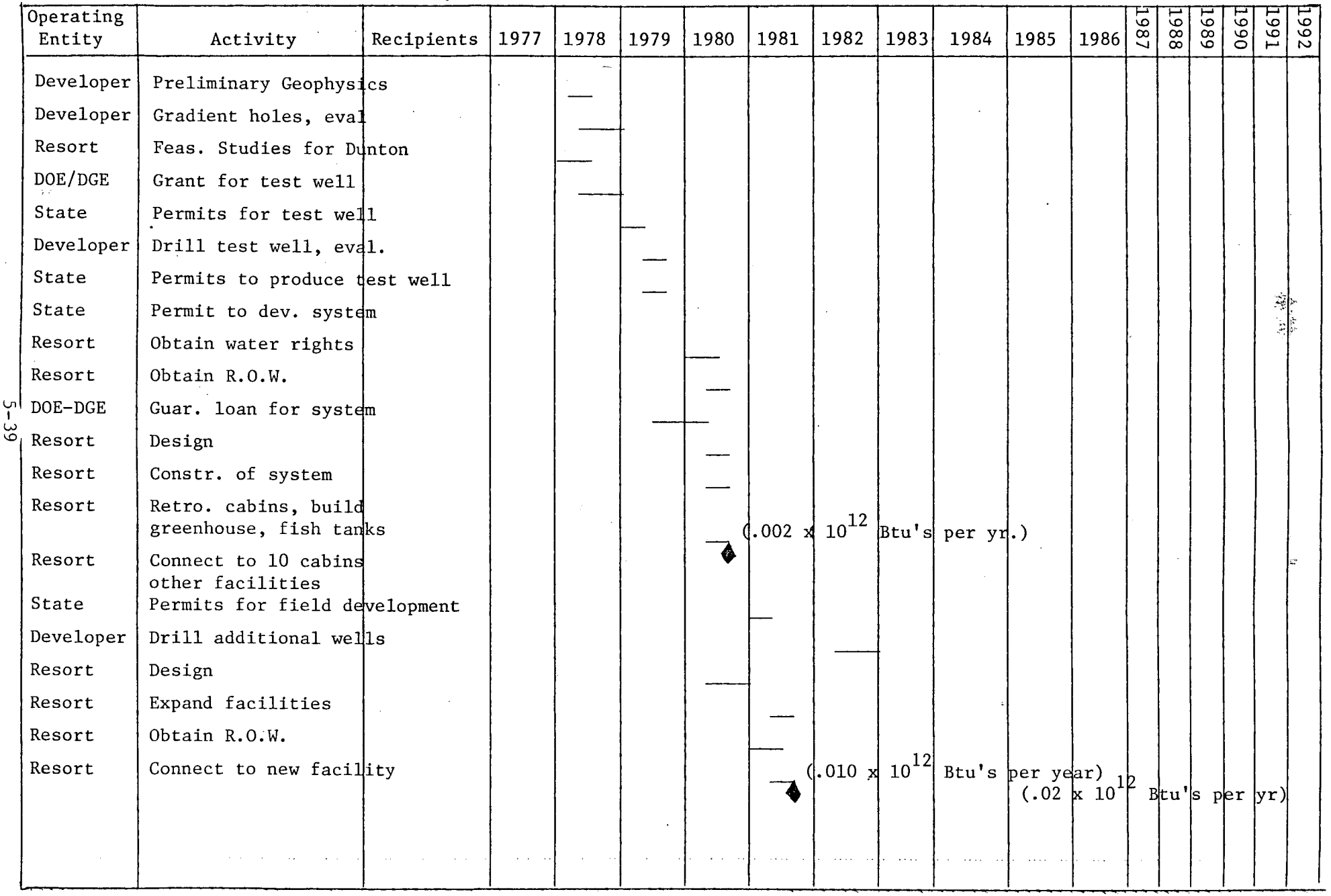
($.06 \times 10^{12}$ Btu's/yr.)

OURAY HOT SPRINGS NO. 49
SITE DEVELOPMENT SCHEDULE

Operating Entity	Activity	Recipients
Developer	Preliminary Geophysics	
Developer	Gradient holes, eval.	
City	Feas. Studies for Ouray space heating	
Owners	Leases	
DOE/DGE	Grant for test well	
Developer	Drill test well, eval.	
State/Co.	Permits to drill test well	
State/City	Permit to dev. system	
City	Water rights	
City	R.O.W.	
DOE/DGE	Guar. loan for system	
City	Design	
City	Constr. of system	
City	Retrofit. homes, bus.	
City	Connect to homes, bus.	
BLM/USFS	Leases on Natl For.	
USGS/State County	Permit for field dev.	
Developer	Drill more wells	
USFS/Owners	Approve R.O.W.	
City	Expand system to as needed, to .15 x 10^{12} Btu's per year by 2020.	

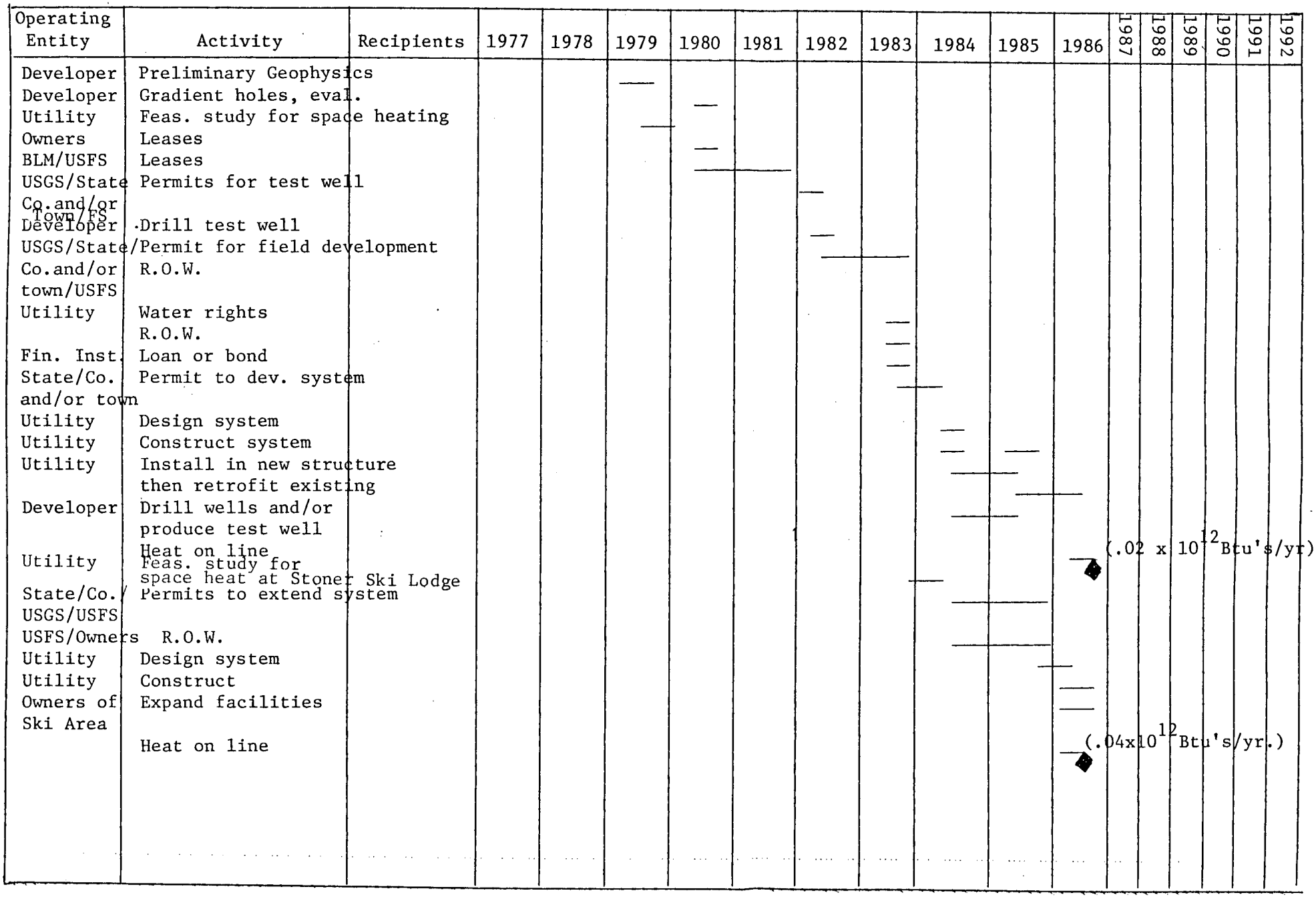


DUNTON/GEYSER/PARADISE NO. 51, 52, 53
SITE DEVELOPMENT SCHEDULE



RICO NO. 54

SCENARIO FOR DEVELOPMENT



PINKERTON/MOUNT NO. 55
SCENARIO FOR DEVELOPMENT

Operating Entity	Activity	Recipients	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Developer	Preliminary Geophysics				—													
Developer	Gradient holes, eval.					—												
Utility	Feas. study for space heating				—													
Owners	Leases					—												
BLM/USFS	Leases					—	—	—										
USGS/State Co. and/or town/FS	Permits for test well							—										
Developer	Drill test well							—										
USGS/State/ Co.and/or town/USFS	Permit for field development	R.O.W.						—	—	—								
Utility	Water rights								—	—								
	R.O.W.								—	—								
Fin. Inst.	Loan or bond								—	—								
State/Co. and/or town	Permit to dev. system								—	—								
Utility	Design system									—	—							
Utility	Construct system									—	—	—						
Utility	Install in new structure, then retrofit existing									—	—	—						
Developer	Drill wells and/or									—	—	—						
	Heat on line											◆	(.09 x 10^{12} Btu s/yr.)					

TRIPP/TRIMBLE NO. 56

SCENARIO FOR DEVELOPMENT

Operating Entity	Activity	Recipients	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Developer	Preliminary Geophysics				—													
Developer	Gradient holes, eval.					—												
Utility	Feas. Studies for Space heating					—												
Owners	Leases					—												
State/Co./ and/or town	Permits for test well						—											
Developer	Drill test well, eval.						—											
State/Co./ and/or Town	Permit to dev. system						—											
Utility	Water rights						—											
	R.O.W.						—											
Fin. Inst.	Loan or bond						—											
Utility	Design system							—										
Utility	Construct system							—	—									
Utility	Install in new structure, then retrofit existing							—	—	—								
Developer	Permit to dev. well						—											
Developer	Dev. test well							—										
	Heat on line								—	◆ (.07 x 10^{12} Btu's/yr.)								

SITE SCENARIOS FOR THE STATE OF NEVADA

NEVADA GEOTHERMAL AREA SCENARIOS 1-26

APPENDIX A.

FACTS AND ASSUMPTIONS PERTINENT TO THE INTERPRETATION OF NEVADA SCENARIOS

(1) Site Defined. A site (i.e. geothermal site, as in site specific scenario) is an anomalous thermal locality which has, or may have, the potential to be developed as a commercially viable geothermal resource.

Each site has one or more of the following elements:

(a) A spring having water temperature of 21°C (70°F) for localities north of 38°N. latitude. South of this latitude the ambient air temperature noticeably increases, with a corresponding increase in the ground-water temperature. Therefore, south of 38°N. latitute thermal waters are taken to be 26° to 29°C (80° to 85°F) and warmer.

(b) Well water having an anomalously high temperature for the depth at which it is recorded. The geothermal gradient is assumed to be 1° per 114 meters (1°F per 75 feet).

(c) Any geothermal leasing activity such as a lease or lease application.

(2) High, Intermediate, and Low Temperature Sites. Sites have been separated into three categories, consistent with USGS Circular 726, which are based upon the measured or estimated reservoir temperature:

(a) High Temperature. Greater than 150°C; generally suitable for electric power generation.

(b) Intermediate temperature. 90° to 150°C; possibly suitable for electric power generation above 130°C; below 130°C, suitable for direct thermal applications.

(c) Low temperature. Less than 90°C; suitable only for direct thermal utilization.

Low temperature sites are present in all sections of the State, but are dominant in those sections where high and intermediate temperature sites are prominent.

(3) Site Characteristics. Where exploratory or development data are not available to give direct or indirect quantification of reservoir characteristics (i.e., temperature, volume, depth, etc.), subjective methods of resource assessment and evaluation have been applied in order to partially *quantify* each geothermal site for *PLANNING USE ONLY.*

The technical and non-technical characteristics of each site have been compiled and compared with those of sites which have (1) a drilled reservoir, or (2) a geothermometer estimate by the USGS (in Circular 726). Table I is a partial list of the characteristics, each of which have, or potentially have, an influence on the interpretative value and ranking of a Site or Area.

TABLE I. Comparative Characteristics for Site Specific and Area Scenarios

Land/Lease
- National Resource Land
  - KGRA (Competative)
  - KGRA Lease Application
  - KGRA Lease
  - Non-KGRA (Non-competative)
  - Non-KGRA Lease Application
  - Non-KGRA Lease
  - Geo-Sim
  - Closed Cases
- State Land Lease
- Private Land Lease
- Indian Land Lease
- Withdrawn Lands
  - Within
  - Adjacent
  - Near
- Operating Unit Applied For
- Operating Unit
- Lease Application/Lease Held By:
  - Major Companies
  - Small Companies
  - Individuals

Geophysical
- Aeromagnetic
- Magneto-Telluric
- Gravity
- Ground Noise
- Passive Seismic
- Active Seismic
- Electrical
  - Induced Polarization
  - Self Potential
- Geophysical Survey

Drilling
- Temperature Gradient Holes (Number)
- Temperature Gradient Holes to 100' (Number)
- Temperature Gradient Holes 101' - 500' (Number)
- Exploratory Well (Number)
- Exploratory Well Less than 1,000' (Number)
- Exploratory Well 1,000 - 5,000' (Number)
- Exploratory Well Greater than 5,000' (Number)
- Stratigraphic Hole (Number)
- Producing Wells (Number)
- Depth to Reservoir Under 5,000'
- Depth to Reservoir 5,000 - 8,000'
- Depth to Reservoir Over - 8,000'

Water/Geochemistry
- Thermal Springs (Number)
- (Calcareous Tufa Deposit Presently Forming)
- (Silicious Sinter Deposit Presently Forming)
- Calcareous Tafa Deposit (Inactive)
- Silicious Sinter Deposit (Inactive)
- Water Wells (Number)
- Water Analysis Available (Number)
- Highest Recorded Surface Temperature
- Estimated Reservoir Temperature
- Total Dissolved Solids (ppm)
- Favorable Geochemistry

Geology
- Localized Thermal Trend
- Regional Thermal Trend
- Significant Faulting Present
- Volcanism Less than 6 Million Years old
- Volcanism 17 to 6 Million Years old
- Volcanism 34 to 17 Million Years old
- Volcanism 43 to 34 Million Years old

Transmission
- Distance to Power Transmission Line 0-10 km
- Distance to Power Transmission Line 11-50 km
- Distance to Power Transmission Line Greater than 50 km

Thermal Resource Presently Used For
Bathing
Greenhousing/Space Heating
Commercial Processing
Electrical Power Generation

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(4) Quantification of Reservoir Characteristics - Temperature and Volume. All the reservoirs are assumed to be hot-water convection systems. Calculations for effective porosity and permeability, contained heat and useable heat, follow the methods used in USGS Circular 726. For most of the sites, significant departure from Circular 726 is in the more optimistic reservoir temperatures and volumes.

(a) Temperature. For the vast majority of sites, deep drilling has not penetrated the reservoir. Few sites have a recorded geothermometer temperature, and those which have been published are believed to be on the conservative (i.e. low) side. The Hot-Water Convection Systems charts in the Nevada Geothermal Area Scenarios (Appendix A) give SiO_2 and Na-K-Ca "Geochemical" temperatures, and actual "Subsurface" temperatures (from reservoir drilling tests). The "Energy Potential" for each site has been calculated, in part, using a *planning* reservoir temperature (shown in parentheses) which takes into account "Geochemical" and "Subsurface" temperatures of sites close by. *Planning* temperatures are highly subjective, and are drawn largely from geologic inference.

(b) Volume. The reservoir volumes given in the Hot-Water Convection Systems charts in the Nevada Geothermal Area Scenarios (Appendix A), are largely *planning* volumes - that is, most are quite subjective. Even those that have been drilled are at best semi-quantitative. The majority of the volumes were arrived at after considering: (1) Volumes of the better known sites such as Beowawe Geysers and Brady's, (2) size and ownership of lease blocks, and (3) the areal extent of detailed temperature gradient holes and geophysical surveys. The minimum reservoir volumes are assumed to be either 5 km^3 or 10 km^3, a factor of two to four times larger than the minimum taken by USGS in Circular 726, which are considered to be conservative (i.e., low).

Estimates of useable energy for each Area should be considered optimistic valuations of the potential resource. USGS suggests that five times the presently known resource has yet to be discovered.

(5) Most of the high and intermediate temperature geothermal sites will be discovered and developed in the regions where:

(a) Circular 726 sites are situated,

(b) Hotter spring waters have been recorded, and

(c) Exploration companies have shown the most intense interest by way of leasing and exploration activity.

(6) Low temperature sites situated at existing cities and towns will be developed with two decades.

(7) The larger energy companies will develop most of the sites suitable for eletric power generation. Numerous smaller companies will develop the intermediate and low temperatures resource for industrial processing and agricultural uses.

(8) Present technology for converting geothermal energy to electrical and direct thermal uses will be vastly improved in:

(a) efficiency of conversion, and

(b) minimum reservoir temperatures applicable, between now and the year 2020. Technology advances will permit:

a. Increased electrical power generation from existing wells.

b. Expansion of existing fields outward into the lower temperature periphery of existing high and intermediate temperature fields.

c. Utilization of upper intermediate temperature sites which initially will be suitable only for direct thermal uses.

EXPLANATION FOR AREA SHEETS

ENVIRONMENT: Federal environmental decisions relating to availability of federal lands for geothermal resource leasing. All data taken from Environmental Assessment Records prepared by BLM.

CRIT. R.: Critical Restrictions. Restrictions to lessee, in addition to those restrictions covered in the Geothermal Resource Lease Application (Sec. 14 and 18).

EXCLUD. PEND.: Excluded from Leasing. Pending additional environmental studies.

EXCLUD.: Excluded from all leasing.

LAND STATUS: Geothermal leasing status on federal lands.

LSE. APLN.: Lease Application

CLOSED: Closed cases. Application never became lease. In theory the land is available for geothermal leasing.

GEO. SIM.: Geothermal Simultaneous Drawing. These applications became leases, then were terminated or relinquished by the lessee. These parcels are held for simultaneous drawing.

OPEN: Open - No leases presently recorded for site.

A.P.P.: Area Potential Prospectively. As outlined by U.S.G.S., possible geothermal resource areas.

OTHER or KGRA: KGRA - Known Geothermal Resource

OWNERSHIP INTEREST:

MAJOR: Major company interest or holdings.

MINOR: Minor company interest or holdings.

IND./INV.: Individual and/or investment group interest or holdings.

INTENTS: "Intent to Conduct Geothermal Resource Exploration" are filed with U.S.G.S.

GEO.: Geophysical work only. No Drilling (i.e.= Gravity, magnetotelluric and other surveys)

DRILL: Drilling of shallow temperature gradient holes.

OTHER: Any exploration work not included in above categories.

(NOTE: The filing of the Intent to conduct geothermal resource exploration Does Not imply the work was completed.)

NEVADA GEOTHERMAL AREA 1 SCENARIO

HOT-WATER CONVECTION SYSTEMS IN AREA 1.

Location	Temperatures °C			Reservoir Assumptions		Energy Potential		
Site	Surface (1)	Geochemical SiO_2 (2)	Geochemical Na-K-Ca (2)	Subsurface (3)	Volume km^3 (4)	Heat content 10^{18} cal (5)	Recovery Factor e_r (6)	Electrical Potential MW_e-30yrs.	Thermal Energy for Direct Use Quads (7)
The Needles Rocks	98	137	214	145 (200)	20	2.2	0.025	245	
Surprise Valley	Hot			(185)	10	1.0	0.02	90	
Smoke Creek Desert	23			(200)	10	1.1	0.025	125	
Hot Springs Island	49			(185)	10	1.0	0.02	(90) Bird Sanctuary; will not be developed	
Hot Springs Valley	43								
Honey Lake	28								
Virginia Valley	Warm								
Fortynine Lake	22								
Squaw Valley	ND								
Little Sawmill Canyon	28								
Bridge Creek	Warm								
Fales Hot Springs	Warm								
Buffalo Creek	Warm								
Fish Springs	23								
Leonskin Mountain	Hot								
TOTAL:								460	

Footnotes 1 thru 7-see Explanation Page

EXPLANATION TO HOT-WATER CONVECTION SYSTEMS SHEETS

Footnotes

(1) Maximum surface temperature reported from a spring or fumarole.

(2) Predicted using chemical geothermometers, assuming last equilibration in the reservoir; assumes saturation of SiO_2 with respect to quartz, and no loss of Ca from calcite deposition.

(3) Assumed average reservoir temperature based on data presently available. Temperatures from Circular 726 and other sources. Temperatures in parentheses are highly subjective.

(4) From surface manifestations, geophysical data, well records, geologic inference and leasing activity. Assumes 1.5 km^2 if no data pertinent to size is available. Top assumed at depth of 1.5 km if no data available. Bottom assumed at 3 km depth for all convection systems. Calculated from assumed area and thickness.

(5) Calculated as product of assumed volume, volumetric specific heat of 0.6 $cal/cm^3°C$, and temperature in degrees C above 15°C.

(6) 0.02 for 150°-200°C
0.025 for 200°-250°C

(7) 25% Heat Content Recoverable as thermal energy at the surface; 1 Quad= 0.25×10^{18} cal.

Non-Technical Components For Area 1

With the Charles Sheldon Antelope Range and Refuge located in the northern section, the Pyramid Lake Indian Reservation in the southern section and scattered private land throughout the area, approximately 1/3 of the area has restrictions to geothermal leasing. (leasing of indian lands is managed through the Bureau of Indian Affairs). Presently there are no federal environmental constraints on the remaining available public lands in the area. No apparent public opposition to geothermal leasing was expressed during the EAR hearings.

Of the fifteen (15) sites in this area, the Needles Rocks, Anaho Island and South Smoke Creek Desert are located on the Pyramid Lake Indian Reservation. In addition, Anaho Island is also a National Wildlife Refuge. No leasing has occured at any of the sites in this area, nor are there any presently identified KGRAs. Seven of the sites (The Needles Rocks, Anaho Island, Surprise Valley, Middle Lake, Fortynine Lake, Sand Pass and Fish Springs) are located within U.S.G.S. defined Area Potential Prospectively. Several Notices of Intent have been filed for geophysical survey work and shallow temperature gradient holes.

General Statement to Non-Technical Components Section,
Area Scenarios

1. All observations for environmental, leasing and "Intents" are based on data gathered in 1977, which has not been corrected, adjusted or up-dated.

2. All environmental decisions are federal (BLM) as there are no localities in Nevada which require an environmental statement. Nevada has only 2 laws requiring such reports:

   a. Nevada Clean Air Act of 1971. Amended in 1973.

   b. Utility Environmental Protection Act, 1971.
   Amended 1973.
   Requires environmental statement for utility plant siting.

   Protection of environmental values is now explicitly and clearly a major criteria for BLM management activities. All BLM activities are governed by the "Federal Land Policy and Management Act".

3. Areas 15, 16, 17, 18, 19 grouped together make up a zone of Intensive and Extensive geothermal resource interests.

   A little over 1/2 of the total land in this zone is available for geothermal leasing, the remainder is covered by private indian reservation, Bureau of Reclamation withdrawals, wildlife management and refuge, state parks and military use lands. The zone contains 10 KGRAs.

   There has been intensive "Geophysical" and "Shallow Temperature Gradient Hole" interest indicated by numerous filings of "Intent to do Geothermal Resource Exploration" with U.S.G.S. To date we do not know how many of these projects were completed.

This zone does not have extensive environment decisions but some significant sites will be affected by such decisions. (i.e. Tahoe Basin Area and Carson Sink-Alkali Flat East and West)

There has been significant leasing in this zone, both within the KGRA's and its vicinity. The leasing interest is mostly by minor companies and individual and/or investment groups. Some sites showed 100% major company interest, such as Bell Flat, of which very few are still lease applications, the remainder closed cases.

This zone includes 1 of the 2 metropolitan localities in the state: Reno-Sparks - (should include Carson City) with many important communities, good to fair transportation arteries.

Economic Base: Tourism, Agriculture/Livestock, Warehousing. The growth in tourism and warehousing increases population energy needs.

AREA: 1

SITE	ENVIRONMENT			LAND STATUS							OWNERSHIP INTEREST			INTENTS			NOTES
	CRIT.R.	EXCLUD. PEND.	EXCLUD.	LSE. APLN.	CLOSED	LSE.	GEO SIM	OPEN	A.P.P.	OTHER or KGRA	MAJOR	MINOR	IND./ INV.	GEO.	DRILL.	OTHER	
The Needles Rocks								X	X	Ind Res							
Anaho Island								X	X	Ind Res					X		Wildlife Refuge
Surprise Valley								X	X								
Middle Lake								X	X								
Fortynine Lake								X	X								
Sand Pass								X	X								
Fish Springs								X	X								
Warm Sps. Valley								X		Private							
So. Smoke Crk. Desert								X		Ind Res							
Virgin Valley								X									
Squaw Valley								X									
Little Sawmill Cany.								X									
Smoke Creek								X									
Buffalo Creek								X									
Dogskin Mountain								X									

References To Postulated Site Development Schedules And Non-Technical Components Of Areas.

References (indicated by parentheses and corresponding number)

1. Oral Communication:

2. Regional Environmental Analysis Record
   Geothermal oil/gas leasing (BLM) and maps

   a. Carson City District
      Pyramid District, 1975

   b. Winnemucca District
      Sonoma-Gerlach Resource Area
      Buffalo Hills Planning Unit
      1975

   c. Winnemucca District
      Deno, Paradise, Blue Wing and
      Sonoma Planning Units,
      1975

   d. Elko District,
      1975

   e. Battle Mountain District
      1976

   f. Tonopah Resource Area
      1975

   g. Fort Churchill-Clan Alpine Area,
      Carson City District, Nev., 1975

   h. Pine Nut-Walker Area,
      Carson City District, Nev. 1975

   i. Esmeralda Planning Unit,
      Esmeralda and Nye Counties, 1974

3. Lease Books (Nevada Team Data)
   Data obtained from BLM public records and maps.

4. "Intent to Conduct Geothermal Resource Exploration"
   (Filed with U.S.G.S.), (Maps and Folder) and maps.

5. Drilling and Resource Data Sheets.

6. Plan of Operation, Phillips Petroleum Company,
   March 1, 1978 - To drill 6 geothermal wells to 8000'.
   To determine the existence and commercial potential of geothermal resources.
   Estimating starting date - 6-78
   Estimated comp. date - 12-82

COMPOSITE POSTULATED SITE DEVELOPMENT SCHEDULE
FOR AREA 1

SITE NAME	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
The Needles Rocks																						20	20	70	70
Surprise Valley																									
South Smoke Creek Desert																									
Anaho Island																									
Warm Springs Valley																									
Middle Lake																									
Virgin Valley																									
Fortynine Lake																									
Squaw Valley																									
Little Sawmill Canyon																									
Smoke Creek																									
Sand Pass																									
Buffalo Creek																									
Fish Springs																									
Dogskin Mountain																									
TOTAL MWe:																									
TOTAL Quads:																									

20,50,100 = MWe (megawatts electric); electrical power generation.
.037,.04,.017 = Quads (0.252×10^{18} cal.); direct thermal utilization. Quads available for commercial utilization. It is unlikely that the energy developed at each site will be wholly utilized, or utilized in the optimum or most efficient manner.

AREA 1

95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
120	120	170	170	220	220	245	245	245	245	245	245	245	245	245	245	245	245	245	245	245	245	245	245	245	245
							20	20	70	70	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90
																25	25	75	75	125	125	125	125	125	125

AREA: 1

SITE CHARACTERISTICS:

SITE: THE NEEDLES ROCKS

POSTULATED SITE DEVELOPMENT SCHEDULE (FOR FIRST 20 MWe PLANT)

Possible Subsequent Additions (MWe) and On Line Date:

50 MWe	1993	50 MWe	1999
50 MWe	1995	25 MWe	2001
50 MWe	1997		

OPERATING ENTITIES	ACTIVITY	RECIPIENTS	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
BLM	Approve Notice of Intent-	Developer																								
USGS	Approve NOI & Drill Permit	Developer	(1)																							
BLM/Owner	Lease Land	Developer																								
BLM	Process EIA/EIS	CEQ																								
County	Issue Land Use Permits	Developer																								
Developer	Exploratory Drilling & Reservoir Evaluation																									
Developer	Develop Utility Interest																									
Developer & Utility	Feasibility Study																									
Producer (Developer) & Utility	Financial Negotiations																									
Producer	Site Selection																									
Producer & Utility	Design																									
Producer & Utility	Commitment to Development																									
Producer & Utility	Prepare Master Development Plan	BLM, USGS																								
Utility	Prepare Environmental Data Statement	BLM, FPC STATE, County																								
BLM, FPC STATE, USGS	Certify Plant & Site Issue Permits	Producer & Utility																								
USGS	Process EIA/EIS (Drilling)	CEQ																								
FPC	Process EIA/EIS (Plant)	CEQ																								
FPC	Process EIA/EIS (Transmission Line)	CEQ																								
Producer	Development Drilling																									
Utility	Plant Construction																									
Utility	Install Transmission Line (40 km)																									

(1) Deep Hole Drilled & Abandoned, 1964

NEVADA GEOTHERMAL AREA 2 SCENARIO

HOT-WATER CONVECTION SYSTEMS IN AREA 2 .

Location	Temperatures °C			Reservoir Assumptions		Energy Potential		
Site	Surface (1)	Geochemical SiO_2 (2)	Geochemical Na-K-Ca (2)	Subsurface (3)	Volume km^3 (4)	Heat content 10^{18} cal (5)	Recovery Factor e_r (6)	Electrical Potential MW_e-30yrs.	Thermal Energy for Direct Use Quads (7)
Dyke Hot Springs	70	129	137	140 (200)	20	2.2	0.025	245	
Baltazor Hot Springs	93			(185)	10	1.0	0.02	90	
Bilk Creek Reservoir	57			(200)	10	1.1	0.025	125	
Bog Hot Springs	88	108	109	115 (170)	10	0.9	0.02	80	
Howard Hot Spring	73	128	81	130 (200)	10	1.1	0.025	125	
Pinto Hot Springs	94			(185)	10	1.0	0.02	90	
Gridley Lake	42								
McGee Mountain	55								
Virgin Valley Campground	32								
Little Sage Hen Spring	ND								
Quinn River Crossing	24?								
Deer Creek Peak	21								
Cain Springs	23								
TOTAL:								755	

Footnotes 1 thru 7-see Explanation Page

EXPLANATION TO HOT-WATER CONVECTION SYSTEMS SHEETS

Footnotes

(1) Maximum surface temperature reported from a spring or fumarole.

(2) Predicted using chemical geothermometers, assuming last equilibration in the reservoir; assumes saturation of SiO_2 with respect to quartz, and no loss of Ca from calcite deposition.

(3) Assumed average reservoir temperature based on data presently available. Temperatures from Circular 726 and other sources. Temperatures in parentheses are highly subjective.

(4) From surface manifestations, geophysical data, well records, geologic inference and leasing activity. Assumes 1.5 km^2 if no data pertinent to size is available. Top assumed at depth of 1.5 km if no data available. Bottom assumed at 3 km depth for all convection systems. Calculated from assumed area and thickness.

(5) Calculated as product of assumed volume, volumetric specific heat of 0.6 $cal/cm^3°C$, and temperature in degrees C above 15°C.

(6) 0.02 for 150°-200°C
0.025 for 200°-250°C

(7) 25% Heat Content Recoverable as thermal energy at the surface; 1 Quad= 0.25×10^{18} cal.

Non-Technical Components For Area 2

In the northwest corner of this area is part of the Charles Sheldon Antelope Range, and BLM is considering the addition of several more tracts of land to this range. Of the thirteen (13) presently identified sites in this area, none are located within the considered tracts. Two sites, Bog Hot Springs and Virgin Valley Campground are located within the current antelope range. The remainder of sites are without environmental restrictions and are located on federal land.

Leasing activity has been significant within the area, with only five (5) sites without such activity: Bog Hot Springs, Virgin Valley Campground, Quinn River Crossing, Cain Springs and Deer Creek Peak. The most active leasing interest has occured at the Baltazor Hot Springs KGRA-McGee Mountain-Gridley Lake Zone where about 75% of the interest is still in geothermal lease application status. Approximately 90% of the activity at Dyke Hot Springs and Pinto Hot Springs KGRA are now closed cases. Howard Hot Spring and Bilk Creek Reservoir sites have about 90% of their leasing activity now in geo-sim status.

Most of the area is included in U.S.G.S. defined Area Potential Prospectively. There has been quite a few Notices of Intent filed for the area, for both geophysical survey and shallow temperature gradient holes. Most intensive interest indicated for Dyke Hot Springs and McGee Mountain sites.

General Statement to Non-Technical Components Section,
Area Scenarios

1. All observations for environmental, leasing and "Intents" are based on data gathered in 1977, which has not been corrected, adjusted or up-dated.

2. All environmental decisions are federal (BLM) as there are no localities in Nevada which require an environmental statement. Nevada has only 2 laws requiring such reports:

   a. Nevada Clean Air Act of 1971. Amended in 1973.

   b. Utility Environmental Protection Act, 1971.
   Amended 1973.
   Requires environmental statement for utility plant siting.

   Protection of environmental values is now explicitly and clearly a major criteria for BLM management activities. All BLM activities are governed by the "Federal Land Policy and Management Act".

3. Areas 15, 16, 17, 18, 19 grouped together make up a zone of Intensive and Extensive geothermal resource interests.

   A little over 1/2 of the total land in this zone is available for geothermal leasing, the remainder is covered by private indian reservation, Bureau of Reclamation withdrawals, wildlife management and refuge, state parks and military use lands. The zone contains 10 KGRAs.

   There has been intensive "Geophysical" and "Shallow Temperature Gradient Hole" interest indicated by numerous filings of "Intent to do Geothermal Resource Exploration" with U.S.G.S. To date we do not know how many of these projects were completed.

This zone does not have extensive environment decisions but some significant sites will be affected by such decisions. (i.e. Tahoe Basin Area and Carson Sink-Alkali Flat East and West)

There has been significant leasing in this zone, both within the KGRA's and its vicinity. The leasing interest is mostly by minor companies and individual and/or investment groups. Some sites showed 100% major company interest, such as Bell Flat, of which very few are still lease applications, the remainder closed cases.

This zone includes 1 of the 2 metropolitan localities in the state: Reno-Sparks - (should include Carson City) with many important communities, good to fair transportation arteries.

Economic Base: Tourism, Agriculture/Livestock, Warehousing. The growth in tourism and warehousing increases population energy needs.

AREA: 2

SITE	ENVIRONMENT			LAND STATUS							OWNERSHIP INTEREST			INTENTS			NOTES
	CRIT.R.	EXCLUD. PEND.	EXCLUD.	LSE. APLN.	CLOSED	LSE.	GEO SIM	OPEN	A.P.P.	OTHER or KGRA	MAJOR	MINOR	IND./ INV.	GEO.	DRILL.	OTHER	
Pinto Hot Springs				X	X				X	KGRA	X			X			
Baltazor Hot Springs				X					X	KGRA		X	X	X			
McGee Mountain				X		X			X			X			X		
Howard Hot Spring						X	X		X		X	X			X		
Bog Hot Springs								X	X								Sheldon W.L.Refuge
Virgin V. Campground								X									Sheldon W.L.Refuge
Little Sage Hen Sp.						X			X				X				
Bilk Crk. Reservoir						X	X		X			X					
Dyke H. Springs				X	X				X		X	X	X		X		
Quinn River Crossing								X	X								
Cain Springs								X	X					X			
Gridley Lake				X	X							X			X		
Deer Creek Peak								X									

EXPLANATION FOR AREA SHEETS

ENVIRONMENT: Federal environmental decisions relating to availability of federal lands for geothermal resource leasing. All data taken from Environmental Assessment Records prepared by BLM.

CRIT. R.: Critical Restrictions. Restrictions to lessee, in addition to those restrictions covered in the Geothermal Resource Lease Application (Sec. 14 and 18).

EXCLUD. PEND.: Excluded from Leasing. Pending additional environmental studies.

EXCLUD.: Excluded from all leasing.

LAND STATUS: Geothermal leasing status on federal lands.

LSE. APLN.: Lease Application

CLOSED: Closed cases. Application never became lease. In theory the land is available for geothermal leasing.

GEO. SIM.: Geothermal Simultaneous Drawing. These applications became leases, then were terminated or relinquished by the lessee. These parcels are held for simultaneous drawing.

OPEN: Open - No leases presently recorded for site.

A.P.P.: Area Potential Prospectively. As outlined by U.S.G.S., possible geothermal resource areas.

OTHER or KGRA: KGRA - Known Geothermal Resource

OWNERSHIP INTEREST:

MAJOR: Major company interest or holdings.

MINOR: Minor company interest or holdings.

IND./INV.: Individual and/or investment group interest or holdings.

INTENTS: "Intent to Conduct Geothermal Resource Exploration" are filed with U.S.G.S.

GEO.: Geophysical work only. No Drilling (i.e.= Gravity, magnetotelluric and other surveys)

DRILL: Drilling of shallow temperature gradient holes.

OTHER: Any exploration work not included in above categories.

(NOTE: The filing of the Intent to conduct geothermal resource exploration Does Not imply the work was completed.)

References To Postulated Site Development Schedules
And Non-Technical Components Of Areas.

References (indicated by parentheses and corresponding number)

1. Oral Communication:

2. Regional Environmental Analysis Record
   Geothermal oil/gas leasing (BLM) and maps

   a. Carson City District
      Pyramid District, 1975

   b. Winnemucca District
      Sonoma-Gerlach Resource Area
      Buffalo Hills Planning Unit
      1975

   c. Winnemucca District
      Deno, Paradise, Blue Wing and
      Sonoma Planning Units,
      1975

   d. Elko District,
      1975

   e. Battle Mountain District
      1976

   f. Tonopah Resource Area
      1975

   g. Fort Churchill-Clan Alpine Area,
      Carson City District, Nev., 1975

   h. Pine Nut-Walker Area,
      Carson City District, Nev. 1975

   i. Esmeralda Planning Unit,
      Esmeralda and Nye Counties, 1974

3. Lease Books (Nevada Team Data)
   Data obtained from BLM public records and maps.

4. "Intent to Conduct Geothermal Resource Exploration"
   (Filed with U.S.G.S.), (Maps and Folder) and maps.

5. Drilling and Resource Data Sheets.

6. Plan of Operation, Phillips Petroleum Company,
   March 1, 1978 - To drill 6 geothermal wells to 8000'.
   To determine the existence and commercial potential of
   geothermal resources.
   Estimating starting date - 6-78
   Estimated comp. date - 12-82

COMPOSITE POSTULATED SITE DEVELOPMENT SCHEDULE
FOR AREA 2

SITE NAME	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
Dyke Hot Springs																	20	20	70	70	120	120	170	170	220
Baltazor Hot Springs																						20	20	70	70
Bilk Creek Reservoir																									
Bog Hot Springs																									
Howard Hot Spring																									
Pinto Hot Springs																									
Gridley Lake																									
McGee Mountain																									
Virgin Valley Campground																									
Little Sage Hen Spring																									
Quinn River Crossing																									
Deer Creek Peak																									
Cain Springs																									
TOTAL MWe:																									
TOTAL Quads:																									

20,50,100 = MWe (megawatts electric); electrical power generation.
.037,.04,.017 = Quads (0.252×10^{18} cal.); direct thermal utilization. Quads available for commercial utilization. It is unlikely that the energy developed at each site will be wholly utilized, or utilized in the optimum or most efficient manner.

AREA 2

95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
220	245	245	245	245	245	245	245	245	245	245	245	245	245	245	245	245	245	245	245	245	225	225	175	175	125
90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90
			25	25	75	75	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125
									30	30	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
													25	25	75	75	125	125	125	125	125	125	125	125	125
																			20	20	70	70	90	90	90

AREA: 2

SITE CHARACTERISTICS:

SITE: DYKE HOT SPRINGS

Possible Subsequent Additions (MWe) and On Line Date:

50 MWe	1988	50 MWe	1994
50 MWe	1990	25 MWe	1996
50 MWe	1992		

POSTULATED SITE DEVELOPMENT SCHEDULE (FOR FIRST 20 MWe PLANT)

OPERATING ENTITIES	ACTIVITY	RECIPIENTS	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
BLM	Approve Notice of Intent-	Developer																								
USGS	Approve NOI & Drill Permit	Developer																								
BLM/Owner	Lease Land	Developer																								
BLM	Process EIA/EIS	CEQ																								
County	Issue Land Use Permits	Developer																								
Developer	Exploratory Drilling & Reservoir Evaluation																									
Developer	Develop Utility Interest																									
Developer & Utility	Feasibility Study																									
Producer (Developer) & Utility	Financial Negotiations																									
Producer	Site Selection																									
Producer & Utility	Design																									
Producer & Utility	Commitment to Development													△												
Producer & Utility	Prepare Master Development Plan	BLM, USGS																								
Utility	Prepare Environmental Data Statement	BLM, FPC STATE, County																								
BLM, FPC STATE, USGS	Certify Plant & Site Issue Permits	Producer & Utility																								
USGS	Process EIA/EIS (Drilling)	CEQ																								
FPC	Process EIA/EIS (Plant)	CEQ																								
FPC	Process EIA/EIS (Transmission Line)	CEQ																								
Producer	Development Drilling																									
Utility	Plant Construction																									
Utility	Install Transmission Line (40 km)																									

NEVADA GEOTHERMAL AREA 3 SCENARIO

HOT-WATER CONVECTION SYSTEMS IN AREA 3 .

Location	Temperatures °C			Reservoir Assumptions		Energy Potential		
Site	Surface (1)	Geochemical SiO_2 (2)	Geochemical Na-K-Ca (2)	Subsurface (3)	Volume km^3 (4)	Heat content 10^{18} cal (5)	Recovery Factor e_r (6)	Electrical Potential MW_e-30yrs.	Thermal Energy for Direct Use Quads (7)
Cordero Mercury Mine	59			(185)	10	1.0	0.025	90	
Jordan Meadow Mountain	ND								
Fivemile Spring	28								
Ninemile Summit Spring	26								
Quinn River	27								
TOTAL:								90	

Footnotes 1 thru 7-see Explanation Page

EXPLANATION TO HOT-WATER CONVECTION SYSTEMS SHEETS

Footnotes

(1) Maximum surface temperature reported from a spring or fumarole.

(2) Predicted using chemical geothermometers, assuming last equilibration in the reservoir; assumes saturation of SiO_2 with respect to quartz, and no loss of Ca from calcite deposition.

(3) Assumed average reservoir temperature based on data presently available. Temperatures from Circular 726 and other sources. Temperatures in parentheses are highly subjective.

(4) From surface manifestations, geophysical data, well records, geologic inference and leasing activity. Assumes 1.5 km^2 if no data pertinent to size is available. Top assumed at depth of 1.5 km if no data available. Bottom assumed at 3 km depth for all convection systems. Calculated from assumed area and thickness.

(5) Calculated as product of assumed volume, volumetric specific heat of 0.6 $cal/cm^3°C$, and temperature in degrees C above 15°C.

(6) 0.02 for 150°-200°C
0.025 for 200°-250°C

(7) 25% Heat Content Recoverable as thermal energy at the surface; 1 Quad= 0.25×10^{18} cal.

Non-Technical Components For Area 3

Of the five (5) sites in this area, only Jordan Meadow Mountain has direct federal environmental constraints. The constraint is a No Leasing-Pending Additional Environmental Studies for a proposed roadless area. Not all of the site is excluded from leasing. Throughout the area there are other small tracts of land which have a "No Leasing" constraint for Bighorn Sheep and Sage Grouse habitat. These additional restrictions do not directly affect any of the other sites.

Only two (2) sites in the area have shown any leasing activity. The first, Jordan Meadow Mountain is in about 50% geothermal lease and the second site, Cordero Mercury Mine is about 95% leased. There has been no leasing activity at any of the remaining three (3) sites: Fivemile Spring, Ninemile Summit Spring and Quinn River.

Presently there are no KGRAs in the area, and only the two sites with leasing activity are within U.S.G.S. defined Area Potential Prospectively. Of the few Notices of Intent filed for this area, only one site, Cordero Mercury Mine was included. This was an intent to drill shallow temperature gradient holes by Earth Power Company.

General Statement to Non-Technical Components Section,
Area Scenarios

1. All observations for environmental, leasing and "Intents" are based on data gathered in 1977, which has not been corrected, adjusted or up-dated.

2. All environmental decisions are federal (BLM) as there are no localities in Nevada which require an environmental statement. Nevada has only 2 laws requiring such reports:

   a. Nevada Clean Air Act of 1971. Amended in 1973.

   b. Utility Environmental Protection Act, 1971.
   Amended 1973.
   Requires environmental statement for utility plant siting.

   Protection of environmental values is now explicitly and clearly a major criteria for BLM management activities. All BLM activities are governed by the "Federal Land Policy and Management Act".

3. Areas 15, 16, 17, 18, 19 grouped together make up a zone of Intensive and Extensive geothermal resource interests.

   A little over 1/2 of the total land in this zone is available for geothermal leasing, the remainder is covered by private indian reservation, Bureau of Reclamation withdrawals, wildlife management and refuge, state parks and military use lands. The zone contains 10 KGRAs.

   There has been intensive "Geophysical" and "Shallow Temperature Gradient Hole" interest indicated by numerous filings of "Intent to do Geothermal Resource Exploration" with U.S.G.S. To date we do not know how many of these projects were completed.

This zone does not have extensive environment decisions but some significant sites will be affected by such decisions. (i.e. Tahoe Basin Area and Carson Sink-Alkali Flat East and West)

There has been significant leasing in this zone, both within the KGRA's and its vicinity. The leasing interest is mostly by minor companies and individual and/or investment groups. Some sites showed 100% major company interest, such as Bell Flat, of which very few are still lease applications, the remainder closed cases.

This zone includes 1 of the 2 metropolitan localities in the state: Reno-Sparks - (should include Carson City) with many important communities, good to fair transportation arteries.

Economic Base: Tourism, Agriculture/Livestock, Warehousing. The growth in tourism and warehousing increases population energy needs.

AREA: 3

SITE	ENVIRONMENT			LAND STATUS							OWNERSHIP INTEREST			INTENTS			NOTES
	CRIT.R.	EXCLUD. PEND.	EXCLUD.	LSE. APLN.	CLOSED	LSE.	GEO SIM	OPEN	A.P.P.	OTHER or KGRA	MAJOR	MINOR	IND./ INV.	GEO.	DRILL.	OTHER	
Cordero Mercury Mine				X		X			X		X	X	X		X		
Jordan Meadow Mtn.		X		X	X	X	X		X		X	X	X				
Fivemile Spring								X									
Ninemile Summit Sp.								X									
Quinn River								X									

EXPLANATION FOR AREA SHEETS

ENVIRONMENT: Federal environmental decisions relating to availability of federal lands for geothermal resource leasing. All data taken from Environmental Assessment Records prepared by BLM.

CRIT. R.: Critical Restrictions. Restrictions to lessee, in addition to those restrictions covered in the Geothermal Resource Lease Application (Sec. 14 and 18).

EXCLUD. PEND.: Excluded from Leasing. Pending additional environmental studies.

EXCLUD.: Excluded from all leasing.

LAND STATUS: Geothermal leasing status on federal lands.

LSE. APLN.: Lease Application

CLOSED: Closed cases. Application never became lease. In theory the land is available for geothermal leasing.

GEO. SIM.: Geothermal Simultaneous Drawing. These applications became leases, then were terminated or relinquished by the lessee. These parcels are held for simultaneous drawing.

OPEN: Open - No leases presently recorded for site.

A.P.P.: Area Potential Prospectively. As outlined by U.S.G.S., possible geothermal resource areas.

OTHER or KGRA: KGRA - Known Geothermal Resource

OWNERSHIP INTEREST:

MAJOR: Major company interest or holdings.

MINOR: Minor company interest or holdings.

IND./INV.: Individual and/or investment group interest or holdings.

INTENTS: "Intent to Conduct Geothermal Resource Exploration" are filed with U.S.G.S.

GEO.: Geophysical work only. No Drilling (i.e.= Gravity, magnetotelluric and other surveys)

DRILL: Drilling of shallow temperature gradient holes.

OTHER: Any exploration work not included in above categories.

(NOTE: The filing of the Intent to conduct geothermal resource exploration Does Not imply the work was completed.)

References To Postulated Site Development Schedules
And Non-Technical Components Of Areas.

References (indicated by parentheses and corresponding number)

1. Oral Communication:

2. Regional Environmental Analysis Record
   Geothermal oil/gas leasing (BLM) and maps

   a. Carson City District
      Pyramid District, 1975

   b. Winnemucca District
      Sonoma-Gerlach Resource Area
      Buffalo Hills Planning Unit
      1975

   c. Winnemucca District
      Deno, Paradise, Blue Wing and
      Sonoma Planning Units,
      1975

   d. Elko District,
      1975

   e. Battle Mountain District
      1976

   f. Tonopah Resource Area
      1975

   g. Fort Churchill-Clan Alpine Area,
      Carson City District, Nev., 1975

   h. Pine Nut-Walker Area,
      Carson City District, Nev. 1975

   i. Esmeralda Planning Unit,
      Esmeralda and Nye Counties, 1974

3. Lease Books (Nevada Team Data)
   Data obtained from BLM public records and maps.

4. "Intent to Conduct Geothermal Resource Exploration"
   (Filed with U.S.G.S.), (Maps and Folder) and maps.

5. Drilling and Resource Data Sheets.

6. Plan of Operation, Phillips Petroleum Company,
   March 1, 1978 - To drill 6 geothermal wells to 8000'.
   To determine the existence and commercial potential of
   geothermal resources.
   Estimating starting date - 6-78
   Estimated comp. date - 12-82

COMPOSITE POSTULATED SITE DEVELOPMENT SCHEDULE
FOR AREA 3

SITE NAME	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
Cordero Mercury Mine																			20	20	70	70	90	90	90
Jordan Meadow Mountain																									
Fivemile Spring																									
Ninemile Summit Spring																									
Quinn River																									
TOTAL MWe:																									
TOTAL Quads:																									

20,50,100 = MWe (megawatts electric); electrical power generation.
.037,.04,.017 = Quads (0.252×10^{18} cal.); direct thermal utilization. Quads available for commercial utilization. It is unlikely that the energy developed at each site will be wholly utilized, or utilized in the optimum or most efficient manner.

AREA 3

95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	70	70	20

AREA: 3

SITE CHARACTERISTICS:

SITE: CORDERO MERCURY MINE

Possible Subsequent Additions (MWe) and On Line Date:
50 MWe 1990
20 MWe 1992

POSTULATED SITE DEVELOPMENT SCHEDULE (FOR FIRST 20 MWe PLANT)

OPERATING ENTITIES	ACTIVITY	RECIPIENTS	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
BLM	Approve Notice of Intent-	Developer																								
USGS	Approve NOI & Drill Permit	Developer																								
BLM/Owner	Lease Land	Developer																								
BLM	Process EIA/EIS	CEQ																								
County	Issue Land Use Permits	Developer																								
Developer	Exploratory Drilling & Reservoir Evaluation																									
Developer	Develop Utility Interest																									
Developer & Utility	Feasibility Study																									
Producer (Developer) & Utility	Financial Negotiations																									
Producer	Site Selection																									
Producer & Utility	Design																									
Producer & Utility	Commitment to Development													△												
Producer & Utility	Prepare Master Development Plan	BLM, USGS																								
Utility	Prepare Environmental Data Statement	BLM, FPC STATE, County																								
BLM, FPC STATE, USGS	Certify Plant & Site Issue Permits	Producer & Utility																								
USGS	Process EIA/EIS (Drilling)	CEQ																								
FPC	Process EIA/EIS (Plant)	CEQ																								
FPC	Process EIA/EIS (Transmission Line)	CEQ																								
Producer	Development Drilling																									
Utility	Plant Construction																									
Utility	Install Transmission Line (40 km)																									

NEVADA GEOTHERMAL AREA 4 SCENARIO

HOT-WATER CONVECTION SYSTEMS IN AREA 4 .

Location	Temperatures °C				Reservoir Assumptions		Energy Potential		
Site	Surface (1)	Geochemical SiO_2 (2)	Geochemical Na-K-Ca (2)	Subsurface (3)	Volume km^3 (4)	Heat content 10^{18} cal (5)	Recovery Factor e_r (6)	Electrical Potential MW_e-30yrs.	Thermal Energy for Direct Use Quads (7)
Hot Sulphur Springs	90			(185)	20	2.0	0.02	180	
The Hot Springs	59	107	209	(170)	10	0.9	0.02	80	
Dry Creek Mountain	47								
Goosey Lake Flat	Hot								
Midas	Hot								
Deep Creek-Sulphur Creek	ND								
South Fork	ND								
Burns Creek	Warm								
Hot Lake	ND								
Willow Creek Reservoir	ND								
Evans Creek	Hot								
TOTAL:								260	

Footnotes 1 thru 7-see Explanation Page

EXPLANATION TO HOT-WATER CONVECTION SYSTEMS SHEETS

Footnotes

(1) Maximum surface temperature reported from a spring or fumarole.

(2) Predicted using chemical geothermometers, assuming last equilibration in the reservoir; assumes saturation of SiO_2 with respect to quartz, and no loss of Ca from calcite deposition.

(3) Assumed average reservoir temperature based on data presently available. Temperatures from Circular 726 and other sources. Temperatures in parentheses are highly subjective.

(4) From surface manifestations, geophysical data, well records, geologic inference and leasing activity. Assumes 1.5 km^2 if no data pertinent to size is available. Top assumed at depth of 1.5 km if no data available. Bottom assumed at 3 km depth for all convection systems. Calculated from assumed area and thickness.

(5) Calculated as product of assumed volume, volumetric specific heat of 0.6 $cal/cm^3°C$, and temperature in degrees C above 15°C.

(6) 0.02 for 150°-200°C
0.025 for 200°-250°C

(7) 25% Heat Content Recoverable as thermal energy at the surface; 1 Quad= 0.25×10^{18} cal.

Non-Technical Components For Area 4

Approximately 50% of the total area is covered by federal environmental constraints, which directly affects seven (7) of the eleven sites included in this area. Of these particular seven sites, only one (1), South Fork has No Leasing-Pending Additional Environmental Studies (for archelogical investigations). The other six (6): Hot Sulphur Springs, Hot Lake, Midas, Willow Creek, Dry Creek Mountain and Goosey Lake Flat allow leasing, but, are sites with special stipulations regarding seasonal use or entry and restrictions based on multiple uses of site and vicinity.

Nearly 40% of this area is under large blocks of private land, stock driveways and national forest land. Leasing activity has not been extensive, with only one (1) site, Hot Sulphur Springs with any leasing activity. About 2/3 of all activity in this site is under geothermal lease, the remainder of the activity is still in lease application. Present data indicates there are no closed cases at this site. Major companies have shown intensive interest. Only three (3) of the sites: Hot Sulphur Springs, Hot Lake and The Hot Springs are included in U.S.G.S. defined Area Potential Prospectively.

Quite a few Notices of Intent have been filed for area, with only Hot Sulphur Springs and Burns Creek sites directly included in geophysical survey work by Southern Union Production Company.

General Statement to Non-Technical Components Section,
Area Scenarios

1. All observations for environmental, leasing and "Intents" are based on data gathered in 1977, which has not been corrected, adjusted or up-dated.

2. All environmental decisions are federal (BLM) as there are no localities in Nevada which require an environmental statement. Nevada has only 2 laws requiring such reports:

   a. Nevada Clean Air Act of 1971. Amended in 1973.

   b. Utility Environmental Protection Act, 1971.
   Amended 1973.
   Requires environmental statement for utility plant siting.

   Protection of environmental values is now explicitly and clearly a major criteria for BLM management activities. All BLM activities are governed by the "Federal Land Policy and Management Act".

3. Areas 15, 16, 17, 18, 19 grouped together make up a zone of Intensive and Extensive geothermal resource interests.

   A little over 1/2 of the total land in this zone is available for geothermal leasing, the remainder is covered by private indian reservation, Bureau of Reclamation withdrawals, wildlife management and refuge, state parks and military use lands. The zone contains 10 KGRAs.

   There has been intensive "Geophysical" and "Shallow Temperature Gradient Hole" interest indicated by numerous filings of "Intent to do Geothermal Resource Exploration" with U.S.G.S. To date we do not know how many of these projects were completed.

This zone does not have extensive environment decisions but some significant sites will be affected by such decisions. (i.e. Tahoe Basin Area and Carson Sink-Alkali Flat East and West)

There has been significant leasing in this zone, both within the KGRA's and its vicinity. The leasing interest is mostly by minor companies and individual and/or investment groups. Some sites showed 100% major company interest, such as Bell Flat, of which very few are still lease applications, the remainder closed cases.

This zone includes 1 of the 2 metropolitan localities in the state: Reno-Sparks - (should include Carson City) with many important communities, good to fair transportation arteries.

Economic Base: Tourism, Agriculture/Livestock, Warehousing. The growth in tourism and warehousing increases population energy needs.

AREA: 4

SITE	ENVIRONMENT			LAND STATUS							OWNERSHIP INTEREST			INTENTS			NOTES
	CRIT.R.	EXCLUD. PEND.	EXCLUD.	LSE. APLN.	CLOSED	LSE.	GEO SIM	OPEN	A.P.P.	OTHER or KGRA	MAJOR	MINOR	IND./ INV.	GEO.	DRILL.	OTHER	
Hot Sulphur Sps.	X			X		X			X		X	X		X			Some Private
Hot Lake	X								X								Stock Driveway
Midas	X									X							
Willow Crk. Res.	X									X							
Dry Creek Mountain	X									Priv.							
Goosey Lake Flat	X									X							Nat'l For.
South Fork		X								X							
Evans Creek										Priv.							
The Hot Springs									X	Priv.							
Burns Creek										X				X			
Deep Crk-Sulphur Crk										X							

EXPLANATION FOR AREA SHEETS

ENVIRONMENT: Federal environmental decisions relating to availability of federal lands for geothermal resource leasing. All data taken from Environmental Assessment Records prepared by BLM.

CRIT. R.: Critical Restrictions. Restrictions to lessee, in addition to those restrictions covered in the Geothermal Resource Lease Application (Sec. 14 and 18).

EXCLUD. PEND.: Excluded from Leasing. Pending additional environmental studies.

EXCLUD.: Excluded from all leasing.

LAND STATUS: Geothermal leasing status on federal lands.

LSE. APLN.: Lease Application

CLOSED: Closed cases. Application never became lease. In theory the land is available for geothermal leasing.

GEO. SIM.: Geothermal Simultaneous Drawing. These applications became leases, then were terminated or relinquished by the lessee. These parcels are held for simultaneous drawing.

OPEN: Open - No leases presently recorded for site.

A.P.P.: Area Potential Prospectively. As outlined by U.S.G.S., possible geothermal resource areas.

OTHER or KGRA: KGRA - Known Geothermal Resource

OWNERSHIP INTEREST:

MAJOR: Major company interest or holdings.

MINOR: Minor company interest or holdings.

IND./INV.: Individual and/or investment group interest or holdings.

INTENTS: "Intent to Conduct Geothermal Resource Exploration" are filed with U.S.G.S.

GEO.: Geophysical work only. No Drilling (i.e.= Gravity, magnetotelluric and other surveys)

DRILL: Drilling of shallow temperature gradient holes.

OTHER: Any exploration work not included in above categories.

(NOTE: The filing of the Intent to conduct geothermal resource exploration Does Not imply the work was completed.)

References To Postulated Site Development Schedules
And Non-Technical Components Of Areas.

References (indicated by parentheses and corresponding number)

1. Oral Communication:

2. Regional Environmental Analysis Record
   Geothermal oil/gas leasing (BLM) and maps

   a. Carson City District
      Pyramid District, 1975

   b. Winnemucca District
      Sonoma-Gerlach Resource Area
      Buffalo Hills Planning Unit
      1975

   c. Winnemucca District
      Deno, Paradise, Blue Wing and
      Sonoma Planning Units,
      1975

   d. Elko District,
      1975

   e. Battle Mountain District
      1976

   f. Tonopah Resource Area
      1975

   g. Fort Churchill-Clan Alpine Area,
      Carson City District, Nev., 1975

   h. Pine Nut-Walker Area,
      Carson City District, Nev. 1975

   i. Esmeralda Planning Unit,
      Esmeralda and Nye Counties, 1974

3. Lease Books (Nevada Team Data)
   Data obtained from BLM public records and maps.

4. "Intent to Conduct Geothermal Resource Exploration"
   (Filed with U.S.G.S.), (Maps and Folder) and maps.

5. Drilling and Resource Data Sheets.

6. Plan of Operation, Phillips Petroleum Company,
   March 1, 1978 - To drill 6 geothermal wells to 8000'.
   To determine the existence and commercial potential of
   geothermal resources.
   Estimating starting date - 6-78
   Estimated comp. date - 12-82

COMPOSITE POSTULATED SITE DEVELOPMENT SCHEDULE
FOR AREA 4

SITE NAME	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
Hot Sulphur Springs																		30	30	80	80	130	130	180	180
The Hot Springs																									
Dry Creek Mountain																									
Goosey Lake Flat																									
Midas																									
Deep Creek-Sulphur Creek																									
South Fork																									
Burns Creek																									
Hot Lake																									
Willow Creek Reservoir																									
Evans Creek																									
TOTAL MWe:																									
TOTAL Quads:																									

20,50,100 = MWe (megawatts electric); electrical power generation.
.037,.04,.017 = Quads (0.252 x 10^{18} cal.); direct thermal utilization. Quads available for commercial utilization. It is unlikely that the energy developed at each site will be wholly utilized, or utilized in the optimum or most efficient manner.

AREA 4

95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	150	150	100	100
				30	30	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80

AREA: 4

SITE CHARACTERISTICS:

SITE: HOT SULPHUR SPRINGS

Possible Subsequent Additions (MWe) and On Line Date:
50 MWe 1989
50 MWe 1991
50 MWe 1993

POSTULATED SITE DEVELOPMENT SCHEDULE (FOR FIRST 30 MWe PLANT)

OPERATING ENTITIES	ACTIVITY	RECIPIENTS	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
BLM	Approve Notice of Intent-	Developer							—																	
USGS	Approve NOI & Drill Permit	Developer							—																	
BLM/Owner	Lease Land	Developer	(1)					—	—	—	—															
BLM	Process EIA/EIS	CEQ					—	—																		
County	Issue Land Use Permits	Developer									—															
Developer	Exploratory Drilling & Reservoir Evaluation											—	—													
Developer	Develop Utility Interest											—	—													
Developer & Utility	Feasibility Study												—	—												
Producer (Developer) & Utility	Financial Negotiations													—												
Producer	Site Selection													—												
Producer & Utility	Design														—	—										
Producer & Utility	Commitment to Development														△											
Producer & Utility	Prepare Master Development Plan	BLM, USGS													—											
Utility	Prepare Environmental Data Statement	BLM, FPC STATE, County													—											
BLM, FPC STATE, USGS	Certify Plant & Site Issue Permits	Producer & Utility														—	—									
USGS	Process EIA/EIS (Drilling)	CEQ														—										
FPC	Process EIA/EIS (Plant)	CEQ														—										
FPC	Process EIA/EIS (Transmission Line)	CEQ														—										
Producer	Development Drilling																—	—	—							
Utility	Plant Construction																	—	—							
Utility	Install Transmission Line (40 km)																	—	—							

(1) Extended lease time due to some environmental restrictions adjacent to and on small area of Site.

NEVADA GEOTHERMAL AREA 5 SCENARIO

HOT-WATER CONVECTION SYSTEMS IN AREA 5 .

Location	Temperatures °C				Reservoir Assumptions		Energy Potential		
Site	Surface (1)	Geochemical SiO_2 (2)	Geochemical Na-K-Ca (2)	Subsurface (3)	Volume km^3 (4)	Heat content 10^{18} cal (5)	Recovery Factor e_r (6)	Electrical Potential MW_e-30yrs.	Thermal Energy for Direct Use Quads (7)
Humboldt Wells	90	128	191	140 (200)	20	2.2	0.025	245	
Mineral Hot Springs	60	127	129	130 (185)	10	2.0	0.02	180	
Cobre	77								
Goose Creek	43								
Hot Creek Springs	68								
Jackpot	38								
Mary's River Ranch	50								
Rizzi Ranch Hot Spring	41								
San Jacinto Ranch Spring	64								
Tennessee Mountain	40								
Thousand Springs	96?								
Wild Horse Hot Spring	54								
Wine Cup Ranch	59								
Jarbidge Mountains	27								
Rock Spring Creek	29								
Wilkins	Hot								
North Fork	ND								
Gonce Creek	ND								
Clover Valley	Warm								
Winter Creek	ND								
Mulligan Creek	30								
TOTAL:								425	

Footnotes 1 thru 7-see Explanation Page

EXPLANATION TO HOT-WATER CONVECTION SYSTEMS SHEETS

Footnotes

(1) Maximum surface temperature reported from a spring or fumarole.

(2) Predicted using chemical geothermometers, assuming last equilibration in the reservoir; assumes saturation of SiO_2 with respect to quartz, and no loss of Ca from calcite deposition.

(3) Assumed average reservoir temperature based on data presently available. Temperatures from Circular 726 and other sources. Temperatures in parentheses are highly subjective.

(4) From surface manifestations, geophysical data, well records, geologic inference and leasing activity. Assumes 1.5 km^2 if no data pertinent to size is available. Top assumed at depth of 1.5 km if no data available. Bottom assumed at 3 km depth for all convection systems. Calculated from assumed area and thickness.

(5) Calculated as product of assumed volume, volumetric specific heat of 0.6 $cal/cm^3°C$, and temperature in degrees C above 15°C.

(6) 0.02 for 150°-200°C
0.025 for 200°-250°C

(7) 25% Heat Content Recoverable as thermal energy at the surface; 1 Quad= 0.25×10^{18} cal.

Non-Technical Components For Area 5

Approximately 2/3 of the total area is under private land (checkerboard pattern of alternating federal and public lands), national forest and some stock driveways. Of the twenty-one (21) sites located in this area four (4) are directly affected by federal environmental constraints. The decision allows leasing but has stipulations for seasonal occupancy restrictions for: Humboldt Wells, Goose Creek, Mary's River Ranch and Jackpot. Some of the other sites could possibly be affected by these and other environmental decisions for the area because they are located adjacent to the restricted tracts. Approximately 25% of area 5 is subject to some environmental (federal) decision.

Four (4) sites are located on Humboldt National Forest lands: Jarbidge Mountains, Rizzi Ranch Hot Spring, Tennessee Mountain and Wild Horse Hot Spring. When leasing activity becomes directed toward these sites, special environmental restrictions or stipulations may be required.

Presently there are no KGRAs located within the area and leasing activity cannot be considered significant, as only one (1) site has had any leasing action. All of the lease applications filed at Humboldt Wells site are now closed cases, no application went to lease. Eleven of the sites are located within U.S.G.S. Area Potential Prospectively.

There have been very few Notices of Intents filed for this area. Those filed were for both geophysical survey and shallow temperature gradient holes, which covered only a zone by Humboldt Wells to Mary's River Ranch.

There are four communities in this area: Wells, Jackpot, Montello and Mountain City, and the area includes about 2/3 of Elko County.

General Statement to Non-Technical Components Section,

Area Scenarios

1. All observations for environmental, leasing and "Intents" are based on data gathered in 1977, which has not been corrected, adjusted or up-dated.

2. All environmental decisions are federal (BLM) as there are no localities in Nevada which require an environmental statement. Nevada has only 2 laws requiring such reports:

   a. Nevada Clean Air Act of 1971. Amended in 1973.

   b. Utility Environmental Protection Act, 1971.
   Amended 1973.
   Requires environmental statement for utility plant siting.

   Protection of environmental values is now explicitly and clearly a major criteria for BLM management activities. All BLM activities are governed by the "Federal Land Policy and Management Act".

3. Areas 15, 16, 17, 18, 19 grouped together make up a zone of Intensive and Extensive geothermal resource interests.

   A little over 1/2 of the total land in this zone is available for geothermal leasing, the remainder is covered by private indian reservation, Bureau of Reclamation withdrawals, wildlife management and refuge, state parks and military use lands. The zone contains 10 KGRAs.

   There has been intensive "Geophysical" and "Shallow Temperature Gradient Hole" interest indicated by numerous filings of "Intent to do Geothermal Resource Exploration" with U.S.G.S. To date we do not know how many of these projects were completed.

This zone does not have extensive environment decisions but some significant sites will be affected by such decisions. (i.e. Tahoe Basin Area and Carson Sink-Alkali Flat East and West)

There has been significant leasing in this zone, both within the KGRA's and its vicinity. The leasing interest is mostly by minor companies and individual and/or investment groups. Some sites showed 100% major company interest, such as Bell Flat, of which very few are still lease applications, the remainder closed cases.

This zone includes 1 of the 2 metropolitan localities in the state: Reno-Sparks - (should include Carson City) with many important communities, good to fair transportation arteries.

Economic Base: Tourism, Agriculture/Livestock, Warehousing. The growth in tourism and warehousing increases population energy needs.

AREA: 5

SITE	ENVIRONMENT			LAND STATUS							OWNERSHIP INTEREST			INTENTS			
	CRIT.R.	EXCLUD. PEND.	EXCLUD.	LSE. APLN.	CLOSED	LSE.	GEO SIM	OPEN	A.P.P.	OTHER or KGRA	MAJOR	MINOR	IND./ INV.	GEO.	DRILL.	OTHER	NOTES
Humboldt Wells	X			X	X				X								
Goose Creek	X							X	X					X			Some Private
Mary's River Ranch	X							X	X								
Jarbidge Mountains								X									Humboldt Natl For.
Bizzi Ranch H. Sp.								X	X								Humboldt Natl For.
Tennessee Mtn.								X	X								Humboldt Natl For.
Wild Horse H.Sp.								X	X								Humboldt Natl For.
Jackpot	X							X	X								
Hot Creek Springs								X	X								
Mineral Hot Springs								X	X								
San Jacinto Rch. Sp.								X	X								
Thousand Springs								X	X								
Clover Valley								X						X			
Cobre								X									
Wine Cup Ranch								X									
Rock Spring Creek								X									
Wilkins								X									
North Fork								X									
Gonce Creek								X									
Winter Creek								X									
Mulligan Creek								X									

EXPLANATION FOR AREA SHEETS

ENVIRONMENT: Federal environmental decisions relating to availability of federal lands for geothermal resource leasing. All data taken from Environmental Assessment Records prepared by BLM.

CRIT. R.: Critical Restrictions. Restrictions to lessee, in addition to those restrictions covered in the Geothermal Resource Lease Application (Sec. 14 and 18).

EXCLUD. PEND.: Excluded from Leasing. Pending additional environmental studies.

EXCLUD.: Excluded from all leasing.

LAND STATUS: Geothermal leasing status on federal lands.

LSE. APLN.: Lease Application

CLOSED: Closed cases. Application never became lease. In theory the land is available for geothermal leasing.

GEO. SIM.: Geothermal Simultaneous Drawing. These applications became leases, then were terminated or relinquished by the lessee. These parcels are held for simultaneous drawing.

OPEN: Open - No leases presently recorded for site.

A.P.P.: Area Potential Prospectively. As outlined by U.S.G.S., possible geothermal resource areas.

OTHER or KGRA: KGRA - Known Geothermal Resource

OWNERSHIP INTEREST:

MAJOR: Major company interest or holdings.

MINOR: Minor company interest or holdings.

IND./INV.: Individual and/or investment group interest or holdings.

INTENTS: "Intent to Conduct Geothermal Resource Exploration" are filed with U.S.G.S.

GEO.: Geophysical work only. No Drilling (i.e.= Gravity, magnetotelluric and other surveys)

DRILL: Drilling of shallow temperature gradient holes.

OTHER: Any exploration work not included in above categories.

(NOTE: The filing of the Intent to conduct geothermal resource exploration Does Not imply the work was completed.)

References To Postulated Site Development Schedules And Non-Technical Components Of Areas.

References (indicated by parentheses and corresponding number)

1. Oral Communication:

2. Regional Environmental Analysis Record
   Geothermal oil/gas leasing (BLM) and maps

   a. Carson City District
      Pyramid District, 1975

   b. Winnemucca District
      Sonoma-Gerlach Resource Area
      Buffalo Hills Planning Unit
      1975

   c. Winnemucca District
      Deno, Paradise, Blue Wing and
      Sonoma Planning Units,
      1975

   d. Elko District,
      1975

   e. Battle Mountain District
      1976

   f. Tonopah Resource Area
      1975

   g. Fort Churchill-Clan Alpine Area,
      Carson City District, Nev., 1975

   h. Pine Nut-Walker Area,
      Carson City District, Nev. 1975

   i. Esmeralda Planning Unit,
      Esmeralda and Nye Counties, 1974

3. Lease Books (Nevada Team Data)
   Data obtained from BLM public records and maps.

4. "Intent to Conduct Geothermal Resource Exploration"
   (Filed with U.S.G.S.), (Maps and Folder) and maps.

5. Drilling and Resource Data Sheets.

6. Plan of Operation, Phillips Petroleum Company,
   March 1, 1978 - To drill 6 geothermal wells to 8000'.
   To determine the existence and commercial potential of geothermal resources.
   Estimating starting date - 6-78
   Estimated comp. date - 12-82

COMPOSITE POSTULATED SITE DEVELOPMENT SCHEDULE
FOR AREA 5

SITE NAME	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
Humboldt Wells																		20	20	70	70	120	120	170	170
Mineral Hot Springs																									
Cobre																									
Goose Creek																									
Hot Creek Springs																									
Jackpot																									
Mary's River Ranch																									
Rizzi Ranch Hot Spring																									
San Jacinto Ranch Spring																									
Tennessee Mountain																									
Thousand Springs																									
Wild Horse Hot Spring																									
Wine Cup Ranch																									
Jarbidge Mountains																									
Rock Spring Creek																									
Wilkins																									
North Fork																									
Gonce Creek																									
Clover Valley																									
Winter Creek																									
Mulligan Creek																									
TOTAL MWe:																									
TOTAL Quads:																									

20,50,100 = MWe (megawatts electric); electrical power generation.
.037,.04,.017 = Quads (0.252×10^{18} cal.); direct thermal utilization. Quads available for commercial utilization. It is unlikely that the energy developed at each site will be wholly utilized, or utilized in the optimum or most efficient manner.

AREA 5

95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
220	220	245	245	245	245	245	245	245	245	245	245	245	245	245	245	245	245	245	245	245	245	225	225	175	175
										30	30	80	80	130	130	180	180	180	180	180	180	180	180	180	180

AREA: 5

SITE CHARACTERISTICS:

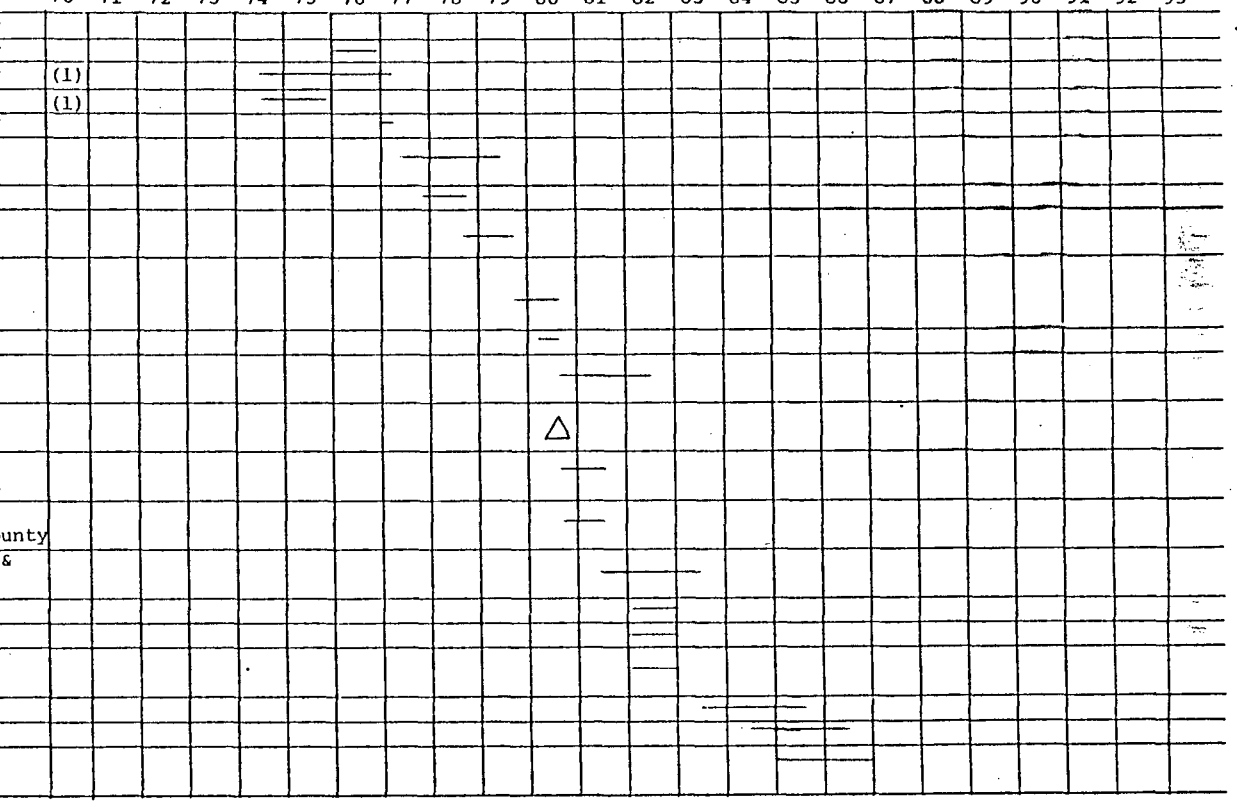
SITE: HUMBOLDT WELLS

Possible Subsequent Additions (MWe) and On Line Date:

50 MWe 1989 50 MWe 1995
50 MWe 1991 25 MWe 1997
50 MWe 1993

POSTULATED SITE DEVELOPMENT SCHEDULE (FOR FIRST 20 MWe PLANT)

OPERATING ENTITIES	ACTIVITY	RECIPIENTS
BLM	Approve Notice of Intent-	Developer
USGS	Approve NOI & Drill Permit	Developer
BLM/Owner	Lease Land	Developer
BLM	Process EIA/EIS	CEQ
County	Issue Land Use Permits	Developer
Developer	Exploratory Drilling & Reservoir Evaluation	
Developer	Develop Utility Interest	
Developer & Utility	Feasibility Study	
Producer (Developer) & Utility	Financial Negotiations	
Producer	Site Selection	
Producer & Utility	Design	
Producer & Utility	Commitment to Development	
Producer & Utility	Prepare Master Development Plan	BLM, USGS
Utility	Prepare Environmental Data Statement	BLM, FPC STATE, County
BLM, FPC STATE, USGS	Certify Plant & Site Issue Permits	Producer & Utility
USGS	Process EIA/EIS (Drilling)	CEQ
FPC	Process EIA/EIS (Plant)	CEQ
FPC	Process EIA/EIS (Transmission Line)	CEQ
Producer	Development Drilling	
Utility	Plant Construction	
Utility	Install Transmission Line (40 km)	



(1) Site located on and adjacent to private land, also, there are about 640 acres of the site which have environmental constraints (leasing allowed with seasonal restrictions). Whatever time to "on line" gained by presence or lease or use of private land leasing/rights-of-way, may be lost in seasonal restrictions. The environmental constraint does not apply to the entire site. No time adjustment made on this Scenario.

NEVADA GEOTHERMAL AREA 6 SCENARIO

HOT-WATER CONVECTION SYSTEMS IN AREA 6 .

Location	Temperatures °C				Reservoir Assumptions		Energy Potential		
Site	Surface (1)	Geochemical SiO_2 (2)	Geochemical Na-K-Ca (2)	Subsurface (3)	Volume km^3 (4)	Heat content 10^{18} cal (5)	Recovery Factor e_r (6)	Electrical Potential MW_e-30yrs.	Thermal Energy for Direct Use Quads (7)
San Emidio Desert	53			(200)	20	2.2	0.025	245	
Gerlach, N.E.	ND			(200)	10	1.1			1.1
Double H. Sps.-Black Rock H. Sps.	94	148	127	150 (200)	60	6.6	0.025	735	
Gerlach	98			(200)	30	3.3	0.025	370	
Cholona	ND			(185)	10	1.0	0.02	90	
Fly Ranch	94	127	154	130 (185)	10	1.0	0.02	90	
Fly Ranch, N.E.	ND			(185)	10	1.0	0.02	90	
Trego	86	129	120	130 (185)	10	1.0	0.02	90	
Donnelly Peak	63								
Parman	39-								
Soldier Meadows Hot Springs	54	113	65	115	12	0.7			
North Fox Range	ND								
North Winnemucca Lake	86								
Sawmill	ND								
Nugent Springs	ND								
Selenite Peak	ND								
TOTAL:								1710	1.1

Footnotes 1 thru 7-see Explanation Page

EXPLANATION TO HOT-WATER CONVECTION SYSTEMS SHEETS

Footnotes

(1) Maximum surface temperature reported from a spring or fumarole.

(2) Predicted using chemical geothermometers, assuming last equilibration in the reservoir; assumes saturation of SiO_2 with respect to quartz, and no loss of Ca from calcite deposition.

(3) Assumed average reservoir temperature based on data presently available. Temperatures from Circular 726 and other sources. Temperatures in parentheses are highly subjective.

(4) From surface manifestations, geophysical data, well records, geologic inference and leasing activity. Assumes 1.5 km^2 if no data pertinent to size is available. Top assumed at depth of 1.5 km if no data available. Bottom assumed at 3 km depth for all convection systems. Calculated from assumed area and thickness.

(5) Calculated as product of assumed volume, volumetric specific heat of 0.6 $cal/cm^3°C$, and temperature in degrees C above 15°C.

(6) 0.02 for 150°-200°C
0.025 for 200°-250°C

(7) 25% Heat Content Recoverable as thermal energy at the surface; 1 Quad= 0.25×10^{18} cal.

Non-Technical Components For Area 6

This area is included within the controversial Black Rock Desert. Most of the controversy is from those who are interested in the protection and/or preservation of natural and historic phenomena associated with this desert. Quite briefly, there is an endangered fish (Soldier Meadows Dace) which is believed to be an ancestor of fish which thrived in ancient Lake Lahontan. The hot springs in the Soldiers Meadow area are the only known habitat for these fish. Soldiers Meadow is also one (1) of the sites in this area and, of course, has been excluded from leasing. Much of the Black Rock Desert is also being recommended for inclusion in the National Registry of Natural Landmarks. Archeologists, and historians are both greatly interested in the possible artifacts (one Clovis Point has been estimated at 11,500 years old). Some of the earliest accounts of the area were made by John C. Fremont. Also, the Black Rock Desert has had wagon trails (Noble Road) and forts (Camp McKee) within its boundary. The present environmental controversy is a deterrent to geothermal activity and development.

Of the sixteen (16) sites in this area, six (6) are covered by federal environment constraints for "Excluded from Leasing": Double Hot Springs-Black Rock Hot Springs, Gerlach, Cholona, Trego, North Winnemucca Lake and Soldiers Meadows Hot Springs. There are eight (8) KGRAs identified for area 6: Double Hot Springs-Black Rock Hot Springs, Gerlach, Gerlach, N.E., Cholona, Fly Ranch, Fly Ranch, N.E., Trego and San Emidio Desert. But, the federal environment decision excluding leasing directly affects four (4) of the KGRAs: Trego, Cholona, Gerlach and Double Hot Springs-Black Rock Hot Springs, removing 50% of the geothermal interest areas.

There has been significant leasing activity in this area with most interest by major companies. Approximately 75% of all lease applications have become closed cases (have not gone to lease). Eleven (11) of the sixteen (16) sites in this area have had some, to significant leasing activity. San Emidio Desert (KGRA) site has about 15% of its activity

in geothermal leases by major companies. Over 50% of the Black Rock Desert has had leasing activity, but 98% never went to lease.

There have been a large number of Notices Of Intents filed for this area (17), with intense interest directed to the Black Rock Desert, including geophysical surveys and shallow temperature gradient holes. Some of the major companies who filed Notices of Intents are Chevron Oil, Southern Union Production, and Phillips Oil Companies.

General Statement to Non-Technical Components Section,

Area Scenarios

1. All observations for environmental, leasing and "Intents" are based on data gathered in 1977, which has not been corrected, adjusted or up-dated.

2. All environmental decisions are federal (BLM) as there are no localities in Nevada which require an environmental statement. Nevada has only 2 laws requiring such reports:

   a. Nevada Clean Air Act of 1971. Amended in 1973.

   b. Utility Environmental Protection Act, 1971.
   Amended 1973.
   Requires environmental statement for utility plant siting.

   Protection of environmental values is now explicitly and clearly a major criteria for BLM management activities. All BLM activities are governed by the "Federal Land Policy and Management Act".

3. Areas 15, 16, 17, 18, 19 grouped together make up a zone of Intensive and Extensive geothermal resource interests.

   A little over 1/2 of the total land in this zone is available for geothermal leasing, the remainder is covered by private indian reservation, Bureau of Reclamation withdrawals, wildlife management and refuge, state parks and military use lands. The zone contains 10 KGRAs.

   There has been intensive "Geophysical" and "Shallow Temperature Gradient Hole" interest indicated by numerous filings of "Intent to do Geothermal Resource Exploration" with U.S.G.S. To date we do not know how many of these projects were completed.

   This zone does not have extensive environment decisions but some significant sites will be affected by such decisions. (i.e. Tahoe Basin Area and Carson Sink-Alkali Flat East and West)

   There has been significant leasing in this zone, both within the KGRA's and its vicinity. The leasing interest is mostly by minor companies and individual and/or investment groups. Some sites showed 100% major company interest, such as Bell Flat, of which very few are still lease applications, the remainder closed cases.

   This zone includes 1 of the 2 metropolitan localities in the state: Reno-Sparks - (should include Carson City) with many important communities, good to fair transportation arteries.

   Economic Base: Tourism, Agriculture/Livestock, Warehousing. The growth in tourism and warehousing increases population energy needs.

AREA: 6

SITE	ENVIRONMENT			LAND STATUS							OWNERSHIP INTEREST			INTENTS			NOTES
	CRIT.R.	EXCLUD. PEND.	EXCLUD.	LSE. APLN.	CLOSED	LSE.	GEO SIM	OPEN	A.P.P.	OTHER or KGRA	MAJOR	MINOR	IND./ INV.	GEO.	DRILL.	OTHER	
Dbl. Hot Springs- Blk. Rock H. Sps.			X	X	X				X	KGRA	X	X	X	X			Blk. Rock Desert
Gerlach			X	X	X				X	KGRA	X			X	X		Blk. Rock Desert
Gerlach, N.E.				X					X	KGRA	X	X	X	X			
Cholona			X	X	X				X	KGRA	X		X	X			Blk. Rock Desert
Fly Ranch				X	X	X			X	KGRA	X	X	X	X			
Fly Ranch, N.E.				X	X				X	KGRA	X			X			
Trego			X	X	X				X	KGRA				X			Blk. Rock Desert
San Emidio Desert				X	X	X			X	KGRA	X			X	X		
Donnelly Peak								X	X					X			
No. Winnemucca Lake			X					X	X								
Sawmill								X	X								
Soldier Mead.H.Sps.			X	X	X						X	X	X	X			
Selenite Peak						X			X		X						
North Fox Range						X			X		X		X				
Parman								X						X			
Nugent Springs								X									

EXPLANATION FOR AREA SHEETS

ENVIRONMENT: Federal environmental decisions relating to availability of federal lands for geothermal resource leasing. All data taken from Environmental Assessment Records prepared by BLM.

CRIT. R.: Critical Restrictions. Restrictions to lessee, in addition to those restrictions covered in the Geothermal Resource Lease Application (Sec. 14 and 18).

EXCLUD. PEND.: Excluded from Leasing. Pending additional environmental studies.

EXCLUD.: Excluded from all leasing.

LAND STATUS: Geothermal leasing status on federal lands.

LSE. APLN.: Lease Application

CLOSED: Closed cases. Application never became lease. In theory the land is available for geothermal leasing.

GEO. SIM.: Geothermal Simultaneous Drawing. These applications became leases, then were terminated or relinquished by the lessee. These parcels are held for simultaneous drawing.

OPEN: Open - No leases presently recorded for site.

A.P.P.: Area Potential Prospectively. As outlined by U.S.G.S., possible geothermal resource areas.

OTHER or KGRA: KGRA - Known Geothermal Resource

OWNERSHIP INTEREST:

MAJOR: Major company interest or holdings.

MINOR: Minor company interest or holdings.

IND./INV.: Individual and/or investment group interest or holdings.

INTENTS: "Intent to Conduct Geothermal Resource Exploration" are filed with U.S.G.S.

GEO.: Geophysical work only. No Drilling (i.e.= Gravity, magnetotelluric and other surveys)

DRILL: Drilling of shallow temperature gradient holes.

OTHER: Any exploration work not included in above categories.

(NOTE: The filing of the Intent to conduct geothermal resource exploration Does Not imply the work was completed.)

References To Postulated Site Development Schedules
And Non-Technical Components Of Areas.

References (indicated by parentheses and corresponding number)

1. Oral Communication:

2. Regional Environmental Analysis Record
   Geothermal oil/gas leasing (BLM) and maps

   a. Carson City District
      Pyramid District, 1975

   b. Winnemucca District
      Sonoma-Gerlach Resource Area
      Buffalo Hills Planning Unit
      1975

   c. Winnemucca District
      Deno, Paradise, Blue Wing and
      Sonoma Planning Units,
      1975

   d. Elko District,
      1975

   e. Battle Mountain District
      1976

   f. Tonopah Resource Area
      1975

   g. Fort Churchill-Clan Alpine Area,
      Carson City District, Nev., 1975

   h. Pine Nut-Walker Area,
      Carson City District, Nev. 1975

   i. Esmeralda Planning Unit,
      Esmeralda and Nye Counties, 1974

3. Lease Books (Nevada Team Data)
   Data obtained from BLM public records and maps.

4. "Intent to Conduct Geothermal Resource Exploration"
   (Filed with U.S.G.S.), (Maps and Folder) and maps.

5. Drilling and Resource Data Sheets.

6. Plan of Operation, Phillips Petroleum Company,
   March 1, 1978 - To drill 6 geothermal wells to 8000'.
   To determine the existence and commercial potential of
   geothermal resources.
   Estimating starting date - 6-78
   Estimated comp. date - 12-82

COMPOSITE POSTULATED SITE DEVELOPMENT SCHEDULE
FOR AREA 6

SITE NAME	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
San Emidio Desert																20	20	70	70	120	120	170	170	220	220
Gerlach, N.E.																					.037	.037	.037	.037	.037
Double H. Sps.-Black Rock H. Sps.																									
Gerlach																									
Cholona																									
Fly Ranch																									
Fly Ranch, N.E.																									
Trego																									
Donnelly Peak																									
Farman																									
Soldier Meadows Hot Springs																									
North Fox Range																									
North Winnemucca Lake																									
Sawmill																									
Nugent Springs																									
Selenite Peak																									
TOTAL MWe:																									
TOTAL Quads:																									

20,50,100 = MWe (megawatts electric); electrical power generation.
.037,.04,.017 = Quads (0.252×10^{18} cal.); direct thermal utilization. Quads available for commercial utilization. It is unlikely that the energy developed at each site will be wholly utilized, or utilized in the optimum or most efficient manner.

AREA 6

95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
245	245	245	245	245	245	245	245	245	245	245	245	245	245	245	245	245	245	245	245	225	225	175	175	125	125
.037	.037	.037	.037	.037	.037	.037	.037	.037	.037	.037	.037	.037	.037	.037	.036	.036	.036	.036	.036	.036	.036	.036	.036	.036	.036
	35	35	135	135	235	235	335	335	435	435	535	535	635	635	685	685	735	735	735	735	735	735	735	735	735
						20	20	120	120	220	220	320	320	370	370	370	370	370	370	370	370	370	370	370	370
															20	20	70	70	90	90	90	90	90	90	90
																		20	20	70	70	90	90	90	90
																			20	20	70	70	90	90	90
																					20	20	70	70	90

AREA: 6

SITE CHARACTERISTICS:

SITE: SAN EMIDIO DESERT

Possible Subsequent Additions (MWe) and On Line Date:

50 MWe	1987	50 MWe	1993
50 MWe	1989	25 MWe	1995
50 MWe	1991		

POSTULATED SITE DEVELOPMENT SCHEDULE (FOR FIRST 20 MWe PLANT)

OPERATING ENTITIES	ACTIVITY	RECIPIENTS	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
BLM	Approve Notice of Intent-	Developer																								
USGS	Approve NOI & Drill Permit	Developer																								
BLM/Owner	Lease Land	Developer																								
BLM	Process EIA/EIS	CEQ																								
County	Issue Land Use Permits	Developer																								
Developer	Exploratory Drilling & Reservoir Evaluation																									
Developer	Develop Utility Interest																									
Developer & Utility	Feasibility Study																									
Producer (Developer) & Utility	Financial Negotiations																									
Producer	Site Selection																									
Producer & Utility	Design																									
Producer & Utility	Commitment to Development											△														
Producer & Utility	Prepare Master Development Plan	BLM, USGS																								
Utility	Prepare Environmental Data Statement	BLM, FPC STATE, County																								
BLM, FPC STATE, USGS	Certify Plant & Site Issue Permits	Producer & Utility																								
USGS	Process EIA/EIS (Drilling)	CEQ																								
FPC	Process EIA/EIS (Plant)	CEQ																								
FPC	Process EIA/EIS (Transmission Line)	CEQ																								
Producer	Development Drilling																									
Utility	Plant Construction																									
Utility	Install Transmission Line (40 km)																									

NEVADA GEOTHERMAL AREA 7 SCENARIO

HOT-WATER CONVECTION SYSTEMS IN AREA 7 .

Location	Temperatures °C			Reservoir Assumptions		Energy Potential		
Site	Surface (1)	Geochemical SiO_2 (2)	Geochemical Na-K-Ca (2)	Subsurface (3)	Volume km^3 (4)	Heat content 10^{18} cal (5)	Recovery Factor e_r (6)	Electrical Potential MW_e-30yrs.	Thermal Energy for Direct Use Quads (7)
MacFairlane's	77			(185)	10	1.0	0.02	90	
Sulphur	ND			(185)	10	1.0	0.02	90	
North Valley	ND								
DeLong Spring	26								
TOTAL:								180	

Footnotes 1 thru 7-see Explanation Page

EXPLANATION TO HOT-WATER CONVECTION SYSTEMS SHEETS

Footnotes

(1) Maximum surface temperature reported from a spring or fumarole.

(2) Predicted using chemical geothermometers, assuming last equilibration in the reservoir; assumes saturation of SiO_2 with respect to quartz, and no loss of Ca from calcite deposition.

(3) Assumed average reservoir temperature based on data presently available. Temperatures from Circular 726 and other sources. Temperatures in parentheses are highly subjective.

(4) From surface manifestations, geophysical data, well records, geologic inference and leasing activity. Assumes 1.5 km^2 if no data pertinent to size is available. Top assumed at depth of 1.5 km if no data available. Bottom assumed at 3 km depth for all convection systems. Calculated from assumed area and thickness.

(5) Calculated as product of assumed volume, volumetric specific heat of 0.6 $cal/cm^3°C$, and temperature in degrees C above 15°C.

(6) 0.02 for 150°-200°C
0.025 for 200°-250°C

(7) 25% Heat Content Recoverable as thermal energy at the surface; 1 Quad= 0.25×10^{18} cal.

Non-Technical Components For Area 7

Only 20% of this total area is covered by the checkerboard pattern of alternating private and federal land sections. Remainder is national resource land. There are only four (4) sites in this area and they are without direct environmental constraints. Although the sites of Sulphur and MacFairlane's are located within the boundry of the Black Rock Desert, there are no environmental restrictions on this eastern edge. The MacFairlane's site is located adjacent to a very large block of "No Leasing" environmental constraints to the west which may, or may not disturb any geothermal development interests.

Presently there are no identified KGRAs within the area but impressive leasing activity has occured at MacFairlane's with 80% of its applications in lease, and, at Sulphur which has 100% geothermal leases.

There have been a significant number (5) of Notices of Intents filed within this area. Concentration has been indicated for the MacFairlane's and Sulphur sites and vicinity.

General Statement to Non-Technical Components Section,
Area Scenarios

1. All observations for environmental, leasing and "Intents" are based on data gathered in 1977, which has not been corrected, adjusted or up-dated.

2. All environmental decisions are federal (BLM) as there are no localities in Nevada which require an environmental statement. Nevada has only 2 laws requiring such reports:

   a. Nevada Clean Air Act of 1971. Amended in 1973.

   b. Utility Environmental Protection Act, 1971.
   Amended 1973.
   Requires environmental statement for utility plant siting.

   Protection of environmental values is now explicitly and clearly a major criteria for BLM management activities. All BLM activities are governed by the "Federal Land Policy and Management Act".

3. Areas 15, 16, 17, 18, 19 grouped together make up a zone of Intensive and Extensive geothermal resource interests.

   A little over 1/2 of the total land in this zone is available for geothermal leasing, the remainder is covered by private indian reservation, Bureau of Reclamation withdrawals, wildlife management and refuge, state parks and military use lands. The zone contains 10 KGRAs.

   There has been intensive "Geophysical" and "Shallow Temperature Gradient Hole" interest indicated by numerous filings of "Intent to do Geothermal Resource Exploration" with U.S.G.S. To date we do not know how many of these projects were completed.

This zone does not have extensive environment decisions but some significant sites will be affected by such decisions. (i.e. Tahoe Basin Area and Carson Sink-Alkali Flat East and West)

There has been significant leasing in this zone, both within the KGRA's and its vicinity. The leasing interest is mostly by minor companies and individual and/or investment groups. Some sites showed 100% major company interest, such as Bell Flat, of which very few are still lease applications, the remainder closed cases.

This zone includes 1 of the 2 metropolitan localities in the state: Reno-Sparks - (should include Carson City) with many important communities, good to fair transportation arteries.

Economic Base: Tourism, Agriculture/Livestock, Warehousing. The growth in tourism and warehousing increases population energy needs.

AREA: 7

SITE	ENVIRONMENT			LAND STATUS							OWNERSHIP INTEREST			INTENTS			NOTES
	CRIT.R.	EXCLUD. PEND.	EXCLUD.	LSE. APLN.	CLOSED	LSE.	GEO SIM	OPEN	A.P.P.	OTHER OR KGRA	MAJOR	MINOR	IND./ INV.	GEO.	DRILL.	OTHER	
MacFairlane's				X	X	X			X		X			X			
Sulphur						X	X				X			X	X		
North Valley								X									
DeLong Spring								X									

EXPLANATION FOR AREA SHEETS

ENVIRONMENT: Federal environmental decisions relating to availability of federal lands for geothermal resource leasing. All data taken from Environmental Assessment Records prepared by BLM.

- CRIT. R.: Critical Restrictions. Restrictions to lessee, in addition to those restrictions covered in the Geothermal Resource Lease Application (Sec. 14 and 18).
- EXCLUD. PEND.: Excluded from Leasing. Pending additional environmental studies.
- EXCLUD.: Excluded from all leasing.

LAND STATUS: Geothermal leasing status on federal lands.

- LSE. APLN.: Lease Application
- CLOSED: Closed cases. Application never became lease. In theory the land is available for geothermal leasing.
- GEO. SIM.: Geothermal Simultaneous Drawing. These applications became leases, then were terminated or relinquished by the lessee. These parcels are held for simultaneous drawing.
- OPEN: Open - No leases presently recorded for site.
- A.P.P.: Area Potential Prospectively. As outlined by U.S.G.S., possible geothermal resource areas.
- OTHER or KGRA: KGRA - Known Geothermal Resource

OWNERSHIP INTEREST:

- MAJOR: Major company interest or holdings.
- MINOR: Minor company interest or holdings.
- IND./INV.: Individual and/or investment group interest or holdings.

INTENTS: "Intent to Conduct Geothermal Resource Exploration" are filed with U.S.G.S.

- GEO.: Geophysical work only. No Drilling (i.e.= Gravity, magnetotelluric and other surveys)
- DRILL: Drilling of shallow temperature gradient holes.
- OTHER: Any exploration work not included in above categories.

(NOTE: The filing of the Intent to conduct geothermal resource exploration Does Not imply the work was completed.)

References To Postulated Site Development Schedules
And Non-Technical Components Of Areas.

References (indicated by parentheses and corresponding number)

1. Oral Communication:

2. Regional Environmental Analysis Record
   Geothermal oil/gas leasing (BLM) and maps

   a. Carson City District
      Pyramid District, 1975

   b. Winnemucca District
      Sonoma-Gerlach Resource Area
      Buffalo Hills Planning Unit
      1975

   c. Winnemucca District
      Deno, Paradise, Blue Wing and
      Sonoma Planning Units,
      1975

   d. Elko District,
      1975

   e. Battle Mountain District
      1976

   f. Tonopah Resource Area
      1975

   g. Fort Churchill-Clan Alpine Area,
      Carson City District, Nev., 1975

   h. Pine Nut-Walker Area,
      Carson City District, Nev. 1975

   i. Esmeralda Planning Unit,
      Esmeralda and Nye Counties, 1974

3. Lease Books (Nevada Team Data)
   Data obtained from BLM public records and maps.

4. "Intent to Conduct Geothermal Resource Exploration"
   (Filed with U.S.G.S.), (Maps and Folder) and maps.

5. Drilling and Resource Data Sheets.

6. Plan of Operation, Phillips Petroleum Company,
   March 1, 1978 - To drill 6 geothermal wells to 8000'.
   To determine the existence and commercial potential of
   geothermal resources.
   Estimating starting date - 6-78
   Estimated comp. date - 12-82

COMPOSITE POSTULATED SITE DEVELOPMENT SCHEDULE
FOR AREA 7

SITE NAME	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
MacFairlane's																20	20	70	70	90	90	90	90	90	90
Sulphur																									
North Valley																									
DeLong Spring																									

TOTAL MWe:
TOTAL Quads:

20,50,100 = MWe (megawatts electric); electrical power generation.
.037,.04,.017 = Quads (0.252×10^{18} cal.); direct thermal utilization. Quads available for commercial utilization. It is unlikely that the energy developed at each site will be wholly utilized, or utilized in the optimum or most efficient manner.

AREA 7

95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	70	70	20	20		
																					20	20	70	70	90

AREA: 7

SITE CHARACTERISTICS:

SITE: MacFAIRLANE'S

Possible Subsequent Additions (MWe) and On Line Date:

50 MWe 1987
20 MWe 1989

POSTULATED SITE DEVELOPMENT SCHEDULE (FOR FIRST 20 MWe PLANT)

OPERATING ENTITIES	ACTIVITY	RECIPIENTS	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
BLM	Approve Notice of Intent-	Developer						—	—																	
USGS	Approve NOI & Drill Permit	Developer						—	—																	
BLM/Owner	Lease Land	Developer						—	—																	
BLM	Process EIA/EIS	CEQ						—																		
County	Issue Land Use Permits	Developer							—	—																
Developer	Exploratory Drilling & Reservoir Evaluation									—	—															
Developer	Develop Utility Interest									—																
Developer & Utility	Feasibility Study										—															
Producer (Developer) & Utility	Financial Negotiations											—														
Producer	Site Selection											—														
Producer & Utility	Design												—	—												
Producer & Utility	Commitment to Development											△														
Producer & Utility	Prepare Master Development Plan	BLM, USGS											—													
Utility	Prepare Environmental Data Statement	BLM, FPC STATE, County											—													
BLM, FPC STATE, USGS	Certify Plant & Site Issue Permits	Producer & Utility												—	—											
USGS	Process EIA/EIS (Drilling)	CEQ												—												
FPC	Process EIA/EIS (Plant)	CEQ												—												
FPC	Process EIA/EIS (Transmission Line)	CEQ												—												
Producer	Development Drilling														—	—	—									
Utility	Plant Construction														—	—	—									
Utility	Install Transmission Line (40 km)															—	—									

NEVADA GEOTHERMAL AREA 8 SCENARIO

HOT-WATER CONVECTION SYSTEMS IN AREA 8 .

Location	Temperatures °C			Reservoir Assumptions		Energy Potential		
Site	Surface (1)	Geochemical SiO_2 (2)	Geochemical Na-K-Ca (2)	Subsurface (3)	Volume km^3 (4)	Heat content 10^{18} cal (5)	Recovery Factor e_r (6)	Electrical Potential MW_e-30yrs.	Thermal Energy for Direct Use Quads (7)
Rye Patch	ND			182 (185)	60	6.1	0.02	540	
Colado	68-			(185)	20	2.0	0.02	180	
South Eugene Mountains	ND			(185)	20	2.0	0.02	180	
TOTAL:								900	

Footnotes 1 thru 7-see Explanation Page

of a year, the space heating system will function at a certain percent of its peak capacity, and this element is defined as the load factor.

Having thus calculated gross revenues, net revenues are gross revenues less operating costs and taxes. Property taxes are assumed proportional to the plant investment. In the case of total cost,

$$TC_t = [OCE_t + (BR)\ (DK) + DEPRD_t] \times [\sum_{j=1}^{t} (TNV_j - IDC_j)],$$

$$t = EXP + DVP \qquad (2.20a)$$

$$TC_t = [OCP_t + (BR)\ (DK) + DEPRD_t] \times [\sum_{j=1}^{t} (TNV_j - IDC_j)]$$

$$+ PTX_t,\ t = EXP + DVP + 1,\ EXP + DVP + 2, \ldots, T \qquad (2.20b)$$

OCE_t = Percent of drilling costs which constitutes operating expenses

OCP_t = Percent of drilling and plant costs which constitutes operating expenses

PTX_t = Property taxes during year T

$$PTX_t = [PTXR_t]\ [PLV] \qquad (2.21)$$

$PTXR_t$ = Property tax rate

$$OCE_t = C(1 + \dot{C})^t \qquad (2.22)$$

$$OCP_t = PC\ (1 + \dot{PC})^t \qquad (2.23)$$

C = Base year percentage; input variable,

$\dot{C}$ = Rate of increase of C over time; input variable

PC = Base year percentage; input variable

$\dot{PC}$ = Rate of increase of PC over time; input variable

$DEPRD_t$ = Depreciation for drilling investment in year t

$$DEPRD_t = (D + 1 - t) \Big/ \sum_{j=1}^{D} j \qquad (2.24)$$

D = period of depreciation for drilling and leasing (Input)

Finally, income taxes are computed

$$TX_t = \{TXRT\} \{[REV_t (1 - Z)] - [TC_t - (BR \cdot DK + DEPRD_t) \quad (2.25)$$

$$\left(\sum_{j=1}^{t} TNV_t - IDC_t\right)]$$

$$- [Y - (DEPRD_t) \sum_{j=1}^{t} LNV_j) + DNVD_t + DEPRN_t \cdot PLV]\}$$

$$- \{[CRRT] [(1 - Y) \{\sum_{j=1}^{t} LNV_j + PLV\}]\}$$

TXRT = Tax rate (Input)

Z = Depletion allowance (Input)

Y = Percentage tangible investment (Input)

$DNVD_t$ = A dollar amount for depreciation of drilling investment in year t

DLPRN = Depreciation for plant investment in year t

CRRT = Investment tax credit rate (Input)

$$DNVD_t = \sum_{j=1}^{t} DNV \cdot DEPRD_{t-j+1} \quad (2.26)$$

$$DEPRN_t = 0, \quad t \leq PPY \quad (2.27a)$$

$$= (N + PPY + 1 - t) / \sum_{j=1}^{N}, \quad t > PPY \quad (2.27b)$$

N = Depreciation period for plant; input variable

All of the appropriate terms in equation (2.2) are now known, except for R. Any variables which have not been identified are manual inputs to the simulation model. Equation (2.2) is a polynomial of order T, and it is solved iteratively for a value of R.

APPENDIX 3

THE GEOTHERMAL RPPM DATABASE

The Regional Program Progress Monitor (RPPM) Database was created for the Regional Operations Research Program for Development of Geothermal Energy in the Southwest United States, ERDA Contract No. EG-77-S043992.

The Database has been implemented on the IBM System/360 at the New Mexico State University (NMSU) Computer Center. The APL language has been used in file definition, update, retrieval and formatting. Use of APL as the host language permits interactive access to the Database from core team offices throughout the NMSU campus.

The Database contains no classified or proprietary data. Since the Database is designed to meet Project needs, it is likely to be modified in the future as Project requirements change. This report describes the Database as of May 5, 1978. The status of the Database at any time may be determined by contacting the Core Team at NMSU.

This report was prepared by John Nance, Roy Heath and Pat O'Dea of the Physical Science Laboratory, New Mexico State University.

DATABASE STRUCTURE

The RPPM Database consists of three relations: SITE, CITY and COUNTY. The SITE relation contains data on approximately 350 geothermal locations in the five state Southwest Region. The data has been collected from a variety of sources. A source code has been provided for each data item, where source might be of importance. A description of sources and source codes may be found in Table 4.

The CITY relation contains data on approximately 1000 U. S. cities in or near the Southwest Region. The population data was compiled from the 1970 Report of the Bureau of the Census. It includes all incorporated places with a population greater than 500 persons and all unincorporated places with a population greater than 1500 persons. The London Times Atlas was the primary source for latitude and longitude.

The COUNTY relation contains approximately 450 counties in or near the Southwest Region.

DOMAIN NUMBER	DOMAIN	UNITS	FIELD SIZE
* 1	**Site ID	-	4
2	Site Name	-	20
* 3	County Code	-	3
* 4	Latitude	Degrees North	2
* 5	Latitude	Minutes North	2
* 6	Longitude	Degrees West	3
* 7	Longitude	Minutes West	2
8	Township	-	4
9	Range	-	4
10	Section	-	2
*11	Reservoir Volume	cubic kilometers	6.2
12	Source of Reservoir Volume	-	2
*13	Subsurface Temperature	degrees Celsius	3
14	Source of Subsurface Temp	-	2
*15	Surface Temperature	degrees Celsius	3
16	Source of Surface Temp	-	2
*17	Estimated Temp (Swanberg)	degrees Celsius	3
*18	Measured Temp (Swanberg)	degrees Celsius	3
*19	Thermal Gradient	degrees Celsius/km	3
20	Source of Thermal Gradient	-	2
*21	Dissolved Solids	parts per thousand	3
22	Source of Dissolved Solids	-	2
*23	Flowrate	liters per second	3
24	Source of Flowrate	-	2

Table 1. Contents of the SITE File (Relation)

DOMAIN NUMBER	DOMAIN	UNITS	FIELD SIZE
* 1	**City ID	-	5
* 2	Latitude	Degrees North	2
* 3	Latitude	Minutes North	2
* 4	Longitude	Degrees West	3
* 5	Longitude	Minutes West	2
* 6	Population	-	6
7	County Name	-	12
8	City Name	-	25

Table 2. Contents of the CITY File (Relation)

*Indicates a valid qualifying domain
**Indicates primary key

DOMAIN NUMBER	DOMAIN	UNITS	FIELD SIZE
* 1	**County ID	-	4
2	County Name	-	12

Table 3. Contents of the COUNTY File (Relation)

*Indicates a valid qualifying domain
**Indicates primary key

SOURCE CODE	SOURCE
1	U. S. Geological Survey, Circular 726
2	Dr. C. Swanberg, or NMSU Dept. of Earth Sciences
3	MITRE
4	Arizona State Team
5	Colorado State Team
6	Nevada State Team
7	New Mexico State Team
8	Utah State Team
9	U. S. Dept. of Energy
10	NOAA
11	New Mexico Energy Institute
12	GEOTHERM Database
13	W. K. Summers, or New Mexico Bureau of Mines and Mineral Resources
14	U. S. Bureau of the Census Report for 1970
15	U. S. Bureau of the Census Update 1976
16	London Times Atlas
17	U. S. Geological Survey - Waring
18	Stone & Mizell, or New Mexico Bureau of Mines and Mineral Resources

Table 4. Source Codes used in the RPPM Database

DATABASE ACCESS

The RPPM Database may be accessed through terminals communicating with the System/360 at the NMSU Computer Center. Access requires approval of the Geothermal Operations Research Project Director, and use of a private APL workspace. Access from a public workspace is not permitted.

Presently, users are permitted to retrieve data, but not modify it. Update operations may be performed only by the Database Administrator.

DATA RETRIEVAL

The APL routines necessary for data retrieval are found in the workspace 310733401 RPPM. After signing on to a private APL workspace, execute the following command.

```
)LOAD 310733401 RPPM
```

A description of commands follows.

```
OPEN 'relation name'
```

The OPEN command must be executed before any retrievals are attempted. Only one relation may be "open" at once. Valid relation names are SITE, CITY, and COUNTY. Refer to the preceding section, DATABASE STRUCTURE (Tables 1, 2 and 3), for a detailed description of each relation.

```
arg1 GET arg2
```

The GET command actually retrieves data from the Database. It may be executed only after an OPEN command has been issued. It accesses only the currently "open" relation.

Arg1 is a numerical list of domains being retrieved. It may include any domain number or combination of domain numbers.

Arg2 is a four element numeric vector. Element one is the number of the qualifying domain (the domain over which the search is to occur). Only those domains which contain numeric data can be searched, and are indicated in the section DATABASE STRUCTURE. Elements three and four, respectively, provide the lower and upper limits of the search. Element two restricts the search by state as follows:

4	Arizona
5	Colorado
6	Nevada
7	New Mexico
8	Utah
0	no restriction

Retrieval examples using GET:

```
1 2 13 GET 13 0 100 200
```

This command retrieves the Site ID (domain 1), Site Name (domain 2), and Subsurface Temperature (domain 13) for each site in all states (because element 2 of arg2 = 0) whose Subsurface Temperature (element 1 of arg2 = 13) is greater than or equal to 100 and less than or equal to 200 (elements 3 and 4 of arg2).

```
1 2 11 GET 11 7 2.26 1000
```

This command retrieves Site ID (domain 1), Site Name (domain 2), and Reservoir Volume (domain 11) for each site in New Mexico (element 2 of arg2 = 7) whose Reservoir Volume (element 1 of arg2 = 11) is greater than or equal to 2.26 and less than or equal to 1000 (elements 3 and 4 of arg2).

```
15 GET 3 6 601 601
```

This command retrieves the Surface Temperature (domain 15) of each site in Nevada whose County Code (element 1 of arg2) is equal to 601.

To store the results of a retrieval for future processing, the syntax of the GET command may be altered as follows:

```
X← arg1 GET arg2
```

where X is a variable name provided by the user.

CLOSE

Each "open" relation must be "closed" with the CLOSE command before another may be "opened". It is not necessary to specify the name of the relation to be "closed".

ARIZONA

ID	SITE NAME	COUNTY	LAT	LONG	TOWN SHIP	RANGE	SEC
4017	AGUA CALIENTE	407	33 0	113 18			
4018	ARTESIAN H W	405	32 43	109 43			
4026	ARTESIA AREA	405	32 41	109 42			
4022	BARNGAN MTN	414	33 7	113 25			
4024	BOWIE AREA	402	32 19	109 29			
4016	BUCKHORN AREA	407	33 25	111 42			
4032	CASA GRANDE	411	32 53	111 45	6S	6E	
4012	CASTLE H S	413	33 59	112 22			
4008	CAT TANK	405	32 44	109 23			
4002	CLIFTON HOT SPRINGS	406	33 4	109 18			
4007	COFFERS H S	408	34 42	113 35			
4006	COOLIDGE H S	404	33 10	110 32			
4013	COOLIDGE AREA	411	32 54	111 34			
4031	COOLIDGE	411	33 02	111 35	5S	8E	
4005	EAGLE CREEK H S	402	33 3	109 26			
4029	ELOY	411	32 45	111 35	10S	8E	
4030	FLORENCE	411	33 05	111 18	4S	10E	
4004	GILLARD HS	406	32 58	109 21			
4015	HOOKERS H S	402	32 20	110 14			
4011	INDIAN H S	405	33 0	109 54			
4009	JAVELINA PEAK	405	32 31	109 26			
4020	LUCATS SPA	405	32 45	109 45			
4033	MAMMOTH	411	32 42	110 35	9S	7E	
4025	MOBIL AREA	407	33 12	112 22			
4019	MT GRAHAM	405	32 52	109 45			
4021	PALOMAS MTS	414	33 0	113 31			
4034	PAPAGO FARMS	410	31 47	112 19	19S	1E	
4028	PHOENIX TEMPE	407	33 24	111 56	1N	4E	
4001	POWER RANCH AREAS	407	33 17	111 41			
4014	RADIUM SPRINGS	414	32 44	114 4			
4010	SAFFORD AREA	405	32 51	109 34			
4023	THEBA	407	32 56	112 45			
4027	TOM NIECE WARM SPR	405	33 4	109 59			
4003	VERDE HOT SPRINGS	413	34 22	111 43			
4035	WIKIEUP	408	34 39	113 39	15N	3W	

TABLE 5. GEOTHERMAL SITE LOCATIONS.

COLORADO

ID	SITE NAME	COUNTY	LAT	LONG	TOWN SHIP	RANGE	SEC
5047	ANTELOPE BIRDSIE	540	37 45	107 2	40N	2W	1
5005	BRANDS RANCH ARTESIA	529	40 42	106 32	9N	81W	31
5025	BROWN CANYON THRML A	508	38 39	106 4	51N	8E	23
5029	CANON CITY HOT SPRIN	522	38 26	105 16	18S	70W	31
5050	CEBOLLA HOT SPRINGS	526	38 16	107 6	46N	2W	4
5016	CEMENT CREEK WS	526	38 50	106 50	14S	84W	18
5021	CHALK CR MT PRINCETN	508	38 44	106 10	15S	78W	19
5022	CHALK CREEK WRIGHT H	508	38 44	106 10	15S	79W	24
5023	CHALK CREEK HORTENSE	508	38 44	106 10	15S	79W	24
5024	CHALK CREEK WOOLMING	508	38 43	106 11	15S	79W	24
5033	CLARK ARTESIAN WELL	551	38 15	104 37	21S	65W	1
5014	COLONEL CHINN HOT WE	515	38 52	107 38	14S	92W	14
5015	CONUNDRUM HOT SPRING	549	39 1	106 53	12S	85W	16
5020	COTTONWOOD CREEK JUM	508	38 49	106 13	14S	79W	21
5002	CRAIG WARM WATER WEL	541	40 30	107 33	6N	91W	1
5039	DEXTER MCINTYRE	511	37 18	105 48	35N	11E	8
5032	DON K RANCH ARTESIAN	522	38 10	105 1	22S	68W	5
5010	DOTSERO WARM SPRINGS	519	39 38	107 6	5S	87W	12
5054	DUNTON GEYSR PARADIS	517	37 46	108 6	41N	11W	32
5041	DUTCH CROWLY STINKNG	504	37 2	106 48	32N	2E	18
5008	ELDORADO	507	39 56	105 16	1S	71W	25
5043	EOFF ARTESIAN WELL	504	37 11	107 0	34N	1W	7
5031	FLORENCE ARTESIAN WE	522	38 25	105 3	19S	68W	7
5030	FREMONT NATATORIUM	522	38 28	105 12	18S	40W	26
5061	FULL N WIDER WARM SP	555	38 18	105 59			
5011	GLENWOOD HOT SPRINGS	523	39 33	107 19	6S	89W	9
5019	HARTSELL HOT SPRINGS	547	39 1	105 48	12S	75W	8

TABLE 5. GEOTHERMAL SITE LOCATIONS.

COLORADO

ID	SITE NAME	COUNTY	LAT	LONG	TOWN SHIP	RANGE	SEC
5007	HAYSTACK BUTTE WWW	507	40 6	105 14	2N	70W	33
5006	HOT SULPHUR SPRINGS	525	40 5	106 7	1N	78W	3
5009	IDAHO HOT SPRINGS	510	39 44	105 31	4S	73W	1
5001	JUNIPER	541	40 28	107 57	6N	94W	16
5053	LEMON HOT SPRING	557	38 01	108 3	44N	11W	34
5034	MINERAL HOT SPRINGS	555	38 10	105 55	45N	9E	12
5051	ORVIS HOT SPRING	546	38 8	107 44	45N	8W	22
5052	OURAY HOT SPRINGS	546	38 1	107 40	44N	7W	31
5044	PAGOSA SPRINGS	504	37 16	107 1	35N	2W	13
5013	PENNY AVALANCHE HS	549	39 14	107 13	10S	88W	4
5058	PINKERTON	534	37 27	107 48	37N	9W	25
5026	PONCHA HOT SPRINGS	508	38 30	106 5	49N	8E	15
5045	RAINBOW HOT SPRING	540	37 31	106 57	38N	1W	9
5017	RANGER WARM SPRING	526	38 49	106 52	14S	85W	22
5018	RHODES WARM SPRING	547	39 10	106 4	10S	78W	24
5057	RICO	517	37 42	108 2	40N	11W	
5003	ROUT HS	554	40 34	106 51	7N	84W	18
5037	SAND DUNES SWIMMING	502	37 47	105 51	41N	10E	27
5036	SEAWS WARM SPRING	555	37 45	106 19	41N	6E	33
5012	SOUTH CANYON HOT SPR	523	39 33	107 24	6S	90W	2
5038	SPLASHLAND HOT WATER	502	37 29	105 51	38N	10E	34
5004	STEAMBOAT SPRINGS	554	40 29	106 50	6N	84W	17
5059	TRIPP AND TRIMBLE WS	534	37 23	107 51	36N	9W	10
5035	VALLEY VIEW HOT SPRI	555	38 12	105 49	46N	10E	36
5046	WAGON WHEEL GAP HS	540	37 41	106 50	41N	1E	35
5027	WELLSVILLE SWISSVALE	508	38 29	105 55	49N	10E	18
5049	WUANITA HOT SPRINGS	526	38 31	106 31	49N	4E	11

TABLE 5. GEOTHERMAL SITE LOCATIONS.

NEVADA

ID	SITE NAME	COUNTY	LAT	LONG	TOWN SHIP	RANGE	SEC
6063	ALKALI HOT SPRING	0	37 50	117 20			
6064	ASH SPRINGS	0	37 28	115 11			
6016	BALTAZOR HS	0	41 55	118 43			
6040	BARTHOLOMAE	0	39 24	116 21			
6065	BENNETT SPRINGS	0	37 47	114 32			
6001	BEOWAWE H S	0	40 34	116 35			
6066	BIG LOCKES SPRING	0	38 33	115 46			
6067	BIG SPRING	0	36 23	116 17			
6068	BIG SPRINGS	0	40 58	114 31			
6022	BLACK ROCK DESERT	0	40 57	118 58			
6069	BLUE EAGLE SPRINGS	0	38 34	115 32			
6070	BOILING SPRING	0	40 16	119 23			
6071	BORAX SPRING	0	39 20	118 38			
6059	BOWERS H S	0	39 14	119 56			
6058	BO6 H S	0	41 56	118 48			
6002	BRADY HOT SP	0	39 47	119 0			
6072	BROOKS SPRING	0	40 50	117 18			
6073	BRUFFEYS HOT SPRINGS	0	40 13	116 4			
6031	BUFFALO VALLEY H S	0	40 22	117 20			
6036	BUTTE SPR	0	40 46	119 7			
6074	BUTTERFIELD SPRINGS	0	38 27	115 1			
6075	CAIN SPRINGS	0	41 15	118 56			
6076	CALIENTE HOT SPRING	0	37 37	114 31			
6077	CARSON HOT SPRINGS	0	39 12	119 45			
6078	CHARNOCK BIG BLUE	0	38 57	117 3			
6030	CHERRY CR H S	0	39 52	114 56			
6079	CHIMNEY SPRINGS	0	38 28	115 47			
6080	COLLAR AND ELBOW SPR	0	40 5	114 39			
6081	CRYSTAL POOL	0	36 25	116 19			
6082	CRYSTAL SPRINGS	0	37 32	115 14			
6025	DARROUGHS HS	0	38 49	117 11			
6083	DELMUES SPRING	0	37 52	114 19			
6084	DEVILS HOLE	0	36 26	116 17			
6056	DIANA PUNCH BOWL	0	39 2	116 40			
6023	DIXIE VALLEY HS	0	39 48	118 4			
6024	DOUBLE HS	0	41 3	119 3			
6026	DYKE H S	0	41 34	118 34			
6044	ELKO HS	0	40 49	115 47			
6085	EMIGRANT SPRINGS	0	38 37	115 3			
6086	FAIRBANKS SPRING	0	36 30	116 21			
6015	FERNLEY HS	0	39 35	119 8			

TABLE 5. GEOTHERMAL SITE LOCATIONS.

NEVADA

ID	SITE NAME	COUNTY	LAT	LONG	TOWN SHIP	RANGE	SEC
6087	FISH SPRINGS	0	40 6	119 53			
6088	FLAG SPRINGS	0	38 25	115 1			
6033	FLY RANCH	0	40 52	119 21			
6089	FLYNN RANCH SPRINGS	0	40 5	116 2			
6090	GAMBLES HOLE	0	41 53	114 7			
6091	GEYSER RANCH SPRINGS	0	38 41	114 37			
6092	GEYSER RANCH SPRINGS	0	38 40	114 38			
6093	GEYSER RANCH SPRINGS	0	38 39	114 38			
6013	GREAT BOILING H S	0	40 40	119 22			
6035	H S NEAR TREBO	0	40 46	119 7			
6094	HAY CORRAL SPRING	0	38 33	115 46			
6095	HICKS HOT SPRINGS	0	36 58	116 43			
6096	HIKO SPRING	0	37 36	115 13			
6097	HORSESHOE RANCH SPRI	0	40 36	116 28			
6098	HOT CREEK SPRING	0	38 23	115 9			
6099	HOT CREEK SPRINGS	0	41 34	115 11			
6100	HOT HOLE ELKO HOT S	0	40 49	115 46			
6032	HOT POT BLOSSOM	0	40 55	117 7			
6008	HOT SULPHUR SP	0	41 28	116 9			
6009	HOT SP NEAR WELLS	0	41 11	114 59			
6010	HOT SP RANCH	0	40 46	117 30			
6027	HOT SULPHUR SP	0	41 9	114 59			
6038	HOT SPR POINT	0	40 24	116 31			
6101	HOT SPRING	0	37 46	117 38			
6102	HOT SPRING	0	38 31	116 22			
6103	HOT SPRINGS	0	39 56	116 41			
6104	HOT SPRINGS	0	39 33	116 22			
6105	HOT SPRINGS	0	40 46	116 2			
6106	HOT SPRINGS	0	40 40	116 50			
6107	HOT SPRINGS	0	40 19	116 3			
6108	HOT SPRING	0	40 19	116 26			
6109	HOT SPRINGS	0	40 12	117 7			
6110	HOT SPRING	0	41 59	114 23			
6111	HOT SPRINGS	0	41 53	115 38			
6112	HOT SPRINGS	0	41 39	115 46			
6113	HOT SPRINGS	0	41 16	115 18			
6029	HOWARD HS	0	41 43	118 30			
6114	HUFFAKER SPRINGS	0	39 25	119 46			
6042	HYDER H S	0	40 1	117 44			
6115	INDIAN SPRINGS	0	36 34	115 40			

TABLE 5. GEOTHERMAL SITE LOCATIONS.

NEVADA

ID	SITE NAME	COUNTY	LAT	LONG	TOWN SHIP	RANGE	SEC
6116	IZZENHOOD RANCH SPRI	0	40 55	116 54			
6117	JACK RABBIT SPRING	0	36 23	116 17			
6007	JERSEY VALLEY HS	0	40 11	117 29			
6118	JOHN SALVIS HOT SPRI	0	39 53	114 54			
6119	KATE SPRING	0	38 33	115 32			
6006	KYLE H S	0	40 24	117 53			
6120	LACKAWANNA SPRINGS	0	39 17	114 52			
6121	LAWTON HOT SPRINGS	0	39 31	119 54			
6014	LEACH HS	0	40 36	117 39			
6011	LEE H S	0	39 13	118 43			
6122	LONGSTREET SPRING	0	36 28	116 20			
6049	LOWER RANCH	0	40 3	117 35			
6123	MACFARLAND HOT SPRIN	0	41 3	118 43			
6124	MANSE SPRINGS	0	36 9	115 54			
6125	MCCOY SPRINGS	0	40 5	117 36			
6126	MCGILL SPRING	0	39 25	114 47			
6034	MINERAL SAN JACINTO	0	41 47	114 43			
6050	MONTE NEVA HS	0	39 38	114 48			
6127	MOON RIVER SPRING	0	38 21	115 11			
6128	MOORES RANCH SPRINGS	0	39 49	115 37			
6129	MOORMAN SPRING	0	38 36	115 8			
6130	MOUND SPRINGS	0	40 19	117 4			
6131	MUD SPRINGS	0	39 38	118 11			
6132	MUD SPRINGS	0	40 39	119 23			
6133	MUDDY SPRING	0	36 43	114 43			
6039	NEAR GOLCONDA	0	40 58	117 30			
6051	NEAR CARLIN	0	40 42	116 8			
6053	NEAR RUBY MARSH	0	40 14	115 25			
6021	NEEDLE ROCKS	0	40 9	119 40			
6055	NEVADA H S	0	38 54	119 25			
6061	NILE SPR	0	41 56	114 5			
6134	PANACA SPRING	0	37 48	114 23			
6135	PEARL HOT SPRINGS	0	37 49	117 29			
6012	PINTO H S	0	41 21	118 47			
6136	POINT OF ROCKS SPRIN	0	36 24	116 16			
6060	POTTS RANCH H S	0	39 5	116 41			
6137	PRESTON SPRINGS	0	38 55	115 5			
6138	RIZZI RANCH HOT SPRI	0	41 47	115 55			
6139	ROGERS SPRING	0	36 29	116 19			
6004	SAN EMIDIO	0	40 24	117 25			

TABLE 5. GEOTHERMAL SITE LOCATIONS.

NEVADA

ID	SITE NAME	COUNTY	LAT	LONG	TOWN SHIP	RANGE	SEC
6140	SHIPLEY HOT SPRING	0	39 57	116 4			
6141	SIRI RANCH SPRING	0	39 59	116 3			
6019	SMITH CREEK VALLEY	0	39 21	117 33			
6017	SODA LAKE	0	39 34	118 49			
6046	SODA SP	0	38 21	118 7			
6057	SOLDIER MEADOWS	0	41 22	119 13			
6043	SOU H S	0	40 5	117 44			
6037	SPENCER H S	0	39 19	116 51			
6142	SPRINGS	0	40 57	114 45			
6143	SPRING	0	40 11	116 48			
6144	SPRING	0	40 59	117 46			
6145	SPRING	0	40 52	117 56			
6146	SPRINGS HOT	0	41 25	114 41			
6147	SPRING HOT	0	41 23	114 10			
6148	SPRING	0	41 42	118 18			
6149	SPRING	0	41 32	118 34			
6062	SSE PATSVILLE	0	41 5	115 55			
6003	STEAMBOAT SP	0	39 23	119 45			
6018	STILLWATER	0	39 31	118 33			
6150	STORM SPRING	0	38 24	115 51			
6005	SULPHUR HS	0	40 35	115 17			
6151	SULPHUR SPRING	0	39 50	116 4			
6045	THE HOT SPR	0	41 25	117 23			
6152	TWIN SPRINGS	0	41 35	119 52			
6153	UPPER WARM SPRING	0	38 32	116 28			
6047	VALLEY OF THE MOON	0	40 14	117 6			
6020	WABUSKA HS	0	39 10	119 11			
6154	WALL SPRING	0	40 41	119 36			
6054	WALLEYS (GENOA) H S	0	38 59	119 50			
6052	WALTI HS	0	39 54	116 35			
6041	WARM SPR	0	38 11	116 23			
6155	WARM SPRINGS	0	36 43	114 43			
6156	WARM SPRINGS	0	40 45	115 2			
6157	WARM SPRINGS	0	41 45	118 50			
6158	WEDELL HOT SPRINGS	0	38 55	118 12			
6028	WELL NEAR GERLACH	0	40 39	119 21			
6159	WEST SPRING	0	41 44	118 55			
6048	WILD HORSE RES	0	41 40	115 48			
6160	WILLIAMS HOT SPRINGS	0	38 57	115 14			
6161	WILSON HOT SPRING	0	38 46	119 10			

TABLE 5. GEOTHERMAL SITE LOCATIONS.

NEW MEXICO

ID	SITE NAME	COUNTY	LAT	LONG	TOWN SHIP	RANGE	SEC
7044	ALEMAN	727	0 0	0 0	15S	2W	
7018	BERINO - MESQUITE	707	32 9	106 40			
7049	CARNE	716	0 0	0 0	24S	7W	
7029	CLIFF AREA	709	32 53	108 35			
7027	CLOSSON	732	35 15	108 19			
7040	CROCKER	727	0 0	0 0	11S	1E	
7033	CROWNPOINT AREA	717	35 42	108 8			
7030	DERRY WARM SPRING	727	32 48	107 17			
7021	E SAN AUGUSTIN PLAIN	728	34 41	107 33			
7023	FAYWOOD HS	709	32 33	108 0			
7041	FREIBORN CANYON	702	0 0	0 0	7S	21W	
7047	GALLINAS CREEK	725	0 0	0 0	17N	15E	
7046	GARTON WELL	717	0 0	0 0	18S	8E	
7010	GILA HS-BELOW BRIDGE	709	33 10	108 13			
7011	GILA HS-MIDDLE FORK	702	33 14	108 14			
7013	GILA HS-DOC CAMPBELL	702	33 12	108 13			
7025	GILA HS-UPR MDL FRK	702	33 17	108 17			
7035	GUADALUPE SP	723	35 36	107 8			
7048	HATCHET MOUNTAIN	712	0 0	0 0	32S	16W	
7036	HOT WELL	723	35 45	106 40			
7038	HUECO-S TULAROSA BAS	719	32 3	106 10			
7004	KILBOURNE HOLE	707	31 58	106 57			
7017	LAS ALTURAS	707	32 16	106 42			
7042	LAS PALOMAS	707	0 0	0 0	14S	5W	
7002	LIGHTNING DOCK	712	32 8	108 50			
7003	LWR SAN FRANCISCO HS	702	33 15	108 53			
7014	MAMBY'S HS	729	36 32	105 41			
7007	MC CAULEY SP (JEMEZ)	723	35 47	106 41			
7045	MCKINLEY WEST	717	35 50	108 30	18N	16W	
7019	MIMBRES HS	709	32 45	107 50			
7012	MONTEZUMA HS	725	35 39	105 17			
7050	NEWMAN SO PAC RR	719	0 0	0 0	26S	8E	
7034	NORTHEAST OF PREWITT	717	35 26	107 53			
7009	OJO CALIENTE	721	36 18	106 3			
7028	PLAYAS VALLEY	712	31 50	108 37			
7020	PONCE DE LEON	729	36 19	105 36			
7008	RADIUM SPRINGS	707	32 30	106 56			
7043	RINCON EAST	707	0 0	0 0	19S	2W	
7005	SAN ANTONIO HS (JEME	723	35 47	106 41			
7039	SAN JUAN BASIN	724	0 0	0 0	24N	18W	
7037	SAN YSIDRO	723	35 32	106 50			
7031	SEDILLO SPRING	728	34 2	106 56			
7006	SPENCE SP (JEMEZ)	723	35 47	106 41			
7024	T OR C	727	33 8	107 15			
7032	TOHATCHI AREA	717	35 55	108 35			
7015	TURKEY CREEK	709	33 7	108 29			
7022	UPR SAN FRANCISCO HS	702	33 50	108 48			
7001	VALLES CALDERA	723	35 53	106 32			
7026	W MESA-BLACK MNTN	707	32 8	106 52			
7016	WHITE SANDS	707	32 20	106 25			

TABLE 5. GEOTHERMAL SITE LOCATIONS.

UTAH

ID	SITE NAME	COUNTY	LAT	LONG	TOWN SHIP	RANGE	SEC
8007	ABRAHAM HS	812	39 37	112 43	14S	8W	10
8015	BECKS HS	818	40 47	111 56	1N	1W	14
8044	BIG WS	823	40 52	112 36	1S	7W	8
8033	BLUE WS	802	41 50	112 24	13N	5W	29
8025	CASTILLA HS	825	40 3	111 32	9S	4E	18
8037	COMO HS	815	41 5	111 40	4N	3E	31
8002	COVE FORT-SULPHURDAL	814	38 36	112 33	25S	6W	
8021	CRATER HS	825	40 28	111 53	5S	1W	25
8006	CRYSTAL HS	818	40 30	111 55	4S	1W	11
8016	CRYSTAL H.S.	802	41 40	112 5	11N	2W	24
8041	DIAMOND FORK WS	825	40 5	111 22	8S	5E	14
8030	FISH SPRINGS	812	39 52	113 25	11S	14W	23
8031	GANDY	814	39 27	113 58	15S	19W	31
8042	GOSHEN WS	825	39 57	111 51	10S	1E	8
8038	GRANTSVILLE	823	40 38	112 31	2S	6W	16
8026	HATTON HS	814	38 51	112 30	22S	6W	35
8013	HOOPER HS	829	41 9	112 12	5N	3W	27
8036	JOHNSONS WS	821	38 36	112 15	25S	3W	27
8004	JOSEPH HS	821	38 38	112 11	25S	4W	23
8022	LAVERKIN HS	827	37 13	113 16	41S	13W	25
8028	LINCOLN POINT WS	825	40 1	111 50	8S	1E	3
8012	MEADOW HS	814	38 50	112 31	22S	6W	26
8018	MIDWAY HS	826	40 31	111 28	3S	4E	26
8009	MONROE(COOPER) HS	821	38 31	112 12	25S	3W	10
8032	MORGANS WS	823	40 24	112 25	5S	5W	9
8010	OGDEN HS	829	41 14	111 58	6N	1W	23
8027	RADIUM(DOTSON) HS	801	38 13	112 55	30S	9W	
8005	RED HILL HS	821	38 38	112 6	25S	3W	11
8040	RICHFIELD WS	821	38 45	112 5	23S	3W	26
8001	ROOSEVELT HS	801	38 30	112 49	26S	9W	34
8039	RUSSELS WS	823	40 22	112 27	5S	5W	17
8019	SARATOGA HS	825	40 28	111 53	5S	1W	25
8029	SPLIT MOUNTAIN WS	824	40 27	109 15	4S	24E	16
8043	STERLING SPR	820	39 12	111 32	19S	2E	4
8011	STINKING SPR	803	41 35	112 14	10N	3W	10
8003	THERMO HS	801	38 11	113 12	30S	9W	21
8020	UDDY HS	802	41 51	112 9	13N	3W	23
8024	UNNAMED HS	802	41 50	114 7	11N	19W	11
8014	UTAH HS	829	41 24	112 2	7N	2W	14
8023	VEYO HS	827	37 19	113 42	40S	16W	7
8034	WARM SPR	802	41 48	113 35	12N	15W	19
8035	WARM SPR-UTAH LAKE	825	40 14	111 46	7S	1E	5
8008	WASATCH HS	818	40 45	111 55	1N	1W	25
8017	WILSON HS	812	39 55	113 26	10S	14W	33

TABLE 5. GEOTHERMAL SITE LOCATIONS.

ARIZONA

SITE ID	SITE NAME	------TEMPERATURE IN DEGREES CELSIUS------- SUBSURFACE	SOURCE	SURFACE	SOURCE	CS EST	CS MEAS
4017	AGUA CALIENTE	0		0		0	46
4018	ARTESIAN H W	0		0		0	44
4026	ARTESIA AREA	0		0		0	33
4022	BARNGAN MTN	0		0		0	39
4024	BOWIE AREA	0		0		0	36
4016	BUCKHORN AREA	0		0		0	49
4032	CASA GRANDE	24	4	0		0	0
4012	CASTLE H S	0		0		105	0
4008	CAT TANK	0		0		115	0
4002	CLIFTON HOT SPRINGS	0		0		160	0
4007	COFFERS H S	0		0		120	0
4006	COOLIDGE H S	0		0		120	0
4013	COOLIDGE AREA	0		0		0	61
4031	COOLIDGE	42	4	0		0	0
4005	EAGLE CREEK H S	0		0		130	0
4029	ELOY	27	4	0		0	0
4030	FLORENCE	28	4	0		0	0
4004	GILLARD HS	0		0		140	0
4015	HOOKERS H S	0		0		0	50
4011	INDIAN H S	0		0		105	0
4009	JAVELINA PEAK	0		0		110	0
4020	LUCATS SPA	0		0		0	42
4033	MAMMOTH	32	4	0		0	0
4025	MOBIL AREA	0		0		0	35
4019	MT GRAHAM	0		0		0	44
4021	PALOMAS MTS	0		0		0	42
4034	PAPAGO FARMS	31	4	0		0	0
4028	PHOENIX TEMPE	34	4	0		0	0
4001	POWER RANCH AREAS	0		0		184	0
4014	RADIUM SPRINGS	0		0		0	53
4010	SAFFORD AREA	0		0		110	0
4023	THEBA	0		0		0	38
4027	TOM NIECE WARM SPR	0		0		0	32
4003	VERDE HOT SPRINGS	0		0		150	0
4035	WIKIEUP	22	4	0		0	0

TABLE 6. GEOTHERMAL SITE TEMPERATURES.

COLORADO

SITE ID	SITE NAME	TEMPERATURE IN DEGREES CELSIUS: SUBSURFACE	SOURCE	SURFACE	SOURCE	CS EST	CS MEAS
5047	ANTELOPE BIRDSIE	44	5	32	5	0	32
5005	BRANDS RANCH ARTESIA	49	5	0	5	0	42
5025	BROWN CANYON THRML A	100	5	25	5	0	25
5029	CANON CITY HOT SPRIN	50	5	40	5	0	40
5050	CEBOLLA HOT SPRINGS	60	5	39	5	135	0
5016	CEMENT CREEK WS	45	5	0	5	0	26
5021	CHALK CR MT PRINCETN	200	5	50	5	120	0
5022	CHALK CREEK WRIGHT H	170	5	69	5	0	0
5023	CHALK CREEK HORTENSE	170	5	82	5	0	0
5024	CHALK CREEK WOOLMING	170	5	39	5	0	0
5033	CLARK ARTESIAN WELL	40	5	25	5	0	25
5014	COLONEL CHINN HOT WE	51	5	42	5	80	0
5015	CONUNDRUM HOT SPRING	45	5	35	5	0	38
5020	COTTONWOOD CREEK JUM	170	5	52	5	105	0
5002	CRAIG WARM WATER WEL	55	5	39	5	90	0
5039	DEXTER MCINTYRE	35	5	20	5	0	20
5032	DON K RANCH ARTESIAN	45	5	28	5	110	0
5010	DOTSERO WARM SPRINGS	39	5	32	5	0	32
5054	DUNTON GEYSR PARADIS	50	5	42	5	0	44
5041	DUTCH CROWLY STINKNG	65	5	27	5	0	70
5008	ELDORADO	35	5	25	5	0	26
5043	EOFF ARTESIAN WELL	50	5	39	5	0	39
5031	FLORENCE ARTESIAN WE	42	5	28	5	0	28
5030	FREMONT NATATORIUM	43	5	35	5	0	36
5061	FULL N WIDER WARM SP	0	0	0	0	0	18
5011	GLENWOOD HOT SPRINGS	65	5	33	5	130	0
5019	HARTSELL HOT SPRINGS	70	5	48	5	105	0

TABLE 6. GEOTHERMAL SITE TEMPERATURES.

COLORADO

SITE ID	SITE NAME	SUBSURFACE TEMPERATURE IN DEGREES CELSIUS	SOURCE	SURFACE TEMPERATURE IN DEGREES CELSIUS	SOURCE	CS EST	CS MEAS
5007	HAYSTACK BUTTE WWW	40	5	28	5	0	28
5006	HOT SULPHUR SPRINGS	75	5	42	5	95	0
5009	IDAHO HOT SPRINGS	80	5	33	5	120	0
5001	JUNIPER	63	5	35	5	0	38
5053	LEMON HOT SPRING	43	5	32	5	140	0
5034	MINERAL HOT SPRINGS	70	5	60	5	105	0
5051	ORVIS HOT SPRING	75	5	52	5	105	0
5052	OURAY HOT SPRINGS	80	5	59	5	0	69
5044	PAGOSA SPRINGS	80	5	46	5	140	0
5013	PENNY AVALANCHE HS	75	5	43	5	150	0
5058	PINKERTON	50	5	29	5	100	0
5026	PONCHA HOT SPRINGS	145	5	55	5	140	0
5045	RAINBOW HOT SPRING	45	5	40	5	0	40
5017	RANGER WARM SPRING	45	5	26	5	0	27
5018	RHODES WARM SPRING	35	5	0	5	0	25
5057	RICO	63	5	39	5	140	0
5003	ROUT HS	138	5	57	5	145	0
5037	SAND DUNES SWIMMING	75	5	44	5	160	0
5036	SHAWS WARM SPRING	45	5	30	5	130	0
5012	SOUTH CANYON HOT SPR	75	5	47	5	105	0
5038	SPLASHLAND HOT WATER	75	5	40	5	160	0
5004	STEAMBOAT SPRINGS	70	5	29	5	120	0
5059	TRIPP AND TRIMBLE WS	58	5	40	5	110	0
5035	VALLEY VIEW HOT SPRI	50	5	34	5	0	37
5046	WAGON WHEEL GAP HS	115	5	52	5	140	0
5027	WELLSVILLE SWISSVALE	40	5	30	5	0	33
5049	WUANITA HOT SPRINGS	135	5	78	5	160	0

TABLE 6. GEOTHERMAL SITE TEMPERATURES.

NEVADA

SITE ID	SITE NAME	------TEMPERATURE IN DEGREES CELSIUS------- SUBSURFACE	SOURCE	SURFACE	SOURCE	CS EST	CS MEAS
6063	ALKALI HOT SPRING	0		59	10	0	0
6064	ASH SPRINGS	0		36	10	0	0
6016	BALTAZOR HS	0		0		170	0
6040	BARTHOLOMAE	0		0		125	0
6065	BENNETT SPRINGS	0		21	10	0	0
6001	BEOWAWE H S	0		0		240	0
6066	BIG LOCKES SPRING	0		37	10	0	0
6067	BIG SPRING	0		28	10	0	0
6068	BIG SPRINGS	0		22	10	0	0
6022	BLACK ROCK DESERT	0		0		150	0
6069	BLUE EAGLE SPRINGS	0		27	10	0	0
6070	BOILING SPRING	0		86	10	0	0
6071	BORAX SPRING	0		81	10	0	0
6059	BOWERS H S	0		0		0	46
6058	BO6 H S	0		0		0	54
6002	BRADY HOT SP	0		0		214	0
6072	BROOKS SPRING	0		34	10	0	0
6073	BRUFFEYS HOT SPRINGS	0		66	10	0	0
6031	BUFFALO VALLEY H S	0		0		130	0
6036	BUTTE SPR	0		0		130	0
6074	BUTTERFIELD SPRINGS	0		23	10	0	0
6075	CAIN SPRINGS	0		23	10	0	0
6076	CALIENTE HOT SPRING	0		53	10	0	0
6077	CARSON HOT SPRINGS	0		48	10	0	0
6078	CHARNOCK BIG BLUE	0		26	10	0	0
6030	CHERRY CR H S	0		0		130	0
6079	CHIMNEY SPRINGS	0		71	10	0	0
6080	COLLAR AND ELBOW SPR	0		33	10	0	0
6081	CRYSTAL POOL	0		32	10	0	0
6082	CRYSTAL SPRINGS	0		32	10	0	0
6025	DARROUGHS HS	0		0		140	0
6083	DELMUES SPRING	0		21	10	0	0
6084	DEVILS HOLE	0		33	10	0	0
6056	DIANA PUNCH BOWL	0		0		0	59
6023	DIXIE VALLEY HS	0		0		150	0
6024	DOUBLE HS	0		0		145	0
6026	DYKE H S	0		0		140	0
6044	ELKO HS	0		0		115	0
6085	EMIGRANT SPRINGS	0		21	10	0	0
6086	FAIRBANKS SPRING	0		27	10	0	0
6015	FERNLEY HS	0		0		170	0

TABLE 6. GEOTHERMAL SITE TEMPERATURES.

NEVADA

SITE ID	SITE NAME	SUBSURFACE TEMPERATURE IN DEGREES CELSIUS	SOURCE	SURFACE TEMPERATURE IN DEGREES CELSIUS	SOURCE	CS EST	CS MEAS
6087	FISH SPRINGS	0		22	10	0	0
6088	FLAG SPRINGS	0		23	10	0	0
6033	FLY RANCH	0		0		130	0
6089	FLYNN RANCH SPRINGS	0		25	10	0	0
6090	GAMBLES HOLE	0		43	10	0	0
6091	GEYSER RANCH SPRINGS	0		21	10	0	0
6092	GEYSER RANCH SPRINGS	0		21	10	0	0
6093	GEYSER RANCH SPRINGS	0		21	10	0	0
6013	GREAT BOILING H S	0		0		170	0
6035	H S NEAR TREBO	0		0		130	0
6094	HAY CORRAL SPRING	0		37	10	0	0
6095	HICKS HOT SPRINGS	0		43	10	0	0
6096	HIKO SPRING	0		32	10	0	0
6097	HORSESHOE RANCH SPRI	0		57	10	0	0
6098	HOT CREEK SPRING	0		33	10	0	0
6099	HOT CREEK SPRINGS	0		67	10	0	0
6100	HOT HOLE ELKO HOT S	0		33	10	0	0
6032	HOT POT BLOSSOM	0		0		130	0
6008	HOT SULPHUR SP	0		0		180	0
6009	HOT SP NEAR WELLS	0		0		180	0
6010	HOT SP RANCH	0		0		180	0
6027	HOT SULPHUR SP	0		0		140	0
6038	HOT SPR POINT	0		0		125	0
6101	HOT SPRING	0		71	10	0	0
6102	HOT SPRING	0		82	10	0	0
6103	HOT SPRINGS	0		82	10	0	0
6104	HOT SPRINGS	0		40	10	0	0
6105	HOT SPRINGS	0		36	10	0	0
6106	HOT SPRINGS	0		55	10	0	0
6107	HOT SPRINGS	0		26	10	0	0
6108	HOT SPRING	0		85	10	0	0
6109	HOT SPRINGS	0		53	10	0	0
6110	HOT SPRING	0		30	10	0	0
6111	HOT SPRINGS	0		39	10	0	0
6112	HOT SPRINGS	0		54	10	0	0
6113	HOT SPRINGS	0		49	10	0	0
6029	HOWARD HS	0		0		130	0
6114	HUFFAKER SPRINGS	0		34	10	0	0
6042	HYDER H S	0		0		120	0
6115	INDIAN SPRINGS	0		25	10	0	0

TABLE 6. GEOTHERMAL SITE TEMPERATURES.

NEVADA

SITE ID	SITE NAME	SUBSURFACE TEMPERATURE IN DEGREES CELSIUS	SOURCE	SURFACE TEMPERATURE IN DEGREES CELSIUS	SOURCE	CS EST	CS MEAS
6116	IZZENHOOD RANCH SPRI	0		28	10	0	0
6117	JACK RABBIT SPRING	0		27	10	0	0
6007	JERSEY VALLEY HS	0		0		185	0
6118	JOHN SALVIS HOT SPRI	0		65	10	0	0
6119	KATE SPRING	0		22	10	0	0
6006	KYLE H S	0		0		190	0
6120	LACKAWANNA SPRINGS	0		34	10	0	0
6121	LAWTON HOT SPRINGS	0		33	10	0	0
6014	LEACH HS	0		0		170	0
6011	LEE H S	0		0		175	0
6122	LONGSTREET SPRING	0		27	10	0	0
6049	LOWER RANCH	0		0		100	0
6123	MACFARLAND HOT SPRIN	0		76	10	0	0
6124	MANSE SPRINGS	0		23	10	0	0
6125	MCCOY SPRINGS	0		48	10	0	0
6126	MCGILL SPRING	0		28	10	0	0
6034	MINERAL SAN JACINTO	0		0		130	0
6050	MONTE NEVA HS	0		0		0	79
6127	MOON RIVER SPRING	0		33	10	0	0
6128	MOORES RANCH SPRINGS	0		21	10	0	0
6129	MOORMAN SPRING	0		37	10	0	0
6130	MOUND SPRINGS	0		43	10	0	0
6131	MUD SPRINGS	0		21	10	0	0
6132	MUD SPRINGS	0		75	10	0	0
6133	MUDDY SPRING	0		32	10	0	0
6039	NEAR GOLCONDA	0		0		125	0
6051	NEAR CARLIN	0		0		0	79
6053	NEAR RUBY MARSH	0		0		0	65
6021	NEEDLE ROCKS	0		0		150	0
6055	NEVADA H S	0		0		0	61
6061	NILE SPR	0		0		0	43
6134	PANACA SPRING	0		31	10	0	0
6135	PEARL HOT SPRINGS	0		43	10	0	0
6012	PINTO H S	0		0		175	0
6136	POINT OF ROCKS SPRIN	0		33	10	0	0
6060	POTTS RANCH H S	0		0		0	45
6137	PRESTON SPRINGS	0		22	10	0	0
6138	RIZZI RANCH HOT SPRI	0		43	10	0	0
6139	ROGERS SPRING	0		28	10	0	0
6004	SAN EMIDIO	0		0		200	0

TABLE 6. GEOTHERMAL SITE TEMPERATURES.

NEVADA

SITE ID	SITE NAME	------TEMPERATURE IN DEGREES CELSIUS------- SUBSURFACE	SOURCE	SURFACE	SOURCE	CS EST	CS MEAS
6140	SHIPLEY HOT SPRING	0		41	10	0	0
6141	SIRI RANCH SPRING	0		30	10	0	0
6019	SMITH CREEK VALLEY	0		0		160	0
6017	SODA LAKE	0		0		165	0
6046	SODA SP	0		0		105	0
6057	SOLDIER MEADOWS	0		0		0	54
6043	SOU H S	0		0		115	0
6037	SPENCER H S	0		0		125	0
6142	SPRINGS	0		29	10	0	0
6143	SPRING	0		38	10	0	0
6144	SPRING	0		33	10	0	0
6145	SPRING	0		27	10	0	0
6146	SPRINGS HOT	0		58	10	0	0
6147	SPRING HOT	0		45	10	0	0
6148	SPRING	0		26	10	0	0
6149	SPRING	0		39	10	0	0
6062	SSE PATSVILLE	0		0		0	41
6003	STEAMBOAT SP	0		0		210	0
6018	STILLWATER	0		0		165	0
6150	STORM SPRING	0		29	10	0	0
6005	SULPHUR HS	0		0		190	0
6151	SULPHUR SPRING	0		23	10	0	0
6045	THE HOT SPR	0		0		110	0
6152	TWIN SPRINGS	0		21	10	0	0
6153	UPPER WARM SPRING	0		33	10	0	0
6047	VALLEY OF THE MOON	0		0		100	0
6020	WABUSKA HS	0		0		155	0
6154	WALL SPRING	0		28	10	0	0
6054	WALLEYS (GENOA) H S	0		0		0	61
6052	WALTI HS	0		0		0	72
6041	WARM SPR	0		0		120	0
6155	WARM SPRINGS	0		32	10	0	0
6156	WARM SPRINGS	0		18	10	0	0
6157	WARM SPRINGS	0		44	10	0	0
6158	WEDELL HOT SPRINGS	0		62	10	0	0
6028	WELL NEAR GERLACH	0		0		135	0
6159	WEST SPRING	0		42	10	0	0
6048	WILD HORSE RES	0		0		100	0
6160	WILLIAMS HOT SPRINGS	0		53	10	0	0
6161	WILSON HOT SPRING	0		84	10	0	0

TABLE 6. GEOTHERMAL SITE TEMPERATURES.

NEW MEXICO

SITE ID	SITE NAME	------TEMPERATURE IN DEGREES CELSIUS------- SUBSURFACE	SOURCE	SURFACE	SOURCE	CS EST	CS MEAS
7044	ALEMAN	110	7	0		0	0
7018	BERINO - MESQUITE	0		0		120	0
7049	CARNE	30	7	0		0	0
7029	CLIFF AREA	0		0		0	31
7027	CLOSSON	0		0		0	61
7040	CROCKER	0		30	7	0	0
7033	CROWNPOINT AREA	0		0		0	37
7030	DERRY WARM SPRING	0		0		90	0
7021	E SAN AUGUSTIN PLAIN	0		0		0	35
7023	FAYWOOD HS	0		0		0	54
7041	FREIBORN CANYON	0		30	7	0	0
7047	GALLINAS CREEK	0		50	7	0	0
7046	GARTON WELL	0		30	7	0	0
7010	GILA HS-BELOW BRIDGE	0		0		0	44
7011	GILA HS-MIDDLE FORK	0		0		0	65
7013	GILA HS-DOC CAMPBELL	0		0		0	66
7025	GILA HS-UPR MDL FRK	0		0		0	36
7035	GUADALUPE SP	0		0		120	0
7048	HATCHET MOUNTAIN	160	7	0		0	0
7036	HOT WELL	0		0		100	0
7038	HUECO-S TULAROSA BAS	0		0		0	71
7004	KILBOURNE HOLE	0		0		155	0
7017	LAS ALTURAS	0		0		120	0
7042	LAS PALOMAS	0		30	7	0	0
7002	LIGHTNING DOCK	0		0		170	0
7003	LWR SAN FRANCISCO HS	0		0		150	0
7014	MAMBY'S HS	0		0		120	0
7007	MC CAULEY SP (JEMEZ)	0		0		0	32
7045	MCKINLEY WEST	0		60	7	0	0
7019	MIMBRES HS	0		0		0	58
7012	MONTEZUMA HS	0		0		130	0
7050	NEWMAN SO PAC RR	0		60	7	0	0
7034	NORTHEAST OF PREWITT	0		0		0	46
7009	OJO CALIENTE	0		0		130	0
7028	PLAYAS VALLEY	0		0		0	28
7020	PONCE DE LEON	0		0		105	0
7008	RADIUM SPRINGS	0		0		130	0
7043	RINCON EAST	0		50	7	0	0
7005	SAN ANTONIO HS (JEME	0		0		0	56
7039	SAN JUAN BASIN	0		0		0	0
7037	SAN YSIDRO	0		0		80	0
7031	SEDILLO SPRING	0		0		0	34
7006	SPENCE SP (JEMEZ)	0		0		0	42
7024	T OR C	0		0		100	0
7032	TOHATCHI AREA	0		0		0	39
7015	TURKEY CREEK	0		0		0	74
7022	UPR SAN FRANCISCO HS	0		0		0	37
7001	VALLES CALDERA	0		0		240	0
7026	W MESA-BLACK MNTN	0		0		95	0
7016	WHITE SANDS	0		0		120	0

TABLE 6. GEOTHERMAL SITE TEMPERATURES.

UTAH

SITE ID	SITE NAME	------TEMPERATURE IN DEGREES CELSIUS------- SUBSURFACE	SOURCE	SURFACE	SOURCE	CS EST	CS MEAS
8007	ABRAHAM HS	0		0		125	0
8015	BECKS HS	0		0		90	0
8044	BIG WS	0		0		0	18
8033	BLUE WS	0		0		0	27
8025	CASTILLA HS	0		0		0	40
8037	COMO HS	0		0		0	25
8002	COVE FORT-SULPHURDAL	0		0		200	0
8021	CRATER HS	0		0		0	43
8006	CRYSTAL HS	0		0		135	0
8016	CRYSTAL H.S.	0		0		90	0
8041	DIAMOND FORK WS	0		0		0	20
8030	FISH SPRINGS	0		0		0	28
8031	GANDY	0		0		0	27
8042	GOSHEN WS	0		0		0	20
8038	GRANTSVILLE	0		0		0	24
8026	HATTON HS	0		0		0	38
8013	HOOPER HS	0		0		105	0
8036	JOHNSONS WS	0		0		0	25
8004	JOSEPH HS	0		0		140	0
8022	LAVERKIN HS	0		0		0	42
8028	LINCOLN POINT WS	0		0		0	32
8012	MEADOW HS	0		0		105	0
8018	MIDWAY HS	0		0		0	45
8009	MONROE(COOPER) HS	0		0		120	0
8032	MORGANS WS	0		0		0	27
8010	OGDEN HS	0		0		110	0
8027	RADIUM(DOTSON) HS	0		0		0	33
8005	RED HILL HS	0		0		135	0
8040	RICHFIELD WS	0		0		0	22
8001	ROOSEVELT HS	0		0		250	0
8039	RUSSELS WS	0		0		0	22
8019	SARATOGA HS	0		0		0	44
8029	SPLIT MOUNTAIN WS	0		0		0	30
8043	STERLING SPR	0		0		0	19
8011	STINKING SPR	0		0		110	0
8003	THERMO HS	0		0		185	0
8020	UDDY HS	0		0		0	43
8024	UNNAMED HS	0		0		0	42
8014	UTAH HS	0		0		95	0
8023	VEYO HS	0		0		0	42
8034	WARM SPR	0		0		0	27
8035	WARM SPR-UTAH LAKE	0		0		0	25
8008	WASATCH HS	0		0		120	0
8017	WILSON HS	0		0		0	61

TABLE 6. GEOTHERMAL SITE TEMPERATURES.

ARIZONA

SITE ID	SITE NAME	RSVR VOLUME CU KM	SOU RCE	THRM GRAD °C/KM	SOU- RCE	DISS SLDS PPT	SOU- RCE	FLOW RATE L/SEC	SOU- RCE
4017	AGUA CALIENTE	2.25	1	0					
4018	ARTESIAN H W	2.25	1	0					
4026	ARTESIA AREA	2.25	1	0					
4022	BARNGAN MTN	2.25	1	0					
4024	BOWIE AREA	2.25	1	0					
4016	BUCKHORN AREA	2.25	1	234	4				
4032	CASA GRANDE	2.25	1	260	4				
4012	CASTLE H S	2.25	1	0					
4008	CAT TANK	2.25	1	0					
4002	CLIFTON HOT SPRINGS	2.25	1	0					
4007	COFFERS H S	2.25	1	0					
4006	COOLIDGE H S	2.25	1	0					
4013	COOLIDGE AREA	2.25	1	0					
4031	COOLIDGE	2.25	1	514	4				
4005	EAGLE CREEK H S	2.25	1	0					
4029	ELOY	2.25	1	108	4				
4030	FLORENCE	2.25	1	479	4				
4004	GILLARD HS	2.25	1	0					
4015	HOOKERS H S	2.25	1	0					
4011	INDIAN H S	2.25	1	0					
4009	JAVELINA PEAK	2.25	1	0					
4020	LUCATS SPA	2.25	1	0					
4033	MAMMOTH	2.25	1	536	4				
4025	MOBIL AREA	2.25	1	0					
4019	MT GRAHAM	2.25	1	0					
4021	PALOMAS MTS	2.25	1	0					
4034	PAPAGO FARMS	2.25	1	208	4				
4028	PHOENIX TEMPE	2.25	1	0					
4001	POWER RANCH AREAS	2.50	1	0					
4014	RADIUM SPRINGS	2.25	1	0					
4010	SAFFORD AREA	2.25	1	0					
4023	THEBA	2.25	1	0					
4027	TOM NIECE WARM SPR	2.25	1	0					
4003	VERDE HOT SPRINGS	2.25	1	0					
4035	WIKIEUP	2.25	1	0					

TABLE 7. RESERVOIR VOLUME, THERMAL GRADIENT, DISSOLVED SOLIDS AND FLOW RATE

COLORADO

SITE ID	SITE NAME	RSVR VOLUME CU KM	SOU RCE	THRM GRAD °C/KM	SOU-RCE	DISS SLDS PPT	SOU-RCE	FLOW RATE L/SEC	SOU-RCE
5047	ANTELOPE BIRDSIE	.94	5						
5005	BRANDS RANCH ARTESIA	.06	5						
5025	BROWN CANYON THRML A	3.82	5						
5029	CANON CITY HOT SPRIN	.04	5						
5050	CEBOLLA HOT SPRINGS	.73	5						
5016	CEMENT CREEK WS	.13	5						
5021	CHALK CR MT PRINCETN	2.48	5						
5022	CHALK CREEK WRIGHT H	2.25	1						
5023	CHALK CREEK HORTENSE	2.25	1						
5024	CHALK CREEK WOOLMING	2.25	1						
5033	CLARK ARTESIAN WELL	.17	5						
5014	COLONEL CHINN HOT WE	.24	5						
5015	CONUNDRUM HOT SPRING	.18	5						
5020	COTTONWOOD CREEK JUM	1.09	5						
5002	CRAIG WARM WATER WEL	.51	5						
5039	DEXTER MCINTYRE	.95	5						
5032	DON K RANCH ARTESIAN	.59	5						
5010	DOTSERO WARM SPRINGS	.17	5						
5054	DUNTON GEYSR PARADIS	.37	5						
5041	DUTCH CROWLY STINKNG	.24	5						
5008	ELDORADO	.28	5						
5043	EOFF ARTESIAN WELL	2.25	1						
5031	FLORENCE ARTESIAN WE	.16	5						
5030	FREMONT NATATORIUM	.17	5						
5061	FULL N WIDER WARM SP	2.25	1						
5011	GLENWOOD HOT SPRINGS	.26	5						
5019	HARTSELL HOT SPRINGS	.34	5						

TABLE 7. RESERVOIR VOLUME, THERMAL GRADIENT, DISSOLVED SOLIDS AND FLOW RATE

COLORADO

SITE ID	SITE NAME	RSVR VOLUME CU KM	SOU RCE	THRM GRAD °C/KM	SOU-RCE	DISS SLDS PPT	SOU-RCE	FLOW RATE L/SEC	SOU-RCE
5007	HAYSTACK BUTTE WWW	.36	5						
5006	HOT SULPHUR SPRINGS	.64	5						
5009	IDAHO HOT SPRINGS	.88	5						
5001	JUNIPER	.16	5						
5053	LEMON HOT SPRING	.27	5						
5034	MINERAL HOT SPRINGS	7.89	5						
5051	ORVIS HOT SPRING	.22	5						
5052	OURAY HOT SPRINGS	1.63	5						
5044	PAGOSA SPRINGS	.34	5						
5013	PENNY AVALANCHE HS	1.27	5						
5058	PINKERTON	.14	5						
5026	PONCHA HOT SPRINGS	1.73	5						
5045	RAINBOW HOT SPRING	.78	5						
5017	RANGER WARM SPRING	.13	5						
5018	RHODES WARM SPRING	1.21	5						
5057	RICO	1.37	5						
5003	ROUT HS	.39	5						
5037	SAND DUNES SWIMMING	.59	5						
5036	SHAWS WARM SPRING	.25	5						
5012	SOUTH CANYON HOT SPR	.08	5						
5038	SPLASHLAND HOT WATER	.59	5						
5004	STEAMBOAT SPRINGS	.10	5						
5059	TRIPP AND TRIMBLE WS	.39	5						
5035	VALLEY VIEW HOT SPRI	.83	5						
5046	WAGON WHEEL GAP HS	1.67	5						
5027	WELLSVILLE SWISSVALE	.18	5						
5049	WUANITA HOT SPRINGS	.22	5						

TABLE 7. RESERVOIR VOLUME, THERMAL GRADIENT, DISSOLVED SOLIDS AND FLOW RATE

NEVADA

SITE ID	SITE NAME	RSVR VOLUME CU KM	SOURCE	THRM GRAD °C/KM	SOURCE	DISS SLDS PPT	SOURCE	FLOW RATE L/SEC	SOURCE
6063	ALKALI HOT SPRING	2.25	1						
6064	ASH SPRINGS	2.25	1						
6016	BALTAZOR HS	3.00	1						
6040	BARTHOLOMAE	2.25	1						
6065	BENNETT SPRINGS	2.25	1						
6001	BEOWAWE H S	42.00	1						
6066	BIG LOCKES SPRING	2.25	1						
6067	BIG SPRING	2.25	1						
6068	BIG SPRINGS	2.25	1						
6022	BLACK ROCK DESERT	2.25	1						
6069	BLUE EAGLE SPRINGS	2.25	1						
6070	BOILING SPRING	2.25	1						
6071	BORAX SPRING	2.25	1						
6059	BOWERS H S	2.25	1						
6058	BO6 H S	4.00	1						
6002	BRADY HOT SP	30.00	1						
6072	BROOKS SPRING	2.25	1						
6073	BRUFFEYS HOT SPRINGS	2.25	1						
6031	BUFFALO VALLEY H S	10.00	1						
6036	BUTTE SPR	2.25	1						
6074	BUTTERFIELD SPRINGS	2.25	1						
6075	CAIN SPRINGS	2.25	1						
6076	CALIENTE HOT SPRING	2.25	1						
6077	CARSON HOT SPRINGS	2.25	1						
6078	CHARNOCK BIG BLUE	2.25	1						
6030	CHERRY CR H S	2.25	1						
6079	CHIMNEY SPRINGS	2.25	1						
6080	COLLAR AND ELBOW SPR	2.25	1						
6081	CRYSTAL POOL	2.25	1						
6082	CRYSTAL SPRINGS	2.25	1						
6025	DARROUGHS HS	2.25	1						
6083	DELMUES SPRING	2.25	1						
6084	DEVILS HOLE	2.25	1						
6056	DIANA PUNCH BOWL	2.25	1						
6023	DIXIE VALLEY HS	3.00	1						
6024	DOUBLE HS	20.00	1						
6026	DYKE H S	2.25	1						
6044	ELKO HS	3.00	1						
6085	EMIGRANT SPRINGS	2.25	1						
6086	FAIRBANKS SPRING	2.25	1						
6015	FERNLEY HS	2.25	1						

TABLE 7. RESERVOIR VOLUME, THERMAL GRADIENT, DISSOLVED SOLIDS AND FLOW RATE

NEVADA

SITE ID	SITE NAME	RSVR VOLUME CU KM	SOU RCE	THRM GRAD °C/KM	SOU-RCE	DISS SLDS PPT	SOU-RCE	FLOW RATE L/SEC	SOU-RCE
6087	FISH SPRINGS	2.25	1						
6088	FLAG SPRINGS	2.25	1						
6033	FLY RANCH	16.00	1						
6089	FLYNN RANCH SPRINGS	2.25	1						
6090	GAMBLES HOLE	2.25	1						
6091	GEYSER RANCH SPRINGS	2.25	1						
6092	GEYSER RANCH SPRINGS	2.25	1						
6093	GEYSER RANCH SPRINGS	2.25	1						
6013	GREAT BOILING H S	25.00	1						
6035	H S NEAR TREBO	2.25	1						
6094	HAY CORRAL SPRING	2.25	1						
6095	HICKS HOT SPRINGS	2.25	1						
6096	HIKO SPRING	2.25	1						
6097	HORSESHOE RANCH SPRI	2.25	1						
6098	HOT CREEK SPRING	2.25	1						
6099	HOT CREEK SPRINGS	2.25	1						
6100	HOT HOLE ELKO HOT S	2.25	1						
6032	HOT POT BLOSSOM	2.25	1						
6008	HOT SULPHUR SP	2.25	1						
6009	HOT SP NEAR WELLS	2.25	1						
6010	HOT SP RANCH	2.25	1						
6027	HOT SULPHUR SP	2.25	1						
6038	HOT SPR POINT	7.50	1						
6101	HOT SPRING	2.25	1						
6102	HOT SPRING	2.25	1						
6103	HOT SPRINGS	2.25	1						
6104	HOT SPRINGS	2.25	1						
6105	HOT SPRINGS	2.25	1						
6106	HOT SPRINGS	2.25	1						
6107	HOT SPRINGS	2.25	1						
6108	HOT SPRING	2.25	1						
6109	HOT SPRINGS	2.25	1						
6110	HOT SPRING	2.25	1						
6111	HOT SPRINGS	2.25	1						
6112	HOT SPRINGS	2.25	1						
6113	HOT SPRINGS	2.25	1						
6029	HOWARD HS	2.25	1						
6114	HUFFAKER SPRINGS	2.25	1						
6042	HYDER H S	2.25	1						
6115	INDIAN SPRINGS	2.25	1						

TABLE 7. RESERVOIR VOLUME, THERMAL GRADIENT, DISSOLVED SOLIDS AND FLOW RATE

NEVADA

SITE ID	SITE NAME	RSVR VOLUME CU KM	SOURCE	THERM GRAD °C/KM	SOURCE	DISS SLDS PPT	SOURCE	FLOW RATE L/SEC	SOURCE
6116	IZZENHOOD RANCH SPRI	2.25	1						
6117	JACK RABBIT SPRING	2.25	1						
6007	JERSEY VALLEY HS	2.25	1						
6118	JOHN SALVIS HOT SPRI	2.25	1						
6119	KATE SPRING	2.25	1						
6006	KYLE H S	2.25	1						
6120	LACKAWANNA SPRINGS	2.25	1						
6121	LAWTON HOT SPRINGS	2.25	1						
6014	LEACH HS	10.00	1						
6011	LEE H S	2.25	1						
6122	LONGSTREET SPRING	2.25	1						
6049	LOWER RANCH	2.25	1						
6123	MACFARLAND HOT SPRIN	2.25	1						
6124	MANSE SPRINGS	2.25	1						
6125	MCCOY SPRINGS	2.25	1						
6126	MCGILL SPRING	2.25	1						
6034	MINERAL SAN JACINTO	2.25	1						
6050	MONTE NEVA HS	2.25	1						
6127	MOON RIVER SPRING	2.25	1						
6128	MOORES RANCH SPRINGS	2.25	1						
6129	MOORMAN SPRING	2.25	1						
6130	MOUND SPRINGS	2.25	1						
6131	MUD SPRINGS	2.25	1						
6132	MUD SPRINGS	2.25	1						
6133	MUDDY SPRING	2.25	1						
6039	NEAR GOLCONDA	2.25	1						
6051	NEAR CARLIN	2.25	1						
6053	NEAR RUBY MARSH	2.25	1						
6021	NEEDLE ROCKS	3.00	1						
6055	NEVADA H S	2.25	1						
6061	NILE SPR	2.25	1						
6134	PANACA SPRING	2.25	1						
6135	PEARL HOT SPRINGS	2.25	1						
6012	PINTO H S	7.50	1						
6136	POINT OF ROCKS SPRIN	2.25	1						
6060	POTTS RANCH H S	2.25	1						
6137	PRESTON SPRINGS	2.25	1						
6138	RIZZI RANCH HOT SPRI	2.25	1						
6139	ROGERS SPRING	2.25	1						
6004	SAN EMIDIO	2.25	1						

TABLE 7. RESERVOIR VOLUME, THERMAL GRADIENT, DISSOLVED SOLIDS AND FLOW RATE

NEVADA

SITE ID	SITE NAME	RSVR VOLUME CU KM	SOU RCE	THRM GRAD °C/KM	SOU-RCE	DISS SLDS PPT	SOU-RCE	FLOW RATE L/SEC	SOU-RCE
6140	SHIPLEY HOT SPRING	2.25	1						
6141	SIRI RANCH SPRING	2.25	1						
6019	SMITH CREEK VALLEY	2.25	1						
6017	SODA LAKE	12.50	1						
6046	SODA SP	2.25	1						
6057	SOLDIER MEADOWS	12.00	1						
6043	SOU H S	2.25	1						
6037	SPENCER H S	2.25	1						
6142	SPRINGS	2.25	1						
6143	SPRING	2.25	1						
6144	SPRING	2.25	1						
6145	SPRING	2.25	1						
6146	SPRINGS HOT	2.25	1						
6147	SPRING HOT	2.25	1						
6148	SPRING	2.25	1						
6149	SPRING	2.25	1						
6062	SSE PATSVILLE	2.25	1						
6003	STEAMBOAT SP	16.00	1						
6018	STILLWATER	25.00	1						
6150	STORM SPRING	2.25	1						
6005	SULPHUR HS	10.00	1						
6151	SULPHUR SPRING	2.25	1						
6045	THE HOT SPR	2.25	1						
6152	TWIN SPRINGS	2.25	1						
6153	UPPER WARM SPRING	2.25	1						
6047	VALLEY OF THE MOON	2.25	1						
6020	WABUSKA HS	2.25	1						
6154	WALL SPRING	2.25	1						
6054	WALLEYS (GENOA) H S	2.25	1						
6052	WALTI HS	3.00	1						
6041	WARM SPR	2.25	1						
6155	WARM SPRINGS	2.25	1						
6156	WARM SPRINGS	2.25	1						
6157	WARM SPRINGS	2.25	1						
6158	WEDELL HOT SPRINGS	2.25	1						
6028	WELL NEAR GERLACH	2.25	1						
6159	WEST SPRING	2.25	1						
6048	WILD HORSE RES	2.25	1						
6160	WILLIAMS HOT SPRINGS	2.25	1						
6161	WILSON HOT SPRING	2.25	1						

TABLE 7. RESERVOIR VOLUME, THERMAL GRADIENT, DISSOLVED SOLIDS AND FLOW RATE

NEW MEXICO

SITE ID	SITE NAME	RSVR VOLUME CU KM	SOU RCE	THRM GRAD C/KM	SOU- RCE	DISS SLDS PPT	SOU- RCE	FLOW RATE L/SEC	SOU- RCE
7044	ALEMAN	2.25	1						
7018	BERINO - MESQUITE	2.25	1						
7049	CARNE	2.25	1						
7029	CLIFF AREA	2.25	1						
7027	CLOSSON	2.25	1						
7040	CROCKER	2.25	1						
7033	CROWNPOINT AREA	2.25	1						
7030	DERRY WARM SPRING	2.25	1						
7021	E SAN AUGUSTIN PLAIN	2.25	1						
7023	FAYWOOD HS	2.25	1						
7041	FREIBORN CANYON	2.25	1						
7047	GALLINAS CREEK	2.25	1						
7046	GARTON WELL	2.25	1						
7010	GILA HS-BELOW BRIDGE	2.25	1						
7011	GILA HS-MIDDLE FORK	2.25	1						
7013	GILA HS-DOC CAMPBELL	2.25	1						
7025	GILA HS-UPR MDL FRK	2.25	1						
7035	GUADALUPE SP	2.25	1						
7048	HATCHET MOUNTAIN	2.25	1						
7036	HOT WELL	2.25	1						
7038	HUECO-S TULAROSA BAS	2.25	1						
7004	KILBOURNE HOLE	2.25	1						
7017	LAS ALTURAS	2.25	1						
7042	LAS PALOMAS	2.25	1						
7002	LIGHTNING DOCK	2.25	1						
7003	LWR SAN FRANCISCO HS	2.25	1						
7014	MAMBY'S HS	2.25	1						
7007	MC CAULEY SP (JEMEZ)	2.25	1						
7045	MCKINLEY WEST	2.25	1						
7019	MIMBRES HS	2.25	1						
7012	MONTEZUMA HS	2.25	1						
7050	NEWMAN SO PAC RR	2.25	1						
7034	NORTHEAST OF PREWITT	2.25	1						
7009	OJO CALIENTE	2.25	1						
7028	PLAYAS VALLEY	2.25	1						
7020	PONCE DE LEON	2.25	1						
7008	RADIUM SPRINGS	2.25	1						
7043	RINCON EAST	2.25	1						
7005	SAN ANTONIO HS (JEME	2.25	1						
7039	SAN JUAN BASIN	2.25	1						
7037	SAN YSIDRO	2.25	1						
7031	SEDILLO SPRING	2.25	1						
7006	SPENCE SP (JEMEZ)	2.25	1						
7024	T OR C	2.25	1						
7032	TOHATCHI AREA	2.25	1						
7015	TURKEY CREEK	2.25	1						
7022	UPR SAN FRANCISCO HS	2.25	1						
7001	VALLES CALDERA	130.00	1						
7026	W MESA-BLACK MNTN	2.25	1						
7016	WHITE SANDS	2.25	1						

TABLE 7. RESERVOIR VOLUME, THERMAL GRADIENT, DISSOLVED SOLIDS AND FLOW RATE

UTAH

SITE ID	SITE NAME	RSVR VOLUME CU KM	SOURCE	THRM GRAD °C/KM	SOURCE	DISS SLDS PPT	SOURCE	FLOW RATE L/SEC	SOURCE
8007	ABRAHAM HS	2.25	1						
8015	BECKS HS	2.25	1						
8044	BIG WS	2.25	1						
8033	BLUE WS	2.25	1						
8025	CASTILLA HS	2.25	1						
8037	COMO HS	2.25	1						
8002	COVE FORT-SULPHURDAL	22.50	1						
8021	CRATER HS	2.25	1						
8006	CRYSTAL HS	2.25	1						
8016	CRYSTAL H.S.	2.25	1						
8041	DIAMOND FORK WS	2.25	1						
8030	FISH SPRINGS	2.25	1						
8031	GANDY	2.25	1						
8042	GOSHEN WS	2.25	1						
8038	GRANTSVILLE	2.25	1						
8026	HATTON HS	2.25	1						
8013	HOOPER HS	2.25	1						
8035	JOHNSONS WS	2.25	1						
8004	JOSEPH HS	2.25	1						
8022	LAVERKIN HS	2.25	1						
8028	LINCOLN POINT WS	2.25	1						
8012	MEADOW HS	2.25	1						
8018	MIDWAY HS	2.25	1						
8009	MONROE(COOPER) HS	2.25	1						
8032	MORGANS WS	2.25	1						
8010	OGDEN HS	2.25	1						
8027	RADIUM(DOTSON) HS	2.25	1						
8005	RED HILL HS	2.25	1						
8040	RICHFIELD WS	2.25	1						
8001	ROOSEVELT HS	8.00	1						
8039	RUSSELS WS	2.25	1						
8019	SARATOGA HS	2.25	1						
8029	SPLIT MOUNTAIN WS	2.25	1						
8043	STERLING SPR	2.25	1						
8011	STINKING SPR	2.25	1						
8003	THERMO HS	2.25	1						
8020	UDDY HS	2.25	1						
8024	UNNAMED HS	2.25	1						
8014	UTAH HS	2.25	1						
8023	VEYO HS	2.25	1						
8034	WARM SPR	2.25	1						
8035	WARM SPR-UTAH LAKE	2.25	1						
8008	WASATCH HS	2.25	1						
8017	WILSON HS	2.25	1						

TABLE 7. RESERVOIR VOLUME, THERMAL GRADIENT, DISSOLVED SOLIDS AND FLOW RATE

ARIZONA

CITY ID	CITY NAME	COUNTY NAME	POPULATION	LAT	LONG
04001	AJO	PIMA	5881	32 24	112 51
04002	APACHE JUNCTION	PINAL	2390	33 26	111 32
04003	AVONDALE	MARICOPA	6304	33 28	112 22
04004	BAGDAD	YAUAPAI	2079	38 16	113 12
04005	BENSON	COCHISE	2839	31 58	110 19
04006	BISBEE	COCHISE	8328	31 27	109 55
04007	BUCKEYE	MARICOPA	2599	33 25	112 34
04008	BYLAS	GRAHAM	1125	33 04	110 11
04009	CASA GRANDE	PINAL	10536	32 52	111 46
04010	CASHION	MARICOPA	2705	33 22	112 28
04011	CENTRAL HEIGHTS	GILA	2289	00 00	000 00
04012	CHANDLER	MARICOPA	13763	33 19	111 49
04013	CLARKDALE	YAUAPAI	892	34 49	112 03
04014	CLAYPOOL	GILA	2245	33 25	110 52
04015	CLIFTON	GREENLEE	5087	33 04	109 17
04016	COOLIDGE	PINAL	4651	32 58	111 30
04017	COTTONWOOD	YAUAPAI	2815	34 45	112 00
04018	DOUGLAS	COCHISE	12462	31 21	109 34
04019	DUNCAN	GREENLEE	773	32 43	109 06
04020	EAGER	APACHE	1279	34 79	109 19
04021	EL MIRAGE	MARICOPA	3258	33 39	112 21
04022	ELOY	PINAL	5381	32 45	111 33
04023	FLAGSTAFF	COCONINO	26117	35 12	111 38
04024	FLORENCE	PINAL	2173	33 02	111 22
04026	FREDONIA	COCONINO	798	36 57	112 31
04025	FT HUACHUCA	COCHISE	6659	31 34	110 24
04027	GILA BEND	MARICOPA	1795	32 56	112 42
04028	GILBERT	MARICOPA	1971	33 22	111 46
04029	GLENDALE	MARICOPA	36228	33 34	112 10
04030	GLOBE	GILA	7333	33 23	110 48
04031	GOODYEAR	MARICOPA	2140	33 29	112 23
04032	GRAND CANYON	COCONINO	1011	36 04	112 07
04033	HAYDEN	GILA	1283	33 01	110 48
04034	HOLBROOK	NAVAJO	4759	34 54	110 11
04035	HUACHUCA	COCHISE	1233	31 34	110 21
04036	KEARNEY	PINAL	2829	33 00	110 55
04037	KINGMAN	MOHAVE	7312	35 12	114 02
04038	LITCHFIELD PARK	MARICOPA	1664	33 32	112 20
04039	LUKE AFB	MARICOPA	5047	33 34	112 27
04040	MAMMOTH	PINAL	1953	32 43	110 40
04041	MESA	MARICOPA	62853	33 25	115 50
04042	MIAMI	GILA	3394	33 24	110 54
04043	NOGALES	SANTA CRUZ	8946	31 20	110 56

TABLE 8. CITY ID, CITY NAME, COUNTY NAME, POPULATION, LATITUDE AND LONGITUDE

ARIZONA

CITY ID	CITY NAME	COUNTY NAME	POPULATION	LAT	LONG
04044	PAGE	COCONINO	1439	36 57	111 28
04045	PARADISE VALLEY	MARICOPA	7155	33 40	111 55
04046	PARKER	YUMA	1948	34 09	114 18
04047	PATAGONIA	SANTA CRUZ	630	31 33	110 46
04048	PAYSON	GILA	1490	34 16	111 20
04049	PEORIA	MARICOPA	4792	33 38	112 13
04050	PHOENIX	MARICOPA	581562	33 30	112 03
04051	PIMA	GRAHAM	1184	32 53	109 50
04052	PLANTSITE	GREENLEE	1077	33 02	109 18
04053	PRESCOTT	YAVAPAI	13030	34 34	112 28
04054	SAFFORD	GRAHAM	5333	32 50	109 43
04056	SAN CARLOS	GILA	2542	33 22	110 29
04057	SAN MANUEL	PINAL	4332	32 28	110 40
04058	SCOTTSDALE	MARICOPA	67823	33 31	111 53
04059	SEDONA	COCONINO	2022	34 53	111 45
04060	SHONHOW	NAVAJO	2285	34 16	110 03
04061	SIERRA VISTA	COCHISE	6689	31 36	110 18
04062	SNOWFLAKE	NAVAJO	1833	34 32	110 05
04063	SOMERTON	YUMA	2225	32 35	114 44
04064	SOUTH TUCSON	PIMA	6220	32 14	110 57
04065	SPRINGERVILLE	APACHE	1038	34 09	109 18
04055	ST JOHNS	APACHE	1320	34 30	109 24
04066	STARGO	GREENLEE	1194	33 06	109 23
04067	SUN CITY	MARICOPA	13670	33 37	112 13
04068	SUPERIOR	PINAL	4975	33 18	116 06
04069	SURPRISE	MARICOPA	2427	33 41	112 23
04070	TAYLOR	NAVAJO	888	34 29	110 05
04071	TEMPE	MARICOPA	62907	33 25	111 55
04072	THATCHER	GRAHAM	2320	32 50	109 46
04073	TOLLESON	MARICOPA	3881	33 29	112 15
04074	TOMBSTONE	COCHISE	1241	31 44	110 04
04075	TUCSON	PIMA	262933	32 15	110 57
04076	WEST YUMA	YUMA	5552	32 40	114 39
04077	WICKENBURG	MARICOPA	2698	33 59	112 44
04078	WILLCOX	COCHISE	2568	32 16	109 50
04079	WILLIAMS	COCONINO	2386	35 16	112 10
04080	WILLIAMS AFB	MARICOPA	3443	33 19	111 45
04081	WINKELMAN	GILA	974	33 00	110 48
04082	WINSLOW	NAVAJO	8066	35 01	110 43
04083	YOUNGTOWN	MARICOPA	1886	33 39	112 14
04084	YUMA	YUMA	29007	32 40	114 39
04085	YUMA PROVING GROUND	YUMA	1349	32 43	114 24
04086	YUMA STATION	YUMA	3460	00 00	000 00

TABLE 8. CITY ID, CITY NAME, COUNTY NAME, POPULATION, LATITUDE AND LONGITUDE

COLORADO

CITY ID	CITY NAME	COUNTY NAME	POPULATION	LAT	LONG
05001	AGUILAR	LAS ANIMAS	699	37 25	104 40
05002	AKRON	WASHINGTON	1775	40 09	103 13
05003	ALAMOSA	ALMOSA	6985	37 28	105 54
05004	ALAMOSA EAST	ALAMOSA	1040	37 28	105 54
05005	ANTONITO	CONEJOS	1113	37 04	106 01
05006	APPLEWOOD	JEFFERSON	8214	00 00	000 00
05007	ARVADA	JEFFERSON	46814	39 47	105 07
05008	ASPEN	PITKIN	2404	39 12	106 49
05009	AULT	WELD	841	40 35	104 44
05010	AURORA	ARAPAHOE	74974	39 45	104 50
05011	AUSTIN	DELTA	1163	38 47	107 57
05012	BENNETT	ADAMS	613	39 45	104 25
05013	BERTHAUD	LARIMER	1446	40 19	105 05
05014	BOULDER	BOULDER	66870	40 02	105 16
05015	BOW MAR	ARAPAHOE	945	39 38	105 03
05016	BRECKENRIDGE	SUMMIT	548	39 29	106 03
05017	BRIGHTON	ADAMS	8309	39 59	104 50
05018	BROOMFIELD	BOULDER	7261	39 50	105 07
05019	BRUSH	MORGAN	3377	40 15	103 36
05020	BUENA VISTA	CHAFFEE	1962	38 44	106 10
05021	BURLINGTON	KIT CARSON	2828	39 17	102 17
05022	CANON CITY	FREMONT	9206	38 27	105 14
05023	CARBONDALE	GARFIELD	726	39 23	107 13
05024	CASTLE ROCK	DOUGLAS	1531	39 23	104 53
05025	CEDAREDGE	DELTA	581	38 44	107 55
05026	CENTER	RIO GRANDE	1470	37 45	106 07
05027	CHERRY HILLS VLG	ARAPAHOE	4605	39 38	104 51
05028	CHEYENNE WELLS	CHEYENNE	982	38 48	102 30
05029	COLORADO SPRINGS	EL PASO	135000	38 50	104 50
05030	COMMERCE CITY	ADAMS	17407	39 50	104 55
05031	CORTEZ	MONTEZUMA	6032	37 22	108 36
05032	CRAIG	MOFFAT	4205	40 30	107 33
05033	CREEDE	MINERAL	653	37 52	106 56
05034	DEL NORTE	RIO GRANDE	1569	37 40	106 22
05035	DELTA	DELTA	3694	38 42	108 04
05036	DENVER	DENVER	514000	39 45	105 00
05037	DERBY	ADAMS	10206	00 00	000 00
05038	DOLORES	MONTEZUMA	820	37 28	108 30
05039	DOVE CREEK	DOLORES	619	37 46	108 55
05040	DURANGO	LA PLATA	10333	37 16	107 53

TABLE 8. CITY ID, CITY NAME, COUNTY NAME, POPULATION, LATITUDE AND LONGITUDE

COLORADO

CITY ID	CITY NAME	COUNTY NAME	POPULATION	LAT	LONG
05041	EADS	KIOWA	795	38 28	102 48
05042	EAGEL	EAGLE	790	39 39	106 50
05043	EAST CANON	FREMONT	1805	38 27	105 14
05044	EATON	WELD	1389	40 32	104 43
05045	EDGEWATER	JEFFERSON	4866	39 45	105 04
05046	ENGLEWOOD	ARAPAHOE	33695	39 39	105 00
05047	ERIE	BOULDER	1090	40 03	105 04
05048	ESTES PARK	LARIMER	1616	40 24	105 32
05049	EVANS	WELD	2570	39 35	105 39
05050	EVERGREEN	JEFFERSON	2321	39 38	105 20
05051	FEDERAL HEIGHTS	ADAMS	1502	39 52	105 01
05052	FIRESTONE	WELD	570	40 05	104 55
05053	FLAGLER	KIT CARSON	615	39 17	103 05
05054	FLORENCE	FREMONT	2846	38 23	105 07
05060	FOUNTAIN	EL PASO	3515	38 40	104 44
05061	FOWLER	OTERO	1241	38 07	104 03
05062	FREDERICK	WELD	696	40 05	104 55
05063	FRUITA	MESA	1822	39 08	108 44
05055	FT CARSON	EL PASO	19399	38 45	104 50
05056	FT COLLINS	LARIMER	43337	40 35	105 05
05057	FT COLLINS WEST	LARIMER	1693	40 35	105 05
05058	FT LUPTON	WELD	2489	40 04	104 49
05059	FT MORGAN	MORGAN	7594	40 14	103 48
05064	GEORGETOWN	CLEAR CREEK	542	39 42	105 45
05065	GLENDALE	ARAPAHOE	765	39 43	104 56
05066	GLENWOOD SPRINGS	GARFIELD	4106	39 33	107 21
05067	GOLDEN	JEFFERSON	9817	39 45	105 15
05068	GRANADA	PROWERS	551	38 03	102 20
05069	GRANBY	GRAND	554	40 05	105 56
05070	GRAND JUNCTION	MESA	20170	39 04	108 33
05071	GREELEY	WELD	38902	40 26	104 43
05072	GREENWOOD VILLAGE	ARAPAHOE	2578	00 00	000 00
05073	GUNNISON	GUNNISON	4613	38 33	106 55
05074	HAXTUN	PHILLIPS	899	40 38	102 37
05075	HAYDEN	ROUTT	763	40 31	107 17
05076	HOLLY	PROWERS	993	38 04	102 09
05077	HOLYOKE	PHILLIPS	1640	40 34	102 20
05078	HOTCHKISS	DELTA	507	38 47	107 42
05079	HUDSON	WELD	518	40 04	104 37
05080	HUGO	LINCOLN	759	39 07	103 27

TABLE 8. CITY ID, CITY NAME, COUNTY NAME, POPULATION, LATITUDE AND LONGITUDE

COLORADO

CITY ID	CITY NAME	COUNTY NAME	POPULATION	LAT	LONG
05081	IDAHO SPRINGS	CLEAR CREEK	2003	39 44	105 31
05082	IGNACIO	LA PLATA	613	37 06	107 38
05083	JOHNSTOWN	WELD	1191	40 20	104 50
05084	JULESBURG	SEDGWICK	1578	40 59	102 16
05085	KREMMLING	GRAND	764	40 03	106 24
05087	LA JARA	CONEJOS	768	37 17	105 58
05088	LA JUNTA	OTERO	7938	37 59	103 34
05091	LA SALLE	WELD	1227	40 21	104 43
05093	LA VETA	HUERFANO	589	37 30	105 01
05086	LAFAYETTE	BOULDER	3498	39 59	105 06
05089	LAKEWOOD	JEFFERSON	92787	39 44	105 11
05090	LAMAR	PROWERS	7797	38 04	102 37
05092	LAS ANIMAS	BENT	3148	38 03	103 14
05094	LEADVILLE	LAKE	4314	39 14	106 18
05095	LEADVILLE NORTH	LAKE	1717	39 14	106 18
05096	LIMON	LINCOLN	1814	39 16	103 40
05097	LINCOLN PARK	FREMONT	2984	38 24	105 12
05098	LITTLETON SE	ARAPAHOE	22899	39 36	105 02
05099	LITTLETON	ARAPAHOE	26466	39 36	105 02
05100	LONGMONT	BOULDER	23209	40 11	105 06
05101	LOUISVILLE	BOULDER	2409	39 58	105 09
05102	LOVELAND	LARIMER	16220	40 24	105 06
05103	LYONS	BOULDER	958	40 14	105 17
05104	MANASSA	CONEJOS	814	37 11	105 56
05105	MANCOS	MONTEZUMA	709	37 21	108 19
05106	MANITOU SPRINGS	EL PASO	4278	38 51	104 55
05107	MEEKER	RIO BLANCO	1597	40 03	107 56
05108	MILLIKEN	WELD	702	40 21	104 53
05109	MINTURN	EAGLE	706	39 35	106 24
05110	MONTE VISTA	RIO GRANDE	3909	37 34	106 11
05111	MONTROSE	MONTROSE	6496	38 29	107 53
05112	MOUNTAIN VIEW	JEFFERSON	706	00 00	000 00
05113	NATURITA	MONTROSE	820	38 12	108 36
05114	NORTH GLENN	ADAMS	27937	39 53	104 59
05115	NORTH LA JUNTA	OTERO	1249	38 01	103 38
05116	NUCLA	MONTROSE	949	38 17	108 33
05117	OLATHE	MONTROSE	756	38 33	107 57
05118	ORCHARD CITY	MESA	5824	38 50	107 58
05119	ORDWAY	CROWLEY	1017	38 13	103 47

TABLE 8. CITY ID, CITY NAME, COUNTY NAME, POPULATION, LATITUDE AND LONGITUDE

COLORADO

CITY ID	CITY NAME	COUNTY NAME	POPULATION	LAT	LONG
05120	CTIS	WASHINGTON	521	40 09	102 58
05121	OURAY	OURAY	741	38 02	107 40
05122	PAGOSA SPRINGS	ARCHULETA	1360	37 16	107 01
05123	PALISADE	MESA	874	39 05	108 23
05124	PALMER LAKE	EL PASO	947	39 07	104 56
05125	PAONIA	DELTA	1161	38 52	107 35
05126	PLATTEVILLE	WELD	683	40 13	104 50
05127	PUEBLO	PUEBLO	97453	38 17	104 38
05128	RANGELY	RIO BLANCO	1591	40 04	108 48
05129	RED CLIFF	EAGLE	621	39 31	106 22
05130	RIFLE	GARFIELD	2150	39 32	107 47
05131	ROCKY FORD	OTERO	4859	38 03	103 44
05132	SAGUACHE	SAGUACHE	642	38 05	106 10
05133	SALIDA	CHAFFEE	4355	38 33	106 01
05135	SAN LUIS	COSTILLA	781	37 03	105 25
05134	SANFORD	CONEJOS	638	37 16	105 55
05136	SECURITY-WIDEFIELD	EL PASO	15297	38 42	104 44
05137	SHERIDAN	ARAPAHOE	4787	39 39	105 02
05138	SHERRELWOOD	ADAMS	18868	00 00	000 00
05139	SILVERTON	SAN JUAN	797	37 48	107 40
05140	SPRINGFIELD	BACA	1660	37 26	102 36
05141	STEAMBOAT SPRINGS	ROUTT	2340	40 28	106 51
05142	STERLING	LOGAN	10636	40 37	103 13
05143	STRATTON MEADOWS	EL PASO	6223	00 00	000 00
05144	STRATTON	KIT CARSON	790	39 18	102 36
05145	TELLURIDE	SAN MIGUEL	553	37 57	107 48
05146	THORNTON	ADAMS	13326	39 57	105 00
05147	TRINIDAD	LAS ANIMAS	9901	37 11	104 31
05158	URAY	YUMA	1953	40 05	102 14
05148	WALDEN	JACKSON	907	40 43	106 19
05149	WALSENBURG	HUERFANO	4329	37 36	104 48
05150	WALSH	BACA	989	37 24	102 17
05151	WELBY	ADAMS	6875	39 50	104 58
05152	WELLINGTON	LARIMER	691	40 42	105 01
05153	WESTMINSTER	ADAMS	19432	39 49	105 05
05154	WESTMINSTER EAST	ADAMS	7576	39 49	105 05
05155	WHEAT RIDGE	JEFFERSON	29795	39 47	105 13
05156	WINDSOR	WELD	1564	40 28	104 53
05157	WOODLAND PARK	TELLER	1022	39 00	105 04

TABLE 8. CITY ID, CITY NAME, COUNTY NAME, POPULATION, LATITUDE AND LONGITUDE

NEVADA

CITY ID	CITY NAME	COUNTY NAME	POPULATION	LAT	LONG
06001	BABBETT	MINERAL	1579	38 32	118 38
06002	BATTLE MOUNTAIN	LANDER	1856	40 41	117 07
06003	BOULDER CITY	CLARK	5223	39 59	114 51
06004	CALIENTE	LINCOLN	916	37 36	114 31
06005	CARLIN	ELKO	1313	40 44	116 06
06006	CARSON CITY	ORMSBY	15468	39 10	119 46
06007	EAST ELY	WHITE PINE	1992	39 17	114 52
06008	EAST LAS VEGAS	CLARK	6501	36 04	115 03
06009	ELKO CITY	ELKO	7621	40 50	115 46
06010	ELY	WHITE PINE	4175	39 15	114 53
06011	FALLON	CHURCHILL	2959	39 29	118 47
06012	FALLON STATION	CHURCHILL	1045	39 25	118 44
06013	GABBS	NYE	874	38 44	118 07
06014	GARDNERVILLE-MINDEN	DOUGLAS	1320	38 57	119 45
06015	HAWTHORNE	MINERAL	3539	38 31	118 37
06016	HENDERSON	CLARK	16395	36 01	115 00
06017	LAS VEGAS	CLARK	125787	36 10	115 10
06018	LOVELOCK	PERSHING	1571	40 12	118 28
06019	MC GILL	WHITE PINE	2164	39 24	114 47
06020	NELLIS AFB	CLARK	6449	36 15	115 03
06021	NORTH LAS VEGAS	CLARK	36216	36 15	115 07
06022	PARADISE	CLARK	24477	00 00	000 00
06023	RENOE	WASHOE	72863	39 32	119 49
06024	SPARKS	WASHOE	24187	39 34	119 46
06026	SUN VALLEY	WASHOE	2414	00 00	000 00
06025	SUNRISE MANOR	CLARK	10886	00 00	000 00
06027	TONOPAH	NYE	1716	38 05	117 15
06028	VEGAS CREEK	CLARK	8970	00 00	000 00
06029	WELLS	ELKO	1081	41 08	114 58
06030	WINCHESTER	CLARK	13981	00 00	000 00
06031	WINNEMUCCA	HUMBOLDT	3587	40 58	117 45
06032	YERRINGTON	LYON	2010	39 00	119 10

TABLE 8. CITY ID, CITY NAME, COUNTY NAME, POPULATION, LATITUDE AND LONGITUDE

NEW MEXICO

CITY ID	CITY NAME	COUNTY NAME	POPULATION	LAT	LONG
07001	ALAMOGORDO	OTERO	23035	32 54	105 57
07002	ALBUQUERQUE	BERNALILLO	243751	35 05	106 38
07003	ANTHONY	DONA ANA	1728	32 00	106 36
07004	ARTESIA	EDDY	10315	32 51	104 24
07005	AZTEC	SAN JUAN	3354	36 49	108 59
07006	BAYARD	GRANT	2908	32 47	108 07
07007	BELEN	VALENCIA	4823	34 39	106 48
07008	BERNALILLO	SANDOVAL	2016	35 18	106 34
07009	BLOOMFIELD	SAN JUAN	1574	36 43	107 59
07010	CANNON	CURRY	5461	34 14	103 15
07011	CARLSBAD	EDDY	21297	32 25	104 14
07012	CARRIZOZO	LINCOLN	1123	33 39	105 54
07013	CENTRAL	GRANT	1864	32 47	108 09
07014	CHAMA	RIO ARRIBA	899	36 54	106 36
07015	CIMARRON	COLFAX	927	36 30	104 55
07016	CLAYTON	UNION	2931	36 27	103 12
07017	CLOUDCROFT	OTERO	525	32 58	105 46
07018	CLOVIS	CURRY	28495	34 14	103 13
07019	DEMING	LUNA	8343	32 17	107 46
07020	DEXTER	CHAVES	746	33 11	104 22
07021	ESPANOLA	RIO ARRIBA	4528	35 59	106 05
07022	ESTANCIA	TORRENCE	721	34 45	106 04
07023	EUNICE	LEA	2641	32 26	103 09
07024	FARMINGTON	SAN JUAN	21979	36 43	108 12
07025	FT SUMNER	DE BACA	1615	34 27	104 16
07026	GALLUP	MC KINLEY	14596	35 35	108 46
07027	GRANTS	VALENCIA	8768	35 10	107 51
07028	HAGERMAN	CHAVES	953	33 06	104 20
07029	HATCH	DONA ANA	867	32 39	107 10
07030	HOBBS	LEA	26025	32 42	103 08
07031	HOLLOMAN	OTERO	8001	32 51	105 57
07032	HURLEY	GRANT	1796	32 41	108 07
07033	ISLETA PUEBLO	BERNALILLO	1080	34 55	106 43
07034	JAL	LEA	2602	32 05	103 12
07035	JEMEZ PUEBLO	SANDOVAL	1197	35 37	106 44
07036	LA MESILLA	DONA ANA	1713	32 17	106 48
07037	LAS CRUCES	DONA ANA	37857	32 18	106 47
07038	LAS VEGAS	SAN MIGUEL	7528	35 36	105 15
07039	LAS VEGAS WEST	SAN MIGUEL	6307	35 36	105 15
07040	LORDSBURG	HIDALGO	3429	32 22	108 43
07041	LOS ALAMOS	LOS ALAMOS	11310	35 52	106 19

TABLE 8. CITY ID, CITY NAME, COUNTY NAME, POPULATION, LATITUDE AND LONGITUDE

NEW MEXICO

CITY ID	CITY NAME	COUNTY NAME	POPULATION	LAT	LONG
07042	LOS LUNAS	VALENCIA	973	34 48	106 46
07043	LOS RANCHOS DE ALBQ	BERNALILLO	1900	35 08	106 38
07044	LOVING	EDDY	1192	32 17	104 06
07045	LOVINGTON	LEA	8915	32 58	103 21
07046	MAGDALENA	SOCORRO	652	34 06	107 14
07047	MEADOW VISTA	DONA ANA	1402	00 00	000 00
07048	MELROSE	CURRY	636	34 26	103 38
07049	MILAN	VALENCIA	2185	35 11	108 48
07050	MORIARTY	TORRENCE	758	34 59	106 03
07051	MOUNTAINAIR	TORRENCE	1022	34 32	106 16
07052	NORTH VALLEY	BERNALILLO	10366	35 05	106 38
07053	PECOS	SAN MIGUEL	598	35 34	105 41
07054	PORTALES	ROOSEVELT	10554	34 12	103 20
07055	QUESTA	TAOS	1095	36 43	105 36
07056	RATON	COLFAX	6962	36 54	104 27
07057	ROSWELL	CHAVES	33908	33 24	104 33
07058	RUIDOSO	LINCOLN	2216	33 20	105 42
07059	RUIDOSO DOWNS	LINCOLN	702	33 20	105 39
07061	SAN FELIPE PUEBLO	SANDOVAL	1187	35 26	106 27
07060	SANDIA	BERNALILLO	6867	35 08	106 19
07062	SANTA FE	SANTA FE	41167	35 41	105 57
07063	SANTA ROSA	GUADALUPE	2485	34 56	104 42
07064	SANTO DOMINGO PUEBLO	SANDOVAL	1662	35 35	106 28
07065	SILVER CITY	GRANT	7751	32 47	108 16
07066	SOCORRO	SOCORRO	4687	34 04	106 55
07067	SOUTH VALLEY	BERNALILLO	29389	35 05	106 38
07068	SPRINGER	COLFAX	1574	36 22	104 36
07069	TAOS	TAOS	2475	36 24	105 35
07070	TAOS PUEBLO	TAOS	1030	36 26	105 34
07071	TATUM	LEA	982	33 16	103 18
07072	TEXICO	CURRY	772	34 14	103 05
07073	TRUTH OR CONSEQUENCES	SIERRA	4656	33 08	107 16
07074	TUCUMCARI	QUAY	7189	35 11	103 44
07075	TULAROSA	OTERO	2851	33 04	106 02
07076	UNIV PK-TORTUGAS	DONA ANA	4165	32 18	106 47
07077	VAUGHN	GUADALUPE	867	34 35	105 14
07078	WAGON MOUND	MORA	630	36 01	104 44
07079	WHITE ROCK	LOS ALAMOS	3861	35 48	106 16
07080	WHITE SANDS	DONA ANA	4167	32 47	106 04
07081	ZUNI PUEBLO	MC KINLEY	3958	35 05	108 52

TABLE 8. CITY ID, CITY NAME, COUNTY NAME, POPULATION, LATITUDE AND LONGITUDE

UTAH

CITY ID	CITY NAME	COUNTY NAME	POPULATION	LAT	LONG
08001	ALPINE	UTAH	1047	40 29	111 47
08002	AMERICAN FORK	UTAH	7713	40 24	111 48
08003	BEAVER	BEAVER	1453	38 18	112 38
08004	BLANDING	SAN JUAN	2250	37 37	109 29
08005	BOUNTIFUL	DAVIS	27853	40 54	111 54
08006	BRIGHAM CITY	BOX ELDER	14007	41 30	112 02
08007	CASTLE DALE	EMERY	541	39 12	111 00
08008	CEDAR CITY	IRON	8946	37 40	113 04
08009	CENTERVILLE	DAVIS	3268	40 56	111 54
08010	CLEARFIELD	DAVIS	13316	41 07	112 03
08011	CLINTON	DAVIS	1768	41 14	112 08
08012	COALVILLE	SUMMIT	864	40 55	111 25
08013	COTTONWOOD HEIGHTS	SALT LAKE	8431	40 38	111 49
08014	DELTA	MILLARD	1610	39 22	112 35
08015	DRAGERTON	CARBON	1614	39 32	110 25
08016	DUCHESNE	DUCHESNE	1094	40 10	110 24
08017	DUGWAY	TOOELE	2357	40 15	112 50
08018	EAST LAYTON	DAVIS	763	40 56	111 59
08019	EAST MILLCREEK	SALT LAKE	26579	40 41	111 49
08020	ENTERPRISE	WASHINGTON	844	37 43	113 43
08021	EPHRAIM	SANPETE	2127	39 21	111 35
08022	ESCALANTE	GARFIELD	638	37 47	111 35
08023	EUREKA	JUAB	753	39 57	112 09
08024	FAIRVIEW	SANPETE	696	39 38	111 27
08025	FARMINGTON	DAVIS	2526	40 50	111 55
08026	FERRON	EMERY	663	39 00	111 04
08027	FILLMORE	MILLARD	1411	38 58	112 20
08028	FRIUT HEIGHTS	DAVIS	800	00 00	000 00
08029	GARLAND	BOX ELDER	1187	41 45	112 10
08030	GRANGER-HUNTER	SALT LAKE	9029	40 41	111 58
08031	GRANITE PARK	SALT LAKE	9573	40 07	113 16
08032	GRANTSVILLE	TOOELE	2931	40 36	112 29
08033	GREEN RIVER	EMERY	1033	38 55	109 55
08034	GUNNISON	SANPETE	1073	39 09	111 50
08035	HARRISVILLE	WEBER	603	00 00	000 00
08036	HEBER CITY	WASATCH	3245	40 32	111 22
08037	HELPER	CARBON	1964	39 40	110 51
08038	HOLLADAY	SALT LAKE	23014	40 40	111 50
08039	HONEYVILLE	BOX ELDER	640	41 32	112 02
08040	HUNTINGTON	EMERY	857	39 19	110 58
08041	HUNTSVILLE	WEBER	553	41 15	111 45
08042	HURRICANE	WASHINGTON	1408	37 10	113 16

TABLE 8. CITY ID, CITY NAME, COUNTY NAME, POPULATION, LATITUDE AND LONGITUDE

UTAH

CITY ID	CITY NAME	COUNTY NAME	POPULATION	LAT	LONG
08043	HYDE PARK	CACHE	1025	41 50	111 50
08044	HYRUM	CACHE	2340	41 39	111 50
08045	KAMAS	SUMMIT	806	40 40	111 16
08046	KANAB	KANE	1381	37 03	112 32
08047	KAYSVILLE	DAVIS	6192	41 03	111 56
08048	KEARNS	SALT LAKE	17071	40 43	112 02
08049	LAYTON	DAVIS	13603	40 56	111 59
08050	LEHI	UTAH	4659	40 25	111 51
08051	LEWISTON	CACHE	1244	41 57	111 53
08052	LINDON	UTAH	1644	40 20	111 45
08053	LOGAN	CACHE	22333	41 45	111 50
08057	MABLETON	UTAH	1980	40 10	111 35
08054	MAESER	UINTAH	1248	40 27	109 38
08055	MAGNA	SALT LAKE	5509	40 43	112 06
08056	MANTI	SANPETE	1803	39 16	111 38
08058	MIDVALE	SALT LAKE	7840	40 37	111 55
08059	MIDWAY	WASATCH	804	40 32	111 25
08060	MILFORD	BEAVER	1304	38 22	113 00
08061	MOAB	GRAND	4793	38 35	109 34
08062	MONROE	SEVIER	918	38 38	112 06
08063	MONTICELLO	SAN JUAN	1431	37 53	109 22
08064	MORGAN CITY	MORGAN	1586	41 02	111 40
08065	MORONI	SANPETE	894	39 33	111 35
08066	MOUNT OLYMPUS	SALT LAKE	5909	00 00	000 00
08067	MOUNT PLEASANT	SANPETE	1516	39 33	111 29
08068	MURRAY	SALT LAKE	21206	40 40	111 53
08069	NEPHI	JUAB	2699	39 43	111 50
08070	NORTH LOGAN	CACHE	1405	41 46	111 50
08071	NORTH OGDEN	WEBER	5257	41 19	111 59
08072	NORTH SALT LAKE	DAVIS	2143	40 47	111 55
08073	OGDEN	WEBER	69478	41 14	111 59
08074	ONAQUI	TOOELE	541	00 00	000 00
08075	ORANGEVILLE	EMERY	511	39 15	110 55
08076	OREM	UTAH	25729	40 20	111 45
08077	PANGUITCH	GARFIELD	1318	37 49	112 27
08078	PARK CITY	SUMMIT	1193	40 39	111 30
08079	PAROWAN	IRON	1423	37 50	112 50
08080	PAYSON	UTAH	4501	40 04	111 45
08081	PERRY	BOX ELDER	909	41 30	112 01
08082	PLAIN CITY	WEBER	1543	41 19	112 06
08083	PLEASANT GROVE	UTAH	5327	40 23	111 45

TABLE 8. CITY ID, CITY NAME, COUNTY NAME, POPULATION, LATITUDE AND LONGITUDE

UTAH

CITY ID	CITY NAME	COUNTY NAME	POPULATION	LAT	LONG
08084	PLEASANT VIEW	WEBER	2028	41 18	112 00
08085	PRICE	CARBON	6218	39 35	110 49
08086	PROVIDENCE	CACHE	1608	41 43	111 48
08087	PROVO	UTAH	53131	40 15	111 40
08088	RANDOLPH	RICH	500	41 41	111 10
08089	RICHFIELD	SEVIER	4471	38 45	112 05
08090	RICHMOND	CACHE	1000	41 57	111 49
08091	RIVERDALE CITY	WEBER	3704	00 00	000 00
08092	RIVER HEIGHTS	CACHE	1008	00 00	000 00
08093	RIVERTON	SALT LAKE	2320	40 32	111 56
08094	ROOSEVELT	DUCHESNE	2005	40 18	110 00
08095	ROY	WEBER	14356	41 07	112 01
08097	SALIM	UTAH	1081	40 04	111 40
08098	SALINA	SEVIER	1494	38 57	111 52
08099	SALT LAKE CITY	SALT LAKE	175885	40 45	111 55
08100	SANDY	SALT LAKE	6438	40 37	111 53
08101	SANTAQUIN	UTAH	1236	39 57	111 42
08102	SMITHFIELD	CACHE	3342	41 50	111 50
08103	SOUTH JORDAN	SALT LAKE	2942	40 32	111 55
08104	SOUTH OGDEN	WEBER	9991	41 12	111 59
08105	SOUTH SALT LAKE1	SALT LAKE	7810	40 42	111 55
08106	SOUTH WEBER	DAVIS	1073	00 00	000 00
08107	SPANISH FORK CITY	UTAH	7284	40 07	111 39
08108	SPRINGVILLE	UTAH	8790	40 10	111 36
08096	ST GEORGE	WASHINGTON	7097	37 06	113 35
08109	SUNSET	DAVIS	6268	00 00	000 00
08110	SYRACUSE	DAVIS	1843	41 05	112 08
08111	TOOELE	TOOELE	12539	40 32	112 18
08112	TREMONTON	BOX ELDER	2794	41 43	112 10
08113	VERNAL	UINTAH	3908	40 26	109 32
08114	WASHINGTON	WASHINGTON	750	37 08	113 30
08115	WASHINGTON TERRACE	WEBER	7241	41 10	111 58
08116	WELLINGTON	CARBON	922	39 33	110 45
08117	WELLSVILLE	CACHE	1267	41 39	111 56
08118	WENDOVER	TOOELE	781	40 45	114 02
08119	WEST BOUNTIFUL	DAVIS	1246	40 50	111 55
08120	WEST JORDAN	SALT LAKE	4221	40 32	111 57
08121	WEST POINT	DAVIS	1020	41 00	112 03
08122	WHITE	SALT LAKE	6402	00 00	000 00
08123	WILLARD	BOX ELDER	1045	41 25	112 03
08124	WOODS GROSS	DAVIS	3124	40 54	111 55

TABLE 8. CITY ID, CITY NAME, COUNTY NAME, POPULATION, LATITUDE AND LONGITUDE

CALIFORNIA

CITY ID	CITY NAME	COUNTY NAME	POPULATION	LAT	LONG
09063	ADELANTO	SANTA BARBAR	2115	34 34	117 25
09180	ALPINE	SAN DIEGO	1570	32 46	116 42
09010	ALTA HILL	NEVADA	1185	0 0	0 0
09001	ALTURAS	MODOC	2799	41 30	120 34
09223	ANDERSON	SHASTA	5492	40 28	122 18
09061	ANGELS CAMP	CALARERAS	1710	38 05	120 33
09066	APPLE VALLEY	SANTA BARBAR	6702	0 0	0 0
09141	ARBUCKLE	COLUSA	1037	39 02	122 04
09146	ARVIN	KERN	5090	35 11	118 50
09170	ATWATER	MERCED	11640	37 20	120 37
09047	AUBURN	PLACER	6570	38 53	121 04
09218	AUGUST SCHOOL AREA	SAN JOAQUINE	6293	0 0	0 0
09148	BAKERSFIELD	KERN	69515	35 20	118 52
09043	BANNING	RIVERSIDE	12034	33 56	116 52
09069	BARSTOW	SANTA BARBAR	17442	34 55	117 01
09287	BEALE EAST	YUBA	7029	39 02	121 27
09288	BEALE WEST	YUBA	2325	39 02	121 28
09044	BEAUMONT	RIVERSIDE	5484	33 56	117 00
09070	BIG BEAR	SANTA BARBAR	5268	34 15	116 53
09130	BIGGS	BUTTE	1115	39 27	121 44
09013	BISHOP	INYO	3498	37 20	118 24
09075	BLOOMINGTON	SANTA BARBAR	3059	0 0	0 0
09037	BLYTHE	RIVERSIDE	7047	33 38	114 35
09038	BLYTHEE	RIVERSIDE	1252	33 38	114 25
09226	BONNYVIEW	SHASTA	4882	0 0	0 0
09151	BORON	KERN	1999	35 05	117 39
09048	BOWMAN AUBURN	PLACER	2089	38 55	121 04
09099	BRAWLEY	IMPERIAL	13746	32 59	115 30
09225	BURNEY	SHASTA	2190	40 55	121 40
09149	BUTTONWILLO	KERN	1193	35 24	119 29
09045	CABAZON	RIVERSIDE	598	33 50	116 47
09100	CALEXICO	IMPERIAL	10625	32 39	115 28
09152	CALIFORNIA CITY	KERN	1309	37 53	122 27
09101	CALIPATRIA	IMPERIAL	1824	33 09	115 30
09111	CALWA	FRESNO	5191	36 41	119 43
09204	CARDIFF-BY-THE-SEA	SAN DIEGO	5724	33 00	117 18
09181	CARLSBAD	SAN DIEGO	14944	33 09	117 20
09171	CASTLE	MERCED	1903	37 20	120 37
09015	CATHEDRAL CITY	RIVERSIDE	3640	33 45	116 27
09229	CENTRAL VALLEY	SHASTA	2361	40 42	122 24
09241	CERES	STANISLAUS	6029	37 36	120 58
09046	CHERRY VALLEY	RIVERSIDE	3165	0 0	0 0
09004	CHESTER	PLUMAS	1531	40 20	121 14
09131	CHICO	BUTTE	19580	39 46	121 50
09132	CHICO NORTH	BUTTE	6656	39 46	121 50
09133	CHICO WEST	BUTTE	4787	39 46	121 50
09153	CHINA LAKE	KERN	11105	35 45	117 36
09071	CHINO	SANTA BARBAR	20411	35 55	117 37
09109	CHOWCHILLA	MADERA	4349	37 07	120 14

TABLE 8. CITY ID, CITY NAME, COUNTY NAME, POPULATION, LATITUDE AND LONGITUDE

CALIFORNIA

CITY ID	CITY NAME	COUNTY NAME	POPULATION	LAT	LONG
09183	CHULA VISTA	SAN DIEGO	67901	32 36	117 05
09112	CLOVIS	FRESNO	13856	36 47	119 43
09020	COACHELLA	RIVERSIDE	8353	33 40	116 10
09113	COALINGA	FRESNO	6161	36 08	120 22
09041	COLFAX	PLACER	798	39 07	120 56
09072	COLTON	SANTA BARBAR	19974	34 05	117 20
09143	COLUSA	COLUSA	3842	39 11	122 00
09262	CORNING	TEHAMA	3573	39 56	122 12
09022	CORONA	RIVERSIDE	27519	33 52	117 34
09185	CORONADO	SAN DIEGO	20910	32 40	117 10
09224	COTTONWOOD	SHASTA	1288	40 24	122 18
09067	CREST FOREST	SANTA BARBAR	3509	0 0	0 0
09065	CUCAMONGA	SANTA BARBAR	3064	0 0	0 0
09074	CUCAMONGA	SANTA BARBAR	2732	0 0	0 0
09271	CUTLER	TULARE	2503	36 30	119 17
09205	DEL MAR	SAN DIEGO	3956	32 57	117 15
09150	DELANO	KERN	14559	35 45	119 16
09175	DELHI	MERCED	2063	37 22	120 45
09254	DENAIR	STANISLAUS	1128	37 25	120 54
09024	DESERT HOT SPRING	RIVERSIDE	2738	33 58	116 30
09264	DINUBA	TULARE	7917	36 31	119 26
09231	DORRIS	SISKIYOU	840	41 57	121 55
09173	DOS PALOS	MERCED	2496	36 59	120 39
09232	DUNSMUIR	SISKIYOU	2214	41 12	122 18
09019	EAGLE MOUTAIN	RIVERSIDE	2454	33 48	115 30
09265	EARLIMART	TULARE	3080	35 52	119 18
09274	EAST POTERVILE	TULARE	4042	0 0	0 0
09129	EASTON	FRESNO	1065	36 35	119 45
09154	EDWARDS	KERN	10331	34 55	117 54
09187	EL CAJON	SAN DIEGO	52273	32 48	116 58
09102	ELCENTRO	IMPERIAL	19272	32 47	115 33
09026	ELSINORE	RIVERSIDE	3530	33 40	117 19
09245	EMPIRE	STANISLAUS	2016	0 0	0 0
09206	ENCINITAS	SAN DIEGO	5375	33 04	117 17
09227	ENTERPRISE	SHASTA	11486	0 0	0 0
09211	ESCALON	SAN JOAQUINE	2366	37 43	121 00
09189	ESCONDIDO	SAN DIEGO	36792	33 07	117 05
09233	ETNA	SISKIYOU	667	41 28	122 54
09267	EXETER	TULARE	4475	36 17	119 09
09190	FALLBROOK	SAN DIEGO	6945	33 23	117 15
09268	FARMERSVILLE	TULARE	3456	36 17	119 10
09114	FIREBAUGH	FRESNO	2517	36 51	120 30
09076	FONTANA	SANTA BARBAR	20673	34 03	117 23
09164	FORD CITY	KERN	3503	35 05	119 30
09234	FORT JONES	SISKIYOU	515	41 37	122 51
09115	FOWLER	FRESNO	2239	36 38	119 41
09165	FRAZIER PARK	KERN	1167	34 51	119 00
09116	FRESNO	FRESNO	165972	36 41	119 47
09087	FT IRWIN	SANTA BARBAR	2991	0 0	0 0

TABLE 8. CITY ID, CITY NAME, COUNTY NAME, POPULATION, LATITUDE AND LONGITUDE

CALIFORNIA

CITY ID	CITY NAME	COUNTY NAME	POPULATION	LAT	LONG
09219	GARDEN ACRES	SAN JOAQUINE	7870	0 0	0 0
09064	GEORGE AFB	SANTA BARBAR	7404	34 30	117 18
09031	GLEN AVON	RIVERSIDE	5759	0 0	0 0
09285	GOSHEN	TULARE	1324	36 20	119 26
09073	GRAND TERRACE	SANTA BARBAR	5901	0 0	0 0
09011	GRASS VALLEY	NEVADA	5149	39 13	121 04
09005	GREENVILLE	PLUMAS	1073	40 09	120 57
09160	GREENACRES	KERN	2116	35 26	119 03
09135	GRIDLEY	BUTTE	3534	39 24	121 42
09174	GUSTINE	MERCED	2793	37 14	121 00
09028	HEMET	RIVERSIDE	12252	33 45	116 58
09029	HEMET EAST	RIVERSIDE	8598	33 45	116 55
09077	HESPERIA	SANTA BARBAR	4592	34 25	117 19
09078	HIGHLAND	SANTA BARBAR	12669	34 08	117 11
09103	HOLTVILLE	IMPERIAL	3496	32 47	115 22
09023	HOMEGARDENS	RIVERSIDE	5116	0 0	0 0
09039	HOMELAND	RIVERSIDE	1187	0 0	0 0
09244	HUGHSON	STANISLAUS	2144	37 35	120 53
09117	HURON	FRESNO	1525	36 14	120 05
09104	IMPERIAL	IMPERIAL	3094	32 51	115 33
09191	IMPERIAL BEACH	SAN DIEGO	20244	32 51	115 33
09016	INDIAN WELLS	RIVERSIDE	760	33 45	116 19
09021	INDIO	RIVERSIDE	14459	33 44	116 14
09057	IONE	AMADOR	2369	38 20	120 55
09269	IVANHOE	TULARE	1595	36 20	119 15
09058	JACKSON	AMADOR	1924	38 19	120 49
09093	JOSHUA TREE	SANTA BARBAR	1211	34 09	116 20
09118	KERMAN	FRESNO	2667	36 42	120 04
09242	KEYES	STANISLAUS	1875	37 31	120 52
09119	KINSSBURG	FRESNO	3843	36 29	119 31
09194	LA MESA	SAN DIEGO	39178	32 45	117 00
09027	LAKELAND VILLAGE	RIVERSIDE	1724	33 32	117 30
09192	LAKESIDE	SAN DIEGO	11991	32 51	116 55
09147	LAMONT	KERN	7007	35 15	118 56
09214	LATHROP	SAN JOAQUINE	2137	0 0	0 0
09120	LATON	FRESNO	1071	36 25	119 42
09195	LEMON GROVE	SAN DIEGO	19690	32 45	116 58
09080	LENWOOD	SANTA BARBAR	3834	34 52	117 05
09054	LINCOLN	PLACER	3176	38 53	121 18
09220	LINCOLN	SAN JOAQUINE	6772	38 53	121 18
09289	LINDA	YUBA	7731	39 05	121 40
09270	LINDSAY	TULARE	5206	36 11	119 05
09258	LIVE OAK	SUTTER	2645	39 16	121 40
09176	LIVINGSTON	MERCED	2588	37 20	120 45
09068	LK. AROWHEAD	SANTA BARBAR	2682	34 10	117 10
09212	LODI	SAN JOAQUINE	28691	38 07	121 18
09079	LOMA LINDA	SANTA BARBAR	6804	34 05	117 13
09092	LOMA LINDA	SANTA BARBAR	2993	34 05	117 13
09014	LONE PINE	INYO	1241	36 35	118 04

TABLE 8. CITY ID, CITY NAME, COUNTY NAME, POPULATION, LATITUDE AND LONGITUDE

CALIFORNIA

CITY ID	CITY NAME	COUNTY NAME	POPULATION	LAT	LONG
09051	LOOMIS	PLACER	1108	38 45	121 15
09177	LOS BANOS	MERCED	9188	37 04	120 51
09008	LOYALTON	SIERRA	945	39 41	120 15
09166	MAICOPA	KERN	740	00 00	000 00
09215	MANTECA	SAN JOAQUINE	13845	37 49	121 15
09034	MARCH AFB	RIVERSIDE	2002	0 0	0 0
09290	MARYSVILLE	YUBA	9353	39 10	121 34
09235	MCCLOUD	SISKIYOU	1643	41 16	122 09
09158	MCFARLAND	KERN	4177	35 37	119 15
09110	MEDERA	MADERA	16044	0 0	0 0
09121	MENDOTA	FRESNO	2705	36 44	120 24
09178	MERCED	MERCED	22670	37 17	120 29
09032	MIRA LOUA	RIVERSIDE	8482	33 55	117 30
09246	MODESTO	STANISLAUS	61712	37 37	121 00
09155	MOJAVE	KERN	2573	35 02	118 11
09236	MONTAGUE	SISKIYOU	890	41 45	122 31
09083	MONTCLAIR	SANTA BARBAR	22546	33 57	117 45
09221	MORADA	SAN JOAQUINE	2936	0 0	0 0
09237	MOUNT SHASTA	SISKIYOU	2163	41 19	122 20
09134	MULBERRY	BUTTE	1795	00 00	000 00
09090	MUSCOY	SANTA BARBAR	7091	0 0	0 0
09197	NATIONAL CITY	SAN DIEGO	43184	32 39	117 06
09081	NEBO CNTR	SANTA BARBAR	1828	0 0	0 0
09084	NEEDLES	SANTA BARBAR	4051	34 51	114 36
C9012	NEVADA CITY	NEVADA	2314	39 16	121 00
09249	NEWMAN	STANISLAUS	2505	37 20	121 04
09035	NORCO	RIVERSIDE	14511	33 47	117 32
09186	NORTH ISLAND	SAN DIEGO	6002	00 00	000 00
09250	OAKDALE	STANISLAUS	6594	37 45	120 50
09198	OCEANSIDE	SAN DIEGO	40494	33 12	117 23
09159	OILDALE	KERN	20586	35 25	119 00
09291	OLIVEHURST	YUBA	8100	39 03	121 32
09085	ONTARIO	SANTA BARBAR	64118	34 04	117 38
09122	ORANGE COVE	FRESNO	3392	36 35	119 17
09144	ORLAND	GLENN	2884	39 45	122 13
09272	OROSI	TULARE	2757	36 31	119 17
09136	OROVILLE	BUTTE	7536	39 31	121 34
09184	OTAY-CASTLE PARK	SAN DIEGO	15445	32 33	117 00
09139	PALERMO	BUTTE	1960	39 27	121 34
09017	PALM DESERT	RIVERSIDE	6171	33 44	116 21
09036	PALM SPRGS	RIVERSIDE	20936	33 49	116 34
09140	PARADISE	BUTTE	14539	39 46	121 38
09123	PARLIER	FRESNO	1993	36 35	119 31
09251	PATTERSON	STANISLAUS	3147	37 29	121 10
09199	PENDLETON NORTH	SAN DIEGO	11803	33 15	117 23
09200	PENDLETON SOUTH	SAN DIEGO	13692	33 15	117 23
09040	PERRIS	RIVERSIDE	4228	33 48	117 12
09273	PIXLEY	TULARE	1584	35 58	119 20
09056	PLACER VILLE	ELDORADO	5416	38 43	120 50

TABLE 8. CITY ID, CITY NAME, COUNTY NAME, POPULATION, LATITUDE AND LONGITUDE

CALIFORNIA

CITY ID	CITY NAME	COUNTY NAME	POPULATION	LAT	LONG
09179	PLANADA	MERCED	2056	37 16	120 18
09059	PLYMOUTH	AMADOR	501	38 29	120 52
09278	POPLAR P	TULARE	1205	36 01	119 02
09275	PORTERVILLE	TULARE	12602	36 05	119 02
09276	PORTERVILLE NORTHWEST	TULARE	2517	36 05	119 02
09277	PORTERVILLE WEST	TULARE	6200	36 05	119 02
09006	PORTOLA	PLUMAS	1625	39 45	120 20
09201	POWAY	SAN DIEGO	9442	32 57	117 00
09230	PROJECT CITY	SHASTA	1431	40 42	122 24
09007	QUINCY	PLUMAS	3343	39 56	120 56
09202	RAMONA	SAN DIEGO	3554	33 02	116 52
09018	RANCHO MIRAG	RIVERSIDE	1298	0 0	0 0
09263	RED BLUFF	TEHAMA	7676	40 11	122 16
09228	REDDING	SHASTA	16659	40 35	122 24
09086	REDLANDS	SANTA BARBAR	36355	34 03	117 10
09124	REEDLEY	FRESNO	8131	36 35	119 27
09089	RIALTO	SANTA BARBAR	38370	34 03	117 21
09266	RICHGROVE	TULARE	1023	35 46	119 08
09156	RIDGECREST	KERN	7629	35 33	117 39
09216	RIPON	SAN JOAQUINE	2679	37 44	121 08
09042	RIVERSIDE	RIVERSIDE	140089	33 59	117 22
09125	RIVERDALE	FRESNO	1722	36 26	119 53
09252	RIVERBANK	STANISLAUS	3949	37 43	120 56
09052	ROCKLIN	PLACER	3039	38 43	121 17
09157	ROSAMOND	KERN	2281	34 52	118 10
09053	ROSEVILLE	PLACER	17895	38 44	121 19
09033	RUBIDOUX	RIVERSIDE	13969	0 0	0 0
09253	SALIDA	STANISLAUS	1456	37 40	121 02
09062	SAN AUDREAS	CALARERAS	1564	38 20	120 40
09091	SAN BERNARDINO	SANTA BARBAR	104251	34 07	117 18
09203	SAN DIEGO	SAN DIEGO	696769	32 45	117 10
09030	SAN JACINTO	RIVERSIDE	4385	33 48	116 58
09127	SAN JUAQUIN	FRESNO	1506	36 35	120 10
09208	SAN MARCOS	SAN DIEGO	3896	0 0	0 0
09126	SANGER	FRESNO	10088	36 41	119 35
09193	SANTEE	SAN DIEGO	19321	32 51	117 00
09209	SANTEE	SAN DIEGO	15858	0 0	0 0
09088	SCARLE VALLEY	SANTA BARBAR	3828	35 30	117 36
09128	SELMA	FRESNO	7459	36 34	119 38
09188	SENTEE	SAN DIEGO	1786	00 00	000 00
09161	SHAFTER	KERN	5327	35 30	119 16
09207	SOLANA BEACH	SAN DIEGO	5023	32 58	117 17
09106	SONORA	TUOLUMNE	3100	38 00	120 21
09055	SOUTH LAKE TAHOE	ELDORADO	12921	39 03	120 00
09137	SOUTH OROVILLE	BUTTE	4111	39 31	121 34
09167	SOUTH TAFT	KERN	2214	35 08	119 28
09243	SOUTH MODESTO P	STANISLAUS	1337	37 37	121 00
09247	SOUTH MODESTO P	STANISLAUS	6552	37 37	121 00

TABLE 8. CITY ID, CITY NAME, COUNTY NAME, POPULATION, LATITUDE AND LONGITUDE

CALIFORNIA

CITY ID	CITY NAME	COUNTY NAME	POPULATION	LAT	LONG
09255	SOUTH TURLOCK	STANISLAUS	1762	37 29	120 50
09261	SOUTH YUBA CITY	SUTTER	5352	39 09	121 36
09182	SPRING VALLEY	SAN DIEGO	29742	32 41	116 57
09196	SPRING VALLEY	SAN DIEGO	24493	00 00	000 00
09217	STOCKTON	SAN JOAQUINE	107644	37 59	121 20
09279	STRATHMORE	TULARE	1221	36 05	119 03
09041	SUN CITY	RIVERSIDE	5519	0 0	0 0
09025	SUNNY MEAD	RIVERSIDE	6708	0 0	0 0
09002	SUSANVILLE	LASSEN	6608	40 26	120 40
09060	SUTTER CREEK	AMADOR	1508	38 24	120 50
09259	SUTTER	SUTTER	1488	38 25	120 54
09168	TAFT	KERN	4285	35 08	119 28
09169	TAFT HEIGHTS	KERN	2108	35 03	119 30
09050	TAHOE	PLACER	1394	39 05	120 00
09162	TEHACHAPI	KERN	4211	35 08	118 27
09280	TERRA BELLA	TULARE	1037	35 58	119 03
09138	THERMALITO	BUTTE	4217	39 31	121 34
09222	TRACY	SAN JOAQUINE	14724	37 43	121 27
09009	TRUCKEE	NEVADA	1392	39 20	120 10
09282	TULARE	TULARE	16235	36 13	119 22
09283	TULARE EAST	TULARE	2361	36 13	119 22
09284	TULARE NORTHWEST	TULARE	1801	36 13	119 22
09238	TULELAKE	SISKIYOU	857	41 54	121 31
09107	TUOLUMNE	TUOLUMNE	1365	37 59	120 15
09256	TURLOCK	STANISLAUS	13992	37 29	120 50
09108	TWAIN HARTE	TUOLUMNE	1484	38 00	120 14
09096	UPLAND	SANTA BARBAR	32551	34 06	117 38
09097	VICTORVILLE	SANTA BARBAR	10845	34 31	117 17
09210	VISTA	SAN DIEGO	24688	33 12	117 15
09163	WASCO	KERN	8269	35 35	119 22
09257	WATERFORD	STANISLAUS	2243	37 37	120 46
09239	WEED	SISKIYOU	2983	41 26	122 23
09105	WEST MORLAND	IMPERIAL	1175	33 03	115 37
09248	WEST MODESTO	STANISLAUS	6135	37 37	121 00
09003	WESTWOOD	LASSEN	1862	40 20	121 00
09292	WHEATLAND	YUBA	1280	39 01	121 24
09142	WILLIAMS	COLUSA	1571	39 09	122 09
09145	WILLOWS	GLENN	4085	39 32	122 10
09172	WINTON	MERCED	3393	00 00	000 00
09213	WOODBRIDGE	SAN JOAQUINE	1397	38 08	121 19
09286	WOODLAKE	TULARE	3371	36 26	119 07
09281	WOODVILLE	TULARE	1031	36 05	119 15
09082	YERMO	SANTA BARBAR	1304	34 55	116 50
09095	YOLLA VALLEY	SANTA BARBAR	3893	33 05	116 30
09240	YREKA	SISKIYOU	5394	41 44	122 39
09260	YUBA CITY	SUTTER	13986	39 09	121 36
09098	YUCAIPA	SANTA BARBAR	19284	33 59	117 00
09094	29 PALMS	SANTA BARBAR	5667	34 09	116 03

TABLE 8. CITY ID, CITY NAME, COUNTY NAME, POPULATION, LATITUDE AND LONGITUDE

IDAHO

CITY ID	CITY NAME	COUNTY NAME	POPULATION	LAT	LONG
10026	ABERDEEN	BINGHAM	1542	42 57	112 50
10001	AMERICAN FALLS	POWER	2769	42 47	112 50
10033	AMMON	BONNEVILLE	1338	43 30	111 57
10037	ARCO	BUTTE	1244	43 38	113 18
10029	BELLEVUE	BLAINE	537	43 27	114 16
10027	BLACKFOOT	BINGHAM	8716	43 13	112 20
10002	BUHL	TWIN FALLS	2975	42 37	114 46
10003	BURLEY	CASSIA	8279	42 32	113 48
10038	CALDWELL	CANYON	14219	43 39	116 40
10004	CHUBBOCK	BANNOCK	2924	42 55	112 26
10005	DOWNEY	BANNOCK	7586	42 26	112 12
10049	DRIGGS	TETON	727	43 45	111 08
10006	FILER	TWIN FALLS	1173	42 36	114 37
10043	GLENNS FERRY	ELMOR	1386	42 57	115 19
10046	GOODING	GOODING	2599	42 56	114 44
10007	GRACE	CARIBOU	826	42 35	111 45
10030	HAILEY	BLAINE	1425	43 31	114 19
10008	HEYBURN	MINIDOKA	1637	42 33	113 46
10009	HOMEDALE	OWYHEE	1411	43 37	116 55
10032	HORSESHOE BEND	BOISE	511	43 55	116 11
10035	IDAHO FALLS	BONNEVILLE	35776	43 30	112 01
10010	INKOM	BANNOCK	522	42 48	112 15
10034	IONA	BONNEVILLE	890	43 33	111 56
10011	JEROME	JEROME	4183	42 44	114 31
10031	KETCHUM	BLAINE	1454	43 41	114 23
10012	KIMBERLY	TWIN FALLS	1557	42 32	114 23
10013	LAVA HOT SPRINGS	BANNOCK	516	42 37	112 00
10015	MALAD CITY	ONEIDA	1848	42 12	112 15
10016	MARSING	OWYHEE	610	43 33	116 48
10014	MC CAMMON	BANNOCK	673	42 39	112 12
10039	MIDDLETON	CANYON	739	43 43	116 37
10017	MONTPELIER	BEAR LAKE	2604	42 20	111 20
10044	MOUNTAIN HOME	ELMOR	6451	43 09	115 42
10045	MOUNTAIN HOME BASE	ELMOR	6038	43 09	115 42
10040	NAMPA	CANYON	20768	43 35	116 34
10018	OAKLEY	CASSIA	656	42 15	113 53
10019	PARIS	BEAR LAKE	615	42 15	111 24
10041	PARMA	CANYON	1228	43 49	116 58
10020	PAUL	MINIDOKA	911	42 37	113 48
10021	POCATELLO	BANNOCK	40036	42 53	112 26
10025	PRESTON	FRANKLIN	3310	42 06	111 53
10022	RUPERT	MINIDOKA	4563	42 37	113 40
10028	SHELLEY	BINGHAM	2614	43 25	112 07
10048	SHOSHONE	LINCOLN	1233	42 57	114 25
10023	SODA SPRINGS	CARIBOU	2977	42 40	111 35
10024	TWIN FALLS	TWIN FALLS	21914	42 34	114 30
10036	UCON	BONNEVILLE	664	43 36	111 58
10047	WENDELL	GOODING	1122	42 47	114 42
10042	WILDER	CANYON	564	43 43	116 40

TABLE 8. CITY ID, CITY NAME, COUNTY NAME, POPULATION, LATITUDE AND LONGITUDE

KANSAS

CITY ID	CITY NAME	COUNTY NAME	POPULATION	LAT	LONG
11020	ATWOOD	RAWLINS	1658	39 48	101 03
11018	BIRD CITY	CHEYENNE	667	39 45	101 32
11023	CIMARRON	GRAY	1373	37 49	100 20
11017	COLBY	THOMAS	4658	39 24	101 04
11025	DIGHTON	LANE	1540	38 28	100 28
11001	ELKHART	MORTON	2089	37 01	101 55
11026	FOWLER	MEADE	588	37 23	100 13
11010	GARDEN CITY	FINNEY	14708	37 57	100 54
11016	GOODLAND	SHERMAN	5510	39 20	101 43
11030	HOXIE	SHERIDAN	1419	39 21	100 27
11002	HUGOTON	STEVENS	2739	37 11	101 22
11004	JOHNSON	STANTON	1038	37 34	101 47
11009	LAKIN	KEARNEY	1570	37 57	101 16
11012	LEOTI	WICHITA	1916	38 28	101 22
11003	LIBERAL	SEWARD	13471	37 03	100 56
11027	MEADE	MEADE	1899	37 17	100 21
11024	MONTEZUMA	GRAY	606	37 35	100 27
11029	NESS CITY	NESS	1756	38 27	99 54
11015	OAKLEY	LOGAN	2327	39 08	100 53
11021	OBERLIN	DECATUR	2291	39 49	100 33
11022	QUINTER	GOVE	930	39 04	100 15
11006	SATANTA	HASKELL	1161	37 26	100 59
11013	SCOTT CITY	SCOTT	4001	38 28	100 55
11014	SHARON SPRINGS	WALLACE	1012	38 54	101 46
11019	ST FRANCIS	CHEYENNE	1725	39 47	101 47
11007	SUBLETTE	HASKELL	1208	37 28	100 52
11008	SYRACUSE	HAMILTON	1720	37 59	101 46
11011	TRIBUNE	GREELEY	1013	38 27	101 46
11005	ULYSSES	GRANT	3779	37 36	101 23
11028	WEST PLAINS	MEADE	857	37 16	100 40

TABLE 8. CITY ID, CITY NAME, COUNTY NAME, POPULATION, LATITUDE AND LONGITUDE

NEBRASKA

CITY ID	CITY NAME	COUNTY NAME	POPULATION	LAT	LONG
12021	ALLIANCE	BOX BUTTE	6862	42 08	102 54
12024	ANSLEY	CUSTER	631	41 19	99 22
12034	ARAPAHOE	FURNAS	1147	40 19	99 52
12025	ARNOLD	CUSTER	752	41 16	100 11
12013	BAYARD	MORRILL	1338	41 46	103 20
12035	BEAVER CITY	FURNAS	802	40 09	99 50
12003	BENKELMAN	DUNDY	1349	40 02	101 31
12012	BRIDGEPORT	MORRILL	1490	41 40	103 05
12026	BROKEN BOW	CUSTER	660	41 26	99 38
12027	CALLAWAY	CUSTER	523	41 18	99 55
12036	CAMBRIDGE	FURNAS	1145	40 18	100 11
12008	CHAPPELL	DEUEL	1204	41 06	102 29
12029	COZAD	DAWSON	4219	40 51	99 59
12001	CULBERTSON	HITCHCOCK	801	40 14	100 49
12033	CURTIS	FRONTIER	1166	40 00	100 30
12014	GERING	SCOTTS BLUFF	5639	41 50	103 30
12041	GORDON	SHERIDAN	2106	42 48	103 12
12030	GOTHEN	DAWSON	3154	00 00	00 00
12042	HAY SPRINGS	SHERIDAN	682	42 41	102 42
12022	HEMINGFORD	BOX BUTTE	734	42 20	103 05
12004	HERSHEY	LINCOLN	526	41 09	100 59
12039	INDIANOLA	RED WILLOW	576	40 16	100 24
12011	KIMBALL	KIMBALL	3680	41 16	103 40
12031	LEXINTON	DAWSON	5618	40 46	99 48
12015	LYMAN	SCOTTS BLUFF	561	41 57	104 02
12040	MCCOOK	RED WILLOW	8285	40 13	100 35
12016	MINATARE	SCOTTS BLUFF	939	41 50	103 30
12017	MITCHELL	SCOTTS BLUFF	1842	41 56	103 48
12018	MORILL	SCOTTS BLUFF	937	41 58	103 58
12038	MULLEN	HOOKER	667	42 03	101 02
12005	NORTH PLATTE	LINCOLN	19447	41 09	100 45
12009	OSHKOSH	GARDEN	1067	41 26	102 22
12032	OVERTON	DAWSON	506	40 44	99 32
12037	OXFORD	FURNAS	878	40 16	99 40
12007	PAXTON	KIETH	503	41 08	101 22
12043	RUSHVILLE	SHERIDAN	1137	42 45	102 27
12028	SARGENT	CUSTER	789	41 39	99 22
12020	SCOTTS BLUFF	SCOTTS BLUFF	14507	41 52	103 40
12010	SIDNEY	CHEYENNE	6403	41 09	103 00
12006	SUTHERLAND	LINCOLN	840	41 10	101 08
12019	TERRYTOWN	SCOTTS BLUFF	747	41 49	103 40
12002	TRENTON	HITCHCOCK	770	40 11	101 01
12023	VALENTINE	CHERRY	2662	42 53	100 31

TABLE 8. CITY ID, CITY NAME, COUNTY NAME, POPULATION, LATITUDE AND LONGITUDE

OKLAHOMA

CITY ID	CITY NAME	COUNTY NAME	POPULATION	LAT	LONG
13001	*BOISE CITY*	*CIMARRON*	1993	36 44	102 31
13003	*GUYMON*	*TEXAS*	7674	36 42	101 30
13004	*HOOKER*	*TEXAS*	1615	36 51	101 13
13002	*KEYES*	*CIMARRON*	569	36 48	102 13
13005	*TEXHOMA*	*TEXAS*	921	36 30	101 47
13006	*TYRONE*	*TEXAS*	588	36 57	101 02

OREGON

CITY ID	CITY NAME	COUNTY NAME	POPULATION	LAT	LONG
14001	*ALTAMONT*	*KLAMATH*	15746	42 12	121 47
14002	*BURNS*	*HARNEY*	3293	43 36	119 03
14003	*CHILOQUIN*	*KLAMATH*	826	42 35	121 53
14004	*FALCON HEIGHTS*	*KLAMATH*	1389	00 00	000 00
14005	*HINES*	*HARNEY*	1407	43 34	119 04
14006	*KLAMATH FALLS*	*KLAMATH*	15775	42 14	121 47
14007	*MERRILL*	*KLAMATH*	722	42 02	121 37
14008	*NYSSA*	*MALHEUR*	2620	43 54	117 00
14009	*ONTARIO*	*MALHEUR*	6523	44 02	116 58
14010	*VALE*	*MALHEUR*	1448	43 59	117 15

TABLE 8. *CITY ID, CITY NAME, COUNTY NAME, POPULATION, LATITUDE AND LONGITUDE*

TEXAS

CITY ID	CITY NAME	COUNTY NAME	POPULATION	LAT	LONG
15056	ABERNATHY	HALE	1921	33 50	101 52
15071	ABERNATHY	LUBBOCK	704	33 50	101 52
15085	AMARILLO	POTTER	86477	35 14	101 50
15035	AMHERST	LAMB	825	34 02	102 26
15018	ANDREWS	ANDREWS	8625	32 19	102 34
15004	ANTHONY	EL PASO	2154	32 00	106 36
15025	ANTON	HOCKLEY	1034	33 51	102 12
15008	BALMORHEA	REEVES	655	31 00	103 46
15010	BARSTOW	WARD	614	31 27	103 24
15087	BIG LAKE	REGAN	2489	31 12	101 29
15062	BIG SPRING	HOWARD	28735	32 15	101 30
15002	BIGGS	EL PASO	4226	31 50	106 23
15064	BORGER	HUTCHINSON	14195	35 39	101 24
15038	BOVINA	PARMER	1428	34 31	102 54
15023	BROWNFIELD	TERRY	9647	33 11	102 16
15065	BUNAVISTA	HUTCHINSON	1402	00 00	000 00
15080	CACTUS	MOORE	644	36 03	102 00
15005	CANUTILLO	EL PASO	1588	31 05	106 37
15086	CANYON	RANDAL	8333	34 58	101 56
15041	CLAUDE	ARMSTRONG	992	35 06	101 22
15063	COAHOMA	HOWARD	1158	32 18	101 17
15016	CRANE	CRANE	3427	31 23	102 22
15049	CROSBYTON	CROSBY	2251	33 40	101 12
15030	DALHART	DALLOM	4340	36 05	102 32
15021	DENVER CITY	YOAKUM	4133	32 58	102 50
15029	DIMMIT	CASTRO	4327	34 33	102 20
15081	DUMAS	MOORE	9771	35 51	101 57
15032	EARTH	LAMB	1152	34 14	102 25
15001	EL PASO	EL PASO	322261	31 45	106 30
15006	FABENS	EL PASO	3241	31 29	106 21
15039	FARWELL	PARMER	1185	31 23	103 03
15053	FLOYDADA	FLOYD	4109	33 58	101 20
15083	FORT STOCKTON	PECOS	8283	30 54	102 54
15040	FRIONA	PARMER	3111	34 38	102 44
15066	FRITCH	HUTCHINSON	1778	35 39	101 36
15003	FT BLISS	EL PASO	13288	31 45	106 30
15011	GRANDFALLS	WARD	622	31 09	102 55
15045	GROOM	CARSON	808	35 12	101 03
15060	GRUVER	HANSFORD	1265	36 14	101 25
15057	HALE CENTER	HALE	1964	34 04	101 52
15089	HAPPY	SWISHER	627	34 44	101 52
15031	HEREFORD	DEAF SMITH	13414	34 49	102 25
15069	IDALOU	LUBBOCK	1729	33 40	101 40
15084	IRAAN	PECOS	996	30 42	101 56
15014	KERMIT	WINKLER	7884	31 49	103 07
15090	KRESS	SWISHER	578	34 22	101 46
15052	LAMESA	DAWSON	11559	32 43	101 57

TABLE 8. CITY ID, CITY NAME, COUNTY NAME, POPULATION, LATITUDE AND LONGITUDE

TEXAS

CITY ID	CITY NAME	COUNTY NAME	POPULATION	LAT	LONG
15026	LEVELLAND	HOCKLEY	11445	33 35	102 23
15033	LITTLEFIELD	LAMB	6738	33 56	102 20
15054	LOCKNEY	FLOYD	2094	34 06	101 25
15050	LORENZO	CROSBY	1206	33 41	101 33
15070	LUBBOCK	LUBBOCK	149101	33 35	101 53
15092	MCCAMEY	UPTON	2647	31 09	102 14
15079	MIDLAND	MIDLAND	59463	32 00	102 09
15012	MONAHANS	WARD	8333	31 35	102 54
15024	MORTON	COCHRAN	2738	33 43	102 56
15028	MULESHOE	BAILEY	4525	34 14	102 44
15017	ODESSA	ECTOR	78380	31 50	102 23
15034	OLTON	LAMB	1782	34 12	102 08
15048	OZONA	CROCKETT	2864	30 43	101 13
15076	O'DONNELL	LYNN	1017	32 58	101 49
15044	PANHANDLE	CARSON	2141	35 21	101 24
15009	PECOS	REEVES	12682	31 25	103 30
15058	PETERSBURG	HALE	1300	33 52	101 35
15067	PHILLIPS	HUTCHINSON	2515	35 42	101 23
15022	PLAINS	YOAKUM	1087	33 12	102 50
15059	PLAINVIEW	HALE	19096	34 12	101 43
15055	POST	GARZA	3854	33 13	101 23
15042	QUITAQUE	BRISCO	601	34 23	101 04
15051	RALLS	CROSBY	1962	33 41	101 23
15093	RANKIN	UPTON	1105	31 14	101 56
15072	REESE	LUBBOCK	2545	00 00	000 00
15019	SEAGRAVES	GAINES	2440	32 56	102 35
15020	SEMINOLE	GAINES	5007	32 43	102 39
15074	SHALLOWATER	LUBBOCK	1339	33 41	102 00
15043	SILVERTON	BRISCO	1026	34 28	101 18
15046	SKELLYTOWN	CARSON	716	35 34	101 11
15075	SLATON	LUBBOCK	6583	33 26	101 40
15061	SPEARMAN	HANSFORD	3435	36 12	101 13
15078	STANTON	MARTIN	2117	32 07	101 47
15068	STINNETT	HUTCHINSON	2014	35 49	101 27
15088	STRATFORD	SHERMAN	2139	36 21	102 05
15036	SUDAN	LAMB	976	34 04	102 32
15027	SUNDOWN	HOCKLEY	1129	33 27	102 28
15082	SUNRAY	MOORE	1854	36 01	101 50
15077	TAHOKA	LYNN	2956	33 10	101 48
15091	TULIA	SWISHER	5294	34 32	101 46
15007	VAN HORN	CULBERSON	2240	31 03	104 51
15037	VEGA	OLDHAM	839	35 14	102 26
15047	WHITE DEER	CARSON	1092	35 27	101 11
15013	WICKETT	WARD	598	31 33	103 01
15015	WINK	WINKLER	1023	31 44	103 10
15073	WOLFFORTH	LUBBOCK	1090	33 30	102 02

TABLE 8. CITY ID, CITY NAME, COUNTY NAME, POPULATION, LATITUDE AND LONGITUDE

WYOMING

CITY ID	CITY NAME	COUNTY NAME	POPULATION	LAT	LONG
16001	AFTON	LINCOLN	1290	42 44	110 55
16002	BASIN	BIG HORN	1145	44 24	108 02
16003	BIG PINEY	SUBLETTE	570	42 32	110 06
16004	BUFFALO	JOHNSON	3394	44 21	106 40
16005	CASPER	NATRONA	39361	42 50	106 20
16006	CHEYENNE	LARAMIE	40914	41 08	104 50
16007	CODY	PARK	5161	44 32	109 04
16008	DOUGLAS	CONVERSE	2677	42 48	105 23
16009	DUBOIS	FREMONT	898	43 32	109 36
16010	EVANSTON	UINTA	4462	41 16	110 58
16011	EVANSVILLE	NATRONA	832	42 51	106 16
16012	FOX FARM	LARAMIE	1329	00 00	000 00
16013	GILETTE	CAMBELL	7194	44 18	105 30
16014	GLENROCK	CONVERSE	1515	42 52	105 52
16015	GREEN RIVER	SWEETWATER	4196	41 33	109 27
16016	GREYBULL	BIG HORN	1953	44 30	108 02
16017	GUERNSEY	PLATTE	793	42 17	104 45
16018	JACKSON	TETON	2101	43 28	110 45
16019	KEMMERER	LINCOLN	2292	41 47	110 33
16020	LANDER	FREMONT	7125	42 49	108 44
16021	LARAMIE	ALBANY	23143	41 20	105 38
16022	LOVELL	BIG HORN	2371	44 50	108 15
16023	LUSK	NIOBRARA	1495	42 47	104 26
16024	LYMAN	UNITA	643	41 20	110 16
16025	MILLS	NATRONA	1724	42 50	106 24
16026	MOORCROFT	CROOK	981	44 15	104 58
16027	MOUNTAIN VIEW	NATRONA	1641	41 16	110 20
16028	NEWCASTLE	WESTON	3432	43 52	104 14
16029	ORCHARD VALLEY	LARAMIE	1015	41 04	104 50
16030	PARADISE VALLEY	NATRONA	1764	42 49	106 24
16031	PINE BLUFFS	LARAMIE	937	41 10	104 06
16032	PINEDALE	SUBLETTE	948	42 51	109 50
16033	POWELL	PARK	4807	44 45	108 46
16034	RAWLINS	CARBON	7855	41 46	107 16
16035	RIVERTON	FREMONT	7995	43 02	108 22
16036	ROCK SPRINGS	SWEETWATER	11657	41 35	109 13
16037	SARATOGA	CARBON	1181	41 28	106 48
16038	SHERIDAN	SHERIDAN	10856	44 48	106 57
16039	SHOSHONI	FREMONT	562	43 15	108 04
16040	SUNDANCE	CROOK	1056	44 23	104 22
16041	THERMOPOLIS	HOT SPRINGS	3063	43 39	108 12
16042	TORRINGTON	GOSHEN	4237	42 05	104 11
16043	UPTON	WESTON	987	44 05	104 36
16044	WARREN	LARAMIE	4527	00 00	000 00
16045	WHEATLAND	PLATTE	2498	42 03	104 57
16046	WORLAND	WASHAKIE	5055	44 01	107 58

TABLE 8. CITY ID, CITY NAME, COUNTY NAME, POPULATION, LATITUDE AND LONGITUDE

ARIZONA

COUNTY ID	COUNTY NAME	COUNTY ID	COUNTY NAME	COUNTY ID	COUNTY NAME
401	APACHE	406	GREELEE	411	PINAL
402	COCHISE	407	MARICOPA	412	SANTA CRUZ
403	COCONINO	408	MOHAVE	413	YAVAPAI
404	GILA	409	NAVAJO	414	YUMA
405	GRAHAM	410	PIMA		

COLORADO

COUNTY ID	COUNTY NAME	COUNTY ID	COUNTY NAME	COUNTY ID	COUNTY NAME
501	ADAMS	522	FREMONT	543	MONTROSE
502	ALAMOSA	523	GARFIELD	544	MORGAN
503	ARAPAHOE	524	GILPIN	545	OTERO
504	ARCHULETA	525	GRAND	546	OURAY
505	BACA	526	GUNNISON	547	PARK
506	BENT	527	HINSDALE	548	PHILLIPS
507	BOULDER	528	HUERFANO	549	PITKIN
508	CHAFFEE	529	JACKSON	550	PROWERS
509	CHEYENNE	530	JEFFERSON	551	PUEBLO
510	CLEAR CREEK	531	KIOWA	552	RIO BLANCO
511	CONEJOS	532	KIT CARSON	553	RIO GRANDE
512	COSTILLA	533	LAKE	554	ROUTT
513	CROWLEY	534	LA PLATA	555	SAGUACHE
514	CUSTER	535	LARIMER	556	SAN JUAN
515	DELTA	536	LAS ANIMAS	557	SAN MIGUEL
516	DENVER	537	LINCOLN	558	SEDGWICK
517	DOLORES	538	LOGAN	559	SUMMIT
518	DOUGLAS	539	MESA	560	TELLER
519	EAGLE	540	MINERAL	561	WASHINTON
520	ELBERT	541	MOFFAT	562	WELD
521	EL PASO	542	MONTEZUMA	563	YUMA

TABLE 9. COUNTY ID AND COUNTY NAME

NEVADA

COUNTY ID	COUNTY NAME	COUNTY ID	COUNTY NAME	COUNTY ID	COUNTY NAME
600	CARSON CITY	606	EUREKA	612	NYE
601	CHURCHILL	607	HUMBOLDT	614	PERSHING
602	CLARK	608	LANDER	615	STOREY
603	DOUGLAS	609	LINCOLN	616	WASHOE
604	ELKO	610	LYON	617	WHITE PINE
605	ESMERALDA	611	MINERAL		

NEW MEXICO

COUNTY ID	COUNTY NAME	COUNTY ID	COUNTY NAME	COUNTY ID	COUNTY NAME
701	BERNALILLO	712	HIDALGO	723	SANDOVAL
702	CATRON	713	LEA	724	SAN JUAN
703	CHAVES	714	LINCOLN	725	SAN MIGUEL
704	COLFAX	715	LOS ALAMOS	726	SANTA FE
705	CURRY	716	LUNA	727	SIERRA
706	DE BACA	717	MCKINLEY	728	SOCORRO
707	DONA ANA	718	MORA	729	TAOS
708	EDDY	719	OTERO	730	TORRANCE
709	GRANT	720	QUAY	731	UNION
710	GUADALUPE	721	RIO ARRIBA	732	VALENCIA
711	HARDING	722	ROOSEVELT		

UTAH

COUNTY ID	COUNTY NAME	COUNTY ID	COUNTY NAME	COUNTY ID	COUNTY NAME
801	BEAVER	811	IRON	821	SEVIER
802	BOX ELDER	812	JUAB	822	SUMMIT
803	CACHE	813	KANE	823	TOOELE
804	CARBON	814	MILLARD	824	UINTAH
805	DAGGETT	815	MORGAN	825	UTAH
806	DAVIS	816	PLUTE	826	WASATCH
807	DUCHESNE	817	RICH	827	WASHINGTON
808	EMERY	818	SALT LAKE	828	WAYNE
809	GARFIELD	819	SAN JUAN	829	WEBER
810	GRAND	820	SANPETE		

TABLE 9. COUNTY ID AND COUNTY NAME

CALIFORNIA

COUNTY ID	COUNTY NAME	COUNTY ID	COUNTY NAME	COUNTY ID	COUNTY NAME
901	ALPINE	908	LASSEN	915	PLUMAS
902	AMADOR	909	MADERA	916	RIVERSIDE
903	CALAVERAS	910	MARIPOSA	917	SAN BERNARDI
904	ELDORADO	911	MODOC	918	SIERRA
905	FRESNO	912	MONO	919	TUOLUMNE
906	IMPERIAL	913	NEVADA		
907	INYO	914	PLACER		

IDAHO

COUNTY ID	COUNTY NAME	COUNTY ID	COUNTY NAME	COUNTY ID	COUNTY NAME
1001	BANNOCK	1005	FRANKLIN	1009	POWER
1002	BEAR LAKE	1006	JEROME	1010	TWIN FALLS
1003	CARIBOU	1007	MINDOKA	1011	OWYHEE
1004	CASSIA	1008	ONEIDA		

KANSAS

COUNTY ID	COUNTY NAME	COUNTY ID	COUNTY NAME	COUNTY ID	COUNTY NAME
1101	CHEYENNE	1107	KEARNY	1113	SEWARD
1102	FINNEY	1108	LOGAN	1114	STANTON
1103	GRANT	1109	MORTON	1115	STEVENS
1104	GREELEY	1110	RAWLINS	1116	THOMAS
1105	HAMILTON	1111	SCOTT	1117	WALLACE
1106	HASKELL	1112	SHERMAN	1118	WICHITA

NEBRASKA

COUNTY ID	COUNTY NAME	COUNTY ID	COUNTY NAME	COUNTY ID	COUNTY NAME
1201	ARTHUR	1207	GARDEN	1213	MCPHERSON
1202	BANNER	1208	HAYES	1214	MORRILL
1203	CHASE	1209	HITCHCOCK	1215	PERKINS
1204	CHEYENNE	1210	KIETH	1216	SCOTTS BLUFF
1205	DEUEL	1211	KIMBALL		
1206	DUNDY	1212	LINCOLN		

TABLE 9. COUNTY ID AND COUNTY NAME

OKLAHOMA

COUNTY ID	COUNTY NAME	COUNTY ID	COUNTY NAME	COUNTY ID	COUNTY NAME
1301	CIMARRON	1302	TEXAS		

OREGON

COUNTY ID	COUNTY NAME	COUNTY ID	COUNTY NAME	COUNTY ID	COUNTY NAME
1401	HARNE	1403	LAKE		
1402	KLAMATH	1404	MALHEUR		

TEXAS

COUNTY ID	COUNTY NAME	COUNTY ID	COUNTY NAME	COUNTY ID	COUNTY NAME
1501	ANDREWS	1508	DEAF SMITH	1515	OLDHAM
1502	BAILEY	1509	ECTOR	1516	PARMER
1503	CASTRO	1510	EL PASO	1517	REEVES
1504	COCHRAN	1511	GAINES	1518	TERRY
1505	CRANE	1512	HARTLEY	1519	WARD
1506	CULBERSON	1513	HOCKLEY	1520	WINKLER
1507	DALLOM	1514	LAMB	1521	YOAKUM

WYOMING

COUNTY ID	COUNTY NAME	COUNTY ID	COUNTY NAME	COUNTY ID	COUNTY NAME
1601	ALBANY	1609	HOT SPRINGS	1617	SHERIDAN
1602	BIG HORN	1610	JOHNSON	1618	SUBLETTE
1603	CAMPBELL	1611	LARAMIE	1619	SWEET WATER
1604	CARBON	1612	LINCOLN	1620	TETON
1605	CONVERSE	1613	NATRONA	1621	UINTA
1606	CROOK	1614	NIOBRARA	1622	WASHKAKIE
1607	FREMONT	1615	PARK	1623	WESTON
1608	GOSHEN	1616	PLATTE		

TABLE 9. COUNTY ID AND COUNTY NAME

APPENDIX 4

SUMMARY OF FEDERAL, STATE, AND PRIVATE ACTIONS RECOMMENDED TO ACCELERATE GEOTHERMAL ENERGY DEVELOPMENT IN THE SOUTHWEST REGION

Prepared by
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Western Energy Planners, Ltd.

for the

Regional Operations Research Program
for Development of Geothermal Energy
in the Southwest United States

DOE Contract No. EG-77-S043992

June 10, 1978

New Mexico State University
New Mexico Energy Institute
Las Cruces, New Mexico

SUMMARY OF FEDERAL, STATE, AND PRIVATE ACTIONS RECOMMENDED TO ACCELERATE GEOTHERMAL ENERGY DEVELOPMENT IN THE SOUTHWEST REGION

1.0 INTRODUCTION

The New Mexico Energy Institute at New Mexico State University, in participation with the States of Arizona, Colorado, Nevada, New Mexico and Utah, is conducting a Regional Operations Research Program for Development of Geothermal Energy in the Southwest United States. The project is funded by the U.S. Department of Energy, Four Corners Regional Commission, and State of New Mexico Energy Resources Board.

The objectives of the program are:

- To develop realistic but aggressive scenarios with certainty factors for the development of each identified geothermal resource area in Arizona, Colorado, Nevada, New Mexico, and Utah.
- To delineate the public actions, together with their schedules required, for the scenarios to materialize.
- To develop a computer-base data storage and retrieval system of a regional program progress monitor of the level of a preliminary working model which is capable of displaying program approach, but not loaded with all available data.

This document addresses the second of the above program objectives, but includes private actions as well as public actions necessary to accelerate geothermal energy development in the Southwest. This report is only one component of the work products directed toward the second objective. The NMEI Core Team and the five State Teams also describe Federal, State and private actions in their quarterly progress reports and in the first year final report. The context of this report is based largely upon a questionnaire prepared by the consultant and distributed to the State Teams and to the Regional Advisory Committee for the Southwest OR Project. It is also based upon direct communications which the consultant has had with the Core Team, the State Teams, geothermal industry representatives, and other State and Federal officials throughout the first year of the project.

This report summarizes recommended actions which are necessary to develop and utilize the geothermal energy resources which exist in the five States of the Southwest Region. The magnitude of the potential geothermal resource is considerable. Both electric and non-electric, direct thermal

applications exist and are being explored. As of this time, however, no commmercial-scale geothermal project is in operation. The Federal and State governments and the private geothermal industry, including utilities, have strong interests in developing the geothermal potential. The actions recommended in this report, if implemented, would speed geothermal development on its way toward a significant contribution to the energy produced, consumed, and exported by the Southwest Region.

The report is divided into three major sections. Section 2.0 delineates actions required of the Federal, State and private sectors for the entire Southwest Region. The first seven "recommended regional actions" are in decreasing order of the priority generated by the questionnaire. The next six action items are not prioritized, except for being of lesser importance than the first seven. Section 3.0 lists actions required more specifically on a state-by-state basis, but include Federal and private actions as well as State actions. Section 4.0 tabulates the various recommended actions by the principal party responsible for implementation--Federal, State and private.

2.0 RECOMMENDED REGIONAL ACTIONS

2.1 Tax Incentives

The number one priority recommendation of the State Teams, the federal agency representatives, and the geothermal developers is to provide state and federal tax incentives to the geothermal industry by the 1980's. Tax incentives similar to those currently received by the oil and gas industry are typically specified, but other special incentives are advised also.

2.1.1 Depletion Allowance

Allowance of the 22 percent depletion allowance and the expensing of intangible drilling costs are the prime tax incentives that are recommended. Some question exists as to whether the geothermal resource is a depletable resource, and, therefore, does it technically qualify for a depletion allowance. However, the mere fact that the question is a real question testifies to the uncertainty of knowledge regarding the several forms of geothermal energy and to the risks to industry in expending funds for geothermal resource development.

It is certainly possible that a resource area may provide geothermal energy for an infinite period of time, but it is also possible that the rate of energy withdrawal may be sufficiently great to cause a short or long term depletion of the energy at the quality and quantity necessary for economic utilization. From the point of view of practical economics, geothermal developers and utility companies must generally scale their construction costs and production schedules on a thirty-year period of amortization and operation. Only actual experience over the next twenty-five to fifty years will prove whether geothermal resources are depletable and whether the thirty years production schedule is realistic. In order to obtain that experience, however, a geothermal resource depletion allowance will have to be provided or the development of geothermal energy will not readily occur.

2.1.2 Intangible Drilling Costs

The case for the expensing of intangible drilling costs for state and federal income tax purposes is identical to that offered by and provided to the oil and gas industry. The risks of obtaining dry holes in geothermal drilling are great. In addition, even if a hot or wet hole is obtained, considerable time elapses between drilling and energy production; these time

periods often see major changes in economic or political conditions which may jeopardize the advancement of the drilled well to an actual energy production well.

2.1.3 Property Taxes

The deferral of property taxes on the geothermal land and physical installation until energy production for commercial purposes occurs is a recommended special tax incentive for the geothermal industry. This recommendation originates not just within the framework of creative tax incentives but primarily because of the aforementioned time intervals between drilling for geothermal field development and energy production from a constructed power facility for commercial transmission and consumption. The time required can easily range from three to six years, so that significant tax savings and increased investment capital can be realized by the geothermal industry.

2.1.4 Exemptions for Non-Productive Leases

A related tax incentive calls for the elimination and or return of property taxes on land leases which have been proven to be non-productive for commercial energy purposes. While special provisions might be necessary to disallow speculative holdings of geothermal leases, the objective of this incentive is to encourage exploration for producing leases without a tax disincentive for non-producing leases.

2.1.5 Investment Tax Credit

An investment tax credit (10%) is advocated for the geothermal development industry. The tax credit would apply to physical equipment and facilities necessary for the production, conversion and transmission of energy of geothermal origin. As with other investment tax credits, the purposes of a geothermal investment tax credit are to stimulate investment of capital funds in geothermal energy equipment and to promote the increased development of geothermal energy as an alternative energy source.

2.1.6 Retrofit Incentive

A tax incentive for the outfitting or the retrofitting of existing business and industry buildings, equipment or processes to utilize direct thermal geothermal energy is recommended. For the energy-using sector of business and

industry, this incentive would complement those tax incentives recommended above for the energy-producing industry. The technology does exist for many low temperature, direct thermal applications of geothermal energy and the geothermal resources exist also. Nevertheless, a stimulus is believed necessary to allow business and industry to adapt their present facilities to a new energy form and to speed the development of specialized low temperature applications.

2.1.7 Early Adoption of Tax Incentives

The final recommendation on tax incentives is that they be instituted by the early 1980's at the latest, for three major reasons: First, the incentives are needed now to stimulate growth and competition within the geothermal industry. Second, the industry is small enough at the present time such that the total geothermal-related taxes going to state and federal treasuries are not all that significant; therefore, it is better to institute the tax credits and exemptions now before their impacts on the state and federal treasuries would require major adjustments in the flow of tax dollars. Third, tax incentives are viewed as absolutely essential for geothermal energy to make a significant contribution to the nation's energy needs.

2.2 Development Drilling

Tax incentives are viewed by the geothermal industry as the primary mechanism for instituting an expanded national and regional effort in geothermal resource assessment and exploration and geothermal field development; i.e. tax incentives would free up the capital necessary for industry itself to support a substantial increase in development drilling. However, geologists, developers, researchers, and state government officials all agree that development drilling must be expanded and supported financially for geothermal development to reach its potential in the Southwestern states. The objectives of an accelerated development drilling program should be (1) to define geophysically the resource areas and (2) to reduce the development risks to the geothermal industry.

Preferred mechanisms for accelerating development drilling are as follows:

- Provide tax incentives to the geothermal industry
- Eliminate stringent environmental restrictions on exploration drilling

- Continue the DOE Case Study Program on bottom-hole drilling information

2.3 Land Leasing and Time Delays

Considerable concern exists by all parties in the Southwest over problems with the leasing of federal and state lands and with time periods associated with regulatory or institutional actions. More specifically, four problems and solutions are identified:

2.3.1 Lease Acreage Limitations

Present Federal law restricts individual or corporate leaseholders of Federal geothermal leases to 2,560 acres per tract and 20,480 acres per state. These limitations were conceived primarily to promote competition among investors and developers and to prevent speculative holdings, but in actual fact are found to be highly restrictive to geothermal development. The time durations for leases and the lease fees are associated problems.

The limitation of 2,560 acres per tract is particularly restrictive because of the still undefined geophysical characteristics of most geothermal resources and the absence of proven knowledge of resource requirements for the economic application of geothermal energy. The 2,560 acre limitation creates severe development engineering and financing problems for a geothermal developer because a given geothermal resource often spans several tracts belonging to different lease holders.

The 20,480 acre per state limitation and the associated time limit of ten years of exploration leases poses another kind of problem. The time period from lease application to commerical energy production is six to twelve years, with a majority of those years required for the various regulatory and institutional processes (permits, EISs, etc.). This acreage limitation often forces a developer to release lands from lease before exploration and development can be completed. A developer is forced to make "speculative" judgements on which lands have energy producing potential in order to keep an active, integrated leasing, exploration, and development program underway in a state.

2.3.2 U.S. Forest Service Land Leases

A majority complaint (from the states of Arizona, Colorado, and New Mexico of the five Southwestern states) is with the inability of the U.S. Forest Service to process geothermal lease applications. The Forest Service has had

lease applications pending since 1974 and/or 1975 in Arizona, Colorado, and New Mexico. It is reported that the lease applications are a low priority item for the Forest Service, because of their lack of personnel and funds to process them. It is recommended that the U.S. Forest Service act more expeditiously on lease applications on a regular basis and act immediately to clear the outstanding applications.

2.3.3 Time Delays on Required Institutional/Regulatory Actions

Reference has already been made to the time intervals required to process lease applications, drilling permits, EISs, etc. At the present time, these actions constitute the majority of the time involved from lease application to energy production. The State Teams and the Core Team in the Southwest Project are currently analyzing the State and Federal procedures that must be followed and are compiling flow charts of sequential steps required. The evaluation has already revealed that, in almost all instances, no time limits are specified by the applicable legislation or the regulative procedures within which the administrative agencies must operate and render definitive actions. It is contended that a considerable reduction in processing time and a significant savings in costs to the developer would occur if specific time limits were prescribed. The geothermal industry would prefer to have a decision, whether positive or negative, than no decision at all.

2.3.4 Restrictive Feature of KGRA's

Federal law prescribes that federal lands will be designated as Known Geothermal Resource Areas (KGRA's), if two or more lease applications are filed for the same or adjoining land areas. The severe consequence of the KGRA designation if that the existing lease applications are voided and the KGRA is opened for competitive bidding. Once again, the KGRA was conceived to promote competitive bidding and to prevent speculative holdings. The actual consequence, however, has been to decelerate substantially geothermal exploration. Developers are highly reluctant to expose themselves to competitive bidding on lands for which they have only limited geochemical/geophysical/geological information bearing upon the geothermal potential. In most all areas of the Southwest, considerable exploration is still required to determine the geothermal potential. The costs associated with competitive bidding on unproven resources are actually a front-end cost deterrent to geothermal exploration and development.

2.4 Favorable Economic Conditions

As with most alternative energy sources and systems (e.g. solar, wind, oil shale, coal gasification, etc.), favorable economic conditions and realistic fuel pricing must prevail for geothermal energy to be competitive economically within state and regional markets. In order to place geothermal energy in a realistic position, two actions are recommended. The first is that oil and natural gas be priced at the world market value or at energy replacement values. The second is that more quantitative supply and demand analyses of geothermal energy be conducted to define the economic conditions required to support geothermal energy development.

2.5 Influence of Environmental Advocates

Among the private, state and federal participants in the Southwest Geothermal Project, there is a very strong posture that environmental advocacy groups have an unduely large influence on and have significantly hindered geothermal development. The negative effect of their actions is regarded as not representative of the majority of citizens and of state and local governments. It is recommended that less attention be given by legislative, regulatory and administrative agencies at both the state and Federal levels to the actions of the environmental advocacy groups and that a more balanced appraisal of energy development and environmental protection be provided.

2.6 Standardization of State Regulatory Provisions

Current restrictions on geothermal development in the Southwest have included that certain states have not generated legislative and regulatory provisions specifically for geothermal energy and that legal definitions of the geothermal resource have not existed. Some states are in the process of approving new regulations; defining leasing terms; etc. Unfortunately, the fluid and unsettled nature of regulations at the state level have caused significant delays of exploration and development action by the geothermal industry.

The Southwest States in general appear to support the development of geothermal energy and are participating cooperatively in the Southwest OR Project. The OR Project does encompass an examination of institutional and regulatory procedures. Yet no concerted, collaborative action has been initiated by the State governments at either the legislative or executive levels to examine the beneficial features of standardized regulatory provisions. It is

recommended that such a detailed examination be a major component of the continuing OR project.

2.7 Environmental Restrictions on Exploration

The existence of environmental factors as a limitation on geothermal development in the Southwest appears twice in the above listings. It appears again here within the specific context of severe limitations on the exploration phase. The geothermal industry regards exploration as that phase of overall development which is essentially 100% financial risk to industry but is their investment for the nation in seeking new energy resources.

The physical aspects of exploration do require moving equipment over relatively unexplored or untouched lands and do cause minimal disturbances to the natural environment. Each new hole drilling is based upon information gained from the preceeding holes drilled and the exploration decisions are made largely in the field; in other words, the drilling pattern and locations can not often be prescribed precisely in advance. Therefore, the exploration phase does not lend itself to the highly specific requirements of EISs and similar regulatory proceedings. In particular, the industry finds that the archaeological impediments to exploration permits give rise to frequent time delays and to additional costs of exploration. In general, the industry finds that there are more environmental barriers to exploration than there are incentives and aids to a positive exploration ethic.

2.8 Low Temperature Technologies

In inventorying the geothermal resources and applications, the State Teams have identified extensive opportunities for low temperature utilization of geothermal energy throughout the Southwest. Many of these applications are for business and industry operations and processes which have not previously been engineered for direct thermal geothermal energy. Technology development is required both for the capturing of the energy from the low temperature reservoirs and for specific business, industrial, and agricultural applications. The Arizona State Team has compiled an extensive list of direct thermal applications and is evaluating their potential for Arizona business and industry.

2.9 Demonstration Projects for Low Temperature Applications

The more advanced of the low temperature, direct thermal applications

of geothermal energy are greenhouse heating and municipal district heating. Several communities throughout the Southwest have feasibility studies underway, have demonstration project proposals pending with the DOE, or are strongly interested in district heating applications. These communities are in need of planning and design assistance from their State governments or consulting engineers; more specifically, the communities need the funds to support these activities. In addition, with an increasing awareness of the potential for district heating (largely generated by the activities of the State Teams during the past year), communities are calling for a continuation and expansion of the DOE program for direct thermal geothermal demonstration projects.

2.10 Water Resources and Water Rights

Concern exists throughout the entire Western region over the effect that the withdrawal of geothermal waters will have on existing water tables used for agricultural, municipal and other purposes. Examples of temporary draw-down of local water tables from geothermal operations have been reported in Utah, for example. The geothermal industry maintains that their deep wells for electrical power production are far below the depths of municipal and agricultural wells and into entirely different aquifers. The question of water rights immediately impinges on geothermal development whenever surface waters or aquifers which supply surface waters are touched by the development. The specific recommendation on this subject is that more attention and more funding be provided to an analysis of water resources and water rights as geothermal development proceeds. In addition, the geothermal industry prefers a legislative remedy, rather than judicial judgement, to the definition of geothermal waters; the industry appears to prefer the DOE proposal to remove "geothermal water" from the Federal "water resource."

2.11 DOE Case Study and Loan Guarantee Programs

The DOE Case Study (bottom hole information) and Loan Guarantee Programs are highly regarded by geologists, geothermal developers, and State government representatives in the Southwest Region. These programs are supportive of the geothermal industry. Whereas both programs initially received cool attention from the geothermal industry, the Case Study Program is drawing more and more participation and the Loan Guarantee Program has several applications approved

or in process. It is being recommended that the Case Study Program be extended beyond its current cut-off date of

The geothermal industry regards the Loan Guarantee Program as a more effective program for stimulating development and commercialization than cost-sharing demonstration projects. Indeed, the Loan Guarantee Program applies at the point of commercialization and revenue generation, which is where the industry prefers to operate. However, the program is not fully useable by the larger geothermal companies, (a) because of the limitation of guarantees of $25 million per project and $50 million per borrower, and (b) because no large company will risk default on such small loans anyway.

Three specific recommendations are advanced to enhance the Loan Guarantee Program: (1) The Congressional limit of $200 million for the entire outstanding amount of guaranteed loans needs to be increased to provide for the surge of geothermal projects that are potentially possible in the 1980's; (2) the requirement for the geothermal "borrower" to put up 25% of the project financing should be modified to allow credits for the actual prior investments by industry to bring the project to the commercializaiton/loan guarantee stage; i.e. the value to the project at the time of loan guarantee application should apply to the 25% financing requirement; and (3) the allowable interest rate by the lender should be reduced to the prime rate rather than 25% over the prime rate (the industry investment of 25% of project financing should be sufficient to guarantee low risk financing to the lender).

2.12 Public Education

Geothermal energy development has not received the financial support nor the public attention that other alternative energy sources have, particularly solar. For the general public, geothermal energy is still largely a mystery and is viewed with scepticism and misunderstanding. The contrast in public perception between solar energy and geothermal is most striking: solar derives from the brilliant radiance of the sun and geothermal derives from the mysterious, dark bowels of the earth! Similarly, solar is promoted as free of environmental impact and geothermal is challenged on land, air, and water factors.

The State Teams have witnessed this dramatic disparity in public perceptions as they have discussed the prospects of geothermal energy use with businesses and communities. Some residents of rural communities will not even listen to proposals for geothermal use. This lack of knowledge and broad misunderstanding of geothermal energy extends throughout the general populace.

The situation allows environmental advocacy groups to dominant decision-making, not only at the local level, but also at the Federal level when energy program funds are allocated.

It is recommended that the DOE and State governments sponsor a major public education program which puts forward the potentials and advantages for geothermal energy.

2.13 Handbooks of Institutional/Regulatory Procedures

As previously mentioned, the State Teams and the Core Team for the OR Project are compiling and analyzing information on the institutional and regulatory procedures for the entire geothermal process. The institutional/regulatory process is different in each State, with different principals, agencies and practices involved. In addition, the process is often complex, providing for different points of entry, time elements, and options for the government decision-maker.

While these procedures are often known to the large geothermal developers and to the utilities, they are generally not known, understood, or accessible to the individual lease applicant, community official, small business/industry energy user, out-of-state investor, etc. Therefore, it is recommended that handbooks of flow charts and instructions be prepared which cover the institutional and regulatory procedures from lease application to specific end uses of the geothermal energy.

3.0 RECOMMENDED STATE-BY-STATE ACTIONS

Many of the recommended actions in Section 2.0 apply to all of the States in the Southwest. In addition to those actions, the following specific actions are needed within the individual States to accelerate geothermal development.

3.1 Arizona

3.1.1 Approval and application of the proposed new State geothermal rules and regulations in order to activate again the leasing of geothermal lands.

3.1.2 Expanded exploratory drilling to assess the geothermal resource potential throughout the State.

3.1.3 Technological studies and technology transfer information on new, primarily direct thermal, uses of geothermal energy by business, industry, and agriculture.

3.1.4 Technology development of absorption cooling and heat pumps for space cooling applicaitons to reduce the demand for electrical energy.

3.2 Colorado

3.2.1 Issuance of leases by the U.S. Forest Service on applications pending since 1974.

3.2.2 Development of geothermal space heating applications to relieve the demand for natural gas.

3.2.3 Financing and planning assistance for community and small business geothermal projects.

3.3 Nevada

3.3.1 Participation of the geothermal industry in the formulation and legislation of State laws and regulations regarding geothermal energy resources in order to provide an institutional/regulatory process conducive to geothermal development.

3.3.2 Integration of State and Federal leasing and regulatory actions to accomodate the fact that 86% of Nevada is Federal land.

3.3.3 Expanded Federal lease acreage allowance per tract and per State to allow access to and utilization of adjoining State and Federal lands.

3.4 New Mexico

3.4.1 Extension of the State lease duration from five years to ten years to conform to Federal standards and to activate leasing of State lands again by the State Land Department.

3.4.2 Eliminate Federal drilling restrictions on depth in order to promote deeper well drilling for space heating applications.

3.4.3 Rejection of unreasonable demands by environmentalists that would halt geothermal development.

3.5 Utah

3.5.1 Industry needs to acquire more drilling rigs to match the requirements indicated by the Utah development scenarios for production well drilling over the next 20 years.

3.5.2 U.S. Congress needs to authorize higher dollar limits for Loan Guarantee Program and make Program applicable to the larger geothermal companies.

3.5.3 State government needs to specify the tax rates on geothermal developments in order to allow the industry to calculate that element of its development costs.

4.0 SUMMARY

In this final section, an attempt is made to summarize the recommended actions by the principal parties which must implement the actions--Federal, State, or private; naturally some multiple responsibility exists.

4.1 Federal Actions

- Provide tax incentives
- Support development drilling
- Accelerate and expand leasing of lands
- Reduce time delays of institutional/regulatory procedures
- Generate favorable economic conditions
- Reduce influence of environmental advocates
- Reduce environmental restrictions on exploration
- Develop technologies and provide demonstration programs for low temperature applications

- Analyze water resources and water rights
- Continue DOE Case Study Program
- Expand Loan Guarantee Program
- Education of the public

4.2 State Actions

- Accelerate leasing of lands
- Reduce time delays of institutional/regulatory procedures
- Standardize regulatory procedures and legal definition of the geothermal resource
- Reduce environmental restrictions on exploration
- Provide planning assistance to communities for low temperature applications
- Clarify water rights related to geothermal resources
- Education of the public
- Provide handbooks of institutional/regulatory procedures

4.3 Private Sector Actions

- Development Drilling
- Participation in DOE Case Study Program
- Utilization of Federal Loan Guarantee Program
- Education of the public
- Expand drilling rig capacity
- Assist in formulation of State laws and regulations
- Develop low temperature technologies

The Task Force was formed to assist the Interagency Geothermal Coordinating Council (IGCC) carry out its mandate "...for developing recommendations for changes and improvements in...(geothermal)... related laws, policies and procedures..." Specifically, the Task Force is responding to the President's commitment to Congress that "The Depts of Interior and Agriculture will streamline leasing and environmental review procedures to remove unnecessary barriers to the development of geothermal resources."

The commitment was prompted by the fact that although the Geothermal Steam Act was passed nearly seven and one-half years ago, there is still no commercial production of this resource on Federal lands.

It is widely known that the cumbersome Federal leasing and permitting program constitutes a major deterrent to timely development. As long as the inhibiting influence of the regulatory program clouds the rate of development on Federal lands, the effects of other impediments cannot be fully and accurately assessed.

The Geothermal Streamlining Task Force has undertaken a study which includes (1) a comprehensive analysis of the elements of the present program designed to identify the sources of delay and quantify delays which are actually occurring; and (2) to determine the potential effects upon program performance of a series of options for program modification. The effectiveness of alternative options will be assessed in terms of their relative ability to support the Department of Energy's projected geothermal power-on-line schedule while adequately protecting the public interest and the environment.

The Albuquerque meeting was chaired by Task Force chairman, W.B. Short of the BLM, with the principal presentation by Bert Jones of DOE. Though attendance was rather sparse, some very pertinent questions and suggestions were offered by Jerry Hall of AMAX. The Task Force was supported by representatives from the US Forest Service, Geological Survey and Bureau of Land Management in this area. The workshop brought forth reviews and comments on the series of options developed by the Task Force, for modifying the geothermal leasing and permitting program.

The Task Force recommendations, massaged and/or amended as a result of the public review meetings was presented to the IGCC at a July 22 meeting in Hawaii.

REGIONAL PLANNING WORKSHOP APRIL 26, 1978

The Southwest Regional Geothermal Development Operations Research Project, due to a organizational change in DOE/DGE, has recently come under the Rocky Mountain/Basin and Range Region.

The New Mexico State OR Team was represented at the planning workshop in Salt Lake City, on April 26, conducted by personnel from DGE Headquarters, DOE Idaho Opertions (ID), DGE Nevada Operations, U.S. Geological Survey, EG & G (the prime contractor to ID), and the Earth Science Laboratory of the University of Utah Research Institute.

Detailed short-and long-term planning activities included all aspects of stimulation of geothermal energy development from resource definition through utilization, encompassing presently existing programs as well as new programs.

Presentations by State Teams addressed the following topics:

(1) Location and nature of known geothermal sites with emphasis on the best sites in terms of development of electrical generating capacity or direct heat uses.

(2) Potential for further resource discovery.

(3) OR data generated to date and its applications.

(4) Recommendations for future DGE programs and initiatives.

REGIONAL PLANNING WORKSHOP JUNE 28, 1978

A second regional planning workshop was held in Salt Lake City on June 28 to review and comment on the DOE/DGE Draft Regional Hydrothermal Development Plan for the Rocky Mountain/Basin and Range Region. Representatives of industry also participated.

GEOTHERMAL STREAMLINING TASK FORCE WORKSHOPS

June 13, 1978 - Albuquerque

June 28 and 29, 1978 - Salt Lake City

The Interagency Geothermal Streamlining Task Force held a series of regional meetings that were held in 4 southwestern cities including Albuquerque.

The purpose was to present and discuss proposals from the Task Force aimed at streamlining the processes for issuing geothermal leases and related permits on Federal lands, as well as to encourage the submission of any new proposals from the public.

The Salt Lake City meeting on June 28-29 included workshop sessions and followed by one day a major DOE regional energy meeting that was attended by energy producers, utilities and governmental organizations from the Rocky Mountain Basin and Range Area including the New Mexico State Team.

A P P E N D I X 3

Regional Federal-Sponsored Activities Attended by the New Mexico State Team

GEOTHERMAL RESEARCH AND DEVELOPMENT PROGRAMS

STATE PROJECTS

Calendar Year	Number of Projects	Total Value of Projects
1974	3	$135,520
1975	6	$252,580
1976	5	$108,633
1977	7	$367,302
1978*	15	$572,713

*including Fiscal Year 1979 Awards

GEOTHERMAL PROJECTS (continued)

Project ID	Project Title	Funding	Status
EMD 78-2232 Young NMSU	Electrical Exploration for Geothermal Resources near San Diego Mountain, New Mexico	$25,420	In Progress
EMD 78-2234 Lansford NMSU	Utilization of Geothermal Energy for Agribusiness Development in Southwestern New Mexico (Part One)	$76,214	In Progress
EMD 78-2236 Marlin NMSU	Southwest Geothermal Regional Operations Research Study	$100,000	In Progress
EMD 78-2321 Reiter NMIMT	Deep Subsurface Temperature Studies in the Basins of New Mexico and Neighboring Geologic Areas	$35,000	In Progress
EMD 78-2333 Miller and LeFebre NMIMT	Heating the New Mexico Tech Campus with Geothermal Energy (Part Two)	$13,944	In Progress

GEOTHERMAL PROJECTS (continued)

Project ID	Project Title	Funding	Status
ERB 77-2203 Morgan NMSU	Active and Passive Seismic Studies of Geothermal Resources in New Mexico and Investigations of Earthquake Hazards to Geothermal Development	$50,000	In Progress
ERB 77-2211 Energy Institute NMSU	Department of Energy and New Mexico Cooperative Program - Low Temperature Geothermal Reservoir Assessment	$15,000	In Progress
ERB 77-2218 Chaturvedi NMSU	Los Alturas Geothermal Reservoir Confirmation Study	$20,000	In Progress
ERB 77-2312 Sanford NMIMT	Seismic Exploration for Shallow Magma Bodies in the Vicinity of Socorro, New Mexico	$36,510	In Progress
ERB 77-2314 Hyakorn and Gelhar NMIMT	Development and Application of a Computer Model for Simulating a Geothermal System in New Mexico (Phase One)	$31,600	In Progress
EMD 78-2120 Landis UNM	Computer Based Chemical and Stable Isotope Modeling of Geothermal Systems in New Mexico	$39,150	In Progress
EMD 78-2122 Kaufman and Houghton UNM	Engineering and Economic Feasibility Study of Hot Water Geothermal Energy in the Albuquerque Area	$57,681	In Progress
EMD 78-2123 Elston UNM	Assessment of the Geothermal Potential of Southwestern New Mexico	$28,820	In Progress (awaiting federal funding)
EMD 78-2135 Jiracek UNM	Evaluation of the Geothermal Resource in the Area of Albuquerque, New Mexico	$76,874	In Progress (awaiting federal funding)
EMD 78-2219 Energy Institute NMSU	Feasibility Study for Establishing a Centralized Geothermal Data Base for New Mexico	$ 6,000	In Progress

GEOTHERMAL PROJECTS (continued)

Project ID	Project Title	Funding	Status
ERB 76-200 Reiter NMIMT	Deep Terrestrial Heat Flow, Measurements in New Mexico and Neighboring Geologic Areas	$20,000	Complete (final draft revision)
ERB 76-201 Chapin NMIMT	Geological Investigation of Socorro Geothermal Area	$28,650	Complete (final draft revision)
ERB 76-205 Gunaji NMSU	Geothermal Application Feasibility Study for the NMSU Campus	$34,249	Complete
ERB 76-210 Stone NMIMT	The New Mexico Geothermal Potential	$ 8,000	Complete
ERB 76-213 Miller NMIMT	Geothermal Application Feasibility Study for the NMIMT Campus	$29,963	Complete
ERB 76-260 LaFrance NMSU	Feasibility Study of Geothermal Energy for Heating Greenhouses	$10,819	Complete (final draft revision)
ERB 76-261 Chaturvedi and Keys NMSU	Use of Geothermal Energy Desalination in New Mexico - A Feasibility Study	$31,149	In Progress (extension requested)
ERB 76-262 Zwerneman NMSU	Regional Operations Research for Development of Geothermal Energy Resources in the Southwestern United States	$100,000	In Progress
ERB 76-263 Sanford and Schule NMIMT	Seismic Exploration for Shallow Magma Bodies in the Vicinity of Socorro, New Mexico	$37,850	In Progress
ERB 76-264 Callender UNM	Evaluation of Geothermal Potential of the Basin and Range Province of New Mexico	$103,235	Complete (final draft revision)
ERB 77-2113 Hsu UNM	An Enhanced Heat Extraction From Dry Rock Geothermal Reservoirs Due to Interacting Secondary Thermal Cracks	$10,000	In Progress

Economics - Basically, geothermal development is costly and involves a high degree of risk. Utilization of this resource is still in its initial stages in many respects. It is not always easy to find geothermal reservoirs, and when a reservoir has been found, individual wells may still fail to yield water of sufficiently high temperature or in sufficient quantity. Because of these risks and the high cost of development, only a few buildings in New Mexico presently use geothermal energy for heating and cooling.

Water Resources and Water Rights - Concern exists throughout the entire western region of the U.S. over the affect that the withdrawal of geothermal waters will have on existing water tables used for agricultural, municipal and other purposes. Temporary draw-down of local water tables by temperature gradient holes has been reported. The geothermal industry maintains that its deep wells for electrical power production extend far below the depths of municipal and agricultural wells and into entirely different aquifers, but the potential for legal disputes over water rights continues to exist wherever any part of a geothermal installation touches surface waters or aquifers which supply surface waters.

Lease Acreage Limitation - The 25,000-acre state limitation on geothermal leasing and the associated time limit of five years on exploration leases pose another kind of problem. The time period from lease application to commercial energy production is 6 to 12 years, with a majority of those years required for the various regulatory and institutional processes (permits, EIS's, etc.). The acreage limitation often forces a developer to discontinue his lease before exploration or development can be completed, because often a developer cannot acquire new land without divesting himself of land he already has. The time-acreage limitation also tends to cause developers to drill hastily and in the wrong places.

Policy Statement

The policy of the State of New Mexico shall be to encourage development and demonstration of technologies both for the production of electrical power and for direct thermal use from New Mexico geothermal resources, and to provide for continued expansion of the utilization of this viable energy resource in an environmentally acceptable manner.

Implementation of State Policy

The following steps should be taken to implement State policy:

1. The State should continue to fund geothermal projects from the Energy Research and Development Fund. Emphasis should be given to projects that will result in drilling programs utilizing information obtained from previous projects.

2. The State should initiate a geothermal space heating demonstration project. In this regard, the 1978 New Mexico Legislature has appropriated $200,000 to the Energy and Minerals Department to be used as matching monies for a space heating demonstration project. Applications for the project are tentatively scheduled to be called for by October, 1978 and will be based on the results of a "low temperature geothermal assessment project" currently in progress.

GEOTHERMAL ENERGY

The Current Situation

Geothermal energy, the natural heat in the earth's crust, has a large potential for direct thermal use and for electrical generation in New Mexico. Recent studies rank this state in the top five in almost every geothermal resource category.

New Mexico's hydrothermal (liquid dominated) sites, located throughout the central and southwestern portions of the state, are presently of the greatest economic interest. Some of these sites contain water hot enough to be used for electrical generation; many contain water too cool for that purpose but warm enough to heat buildings.

In addition, to more than 100 hot springs and numerous volcanoes that, in geological reckoning, can be classified as recently active, New Mexico's borders enclose part of a major underground heat anomaly associated with the Rio Grande Rift. Most of the state's population is located along this rift -- a coincidence that may someday be advantageous to large-scale geothermal development.

Many projects that will partially utilize New Mexico's enormous geothermal potential are now under way. Interest has been shown by private industry, the State, municipalities and the federal government.

The most important project, at least from the short-range economic standpoint, is presently a 50 MW generating facility to be constructed by the Public Service Company of New Mexico and the Union Oil Company in the Valles Caldera west of Los Alamos.

The U.S. Department of Energy has tentatively approved funding for this facility and the plant is scheduled to begin operation in 1982 if final approval is given. It will be one of the nation's major geothermal installations.

An important experiment utilizing hot, dry rock is now being undertaken by the Los Alamos Scientific Laboratory near Fenton Lake. Here cool water is pumped deep into the ground, heated by fractured rocks and recovered as steam. From this experiment, the only one of its kind in the U.S., a great deal has been learned about the hot dry rock process. The installation has a theoretical capacity of 10 MW (electrical).

Sunoco Development Company, Amax Exploration, Chevron Oil, Sandia Laboratories and the State of New Mexico are drilling or will soon drill into hydrothermal systems in New Mexico, and numerous other entities hold geothermal leases that are expected to lead to hydrothermal drilling programs.

Working against geothermal development interests in New Mexico are the following factors:

GEOTHERMAL PROJECTS CONDUCTED UNDER THE NEW MEXICO ENERGY RESEARCH AND DEVELOPMENT ACT (1974-1979)

Project ID	Project Title	Funding	Status
BEF-5 Reiter NMIMT	As Investigation of the Thermal Regime of the Rio Grande Rift and Neighboring Provinces by Employing Very Deep Heat Flow Measurements and Estimates of Crustal Radioactive Heat Generation	$53,200	Complete
BEF-6 Sanford NNIMT	Seismic Investigation of a Magma Layer in the Crust Beneath the Rio Grande Rift near Socorro, New Mexico (and Its Relation to the Geothermal Energy Potential of the Region)	$23,444	Complete
BEF-22 Jiracek UNM	Geothermal Potential of Rio Grande Rift, New Mexico	$74,870	Complete
BEF-67 Swanberg NMSU	Geothermal Investigations in Southwestern New Mexico	$58,876	Complete
BEF-131 Reiter NMIMT	Geothermal Gradient Measurements	$ 2,900	Complete
BEF-166 Landis UNM	Oxygen Isotope Geochemistry and Geothermal Energy Potential in New Mexico	$18,600	In Progress (Final Report Only)
BEF-189 Swanberg NMSU	Geothermal Equipment	$ 1,600	Complete
ERB 75-107 Hsu UNM	Engineering Methods for Predicting Productivity and Longetivity of Hot-Dry-Rock Geothermal Energy Reservoir in the Presence of Thermal Cracks	$48,682	Complete
ERB 75-117 Callender	Evaluation of Geothermal Potential of the Basin and Range Province of New Mexico	$105,928	Complete
ERB 75-300 Sanford NMIMT	Seismic Exploration for Shallow Bodies in the Vicinity of Socorro, N.M.	$22,020	Complete (Final Draft revision)

A P P E N D I X 2

STATE OF NEW MEXICO

GEOTHERMAL RESOURCE AND DEVELOPMENT PROJECTS

The assessment project utilizes $15,000 in state energy research and development funds and some $150,000 in federal monies.

It appears that the principal candidates for demonstration project funds this year will be New Mexico State University, the New Mexico Institute of Mining and Technology, the University of New Mexico and the village of Jemez Springs.

3. The State should adopt the following fiscal policies to stimulate geothermal development:

* Extend the State geothermal lease duration from 5 years to 10.

* Expand the maximum geothermal leasing acreage allowance from 25,000 acres to 50,000

A bill addressing both of these points has been prepared for introduction in the 1979 legislative session.

4. Legal barriers to the development of geothermal resources should be resolved. Further study is needed on the question of whether or not geothermal resources are mineral resources and therefore subject to mineral rights.

5. A tax incentive should be initated for the retrofitting or outfitting of existing business and industry buildings, equipment and processes to utilize geothermal energy. This could be accomplished by adding a Section 72-15A-11.6 of the Income Tax Act to provide an income tax credit of 25 percent of the installed cost of a geothermal energy system, not to exceed $2,500. A bill to this effect has been prepared for introduction in the 1979 legislative session.

6. In order to relieve the demand for petroleum products, the State should encourage and expand development of geothermal space heat application wherever feasible in New Mexico.

7. The State should disseminate further information about geothermal energy utilization to the people of New Mexico through the Energy Extension Service and continue to expand planning assistance for geothermal projects, especially in the residential, agricultural and small business areas.

8. The State should, as is done in the case of solar energy, demonstrate its confidence in geothermal application. This could be done by installing geothermal space heating systems in new or existing State buildings where technically and economically feasible.

9. The State should continue to support efforts on the federal level to authorize a 22 percent depletion allowance for geothermal drilling operations.

A P P E N D I X 1

STATE OF NEW MEXICO

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John Callender, Geology Dept., University of New Mexico

Richard O. Engebretsen and Richard C. Lindwall, Union Oil Company of California

George Jiracek, Geophysicist, UNM

Martha Kline, Bureau of Land Management, Santa Fe

Walt Kowak, Bureau of Land Management, Las Cruces

William Laughlin, Jim Maxwell, and Francis West, Los Alamos Scientific Laboratories

Tom McCant, Rancher and farmer, Animas

Chuck McGlothin, District Ranger, USFS, Jemez Springs

Dr. Richard T. Meyer, Western Energy Planners, Consultants to the Southwest Regional Geothermal O/R Project

Harry Olson, Amax Exploration, Denver, Colorado

Jim Querry, Bureau of Land Management, Santa Fe

Marshall Reiter and William Stone, New Mexico Bureau of Mines

Dr. Allen Sanford, New Mexico Institute of Mining & Technology

Dr. R. San Martin, Director, New Mexico Energy Institute

Dr. Chandler Swanberg, New Mexico State University

Carl Ulvog, New Mexico Oil Conservation Division, EMD

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TABLE 20

SOME POTENTIAL USES FOR GEOTHERMAL RESOURCES

IN NEW MEXICO

POWER GENERATION

SPACE HEATING OF SCHOOLS, OFFICES, STORES, HOMES, WAREHOUSES, AND GREENHOUSES

WATER HEATING

SPACE COOLING

HIGHWAY DE-ICING

FRESH-WATER BY DISTILLATION

BIOMASS PROCESSING FOR FUEL, FERTILIZER

FEEDLOT WARMING

LIVESTOCK PEN WARMING FOR POULTRY, HOGS

WOOL WASHING AND DRYING

FISH HATCHERIES AND FISH FARMING

APPLE, PEACH, PEAR, PRUNE, APRICOT DEHYDRATION AND FREEZE-DRYING

POTATO, ONION, CARROTS, TOMATO, BELL PEPPER, CHILI DEHYDRATION

REFRIGERATION OF FOOD PRODUCTS SUCH AS FRUIT, LETTUCE, SPINACH

WOOD CHEMICALS

MANUFACTURE OF PLYWOOD, VENEER, PARTICLE BOARD, LUMBER CURING

PAPER AND PULP

DAIRY FARMING INCLUDING MILK CHILLING, PASTEURIZATION & CHEESE MFG.

MUSHROOM GROWING

FREEZE DRYING

DRYING AND CURING LIGHT AGGREGATE CEMENT SLABS

SOIL STERILIZATION

SOIL WARMING

SEED DRYING

POULTRY HATCHING

SWIM POOLS, BATHS

TROPICAL GARDENS

SUMMARY AND CONCLUSIONS

This 14 month study has attempted to estimate the potential for geothermal resource development in New Mexico. It has also attempted to identify those conditions that seem to impede that development. As a third objective, it has attempted to identify those actions that seem necessary to advance the development of geothermal resources.

The results show that geothermal resources in New Mexico do have significant potential particularly in the Rio Grande Rift area. Geothermal energy in the amount of 18.2×10^{18} calories was estimated to be in the 49 hydrothermal (hot water) systems identified in New Mexico.

However, geothermal energy use is limited by the distance it can be transported. For that reason, industry has been interest primarily in high-temperature resource for power generation.

New Mexico's largest resource area, the Valles Caldera, is currently in the development phase. For other areas, some leases have been issued, and some preliminary exploration has occurred. Planning and preliminary studies that are both completed and underway may lead to their development in the near future. Seemingly, interest in and awareness of the resources is growing. If leases and permits are made available, along with some economic incentives, some or all of the six potential power-generation sites may be developed by private industry. Perhaps with the assistance of Federal programs initially, lower temperature resources, too, will be developed by private industry. While government can provide opportunities, the outcome depends upon the decisions of numerous individuals throughout the system.

Geothermal resources in New Mexico may turn out to be rather important, not necessarily in generating electricity for export, but to supply energy for use in the state, especially for direct application in agri- and horticulture, for industrial process heat, and for heating and refrigeration, and these areas should be further explored and developed. New Mexico State University is investigating the potential of the nearby Los Alturas geothermal wells for heating campus buildings.

Geothermal energy should preferably be used directly as heat, because conversion into electricity and back into heat is very inefficient. However, it may be possible to gain sweet water as a desirable biproduct through the electric generation process from a high-temperature water convection system and this aspect should also be investigated in detail.

Before extensive development can take place in the state, legal questions will have to be considered with regard to its extraction, comparable to mineral rights, water laws, depletion allowances, etc. Who owns the geothermal resources? How should wells be operated and taxed to minimize depletion? Exploration for geothermal resources is far from complete in New Mexico, and no attempt has yet been made to outline in detail the extent of geothermal resources (recoverable earth heat) in the state. This is necessary together with on-site testing to define New Mexico's geothermal reserves which are geothermal resources competitive with existing energy resources.

TABLE 19

SUMMARY OF STATE LAWS OF 1978 LEGISLATIVE SESSION AFFECTING GEOTHERMAL LEASING AND DEVELOPMENT

Bills That Passed

House Bill 199: Research and Development Appropriation

Authorized $2,500,000 to continue energy research and development and the New Mexico Energy Institute.

Senate Joint Memorial 2

Requested the President to assure that New Mexico is selected as the site for a geothermal demonstration plant. (PNM and Union Oil have submitted a proposal to DOE for $100,000,000 to design and build the plant at Valles Caldera.)

House Bill 2: General Appropriation, Item 14 - Geothermal Space Heating

Appropriates $200,000 to the Energy and Minerals Department, Resources and Development Program, for establishing geothermal space heating demonstration projects. 100% matching funds required.

Bills That Did Not Pass

Senate Bill 199: Geothermal Leases

Would have allowed up to ten years to go into production, instead of the five years now stated by law.

House Bill 193: Geothermal Space Heating Demonstration Projects

Would have appropriated $2,500,000 to the Energy Resources Development Fund for establishing geothermal space heating demonstration projects. 100% matching funds required.

In 1973, the legislature directed the Oil Conservation Commission to regulate the drilling, development and production of geothermal resources and to conserve and prevent waste of geothermal resources in the same manner as it regulated, conserved and prevented waste of natural gas. This general directive was followed, in 1975, by the enactment of the Geothermal Resources Conservation Act (Section 65-11-1 through 65-11-24, NMSA 1953). The act prohibits waste and gives the Oil Conservation Commission broad powers to prevent waste and protect correlative rights. Under the act the commission may: have access to records, require reports; regulate drilling and plugging of wells; limit, allocate, or distribute production; establish spacing units and prevent discrimination in the buying and selling of geothermal resources.

The 1975 legislature also enacted two additional acts relating to geothermal energy. The Energy Research and Development Act (Sections 65-12-1 through 65-12-8, NMSA 1953) created a fund, administered by the Energy Resources Board, for the purpose of financing research or development projects in the energy field. The specific purpose of the act is "to provide the means to seek solutions to fuel and energy problems through energy research and development for benefit to the citizens of New Mexico in the fields of wind, solar, geothermal, fossil, nuclear and all other research...."

The New Mexico Legislature has been quite concerned over the extraction and exploration of the state's natural resources and the resultant benefits to the state for its present and future citizens. Therefore, it has enacted such taxation measures as the resources excise tax, the severance tax, the oil and gas severance tax and the electrical energy tax. None of these taxes specifically apply to geothermal resources although there may be some future debate on whether or not geothermal resources may be considered a "mineral" within the meanings of those acts. There is currently only tax specifically levied on geothermal development, the oil and gas conservation tax. The tax is levied at a rate of nineteen one-hundredths of one percent on the sale value of geothermal energy less transportation costs and royalties. The proceeds of the tax are used to insure proper abandonment of oil and gas wells and to help pay the expenses of the Energy and Minerals Department.

New Mexico's income tax is based upon federal taxable income. Therefore, any tax incentives passed by Congress, such as the deduction for intangible drilling costs and the depletion allowance which are included in the various versions of the National Energy Act now before Congress, would be passed on to New Mexico taxpayers.

Court Cases and Litigation

There have been no court cases concerning geothermal development in New Mexico. However, there are many potential problem areas which will ultimately have to be resolved, either by legislation or litigation. One of these areas concerns whether geothermal resources are "minerals" in cases where the mineral estate has been severed from the surface estate by a grant or reservation of mineral rights.

LEGAL AND INSTITUTIONAL FACTORS AFFECTING GEOTHERMAL DEVELOPMENT

The New Mexico state team achieved a great deal of success in identifying problems, in the legal and institutional areas of geothermal development and formulating remedies. Institutional barriers were identified in the form of federal, state, and local government laws and regulations, such as environmental controls, leasing, permitting, tax laws, and land use policies. This was done through the examination of statutory regulations and court cases. The oil companies and developers were consulted concerning their experience in obtaining geothermal leases and meeting regulatory requirements. Since August, the Energy & Minerals Department in Washington, D.C., has been in touch with the state's congressional senators in an effort to include favorable treatment of geothermal energy in the National Energy Act.

1. State Legislation

The New Mexico Legislature is expressing interest in geothermal energy with some incentives for its development. The 1977 legislature, by a joint memorial, requested the Energy Resources Board and other state agencies to study the feasibility of heating state office buildings with geothermal energy.

The resulting state legislative report (Hatton, 1977) concluded that there is little evidence presently available to indicate any potential geothermal resource beneath Santa Fe. However, it stated that "conversion to geothermal space-heating for numerous state-controlled buildings in /areas of potential/ could, if feasible, save the state large sums of money."

In the special session in 1978, the legislature appropriated $200,000 to establish Geothermal Space Heating Demonstration Projects. This requires 100% matching funds from federal, local or private sources (see Table 13).

2. Legal Provisions

The New Mexico Legislature, in 1967, enacted the Geothermal Resources Act requiring all state lands to be leased through competitive bidding only. Lease terms are for an initial five years. As a result, there are many state leases expiring due to the short term and cannot be renewed. The act restricts the size of any lease to between 640 and 2,560 acres and prohibits any lessee from leasing over 25,000 acres in New Mexico.

The act provides for royalties of ten percent of the gross revenue, excluding transmission charges, received from the sale of steam and eight percent of the net revenue received from the operation of an energy plant and provides for an annual rental fee of one dollar per acre. However, the commissioner of public lands may suspend or reduce royalties and rentals if he finds it necessary to promote development. Other lease requirements and bonding provisions are contained in the act as are certain provisions relating to resource conservation and surface protection. In addition, the commissioner is given broad powers to impose other requirements and terms either by lease negotiation or by regulation.

constraints to geothermal development. In New Mexico appropriate legislation and policy will continue to be enacted that would encourage the use of geothermal resources.

diverted to other investments. Investors will not commit monies unless they can expect a return from their investments as soon as possible. Furthermore, such delays can simply frustrate potential developers such that they abandon the effort.

No state lands have been put up for bid since 1975. Many state leases are expiring and they cannot be renewed if they are not producing. Legislature is needed to change the lease terms from five to ten year term before the State Land Office can announce further sales.

Technology - There are no apparent major constraints to geothermal development arising from technology deficiencies. What could be a problem, however, is that sufficient amounts of the necessary equipment and services might not be available. This includes drill rigs, pipe and other hardware , plus the skilled workers to build and operate the equipment. Furthermore, an increased demand could in the future increase geothermal development costs such that geothermal energy is still not competitive.

Environmental Reports - The most commonly voiced complaints by developers is the repetitive requirements for environmental statements and plans of operation from companies for each step of exploration drilling.

System Development - Although industry is undertaking high-temperature geothermal development, currently no formalized system for low-temperature geothermal development exists in New Mexico. Technicians in numerous fields are evaluating resources, potential uses and constraints, and potential users are exploring geothermal applications in various industrial and agricultural processess. Communities are planning establishment of district heating systems. But for a commercial geothermal energy industry to develop, in this as in any other commercial venture, able and determined enterpreneurs must see and then seize the opportunity to make a profit. Few people are aware of the potential of the resource, know how to use it, and have the necessary funds to develop it.

Water Resources and Water Rights - Concern exists throughout the entire western region of the U.S. over the affect that the withdrawal of geothermal waters will have on existing water tables used for agricultural, municipal and other purposes. Temporary draw-down of local water tables by temperature gradient holes has been reported, for example in Utah. The geothermal industry maintains that its deep wells for electrical power production extend far below the depths of municipal and agricultural wells and into entirely different aquifers, but the potential for legal disputes over water rights continues to exist wherever any part of a geothermal installation touches surface waters or aquifers which supply surface waters.

The availability of water will be a major consideration in New Mexico as in other western states. Most projects will need to avoid excessive consumptive use of water. Heat exchangers can be of help where practicable, as can reinjection of the fluid.

Some of these conditions are now limiting geothermal development. Others are possibilities that may or may not occur in the future. Some conditions are controlled by the federal government, some by the energy industry, some by potential users and potential enterpreneurs, others by the physical attributes of the sites. The U.S. Department of Energy, Geothermal Resources Division, is making a concentrated effort to find ways to relieve

CONSTRAINTS TO GEOTHERMAL DEVELOPMENT

Several conditions have constrained geothermal development in New Mexico. Among the most prominent are federal regulations and procedures for leasing and permit approval and the lack of financial incentives. Other conditions may limit development in the future. Among these are state water policy and laws. Probably the most restrictive constraint, though, is the lack of a system for delivery of geothermal energy for direct use. The following describes these factors working against geothermal development interests in New Mexico.

ECONOMICS

Basically, geothermal development is a costly and "high risk" effort. The actual development of this resource is still in its initial stages in many respects. Locating geothermal resources is not an easy task and, when the reservoirs are located, the development of them involves a high investment risk.

The current tax structure provides no incentives for the encouragement of geothermal exploration.

Financing of geothermal projects can be a serious problem, even though a number of uses are economically feasible, barring retrofitting. Small communities or small business often lack funds to cover substantial front-end expenditures. Lenders may be reluctant to risk funds on innovative or untested projects. In some western states, bond issues are frequently defeated because of the reluctance or inability of taxpayers to become more heavily obligated. In fact, many communities in New Mexico with limited staffs may be severely limited in their ability even to prepare applications for federal grants.

Leases and permits - One severe constraint is the inability of developers to obtain the necessary leases. The checker-board pattern of leases puts many companies in poor land positions for exploration. Many of the companies have explained that unleased land adjacent to leases inhibits exploration. Such open land might be leased by competitors taking advantage of tests on the adjacent leased and explored land. Many resource areas look promising but further exploration is being held up until the adjacent land is leased.

Even if all other conditions are favorable, without leases to protect the company's investment, no development can proceed. In New Mexico, leases on national forest lands are needed in the Santa Fe and Gila districts. Applications for leases on national forest lands have been pending since 1974. In light of the failure of the Forest Service to aid in the issuance of leases, it seems probable that their goals conflict with the goal of acceleration of geothermal development. The problem may well be one of conflicting legislative mandates, which can only be resolved legislatively.

Obtaining permits for geothermal operations on federal lands is sometimes a long and tedious process. Such delays can cause investment funds to be

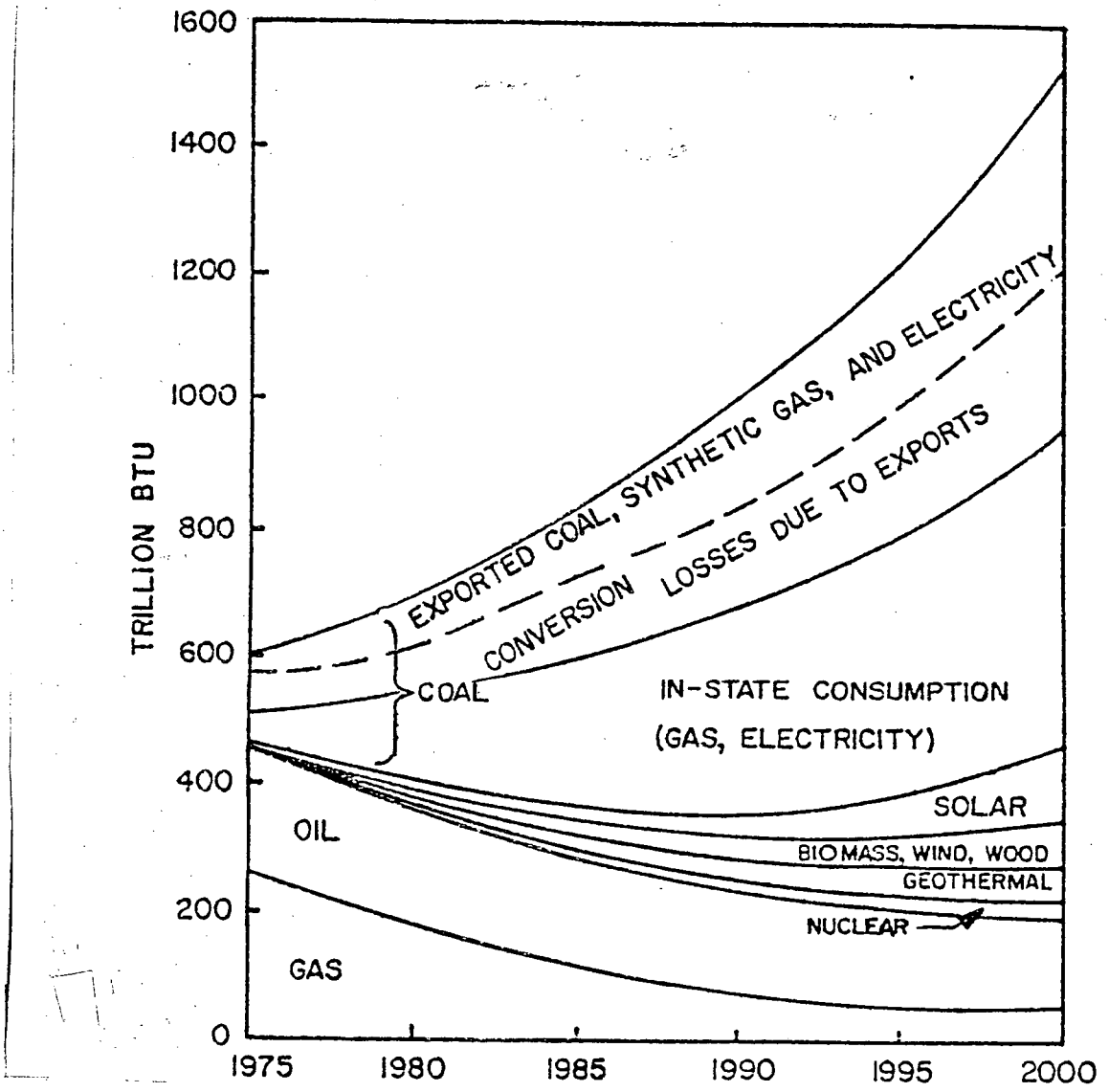


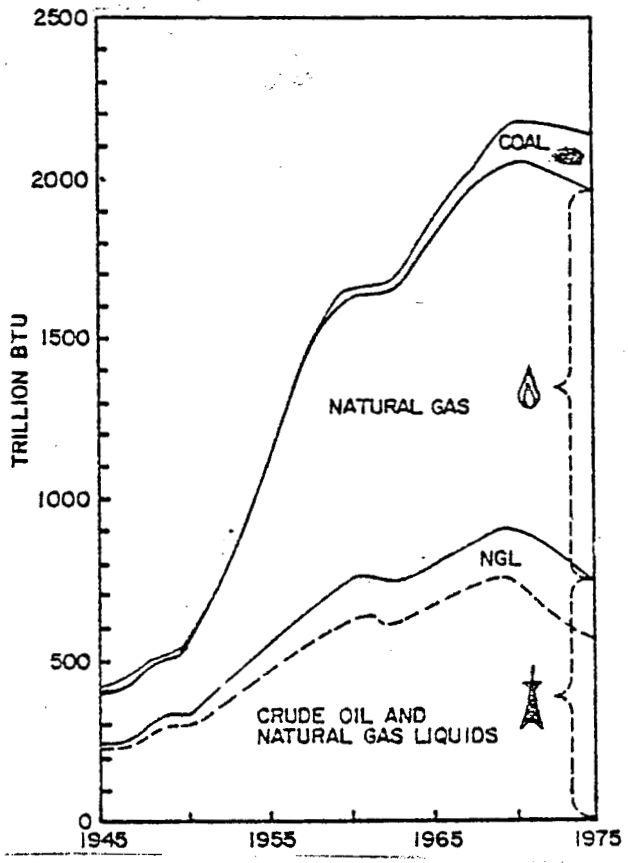
FIGURE 20

Energy consumption in New Mexico by supply source to the year 2000 (including coal export)

Source: Lumsdaine & Lumsdaine,

NMEI 14, 1978

Figure 18. Total New Mexico Energy Production



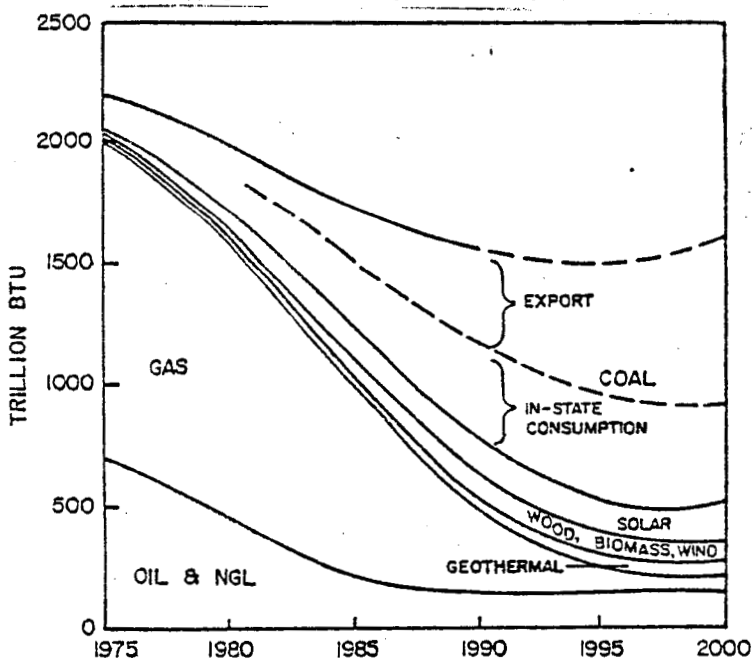


Figure 19. Estimated Future New Mexico Energy Production

STATE OF NEW MEXICO ENERGY SUMMARY

The State of New Mexico exports much more energy than it uses. Large quantities of uranium, oil, natural gas, and some coal are exported annually. Natural gas is currently the primary fuel used by the industrial, residential, and commercial sectors of the state.

New Mexico's industrial sector is relatively small however, it is the largest energy-using sector in the state, accounting for 35% of the total state energy consumption. Approximately 30% of the state's industrial energy consumption goes to the food and kindred-products industry, the wood and lumber industry, and the stone, clay, and glass industry.

The residential and commercial sectors combined are responsible for approximately 25% of the state's energy consumption. Due to the wide range of climates in New Mexico, space conditioning requires air conditioning as well as space heating, space conditioning accounts for approximately 50% of the residential commercial energy requirements.

The Energy Information Administration's recently published annual report estimates that the southwest United States will experience an approximate 2.7% increase per year in energy consumption. This normalized percentage increase will approximately double the New Mexico 1975 energy use by the year 2000.

FIGURE 17

NEW MEXICO ENERGY CONSUMPTION

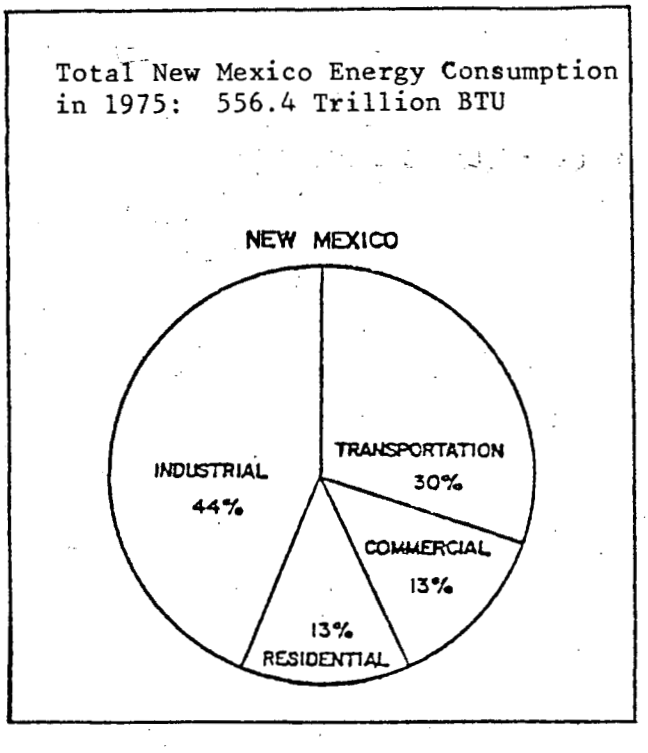


Table 18

Composite Scenarios for Geothermal Power Generation in New Mexico

Site	Total MWe	80	82	84	86	88	90	92	94	96	98	2000	02	04	06	08	10	12
Animas	100				20	20	100	100	100	100	100	100	100	100	100	100	100	100
Kilbourne	50				10	25	50	50	50	50	50	50	50	50	50	50	50	50
Lower San Francisco	20						15	20	20	20	20	20	20	20	20	20	20	20
Radium Spring	30					5	30	30	30	30	30	30	30	30	30	30	30	30
Valles Caldera	2000		50	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500
Cumulative Total			50	100	230	350	595	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700

Table 17

Composite Scenarios for Direct Utilization of Geothermal Resources in New Mexico

Site and Activity	Total MWth	78	80	82	84	86	88	90	92	94	96	98	2000	02	04	06	08	10	12	14	16	18
Socorro Spg. (Campus heating	30					10	20	30	30	30	30	30	30	30	30	30	30	30	30	30	30	20
Kilbourne Hole (Las Alturas & Anthony; Space Heating, Crop Drying, etc.,)	50					20	40	50	50	50	50	50	50	50	50	50	50	50	50	50	50	30
Radium Spg. (Green houses, Crop dehydration)	50					20		50	50	50	50	50	50	50	50	50	50	50	50	50	50	30
Jemez Spg. (Space heating, Agriculture)	60	3	3	3	23	43	60	60	60	60	60	60	60	60	60	60	60	60	57	57	37	17
T or C (Space heating, recreation)	30	2	2	2	30	30	30	30	30	30	30	30	30	30	30	30	30	30	28	28	28	
San Ysidro (Space heating)	20						20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Animas (Space heating, green houses)	40	2	2	22	40	40	40	40	40	40	40	40	40	40	40	40	40	40	38	38	18	
Albuquerque	50					20	40	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Cumulative Total		7	7	27	93	193	290	330	330	330	330	330	330	330	330	330	330	330	323	323	313	237

POSTULATED SITE DEVELOPMENT SCHEDULE
VALLES CALDERA

WBS 7001

OPERATING ENTITIES	ACTIVITY	1977	1978	1979	1980	1981	1982	1983	1984	1986	1990	1995	2000	2020
State, PSC	Process EIR (Transmission Line)			———	———									
Producer	Development Drilling				———	———	———							
Utility	Plant Construction					———	———	———						
Utility	Initial Power Line (16Km)					———	———	———						
Utility	Power on Line (55MW)							•						

Possible Subsequent Additions (MWe) and On Line Date: 100-1986, 100-1988, 100-1990, 100-1991, 100-1992, 100-1993, 100-1994, 100-1995, 100-1996, 100-1997, 100-1998, 100-1999

Table 16

POSTULATED SITE DEVELOPMENT SCHEDULE
VALLES CALDERA

WBS 7001

OPERATING ENTITIES	ACTIVITY	1977	1978	1979	1980	1981	1982	1983	1984	1986	1990	1995	2000	2020
State, Owner County	Issue Permits -- Exploration, Drilling of T.G. holes													
Owner, State	Lease Land													
Developer	Preliminary Geophsical Exploration		COMPLETED											
Developer	Exploratory Drilling and Reservoir Evaluation													
Developer	Develop Utility Interest													
Developer & Utility	Feasibility Study													
Developer & Utility	Financial Negotiations	—	—											
Developer & Utility	Prepare and submit proposal to DOE	—												
Developer & Utility	Site Selection		—											
Developer & Utility	Design		—	—										
Developer & Utility	Commitment to Development		•											
Developer & Utility	Prepare Environmental Data Statement		—	—										
State, PSC	Certify Plant & Site, Issue Permits			—	—									
State	Process EIR (Drilling)			—	—									
State, PSC	Process EIR (Plant)			—	—									

The firm estimates they have encountered 2.5 million acre feet of high temperature (500° - 600°F) hot water and steam that could support a 400 MW generating plant for a 30 to 35 year period. They propose to develop with others a system with additional wells that would utilize the steam portion, about 35 percent of the resource, to drive generators to produce electricity.

30.4 Serious Development Problems

The narrow stripes of federal leased land on the periphery of the Baca Location NO. 1 really does not offer much development opportunity and developers don't have any flexibility in exploration.

Union Oil and PNM will have to prepare and submit an Environment Impact Statement to DOE. The whole review process by DOE on the EIS will then take 13 months. Although a DOE grant is given for the demonstration power plant program to Union Oil, no money will be allocated until December 1979, when the EIS is completely reviewed with satisfaction.

Negotiation for transmission line right-of-way through National Forest land is being handled by PNM, who has had prior dealings with the Forest Service, and a good reputation for doing a careful job. The transmission line will handle at least 250 MW and possibly up to 400 MW.

The plant will use the Stretford process, in which hydrogen sulfide is oxidized to sulfur and water to capture 90% of the hydrogen sulfide in the steam and water. The escaping 1% will, hopefully, not exceed the one hour average of three parts per billion standard. The hydrogen sulfide content of the steam - water is considerably less than at the Geysers, in California, where the allowed emission is 30 ppb. The need for a permit to operate is over two years away, so there is time to evaluate and solve the problem before the plant goes on line.

30.5 Development Scenario

Development is in the advanced stage; the schedule presented here starts with the present stage, in which additional wells are being drilled and financial arrangements are being made to fund construction of the generating plant.

Further plant designing is taking place, particularly pipeline transportation. Construction of plant should begin in 1980.

Site Location: T.19N., R.2E. Redondo Creek

Latitude: $35^{o}53'$N. Longitude: $106^{o}35'$W.

County: Sandoval

Land Ownership: Private - Federal

Land Use: Ranching and timber

Description of KGRA: T. 18, 19, 20, 21, N., R. 2, 3, 4, 5, 6, E. Totaling 168,761 acres

Leasing Status: Approximately four townships of the KGRA lie within the Baca Location #1.

Approximately three townships lie on the flanks of this privately owned area.

NOTE: The Redondo steam field, developed and operated by Union Oil Company of California, is all located within the Baca Location No. 1, privately owned land. On the flanks of the fee land leases awarded in competitive federal sales are held by:

Amax	10,054 acres
Phillips	5,090 acres
Aminoil	10,483 acres

These leases were issued in late 1977 and early 1978.

30.3 Development Status and Activity

This geothermal field has the greatest proven reserves of any in the state. It has been developed over a period of several years by the Union Oil Company and today has ample proven reserves to run the 50 MW plant proposed to be on line by 1982.

Union Oil and Public Service Company of New Mexico have formed a partnership with a $50 million grant from DOE to build a demonstration power plant using the steam - hot water resource to produce electric power. Union Oil and PNM will contribute $25 million each into the project.

Union Oil Company has much experience in the commercial development of California's Geysers Geothermal Field. In New Mexico, it is an operator for a group including itself, Dunigan Enterprises, Inc. and Baca Land and Cattle Company, owners of an extensive private land grant encompassing virtually all of the 12 mile diameter volcanic crater, the group has drilled 17 geothermal steam wells. Of these 17 wells, six are producing wells and three are reinjection wells. Starting in June, 1978, three more wells will be drilled in the Redondo Creek field. The wells range in depth from 6,000 to 9,000 feet and cost up to $1 million each to complete.

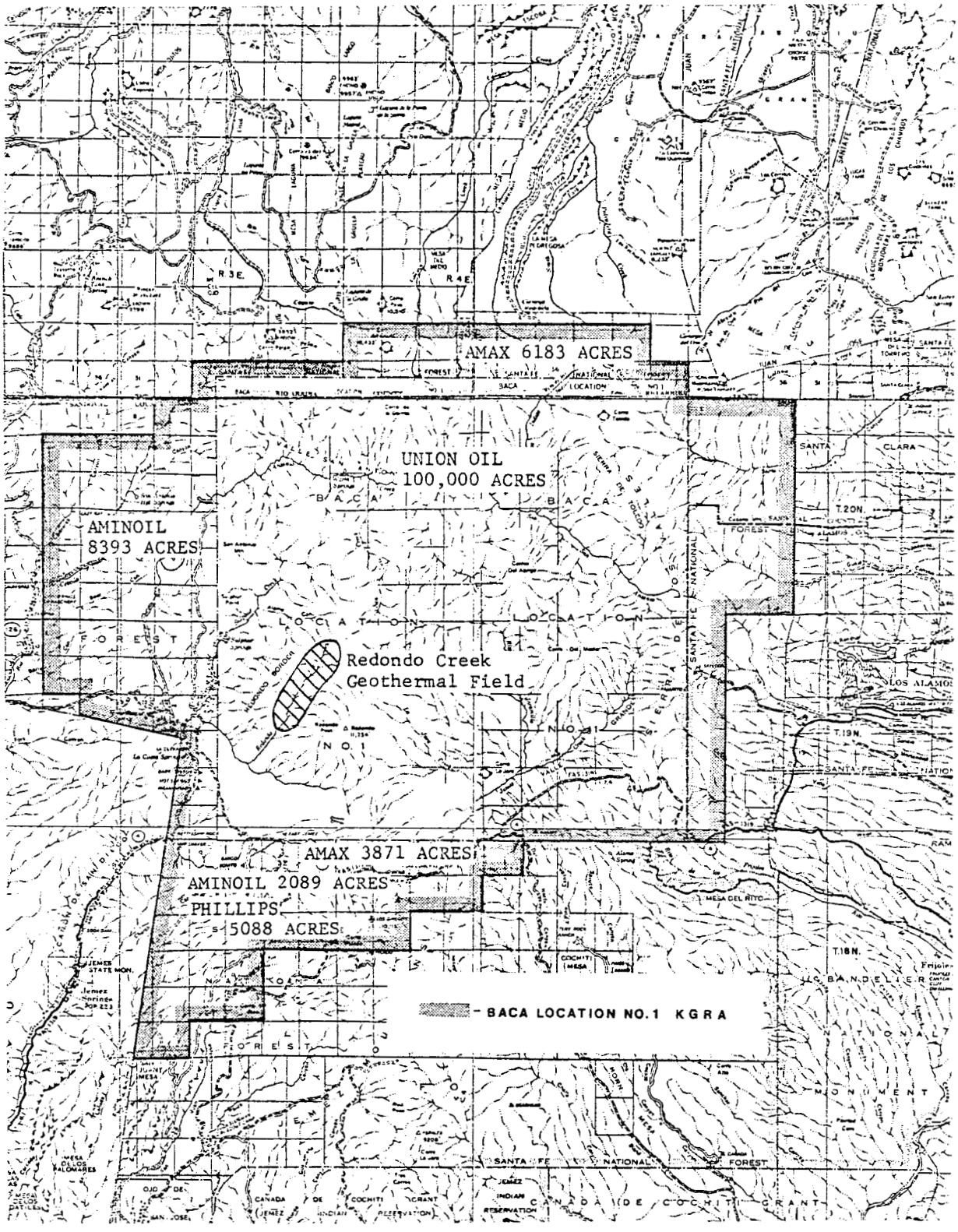


Figure 16. Valles Caldera Geothermal Resource Area

VALLES CALDERA WBS 7001

General Description

The Valles Caldera is a large extinct volcanic structure that comprises the central portion of the Jemez Mountains in North Central New Mexico. It is about 14 miles in diameter. The communities of Los Alamos, White Rock, and Jemez Springs are located on the flanks of this caldera. These communities have a combined population of about 20,000. With the exception of Donigan's Baca Ranch, the caldera area is nearly uninhabited.

Numerous hot springs occur in the area and the United States Geological Survey has designated this area as the Baca Location No. 1 KGRA. This geothermal resource has a large heat capacity in both hot, dry rock and hydrothermal systems.

The Los Alamos Scientific Laboratory has created much interest with their hot dry rock experimental facility at Fenton Lake which is a few miles southwest of the caldera rim. The Federal Government has asked LASL to investigate the possibilities of geothermally heating the lab building in Los Alamos.

The most significant industrial activity to date is that being conducted by Union Oil Company. This company has developed wells in the Redondo Creek area which has rugged topography and is relatively secluded. The hills surrounding the valley are heavily timbered and have an elevation of about 9000 feet.

The field is the one geothermal energy source in the state that is certain to become a producer of energy. An electric generating plant is to be build there, designed to produce about 50,000 kilowatts. This energy will be sent out by wire to the east, to tie to the network in the vicinity which supplies electricity to cities like Santa Fe and Albuquerque. Plans are to have the plant on line in 1982.

30.2 Resource Characteristics - VALLES CALDERA

Surface Fluid Temperature: 88°F in Spring in Sulfur Creek nearby to the West

Subsurface Fluid Temperature: 260-315°C

Total Dissolved Solids: 7000 ppm

Estimated Energy Potential: Identified: 400 MW for 30 years
Inferred : 1,942 MW for 30 years

Type of Overlying Rock: Tuff, Rhyolite

Estimated Depth from Top of Reservoir: 1,000 feet (+) below surface

Estimated Size of Reservoir: 130 km^3 - one mile wide and 1 3/4 mile long (60 cubic miles)

30.3 Development Status and Activity

Bill Chowning, owner of Yucca Lodge in T or C, has rigged up his own space heating system, using refrigeration coils. Water is taken from the hot pool at approximately 108°F, pumped at about 10 psi through the system. It has a fan behind to help distribute heat. Heat is very even and comfortable. Pumping rate is approximately 1½-3 gpm/unit.

There are 10 to 12 thermal wells within a 120 acre hot spot located within town, which could be used for space heating. There have been no corrosion problems with the water in piping. Water contains about 2700 ppm of dissolved solids.

30.4 Severe Development Problems

The townspeople seem to lack interest in developing and using the resource. Evidently they are satisfied with the present heating system with natural gas.

30.5 Development Scenario

Potential for geothermal space heating may be adequate for the town. A recent thesis (UNM) gives an understanding of the geology that will aid in locating a drilling site for a hold that will evaluate porosity, heat flow and water volume. The resulting information will help in deciding on the next step in development. Perhaps a test can be started early next year (1979).

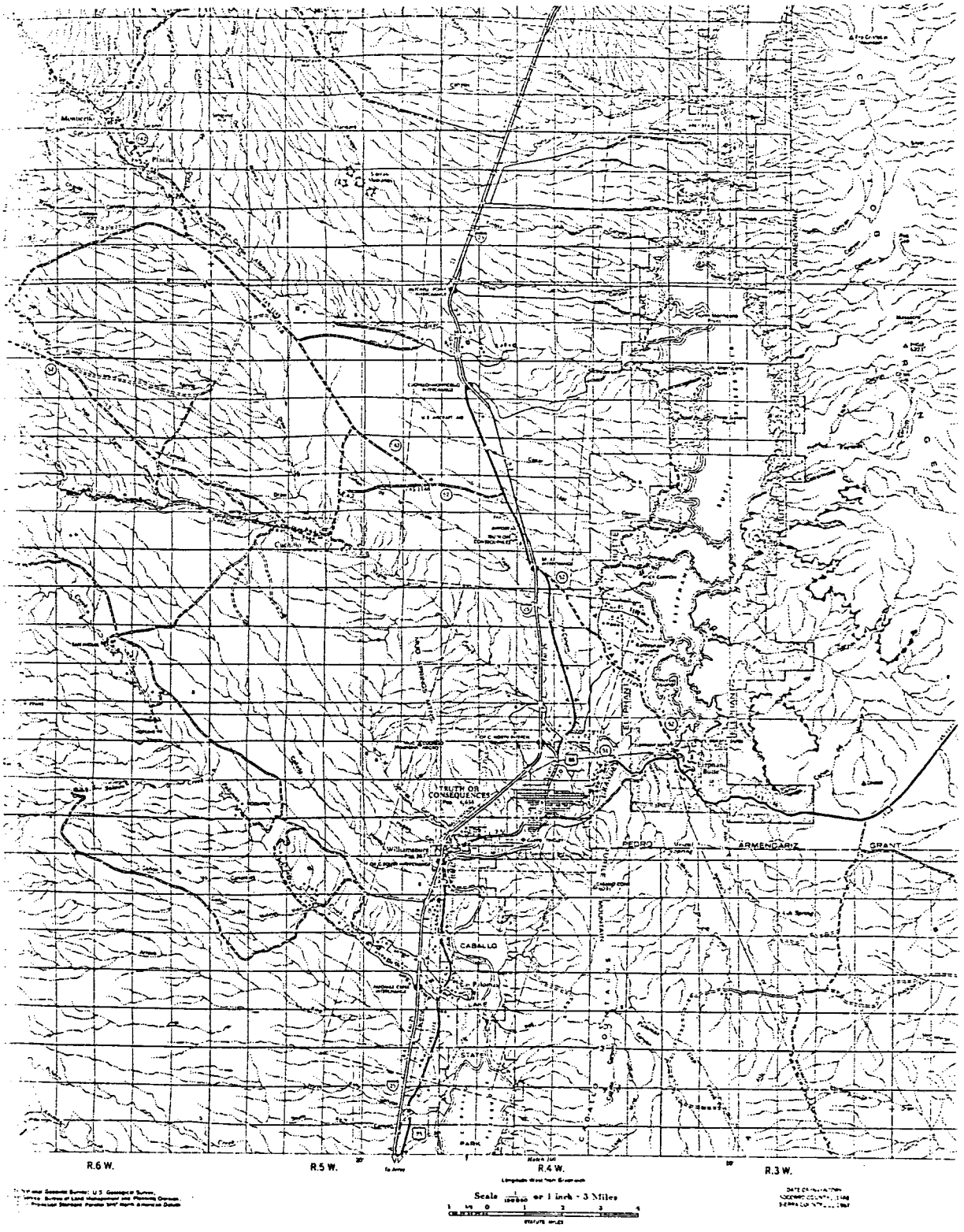


Figure 15. Truth or Consequences Geothermal Resource Area

TRUTH OR CONSEQUENCES WBS 7024

General Description

The Truth or Consequences thermal area occurs along the west side of the Rio Grande River between the northwest-trending Mudsprings Mountain and the Sierra Caballos. The thermal waters apparently occur entirely with T or C. This town has the largest collection of hot springs and wells in the state which resulted in extensive development of spas, mineral baths, and resort hotels.

The communities of T or C and Williamsburg have a combined population of about 6,100 and are entirely dependent on natural gas for heating purposes.

Very little study has been conducted of the geothermal potential in this area. Geothermal leasing of state and federal lands is insignificant. Presently, the general populace does not seem to be receptive towards new potential use and development such as space-heating.

30.2 Resource Characteristics - TRUTH OR CONSEQUENCES

Surface Fluid Temperature: $36^{o}C$ - $46^{o}C$

Subsurface Fluid Temperature: $100^{o}C$

Total Dissolved Solids: 2500 ppm

Estimated Energy Potential: 114.75 X 1015 calories

Type of Overlying Rock: Alluvium and valley fill underlain by Paleozoic Magdalena limestone

Estimated Depth from Top of Reservoir:

Estimated Size of Reservoir:

Site Location: T13S, R4W including city limits of T or C

Latitude: $33^{o}09'$ Longitude: $107^{o}15'$

County: Sierra

Land Ownership: Private residential and commercial property

Land Use: Residential and commercial use

Description of KGRA: None

Leasing Status:

STATE GTR 155 T13S R4W Deuterium Geothermal (this firm is now defunct)
Sec. 16

Table 15

POSTULATED SITE DEVELOPMENT SCHEDULE
SOCORRO

WBS 7055

OPERATING ENTITIES	ACTIVITY	1977	1978	1979	1980	1981	1982	1983	1984	1986	1990	1995	2000	2020
Developer	Conducts casual reconnaissance exploration		—											
BLM, State	Leases Land		—											
USGS	Makes Environment Assessment		—											
USGS, State	Approves Plan of Operation and issues permit to explore		—											
Developer	Conducts geophsical work and drills T.G. holes		—											
USGS	Makes EA for drilling deep exploratory wells			—										
USGS, State	Gives permission to drill			•										
Developer	Drills deep exploratory well			—	—									
Developer	Conducts Feasibility Study			—	—	—								
Developer	Water rights application with State Engineer				—									
USGS	Makes EA for development				—	—								
	Gives permission to develop					•								
Developer	Drills development wells and runs production tests					—	—	—						
USGS	Approves plan of operation						—	—						
Developer/User	District Heating System Installed							—						
Developer/User	Space Heating on line							•						

30.4 Severe Development Problems

Many of New Mexico Tech staff members are opposed to geothermal development of any kind due to "environmental problems" and will not accept any trade-offs with their environmental quality.

Type of Overlying Rock: Volcanic breccia

Estimated Depth from Top of Reservoir:

Estimated Size of Reservoir: Assumed 2.25 km^3

Site Location: R1, 2, 3W and R1E and T1, 2, 3, and 4S

Latitude: $34^{o}2'$ Longitude: $106^{o}56'$

County: Socorro

Land Ownership: 50% - Spanish Land Grant of Socorro
30% - State
20% - Federal

Land Use: Cattle Grazing and Municipality Zoned

Description of KGRA: 89,715 acres in R1, 2W and R1E and T2, 3, and 4S

Leasing Status:

STATE

Gulf Oil	1,820 acres
John Kelly	2,720 acres
J.W. Covello	160 acres
Deuterium Geo.	480 acres

FEDERAL

Sunoco Energy Development Co.	2,565 acres
Wright, Hoover H.	1,920 acres
Wright, Hoover H.	1,489 acres
Wright, Hoover H.	1,914 acres
Aminoil USA, Inc.	2,390 acres
Aminoil USA, Inc.	662 acres
Aminoil USA, Inc.	2,047 acres
Aminoil USA, Inc.	1,920 acres
Sunoco Energy Development Co.	2,073 acres

30.3 Development Status and Activity

A considerable number (7) of geological and geophysical studies have been conducted near Socorro by the New Mexico Tech academicians. In light of this, geothermal heating of the NMIMT campus is being considered seriously. Although no actual drilling has been made, a slim-hole drilling and analysis is anticipated in early 1979. Lease state lands have been extensively explored and federal lands were just recently leased. Nearly all the interested companies have completed preliminary geophysical exploration studies. Sunoco is drilling five temperature gradient holes, 500 feet to 1500 feet during the summer of 1978 and has completed 23 others. Phillips completed 8 T.G.

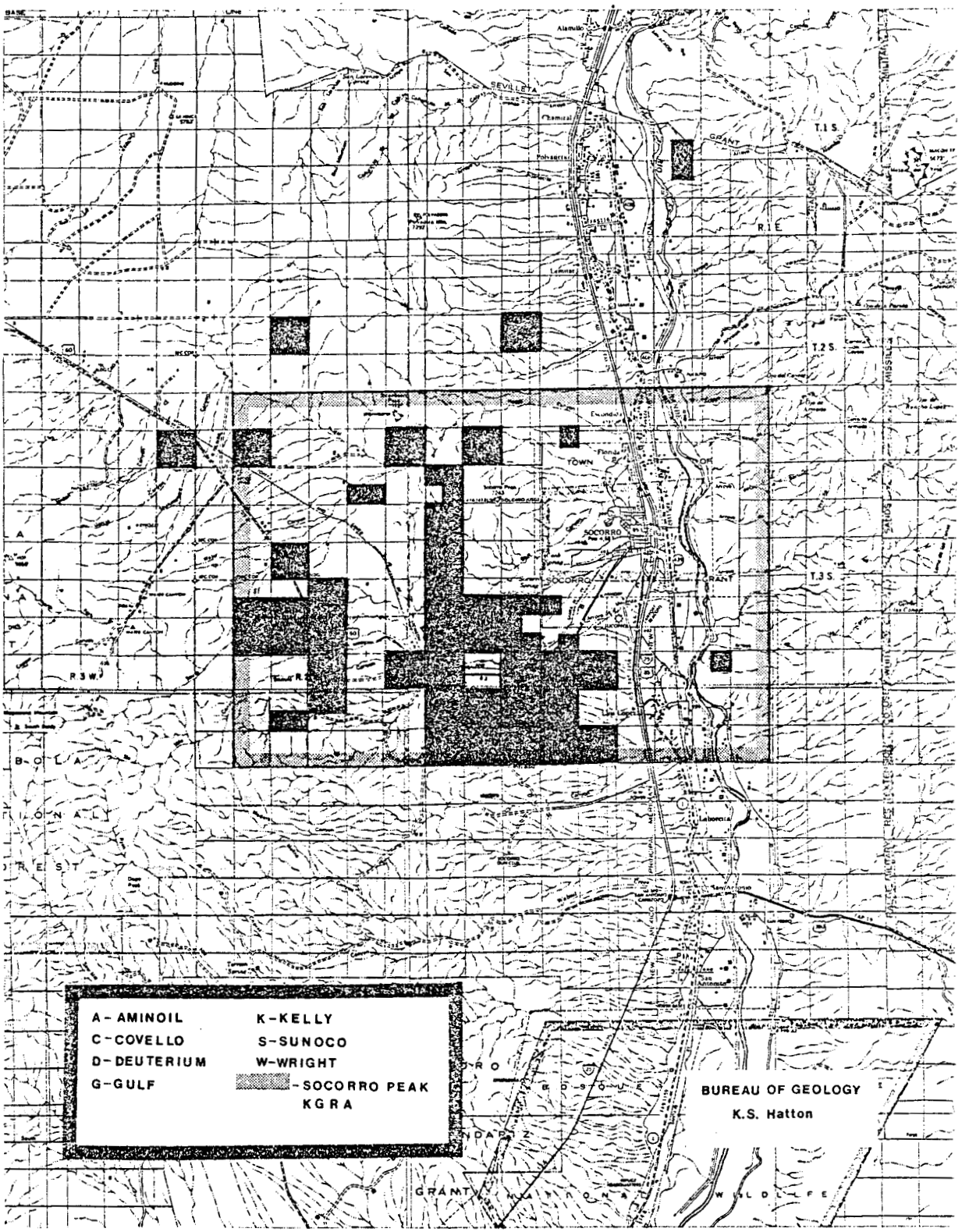


Figure 14. Socorro Geothermal Resource Area

SOCORRO WBS 7005

General Description

The Socorro geothermal area is located in the Rio Grande Valley about 75 miles south of Albuquerque. Discovery of economic sources of geothermal energy in this part of New Mexico would benefit the communities of Socorro San Antonio, Luis Lopez, Florida, Escondida, Polvadera, Lemitar, San Acacia, and Alamillo which have a combined population of about 8,000. A shortage of natural gas in Socorro, by far the largest community in the area, has lead to restrictions on its use, particularly in new residences. Thus the development and use of goethermal energy would have an important effect on the economic development of the region.

The United States Geological Survey has designed 89,715 acres surrounding Socorro as a Known Geothermal Resource Area (KGRA). Most of the scientific data indicating this region has promise as a geothermal resource has been obtained over the past decade by investigators at New Mexico Tech which is located in Socorro. With the possible exception of the KGRA in the Jemez Mountains near Los Alamos, the Socorro KGRA is the most thoroughly investigated geothermal area in the state.

There are three springs in the area that discharge warm waters along a north-trending fault which separates the Socorro Peaks from the Rio Grande Valley. Their temperatures range from 66°F to 112°F.

Perhaps because of the extensive geological and geophysical studies near Socorro, the geothermal industry has shown considerable interest in the area. To date, 6,694 acres of state land and 11,657 acres of federal land have been leased. Some of the major companies that hold leases and/or have active exploration programs in the area are Sunoco, Aminoil, Gulf and Chevron. One company, Sunoco, has started a program of moderately deep drilling, 500 feet to 2000 feet, to test the geothermal potential of the region.

Engineers and geoscientists at New Mexico Tech are investigating the possibility of developing low-grade geothermal energy for campus heating. Drilling of test holes is planned within a year after investigation of some of the possible environmental problems associated with the development of geothermal energy near the campus community.

Source: Al Sanford, New Mexico Institute of Mining Technology

30.2 Resource Characteristics - SOCORRO

Surface Fluid Temperature: 34°C

Subsurface Fluid Temperature: 72°C

Total Dissolved Solids: Approximately 100 ppm

Estimated Energy Potential: Indicated: 7 MW thermal for 30 years
Inferred : 15 MW thermal for 30 years

Land Use: Hot Springs bathing area

Description of KGRA: Three sections in T.15N., R.1E. - 1915 acres

Leasing Status: Much of the land, about 10,000 acres, which has been filed on has been withheld from leasing because it is considered a scenic area of special value. Anshutz and Hunt are appealing this decision.

Cherokee and Pittsburg Coal and Mining Company holds 1920 acres in the area.

Thermal Springs and wells six miles to the north are on Inidan land. Leasing and exploration on Indian lands must be arranged with each Pueblo individually.

Occidental Geothermal has filed for 5073 acres in May, 1978.

30.3 Development Status and Activity

The KGRA consists of three sections in T.15N., R.1E., but much of the not spring activity is about six miles to the north in T.16N., R.1E. and 1 W.

Two oil tests were drilled in this northern area in 1926 on the Rio Salado Anticline, which lies within the Zia Indian Reservation. One of the wells, the Kaseman No. 2, flowed warm water and has been used as a source of hot water for the Warm Springs Bathhouse, located nearby.

No requests to explore in the San Ysidro area have been made. Leases on Indian land are available only through a sale, but there are no plans for such a sale in the near future.

30.4 Serious Development Problems

Obtaining leases on Indian land, which includes most of the area, will be a slow process that might hold up development for several years.

Some lease applications on federal land have been held up because the hot springs are considered to be a unique scenic area.

30.5 Development Schedule

Since little or no exploration has been done in the area and leases on federal and Indian land will be difficult to obtain, no development is predicted for the next five years, at least.

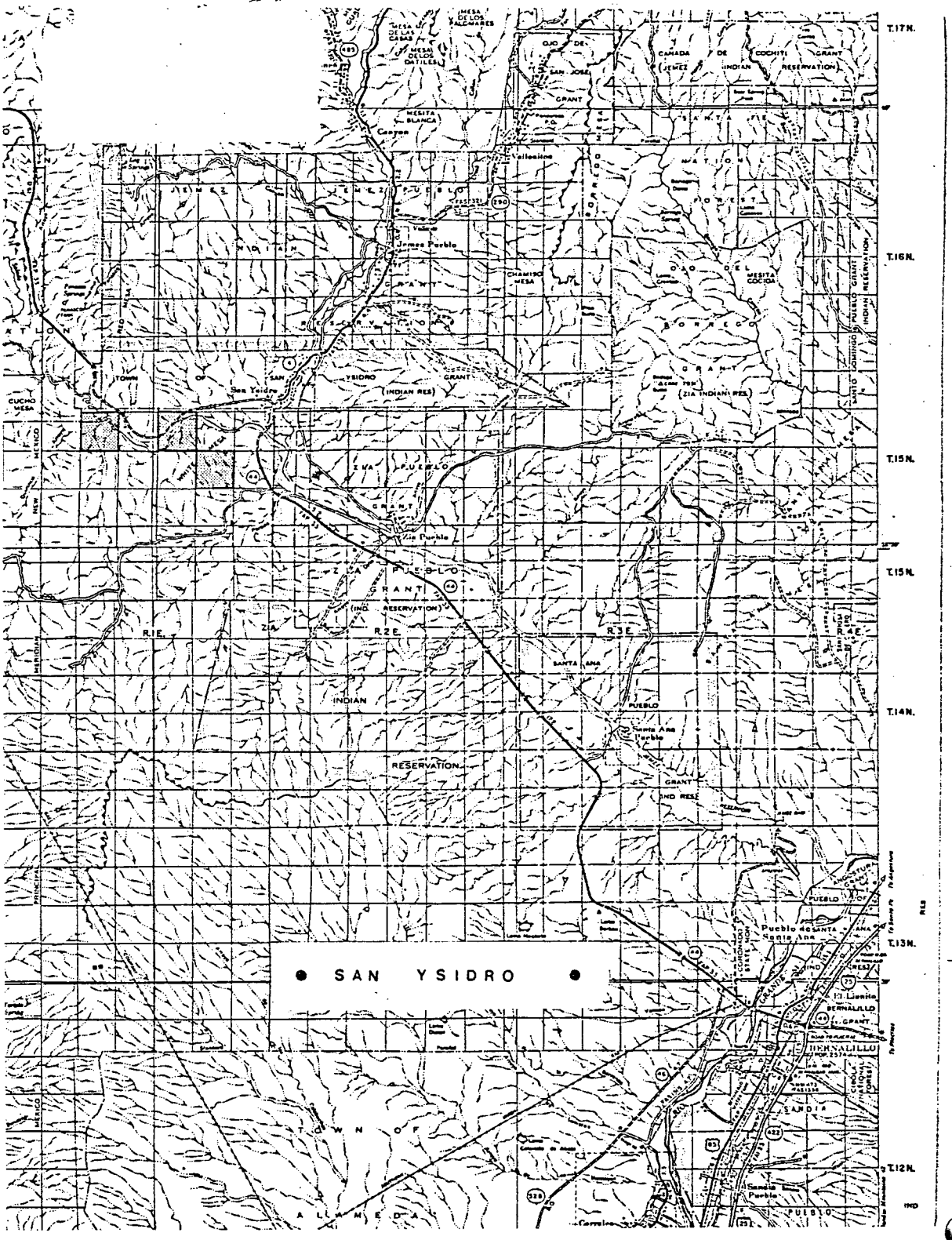


Figure 13. San Ysidro Geothermal Resource Area

SAN YSIDRO WBS 7037

General Description

The San Ysidro geothermal area is located near the Village of San Ysidro at the confluence of the Rio Salado and the Jemez River. Discovery of economic sources of geothermal energy in this part of New Mexico would benefit the communities of Jemez Pueblo, Zia Pueblo, and San Ysidro which have a combined population of about 800.

The populace is heavily dependent on propane gas and electricity for their energy needs. A 115 kv power line by Plains Electric Coop runs through the area.

The United States Geological Survey has designated 5120 acres in the area as a Known Geothermal Resource Area. This is bordered on the north by the Jemez Indian Reservation and on the east and west by the Zia Indian Reservation.

There are several sources of hot wells, springs and warm springs located in the area. Most of these are located on Indian land. Although these springs have been used by the Indians for bathing throughout the years, there is no commercial development and none is planned so far.

The heat capacity of the reservoir is believed to be 23 MW thermal for 30 years and could be sufficient to heat 4550 dwellings for the same time.

Much of the area in which leases have been filed for is being withheld as a scenic area, pending outcome of an appeal. Leasing and exploration, however, is inactive. Leasing and exploration on Indian lands have to be arranged with each Pueblo individually.

30.2 Resource Characertistics - SAN YSIDRO

Surface Fluid Temperature: $50^{o}C$

Subsurface Fluid Temperature: $80^{o}C$

Total Dissolved Solids: 10,000 - 12,000 ppm

Estimated Energy Potential: 23 thermal MW for 30 years
Heat for 4550 dwellings for 30 years

Type of Overlying Rock: Sandstone and shale

Estimated Depth from Top of Reservoir: Unknown

Estimated Size of Reservoir: 2.25 km^3 (assumed)

Site Location: T.15., R.1E./confluence of Rio Salado & Jemez River

Latitude: $35^{o}30'N$ Longitude: $106^{o}40$-5-'N

County: Sandoval

Land Ownership: Mostly Federal and Indian (Zia and Jemez)

POSTULATED SITE DEVELOPMENT SCHEDULE
RADIUM SPRINGS

WBS 7008

OPERATING ENTITIES	ACTIVITY	1977	1978	1979	1980	1981	1982	1983	1984	1986	1990	1995	2000	2020
Utility	Obtains R.O.W. for Powerline							—						
Utility	Plant Construction								——	—				
Utility	Puts power on line									——	——	——	——	

Table 14

POSTULATED SITE DEVELOPMENT SCHEDULE
RADIUM SPRINGS

WBS 7008

OPERATING ENTITIES	ACTIVITY	1977	1978	1979	1980	1981	1982	1983	1984	1986	1990	1995	2000	2020
Developer	Conducts casual reconnaissance exploration	———	———											
BLM, State	Leases Land	———												
USGS	Makes Environment Assessment	———												
USGS, State	Approves Plan of Operation and issues permit to explore		———											
Developer	Conducts geophsical work and drills T.G. holes		———	———										
USGS	Makes EA for drilling deep exploratory wells			———										
USGS, State	Gives permission to drill			———										
Developer	Drills deep exploratory well			———	———									
Developer	Conducts Feasibility Study			———	———									
Developer	Water rights application with State Engineer				———									
USGS	Makes EA for development				———	———								
	Gives permission to develop					———								
Developer	Drills development wells and runs production tests					———	———	———						
PSC	Certifies plant and site						———	———						
	Issue permits							———						
USGS	Approves plan of operation for production							———						

Description of KGRA: 16 sections in upper part of T.21S., R.1W., Totaling 9,812 acres

Leasing Status: Federal leases in the KGRA, obtained by competitive bid held by:

Chevron	1,227 acres
Texaco	1,158 acres
Aminoil	12,354 acres

Hunt filed for lease in 1975 on about 15,000 acres in R.20 and 21S., R.W. The BLM has yet to act on the application, although the EAR has been completed.

30.3 Development Status and Activity

Hunt has completed an electrical resistivity survey and has drilled some temperature gradient holes in the areas. The results are of interest, so Hunt would like to drill some deeper holes in order to verify the trends seen in the shallow holes, but first leases must be obtained.

Chevron has made Magneto - Telluric surveys, a gravity survey and has drilled two temperature gradient holes.

30.4 Severe Development Problems

Hunt filed on approximately 15,000 acres in T.20 and 21S., R.1W., in 1975; the leases have not yet been granted, although the BLM has completed the Environmental Assessment Report on the area. Until the leases are obtained, little further exploration is warranted.

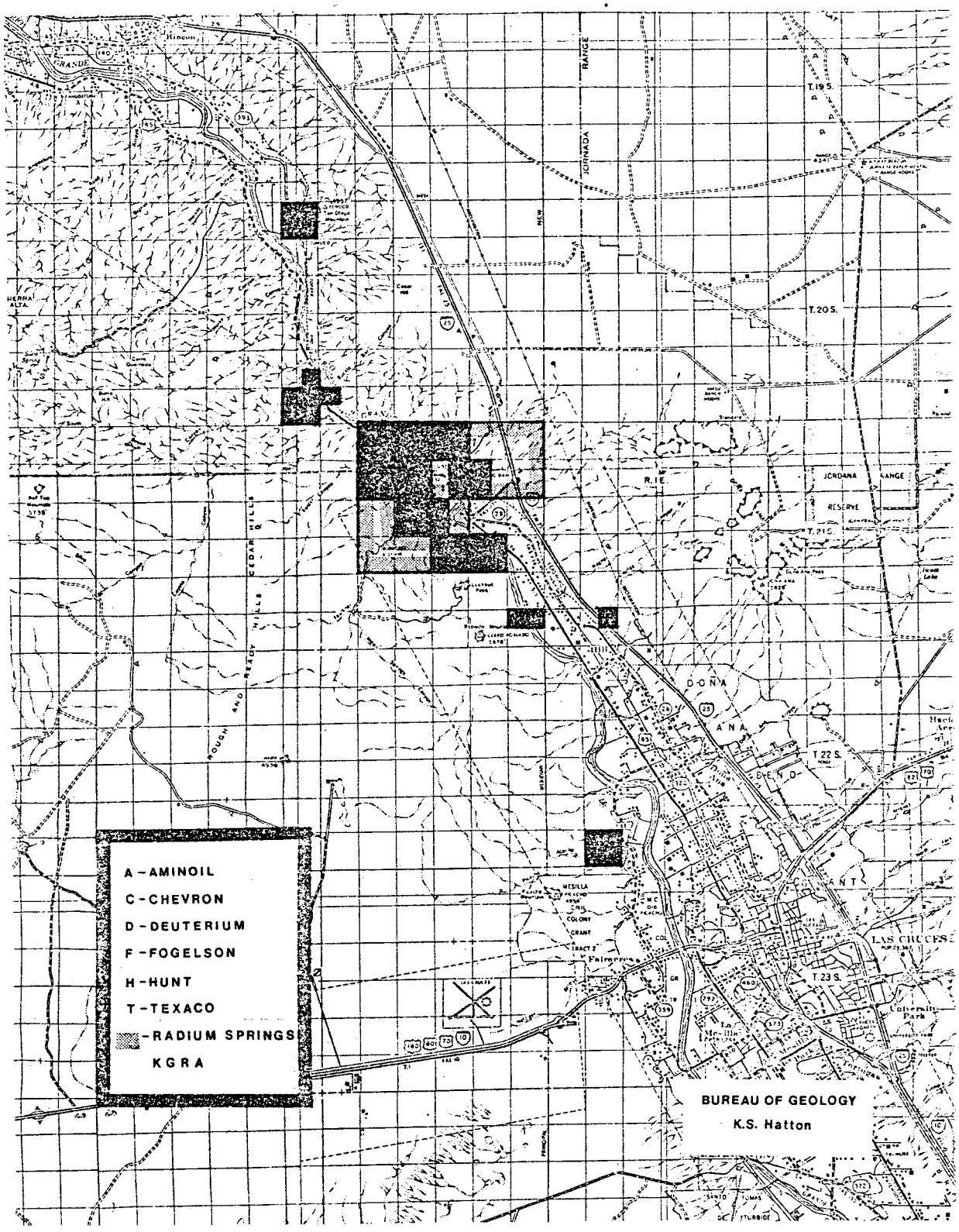


Figure 12. Radio Springs Geothermal Resource Area

RADIUM SPRINGS WBS 7008

General Description

The Radium Springs area is located about 12 miles north of Las Cruces in the Rio Grande Valley. The combined population of the local communities of Radium Springs, Leasburg and Hill is about 1,000. It is to the east of Interstate 25 and includes San Diego Mountain six miles to the north. San Diego Mountains has one of the highest heat flows in the state, indicating a possible shallow hydrothermal system beneath the ground surface.

The Radium Springs Hotel resort has hot springs of temperatures of about 140°F, which is used for bathing and space-heating.

The land in the valley is private but, land outside the valley is state and federal owned. The Radium Springs KGRA, which is centered on the Leasburg Dam, has 9,812 acres.

The potential users of geothermal energy are the area residents who are dependent almost entirely on the extensive agriculture of pecan, onions, chili peppers, and cotton.

Geothermal crop-drying plants could prove very useful here since the energy needs are hampered by limitations on natural gas. El Paso Electric Company conceivably could be the potential utility for geothermal power generation since it has 115 kv line on location.

Chevron is currently drilling temperature gradient test holes in the area.

30.2 Resource Characteristics - RADIUM SPRINGS

Surface Fluid Temperature: 30° - 85°C

Subsurface Fluid Temperature: 130°C - 198°C

Total Dissolved Solids: 3700 ppm

Estimated Energy Potential: Indicated - 41 MW thermal

Type of Overlying Rock: Rhyolite

Estimated Depth from Top of Reservoir: Unknown

Estimated Size of Reservoir: 2.25 km^3 (assumed)

Site Location: T.21S., R.1W., Section 10

Latitude: 32°30'N Longitude: 107°58'W

County: Dona Ana

Land Ownership: State & Federal - some private

Land Use:

Description of KGRA: None

Leasing Status: State GTR 153 T.24N., R.8E., Section 2, A.J. Antweil, 160 acres

Federal application by A.J. Antweil for 7,000 acres surrounding the above state parcel is still pending.

30.3 Development Status and Activity

No leases have been issued, with the exception of one state lease held by A. J. Antweil, and no drilling or exploration has been conducted. Hot Springs are actively used at the resort spa; however, the resort buildings are not geothermally heated, although they could be. The Bureau of Land Management recently has prepared an Environment Assessment Record in consideration of offering public lands for geothermal leasing.

30.4 Severe Development Problems

A.J. Antweil & Company is awaiting action on the federal application for three leases of 7,000 acres in the Ojo Caliente area. After three years, inactivity of the Bureau of Land Management has forced Antweil & Company to postpone preliminary exploration plans. It may be some time (possibly Fall of 1978) before BLM makes a decision based on its recently published EAR. This area is environmentally sensitive in a slight to moderate way.

30.5 Development Scenario

This was developed based on the assumption of federal approval for leasing and exploration.

OJO CALIENTE WBS 7009

General Description

The Ojo Caliente area is located in the Ojo Caliente Valley about 18 miles directly north of Espanola. It consists of moderately rugged country that supports some ranching. The communities consist of La Madera and Ojo Caliente with a combined population of about 500.

Recently, the Bureau of Land Management has selected this area for study for geothermal leasing because industry has shown interest in the area by filing at least three geothermal lease applications. This area is known as the "Ojo Caliente Geothermal Leasing Area." The proposed action is to offer for geothermal leasing about 137,940 acres of public land in Rio Arriba and Taos Counties, New Mexico. The decision based on the final environmental assessment record (to be released in late August) will be made prior to 1979.

There are five hot springs which are owned and operated by Ojo Caliente Mineral Springs Company as a resort spa. Their temperatures range from 90°F to 113°F. A water well located just a quarter mile north reported 132°F at 87 feet depth.

The most reasonable uses of the geothermal resources in the area would be for space heating, greenhouses, or lumber processing plants. If potential occurs for power generation, either Plains Electric Coop or PNM would probably be involved.

30.2 Resource Characteristics - OJO CALIENTE

Surface Fluid Temperature: 113°F 45°C

Subsurface Fluid Temperature: 122°C - 161°C

Total Dissolved Solids:

Estimated Energy Potential:

Type of Overlying Rock: Fractured metarhyolite crisscrossed by pegmtite dikes

Estimated Depth from Top of Reservoir:

Estimated Size of Reservoir: 2.25 cubic km

Site Location: T.24N., R.8E, Section 24

Latitude: 36.31° Longitude: 106.05°

County: Taos

Land Ownership: Primarily private and commercial including: Ojo Caliente Mineral Spring Company

Land Use: Grazing, residential, resort spa

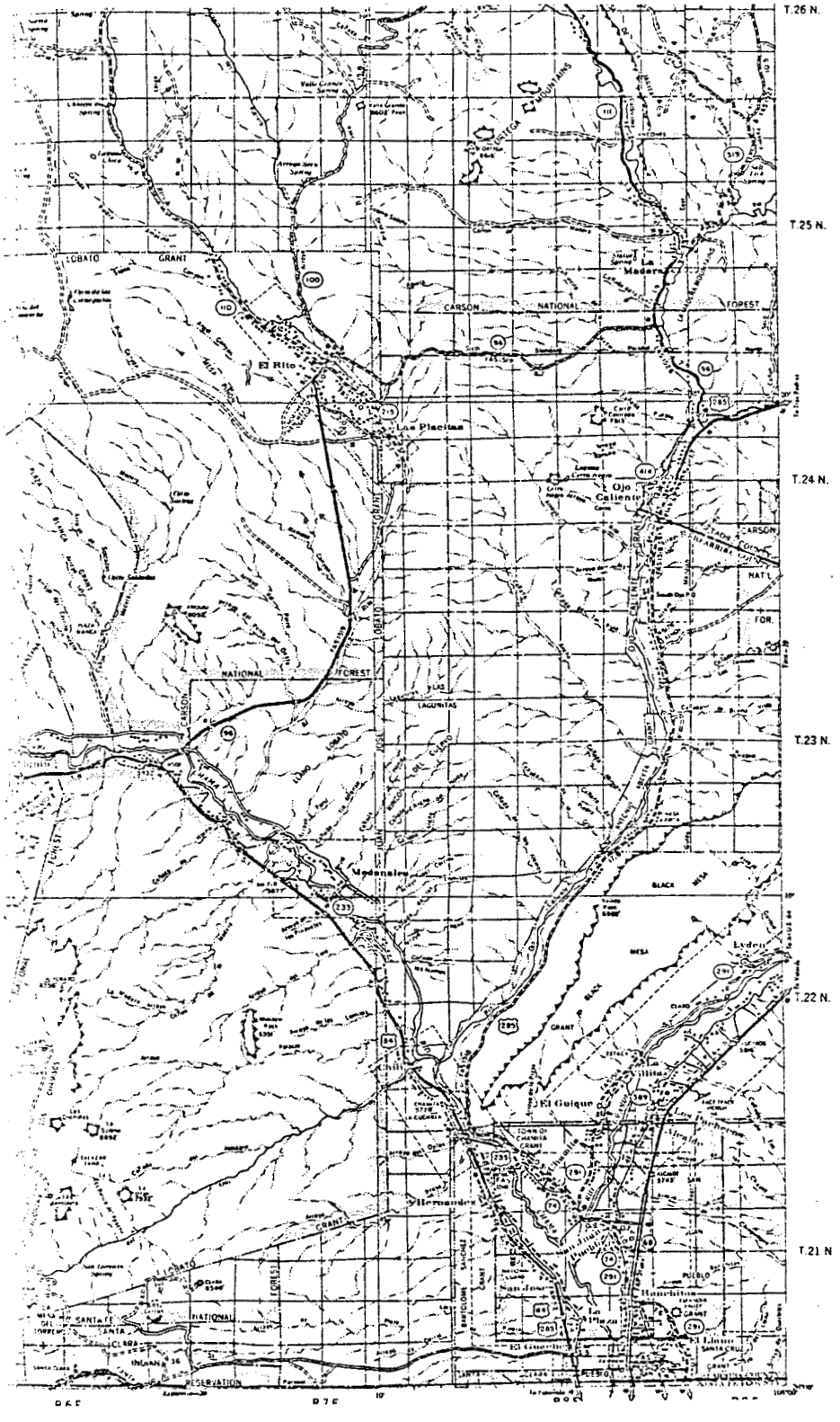


Figure 11. Ojo Caliente Geothermal Resource Area

Description of KGRA: None

Leasing Status: None

30.3 Development Status and Activity

The development in this area is wholly conducted by the state university. A good deal of geophysical exploration has been conducted by some of the NMSU geothermal workers. This includes shallow temperature gradient holes and electrical resistivity tests. The feasibility study for campus space-heating accelerated this spring and verification drilling will begin soon.

30.4 Severe Development Problems

None anticipated.

30.5 Development Scenario

This area is a candidate for the state geothermal space heating demonstration program which provides a state fund of $200,000.

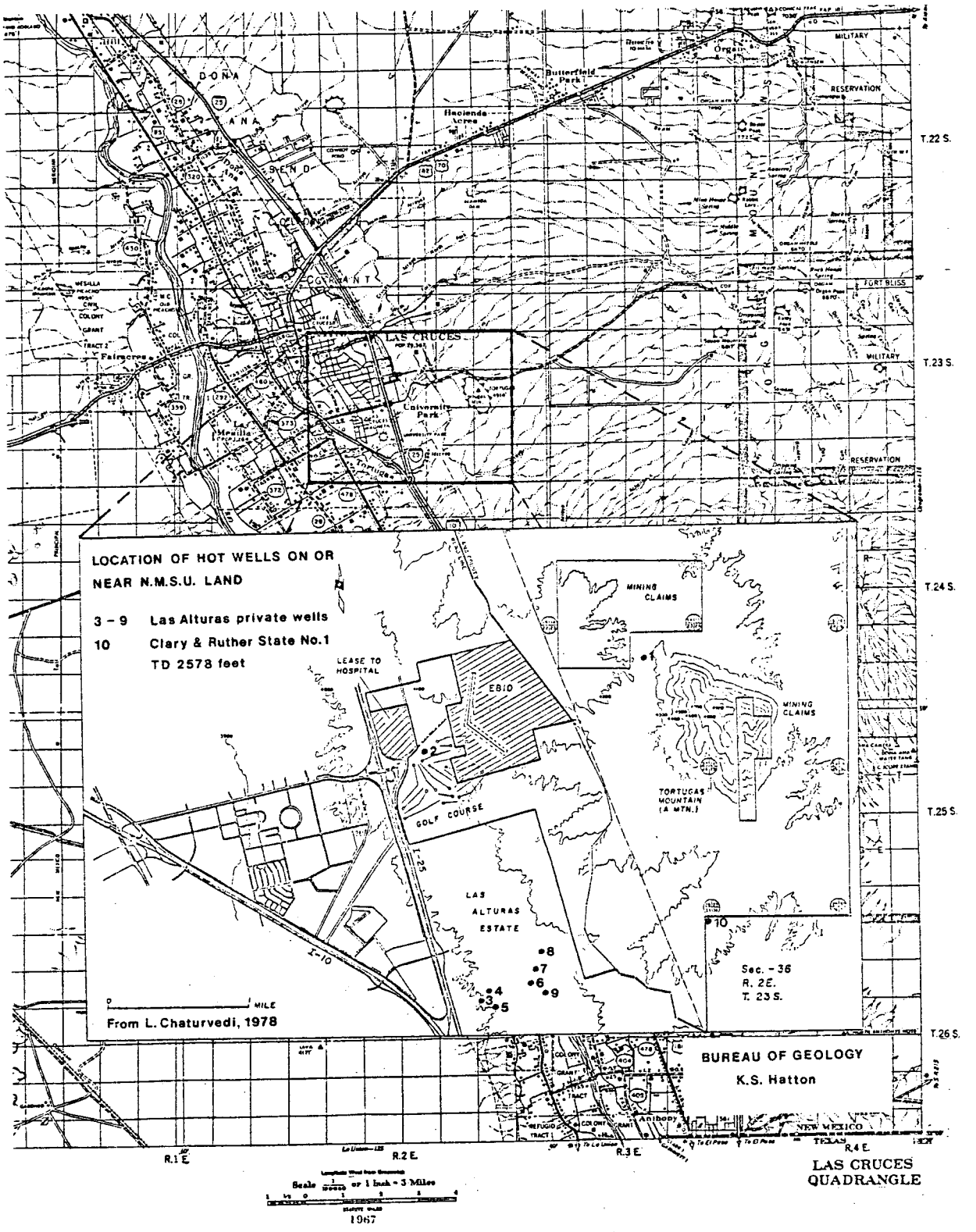


Figure 10. Las Alturas Geothermal Resource Area

LOS ALTURAS WBS 7017

General Description

The Los Alturas area is southeast of Las Cruces on the east edge of the Rio Grande Valley.

This area has a thermal anomaly that underlies a subdivision of the same name and adjacent state university property to the north. When the subdivision started up in 1967, it was beyond the reach of city water and so, the home-owners drilled wells for their water supply. The water from these wells ranged from midely warm ($77^{o}F$) to hot ($113^{o}F$).

In 1948, an oil test well was drilled nearby and it encountered steam and hot water. This same well will be reentered for temperature measurement as part of the NMSU feasibility study to assess the resource potential for meeting heating, cooling, and electrical power needs of the NMSU campus.

Information is being gathered on the thickness and bounds of the aquifer in order to arrive at an estimate of the amount of energy available. Water temperature, however, and the depth at which that temperature might be found can only be proven by drilling.

In conclusion, the Los Alturas and the adjacent Las Cruces area appears highly favorable from the geological point of view and merits continued study.

30.2 Resource Characteristics - LOS ALTURAS

Surface Fluid Temperature: $115^{o}F$ or $46^{o}C$

Subsurface Fluid Temperature: $120^{o}C$

Total Dissolved Solids: Range from 1093 to 1983 ppm

Estimated Energy Potential: 141.75×10^{15} cal. (stored heat)

Type of Overlying Rock: Sand and gravel overlying Mississippian sediments

Estimated Depth from Top of Reservoir:

Estimated Size of Reservoir: 2.25 cubic km

Site Location: Los Alturas Subdivision (adjacent to I-25) and university land including golf course.

Latitude: $32^{o}16'$ Longitude: $106^{o}42'$

County: Dona Ana

Land Ownership: University property of N.M.S.U. and private property of Los Alturas Development Company

Land Use: University: none except golf course; Los Alturas Estates is a residential subdivision.

POSTULATED SITE DEVELOPMENT SCHEDULE
KILBOURNE HOLE

WBS 7004

OPERATING ENTITIES	ACTIVITY	1977	1978	1979	1980	1981	1982	1983	1984	1986	1990	1995	2000	2020
Utility	Plant Construction								———	———				
Utility	Puts power on line									10 MW ▲	25MW ▲	50 MW ▲	———	

Table 13

POSTULATED SITE DEVELOPMENT SCHEDULE
KILBOURNE HOLE

WBS 7004

OPERATING ENTITIES	ACTIVITY	1977	1978	1979	1980	1981	1982	1983	1984	1986	1990	1995	2000	2020
Developer	Conducts casual reconnaissance exploration	———	———											
BLM, State	Leases Land	———												
USGS	Makes Environment Assessment	———												
USGS, State	Approves Plan of Operation and issues permit to explore		———											
Developer	Conducts geophsical work and drills T.G. holes		———											
USGS	Makes EA for drilling deep exploratory wells		———	———										
USGS, State	Gives permission to drill			———										
Developer	Drills deep exploratory well			———	———									
Developer	Conducts Feasibility Study			———	———									
Developer	Water rights application with State Engineer				———									
USGS	Makes EA for development				———	———								
	Gives permission to develop					———								
Developer	Drills production wells and runs tests					———	———	———						
PSC	Certifies plant and site							———						
	Issue permits							———						
USGS	Approves plan of operation for production							———						
Utility	Obtains R.O.W. for Power Line							———						

30.5 Development Scenario

At this time, no reserves have been proven, thus the development plan is highly speculative.

Site Location: R.1W., T.27S., and T.28S.

Latitude: 31° 57'N Longitude: 106° 58'S

County: Dona Ana

Land Ownership: Federal

Land Use: Range

Description of KGRA: 25,133 acres, in R. W, T27 and 28S.

Leasing Status:

Within KGRA: 18,476.45 acres - Anadarko
2,557 acres Phillips

Adjacent to KGRA: 57,849 acres Hunt
6,264 acres Grimm
9,636 acres Schoellkopf

Filed on, but not yet issued:

7,010 acres Geothermal Power Corp.
2,560 acres Cecil J. Folmar
2,560 acres G.W. Seltzer, M.D.

30.3 Development Status and Activity

Anadarko Productions, who seems to be out front in exploration progress in this area, made a ground gravity survey in 1976 in T.27S., R.1W. and in T.28S., R.1W. and conducted a ground electric survey in 1977. Approval has been given by USGS to Anadarko to drill 16 temperature gradient holes 500 feet deep and four holes 2500 feet deep. The Anadarko operation will make the first time the deeper geologic exploration has been conducted here.

Hunt Energy Corporation has conducted a reconnaissance electric resistivity survey south of Kilbourne Hole in the Potrillo Mountains in T.25S., R.3&4W., T.26-29S., R.1-4W, which is midway between Columbus and Anthony, New Mexico.

Hunt has drilled 54 temperature gradient holes in T.25S., R.3&4W., T.26-29S., R.1-4W., also in the Potrillo Mountains. To Hunt, the Kilbourne Hole area looks interesting on the basis of their findings.

Phillips Petroleum has drilled five or six gradient holes. Findings have been disappointing.

30.4 Severe Development Problems

This area is very sparsely populated and it is not very assessable. Consequently, space heating and process heating may not be economical in the immediate area, but could be feasible in the Rio Grande Valley with transported geothermal fluids.

AREA: 20

Possible Subsequent Additions
Quads and On Line Date:

SITE CHARACTERISTICS:

SITE: WABUSKA HOT SPRINGS (1)

POSTULATED SITE DEVELOPMENT SCHEDULE (FOR FIRST 0.03 QUAD DEVELOPMENT)

OPERATING ENTITIES	ACTIVITY	RECIPIENTS	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
BLM	Approve Notice of Intent-	Developer							—																	
USGS	Approve NOI & Drill Permit	Developer							—																	
BLM/Owner	Lease Land	Developer						—	—																	
BLM	Process EIA/EIS	CEQ						—	—																	
County	Issue Land Use Permits	Developer							—																	
Developer	Exploratory Drilling & Reservoir Evaluation									—																
Developer	Develop User Interest									—																
Developer & User	Feasibility Study										—															
Producer(Developer) & User	Financial Negotiations										—	—														
Producer	Site Selection										—	—														
Producer & User	Design											—	—													
Producer & User	Commitment to Development											△														
Producer & User	Prepare Master Development Plan	BLM, USGS										—	—													
User	Prepare Environmental Data Statement	BLM, STATE, County										—	—													
BLM, STATE, USGS	Issue Permits on Site	Producer & User											—	—												
USGS	Process EIA/EIS (Drilling)	CEQ											—	—												
Producer	Development Drilling													—												
User	Plant Construction													—												

(1) Hot water being used for Greenhouse heating now.

AREA: 20

SITE CHARACTERISTICS:

SITE: WABUSKA HOT SPRINGS

Possible Subsequent Additions (MWe) and On Line Date:

50 MWe 1988

POSTULATED SITE DEVELOPMENT SCHEDULE (FOR FIRST 30 MWe PLANT)

OPERATING ENTITIES	ACTIVITY	RECIPIENTS	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
BLM	Approve Notice of Intent-	Developer							—																	
USGS	Approve NOI & Drill Permit	Developer							—																	
BLM/Owner	Lease Land	Developer						—	—																	
BLM	Process EIA/EIS	CEQ						—																		
County	Issue Land Use Permits	Developer								—																
Developer	Exploratory Drilling & Reservoir Evaluation										—	—														
Developer	Develop Utility Interest										—	—														
Developer & Utility	Feasibility Study											—														
Producer (Developer) & Utility	Financial Negotiations												—										—			
Producer	Site Selection												—													
Producer & Utility	Design													—	—											
Producer & Utility	Commitment to Development												△													
Producer & Utility	Prepare Master Development Plan	BLM, USGS												—												
Utility	Prepare Environmental Data Statement	BLM, FPC STATE, County												—												
BLM, FPC STATE, USGS	Certify Plant & Site Issue Permits	Producer & Utility												—	—	—										
USGS	Process EIA/EIS (Drilling)	CEQ													—											
FPC	Process EIA/EIS (Plant)	CEQ													—											
FPC	Process EIA/EIS (Transmission Line)	CEQ													—											
Producer	Development Drilling															—	—	—								
Utility	Plant Construction															—	—	—					—			
Utility	Install Transmission Line (40 km)																—	—								

AREA 20

	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	50	50			
	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03									
		30	30	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
				.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.02	.02

COMPOSITE POSTULATED SITE DEVELOPMENT SCHEDULE
FOR AREA 20

SITE NAME	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
Wabuska Hot Springs																	30	30	80	80	80	80	80	80	80
Wabuska Hot Springs												.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03
Wilson Hot Springs																									
Hind's Hot Springs																									
Carson Hill																									
Churchill Valley																									
Wellington																									
Buckskin Range																									
Mount Wilson																									
TOTAL MWe:																									
TOTAL Quads:																									

20,50,100 = MWe (megawatts electric); electrical power generation.
.037,.04,.017 = Quads (0.252 x 10^{18} cal.); direct thermal utilization. Quads available for commercial utilization. It is unlikely that the energy developed at each site will be wholly utilized, or utilized in the optimum or most efficient manner.

References To Postulated Site Development Schedules
And Non-Technical Components Of Areas.

References (indicated by parentheses and corresponding number)

1. Oral Communication:

2. Regional Environmental Analysis Record
   Geothermal oil/gas leasing (BLM) and maps

   a. Carson City District
      Pyramid District, 1975

   b. Winnemucca District
      Sonoma-Gerlach Resource Area
      Buffalo Hills Planning Unit
      1975

   c. Winnemucca District
      Deno, Paradise, Blue Wing and
      Sonoma Planning Units,
      1975

   d. Elko District,
      1975

   e. Battle Mountain District
      1976

   f. Tonopah Resource Area
      1975

   g. Fort Churchill-Clan Alpine Area,
      Carson City District, Nev., 1975

   h. Pine Nut-Walker Area,
      Carson City District, Nev. 1975

   i. Esmeralda Planning Unit,
      Esmeralda and Nye Counties, 1974

3. Lease Books (Nevada Team Data)
   Data obtained from BLM public records and maps.

4. "Intent to Conduct Geothermal Resource Exploration"
   (Filed with U.S.G.S.), (Maps and Folder) and maps.

5. Drilling and Resource Data Sheets.

6. Plan of Operation, Phillips Petroleum Company,
   March 1, 1978 - To drill 6 geothermal wells to 8000'.
   To determine the existence and commercial potential of
   geothermal resources.
   Estimating starting date - 6-78
   Estimated comp. date - 12-82

EXPLANATION FOR AREA SHEETS

ENVIRONMENT: Federal environmental decisions relating to availability of federal lands for geothermal resource leasing. All data taken from Environmental Assessment Records prepared by BLM.

CRIT. R.: Critical Restrictions. Restrictions to lessee, in addition to those restrictions covered in the Geothermal Resource Lease Application (Sec. 14 and 18).

EXCLUD. PEND.: Excluded from Leasing. Pending additional environmental studies.

EXCLUD.: Excluded from all leasing.

LAND STATUS: Geothermal leasing status on federal lands.

LSE. APLN.: Lease Application

CLOSED: Closed cases. Application never became lease. In theory the land is available for geothermal leasing.

GEO. SIM.: Geothermal Simultaneous Drawing. These applications became leases, then were terminated or relinquished by the lessee. These parcels are held for simultaneous drawing.

OPEN: Open - No leases presently recorded for site.

A.P.P.: Area Potential Prospectively. As outlined by U.S.G.S., possible geothermal resource areas.

OTHER or KGRA: KGRA - Known Geothermal Resource

OWNERSHIP INTEREST:

MAJOR: Major company interest or holdings.

MINOR: Minor company interest or holdings.

IND./INV.: Individual and/or investment group interest or holdings.

INTENTS: "Intent to Conduct Geothermal Resource Exploration" are filed with U.S.G.S.

GEO.: Geophysical work only. No Drilling (i.e.= Gravity, magnetotelluric and other surveys)

DRILL: Drilling of shallow temperature gradient holes.

OTHER: Any exploration work not included in above categories.

(NOTE: The filing of the Intent to conduct geothermal resource exploration Does Not imply the work was completed.)

AREA: 20

SITE	ENVIRONMENT			LAND STATUS							OWNERSHIP INTEREST			INTENTS			NOTES
	CRIT.R.	EXCLUD. PEND.	EXCLUD.	LSE. APLN.	CLOSED	LSE.	GEO SIM	OPEN	A.P.P.	OTHER OR KGRA	MAJOR	MINOR	IND./ INV.	GEO.	DRILL.	OTHER	
Wabuska H. Springs							X		X	KGRA		X					Some Private Land
Wilson Hot Springs				X	X				X	KGRA	X	X		X	X		
Churchill Valley								X	X					X			
Carson Hill								X	X					X			
Buckskin Range			X						X								
Wellington								X	X								Some Private Land
Hind's Hot Spgs.								X									Some Private Land
Moutn Wilson								X	X								

General Statement to Non-Technical Components Section,
Area Scenarios

1. All observations for environmental, leasing and "Intents" are based on data gathered in 1977, which has not been corrected, adjusted or up-dated.

2. All environmental decisions are federal (BLM) as there are no localities in Nevada which require an environmental statement. Nevada has only 2 laws requiring such reports:

   a. Nevada Clean Air Act of 1971. Amended in 1973.

   b. Utility Environmental Protection Act, 1971.
   Amended 1973.
   Requires environmental statement for utility plant siting.

   Protection of environmental values is now explicitly and clearly a major criteria for BLM management activities. All BLM activities are governed by the "Federal Land Policy and Management Act".

3. Areas 15, 16, 17, 18, 19 grouped together make up a zone of Intensive and Extensive geothermal resource interests.

   A little over 1/2 of the total land in this zone is available for geothermal leasing, the remainder is covered by private indian reservation, Bureau of Reclamation withdrawals, wildlife management and refuge, state parks and military use lands. The zone contains 10 KGRAs.

   There has been intensive "Geophysical" and "Shallow Temperature Gradient Hole" interest indicated by numerous filings of "Intent to do Geothermal Resource Exploration" with U.S.G.S. To date we do not know how many of these projects were completed.

This zone does not have extensive environment decisions but some significant sites will be affected by such decisions. (i.e. Tahoe Basin Area and Carson Sink-Alkali Flat East and West)

There has been significant leasing in this zone, both within the KGRA's and its vicinity. The leasing interest is mostly by minor companies and individual and/or investment groups. Some sites showed 100% major company interest, such as Bell Flat, of which very few are still lease applications, the remainder closed cases.

This zone includes 1 of the 2 metropolitan localities in the state: Reno-Sparks - (should include Carson City) with many important communities, good to fair transportation arteries.

Economic Base: Tourism, Agriculture/Livestock, Warehousing. The growth in tourism and warehousing increases population energy needs.

Non-Technical Components For Area 20

Of the eight (8) sites presently identified for this area, only one (1) Buckskin Range is affected by federal environmental constraints. The decision was to exclude the region from leasing for protection of live water and wildlife management. Approximately 65% of the total area is covered by large blocks of private land, Indian Reservation, Indian Allotments, National Forest and State Park lands.

There are two (2) KGRAs in this area: Wabuska Hot Springs with significant leasing activity by major companies, of which about 100% within KGRA are geothermal leases. The second KGRA, Wilson Hot Springs has 100% closed cases. There is no leasing activity at the remaining six (6) sites. All the sites are within U.S.G.S. Area Potential Prospectively.

Significant interest in the area has been indicated by the number of Notices of Intents that have been filed, for both geophysical surveys and shallow temperature gradient holes. Focus of interest has been at the Wabuska Hot Springs and Wilson Hot Springs KGRAs.

EXPLANATION TO HOT-WATER CONVECTION SYSTEMS SHEETS

Footnotes

(1) Maximum surface temperature reported from a spring or fumarole.

(2) Predicted using chemical geothermometers, assuming last equilibration in the reservoir; assumes saturation of SiO_2 with respect to quartz, and no loss of Ca from calcite deposition.

(3) Assumed average reservoir temperature based on data presently available. Temperatures from Circular 726 and other sources. Temperatures in parentheses are highly subjective.

(4) From surface manifestations, geophysical data, well records, geologic inference and leasing activity. Assumes 1.5 km^2 if no data pertinent to size is available. Top assumed at depth of 1.5 km if no data available. Bottom assumed at 3 km depth for all convection systems. Calculated from assumed area and thickness.

(5) Calculated as product of assumed volume, volumetric specific heat of 0.6 $cal/cm^3°C$, and temperature in degrees C above 15°C.

(6) 0.02 for 150°-200°C
0.025 for 200°-250°C

(7) 25% Heat Content Recoverable as thermal energy at the surface; 1 Quad= 0.25×10^{18} cal.

HOT-WATER CONVECTION SYSTEMS IN AREA 20.

Location	Temperatures °C				Reservoir Assumptions		Energy Potential		
Site	Surface (1)	Geochemical SiO_2 (2)	Geochemical Na-K-Ca (2)	Subsurface (3)	Volume km^3 (4)	Heat content 10^{18} cal (5)	Recovery Factor e_r (6)	Electrical Potential MW_e-30yrs.	Thermal Energy for Direct Use Quads (7)
Wabuska Hot Springs	97	145	152	155 (170)	10	0.9	0.02	80	
Wabuska Hot Springs	97			(170)	10	0.9			0.9
Wilson Hot Springs	Hot			(170)	10	0.9	0.02	80	
Hind's Hot Springs	67	104	86	105 (155)	10	0.8			0.8
Carson Hill	ND								
Churchill Valley	ND								
Wellington	67								
Buckskin Range	28								
Mount Wilson	Hot								
TOTAL:								160	1.7

Footnotes 1 thru 7-see Explanation Page

NEVADA GEOTHERMAL AREA 20 SCENARIO

AREA: 19

SITE CHARACTERISTICS:

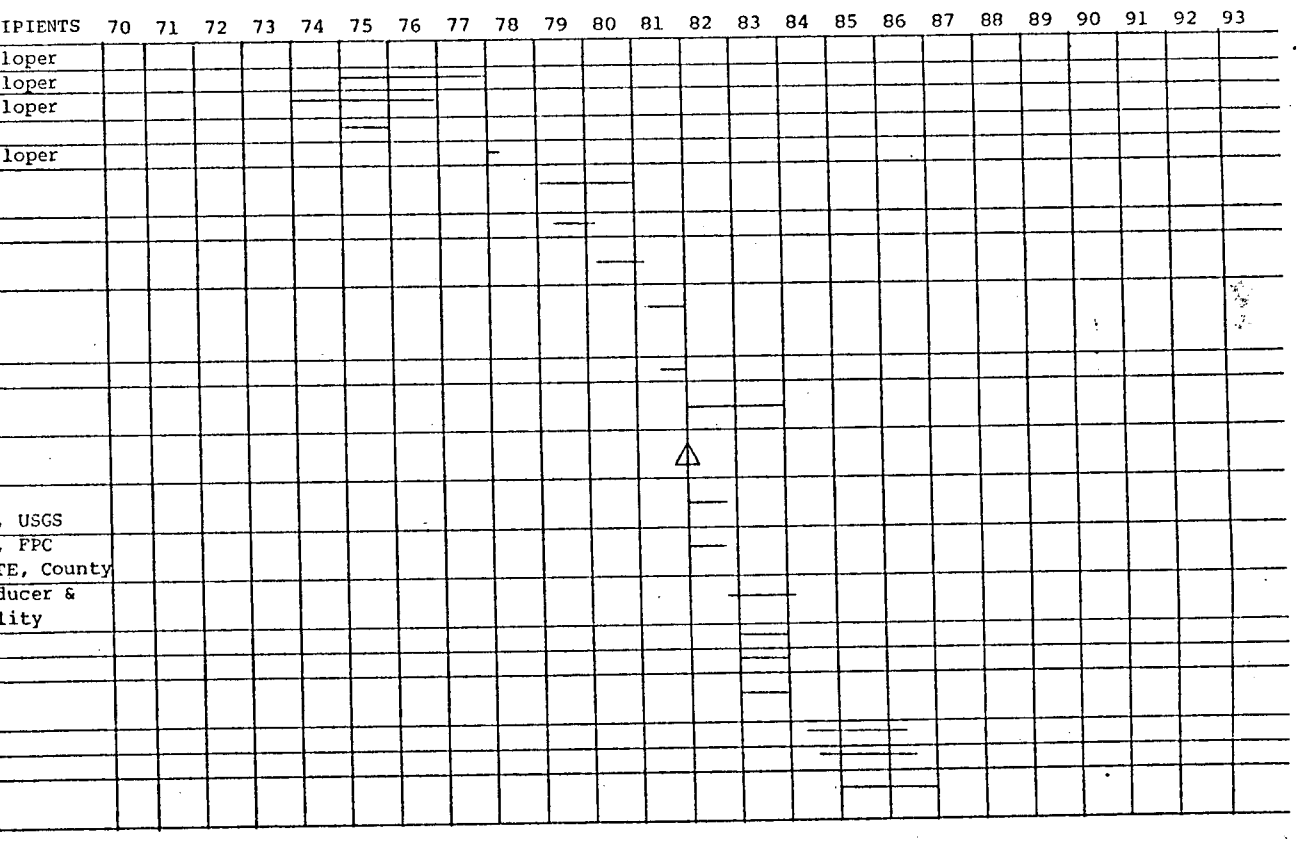
SITE: DIXIE HOT SPRINGS

POSTULATED SITE DEVELOPMENT SCHEDULE (FOR FIRST 20 MWe PLANT)

Possible Subsequent Additions (MWe) and On Line Date:

50 MWe	1989	50 MWe	1995
50 MWe	1991	25 MWe	1997
50 MWe	1993		

OPERATING ENTITIES	ACTIVITY	RECIPIENTS
BLM	Approve Notice of Intent-	Developer
USGS	Approve NOI & Drill Permit	Developer
BLM/Owner	Lease Land	Developer
BLM	Process EIA/EIS	CEQ
County	Issue Land Use Permits	Developer
Developer	Exploratory Drilling & Reservoir Evaluation	
Developer	Develop Utility Interest	
Developer & Utility	Feasibility Study	
Producer (Developer) & Utility	Financial Negotiations	
Producer	Site Selection	
Producer & Utility	Design	
Producer & Utility	Commitment to Development	
Producer & Utility	Prepare Master Development Plan	BLM, USGS
Utility	Prepare Environmental Data Statement	BLM, FPC STATE, County
BLM, FPC STATE, USGS	Certify Plant & Site Issue Permits	Producer & Utility
USGS	Process EIA/EIS (Drilling)	CEQ
FPC	Process EIA/EIS (Plant)	CEQ
FPC	Process EIA/EIS (Transmission Line)	CEQ
Producer	Development Drilling	
Utility	Plant Construction	
Utility	Install Transmission Line (40 km)	



AREA 19

95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
220	220	245	245	245	245	245	245	245	245	245	245	245	245	245	245	245	245	245	245	245	245	225	225	175	175
135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	100
	35	35	85	85	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135
				20	20	70	120	120	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145	145
.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05
									35	35	85	85	135	135	135	135	135	135	135	135	135	135	135	135	135
.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.04	.04	.04	.04	.04	.04	.04
														35	35	85	85	135	135	135	135	135	135	135	135
																			20	20	70	70	120	120	120

COMPOSITE POSTULATED SITE DEVELOPMENT SCHEDULE
FOR AREA 19

SITE NAME	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
Dixie Hot Springs																		20	20	70	70	120	120	170	170
Sou Hot Springs																					35	35	85	85	135
McCoy Springs																									
Hyder Hot Spring																									
Senator																									
Dixie Comstock Mine-Humboldt Msh.																									
IXL																									.05
Buffalo Valley Hot Springs																									
Jersey Valley																									
Fairview Valley																									
Pirouette Mountain																									
South Stillwater Range																									
Table Mountain																									
Northern Clan Alpine Mountains																									
Needle Peak																									
Dry Lake																									
Timber Canyon																									
Mt. Grant																									
TOTAL MWe:																									
TOTAL Quads:																									

20,50,100 = MWe (megawatts electric); electrical power generation.
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      Buffalo Hills Planning Unit
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   c. Winnemucca District
      Deno, Paradise, Blue Wing and
      Sonoma Planning Units,
      1975

   d. Elko District,
      1975

   e. Battle Mountain District
      1976

   f. Tonopah Resource Area
      1975

   g. Fort Churchill-Clan Alpine Area,
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   h. Pine Nut-Walker Area,
      Carson City District, Nev. 1975

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5. Drilling and Resource Data Sheets.

6. Plan of Operation, Phillips Petroleum Company,
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   To determine the existence and commercial potential of geothermal resources.
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   Estimated comp. date - 12-82

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EXCLUD.: Excluded from all leasing.

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GEO. SIM.: Geothermal Simultaneous Drawing. These applications became leases, then were terminated or relinquished by the lessee. These parcels are held for simultaneous drawing.

OPEN: Open - No leases presently recorded for site.

A.P.P.: Area Potential Prospectively. As outlined by U.S.G.S., possible geothermal resource areas.

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MAJOR: Major company interest or holdings.

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INTENTS: "Intent to Conduct Geothermal Resource Exploration" are filed with U.S.G.S.

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DRILL: Drilling of shallow temperature gradient holes.

OTHER: Any exploration work not included in above categories.

(NOTE: The filing of the Intent to conduct geothermal resource exploration Does Not imply the work was completed.)

AREA: 19

SITE	ENVIRONMENT			LAND STATUS							OWNERSHIP INTEREST			INTENTS			NOTES
	CRIT.R.	EXCLUD. PEND.	EXCLUD.	LSE. APLN.	CLOSED	LSE.	GEO SIM	OPEN	A.P.P.	OTHER or KGRA	MAJOR	MINOR	IND./ INV.	GEO.	DRILL.	OTHER	
Sou Hot Springs		X		X	X				X	KGRA	X	X	X				
Hyder Hot Spring				X	X	X	X		X	KGRA	X	X	X	X	X		
Senator				X					X	KGRA	X	X	X	X	X		
McCoy Springs				X					X		X	X	X				
Northern Clan Alpine Mtns.						X	X					X	X				
Jersey Valley						X			X			X	X		X		
Buffalo V. H. Sps.					X	X			X			X	X				
S. Stillwater Range				X		X			X		X			X			
Pirouette Mtn.				X		X			X		X						
Table Mountain				X		X			X		X						
Fairview Valley				X		X			X		X			X			
Dixie Hot Springs				X	X				X	KGRA				X	X		
IXL						X			X								
Dixie ComstockMine -Humboldt Marsh						X			X					X	X		
Mt. Grant				X		X			X		X						
Needle Peak				X	X				X		X						
Dry Lake								X	X								
Timber Canyon								X	X								

General Statement to Non-Technical Components Section,
Area Scenarios

1. All observations for environmental, leasing and "Intents" are based on data gathered in 1977, which has not been corrected, adjusted or up-dated.

2. All environmental decisions are federal (BLM) as there are no localities in Nevada which require an environmental statement. Nevada has only 2 laws requiring such reports:

   a. Nevada Clean Air Act of 1971. Amended in 1973.

   b. Utility Environmental Protection Act, 1971.
   Amended 1973.
   Requires environmental statement for utility plant siting.

   Protection of environmental values is now explicitly and clearly a major criteria for BLM management activities. All BLM activities are governed by the "Federal Land Policy and Management Act".

3. Areas 15, 16, 17, 18, 19 grouped together make up a zone of Intensive and Extensive geothermal resource interests.

   A little over 1/2 of the total land in this zone is available for geothermal leasing, the remainder is covered by private indian reservation, Bureau of Reclamation withdrawals, wildlife management and refuge, state parks and military use lands. The zone contains 10 KGRAs.

   There has been intensive "Geophysical" and "Shallow Temperature Gradient Hole" interest indicated by numerous filings of "Intent to do Geothermal Resource Exploration" with U.S.G.S. To date we do not know how many of these projects were completed.

This zone does not have extensive environment decisions but some significant sites will be affected by such decisions. (i.e. Tahoe Basin Area and Carson Sink-Alkali Flat East and West)

There has been significant leasing in this zone, both within the KGRA's and its vicinity. The leasing interest is mostly by minor companies and individual and/or investment groups. Some sites showed 100% major company interest, such as Bell Flat, of which very few are still lease applications, the remainder closed cases.

This zone includes 1 of the 2 metropolitan localities in the state: Reno-Sparks - (should include Carson City) with many important communities, good to fair transportation arteries.

Economic Base: Tourism, Agriculture/Livestock, Warehousing. The growth in tourism and warehousing increases population energy needs.

There has been extensive interest in both geophysical survey and shallow temperature gradient holes work, indicated by the numerous Notices of Intents filed. Focus of interest has been in zones 1 and 2, North and Central Dixie Valley respectively.

Non-Technical Components For Area 19

A large area with eighteen (18) sites presently identified. Sou Hot Springs KGRA is only site in area with direct federal environmental constraint. The decision cover approximately 2000 acres of this KGRA which are being excluded from leasing pending additional environmental studies for archelogical sites. Most of the sites are located in two important valleys: Dixie and Jersey which are important grazing areas.

Leasing activity has occured at sixteen (16) of the eighteen (18) sites. There appears to be a grouping pattern of activity within the area, with four (4) significant zones:

1. North Dixie Valley

   Three (3) of the five (5) sites in this zone are KGRAs: Sou Hot Springs, Hyder Hot Spring and Senator. Leasing activity has been very significant both in the KGRA's boundaries and in adjacent vicinities. There are many closed cases, some leases for both major and minor companies.

2. Central Dixie Valley

   No KGRAs among the four (4) sites in this zone, but over 55% of the leasing activity for this zone has gone to geothermal leases, and about 35% still in lease application, remainder closed cases. Major companies have shown most interest.

3. South Dixie Valley

   There is one (1) KGRA: Dixie Hot Springs among the three (3) sites for this zone. Most leasing activity has occured beyond the perimeter of the KGRA mostly eastward. Perhaps no more than 20% of the activity is in geothermal lease, with remainder of activity divided between lease applications and closed cases.

4. Jersey Valley

   With only two (2) sites and no KGRAs, this zone has had significant leasing activity, with almost 98% of this activity now in geothermal leases. The Jersey Valley site has 100% leases. Over half of the interest has been by major companies.

EXPLANATION TO HOT-WATER CONVECTION SYSTEMS SHEETS

Footnotes

(1) Maximum surface temperature reported from a spring or fumarole.

(2) Predicted using chemical geothermometers, assuming last equilibration in the reservoir; assumes saturation of SiO_2 with respect to quartz, and no loss of Ca from calcite deposition.

(3) Assumed average reservoir temperature based on data presently available. Temperatures from Circular 726 and other sources. Temperatures in parentheses are highly subjective.

(4) From surface manifestations, geophysical data, well records, geologic inference and leasing activity. Assumes 1.5 km^2 if no data pertinent to size is available. Top assumed at depth of 1.5 km if no data available. Bottom assumed at 3 km depth for all convection systems. Calculated from assumed area and thickness.

(5) Calculated as product of assumed volume, volumetric specific heat of 0.6 $cal/cm^3°C$, and temperature in degrees C above 15°C.

(6) 0.02 for 150°-200°C
0.025 for 200°-250°C

(7) 25% Heat Content Recoverable as thermal energy at the surface; 1 Quad= 0.25×10^{18} cal.

HOT-WATER CONVECTION SYSTEMS IN AREA 19 .

Location	Temperatures °C			Reservoir Assumptions		Energy Potential		
Site	Surface (1)	Geochemical SiO_2 (2)	Geochemical Na-K-Ca (2)	Subsurface (3)	Volume km^3 (4)	Heat content 10^{18} cal (5)	Recovery Factor e_r (6)	Electrical Potential MW_e-30yrs.	Thermal Energy for Direct Use Quads (7)
Dixie Hot Springs	72	143	143	150 (200)	20	2.2	0.025	245	
Sou Hot Springs	93	115	99	115 (185)	15	1.5	0.02	135	
McCoy Springs	49			(185)	15	1.7	0.02	135	
Hyder Hot Spring	79			(200)	15	1.5	0.025	145	
Senator	Boiling			(185)	15	1.5			1.5
Dixie Comstock Mine-Humboldt Marsh	Hot			(185)	15	1.5	0.02	135	
IXL	24-			(170)	15	1.4			1.4
Buffalo Valley Hot Springs	79	125	140	130 (185)	15	1.5	0.02	135	
Jersey Valley	57	143	182	185 (200)	15	1.7	0.025	145	
Fairview Valley	ND								
Pirouette Mountain	ND								
South Stillwater Range	ND								
Table Mountain	ND								
Northern Clan Alpine Mountains	ND								
Needle Peak	ND								
Dry Lake	Warm								
Timber Canyon	24								
Mt. Grant	ND								
TOTAL:								1075	2.9

Footnotes 1 thru 7-see Explanation Page

NEVADA GEOTHERMAL AREA 19 SCENARIO

AREA: 18

Possible Subsequent Additions
Quads and On Line Date:

SITE CHARACTERISTICS:

SITE: SODA LAKE-UPSAL HOGBACK (1)

POSTULATED SITE DEVELOPMENT SCHEDULE (FOR FIRST 0.02 QUAD DEVELOPMENT)

OPERATING ENTITIES	ACTIVITY	RECIPIENTS	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
BLM	Approve Notice of Intent-	Developer																								
USGS	Approve NOI & Drill Permit	Developer																								
BLM/Owner	Lease Land	Developer																								
BLM	Process EIA/EIS	CEQ																								
County	Issue Land Use Permits	Developer																								
Developer	Exploratory Drilling & Reservoir Evaluation																									
Developer	Develop User Interest																									
Developer & User	Feasibility Study																									
Producer (Developer) & User	Financial Negotiations																									
Producer	Site Selection																									
Producer & User	Design																									
Producer & User	Commitment to Development											△														
Producer & User	Prepare Master Development Plan	BLM, USGS																								
User	Prepare Environmental Data Statement	BLM, STATE, County																								
BLM, STATE, USGS	Issue Permits on Site	Producer & User																								
USGS	Process EIA/EIS (Drilling)	CEQ																								
Producer	Development Drilling																									
User	Plant Construction																									

(1) Above based on Fact that this Site was unitized Oct., 1977 with Deep Well Test planned by Chevron.

AREA: 18

SITE CHARACTERISTICS:

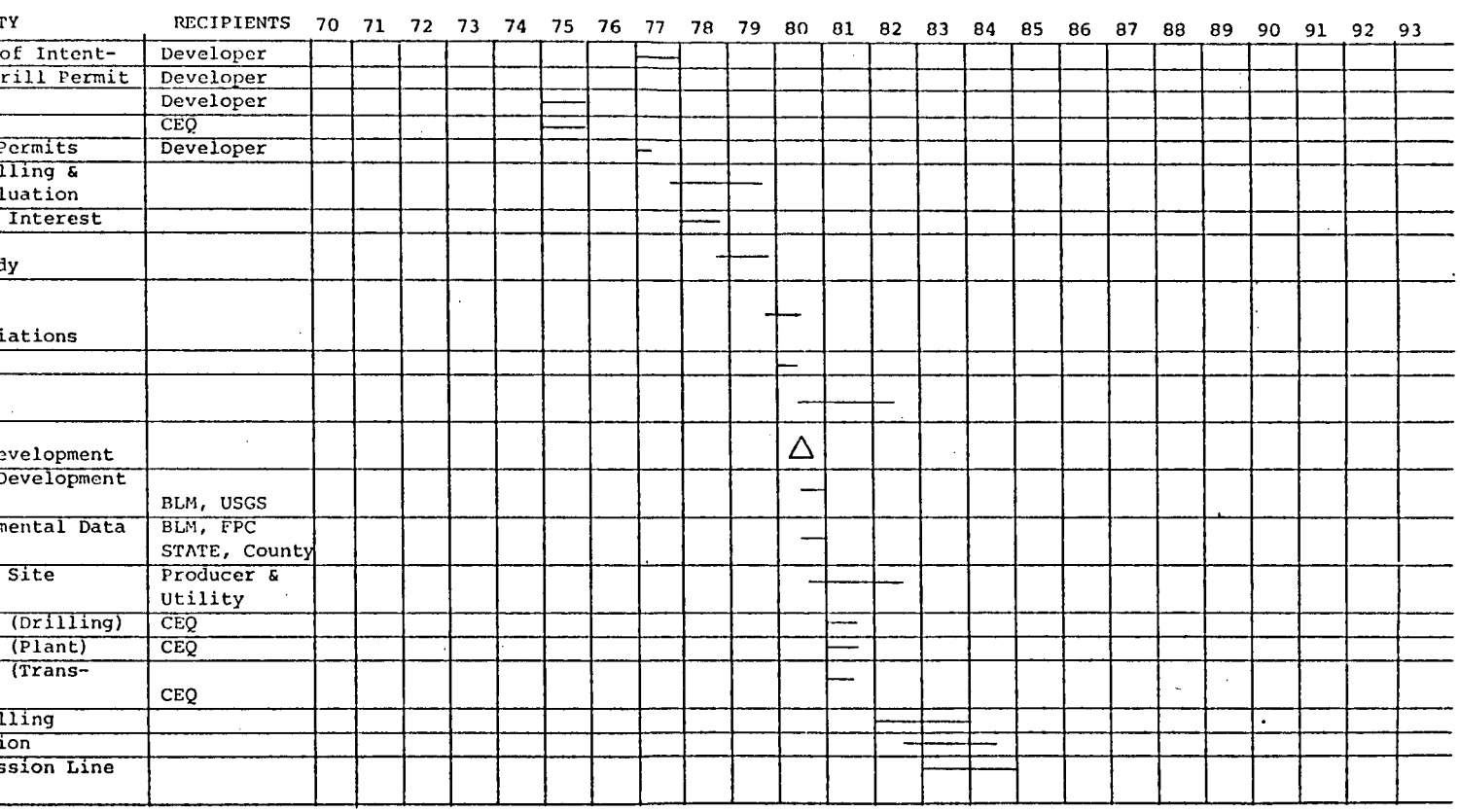
SITE: SODA LAKE-UPSAL HOGBACK (1)

Possible Subsequent Additions (MWe) and On Line Date:

100 MWe 1987
100 MWe 1989
100 MWe 1991
50 MWe 1993

POSTULATED SITE DEVELOPMENT SCHEDULE (FOR FIRST 50 MWe PLANT)

OPERATING ENTITIES	ACTIVITY	RECIPIENTS
BLM	Approve Notice of Intent-	Developer
USGS	Approve NOI & Drill Permit	Developer
BLM/Owner	Lease Land	Developer
BLM	Process EIA/EIS	CEQ
County	Issue Land Use Permits	Developer
Developer	Exploratory Drilling & Reservoir Evaluation	
Developer	Develop Utility Interest	
Developer & Utility	Feasibility Study	
Producer (Developer) & Utility	Financial Negotiations	
Producer	Site Selection	
Producer & Utility	Design	
Producer & Utility	Commitment to Development	
Producer & Utility	Prepare Master Development Plan	BLM, USGS
Utility	Prepare Environmental Data Statement	BLM, FPC STATE, County
BLM, FPC STATE, USGS	Certify Plant & Site Issue Permits	Producer & Utility
USGS	Process EIA/EIS (Drilling)	CEQ
FPC	Process EIA/EIS (Plant)	CEQ
FPC	Process EIA/EIS (Transmission Line)	CEQ
Producer	Development Drilling	
Utility	Plant Construction	
Utility	Install Transmission Line (40 km)	



(1) Based on unitization of KGRA in Oct. 1977-and planned Deep Well Test by Chevron. There could likely be concern from those who frequent area for recreation (Stillwater Wildlife Management).

AREA 18

95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	350	350	250	250	150	150
.02	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02										
80	180	180	280	280	380	380	480	480	530	530	530	530	530	530	530	530	530	530	530	530	530	530	530	530	530
										25	25	75	75	125	125	125	125	125	125	125	125	125	125	125	125
																25	25	75	75	125	125	125	125	125	125
																					25	25	75	75	125
			.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04

COMPOSITE POSTULATED SITE DEVELOPMENT SCHEDULE
FOR AREA 18

SITE NAME	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
Soda Lake-Upsal Hogback																50	50	150	150	250	250	350	350	400	400
Soda Lake-Upsal Hogback												.02	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02
Stillwater																							30	30	80
Carson Lake																									
Lee Hot Springs																									
Eight Mile Flat																									
Stillwater																									
Four Mile Flat																									
North Sand S[illegible]nge																									
Rainbow Moun[illegible]																									
TOTAL MWe:																									
TOTAL Quads:																									

20,50,100 = MWe (megawatts electric); electrical power generation.
.037,.04, .017 = Quads (0.252×10^{18} cal.); direct thermal utilization. Quads available for commercial utilization. It is unlikely that the energy developed at each site will be wholly utilized, or utilized in the optimum or most efficient manner.

References To Postulated Site Development Schedules
And Non-Technical Components Of Areas.

References (indicated by parentheses and corresponding number)

1. Oral Communication:

2. Regional Environmental Analysis Record
   Geothermal oil/gas leasing (BLM) and maps

   a. Carson City District
      Pyramid District, 1975

   b. Winnemucca District
      Sonoma-Gerlach Resource Area
      Buffalo Hills Planning Unit
      1975

   c. Winnemucca District
      Deno, Paradise, Blue Wing and
      Sonoma Planning Units,
      1975

   d. Elko District,
      1975

   e. Battle Mountain District
      1976

   f. Tonopah Resource Area
      1975

   g. Fort Churchill-Clan Alpine Area,
      Carson City District, Nev., 1975

   h. Pine Nut-Walker Area,
      Carson City District, Nev. 1975

   i. Esmeralda Planning Unit,
      Esmeralda and Nye Counties, 1974

3. Lease Books (Nevada Team Data)
   Data obtained from BLM public records and maps.

4. "Intent to Conduct Geothermal Resource Exploration"
   (Filed with U.S.G.S.), (Maps and Folder) and maps.

5. Drilling and Resource Data Sheets.

6. Plan of Operation, Phillips Petroleum Company,
   March 1, 1978 - To drill 6 geothermal wells to 8000'.
   To determine the existence and commercial potential of
   geothermal resources.
   Estimating starting date - 6-78
   Estimated comp. date - 12-82

EXPLANATION FOR AREA SHEETS

ENVIRONMENT: Federal environmental decisions relating to availability of federal lands for geothermal resource leasing. All data taken from Environmental Assessment Records prepared by BLM.

CRIT. R.: Critical Restrictions. Restrictions to lessee, in addition to those restrictions covered in the Geothermal Resource Lease Application (Sec. 14 and 18).

EXCLUD. PEND.: Excluded from Leasing. Pending additional environmental studies.

EXCLUD.: Excluded from all leasing.

LAND STATUS: Geothermal leasing status on federal lands.

LSE. APLN.: Lease Application

CLOSED: Closed cases. Application never became lease. In theory the land is available for geothermal leasing.

GEO. SIM.: Geothermal Simultaneous Drawing. These applications became leases, then were terminated or relinquished by the lessee. These parcels are held for simultaneous drawing.

OPEN: Open - No leases presently recorded for site.

A.P.P.: Area Potential Prospectively. As outlined by U.S.G.S., possible geothermal resource areas.

OTHER or KGRA: KGRA - Known Geothermal Resource

OWNERSHIP INTEREST:

MAJOR: Major company interest or holdings.

MINOR: Minor company interest or holdings.

IND./INV.: Individual and/or investment group interest or holdings.

INTENTS: "Intent to Conduct Geothermal Resource Exploration" are filed with U.S.G.S.

GEO.: Geophysical work only. No Drilling (i.e.= Gravity, magnetotelluric and other surveys)

DRILL: Drilling of shallow temperature gradient holes.

OTHER: Any exploration work not included in above categories.

(NOTE: The filing of the Intent to conduct geothermal resource exploration Does Not imply the work was completed.)

AREA: 18

SITE	ENVIRONMENT			LAND STATUS							OWNERSHIP INTEREST			INTENTS			NOTES
	CRIT.R.	EXCLUD. PEND.	EXCLUD.	LSE. APLN.	CLOSED	LSE.	GEO SIM	OPEN	A.P.P.	OTHER or KGRA	MAJOR	MINOR	IND./ INV.	GEO.	DRILL.	OTHER	
Soda Lake-Upsal						X			X	KGRA	X			X			Some Private
Hogback																	
Stillwater						X			X	KGRA	X			X	X		Wildlife Man.
Lee Hot Springs				X		X								X	X		
Carson Lake				X	X				X					X			Some Bur. Recl.Wdl.
Four Mile Flat				X	X				X					X	X		
Eight Mile Flat				X	X				X					X	X		
Rainbow Mountain			X	X	X				X					X			
North Sand Springs Range			X	X	X				X					X			

General Statement to Non-Technical Components Section,
Area Scenarios

1. All observations for environmental, leasing and "Intents" are based on data gathered in 1977, which has not been corrected, adjusted or up-dated.

2. All environmental decisions are federal (BLM) as there are no localities in Nevada which require an environmental statement. Nevada has only 2 laws requiring such reports:

   a. Nevada Clean Air Act of 1971. Amended in 1973.

   b. Utility Environmental Protection Act, 1971.
   Amended 1973.
   Requires environmental statement for utility plant siting.

   Protection of environmental values is now explicitly and clearly a major criteria for BLM management activities. All BLM activities are governed by the "Federal Land Policy and Management Act".

3. Areas 15, 16, 17, 18, 19 grouped together make up a zone of Intensive and Extensive geothermal resource interests.

   A little over 1/2 of the total land in this zone is available for geothermal leasing, the remainder is covered by private indian reservation, Bureau of Reclamation withdrawals, wildlife management and refuge, state parks and military use lands. The zone contains 10 KGRAs.

   There has been intensive "Geophysical" and "Shallow Temperature Gradient Hole" interest indicated by numerous filings of "Intent to do Geothermal Resource Exploration" with U.S.G.S. To date we do not know how many of these projects were completed.

This zone does not have extensive environment decisions but some significant sites will be affected by such decisions. (i.e. Tahoe Basin Area and Carson Sink-Alkali Flat East and West)

There has been significant leasing in this zone, both within the KGRA's and its vicinity. The leasing interest is mostly by minor companies and individual and/or investment groups. Some sites showed 100% major company interest, such as Bell Flat, of which very few are still lease applications, the remainder closed cases.

This zone includes 1 of the 2 metropolitan localities in the state: Reno-Sparks - (should include Carson City) with many important communities, good to fair transportation arteries.

Economic Base: Tourism, Agriculture/Livestock, Warehousing. The growth in tourism and warehousing increases population energy needs.

Non-Technical Components For Area 18

The Stillwater Wildlife Management area, Indian Reservation land, military and Bureau of Reclamation withdrawals and private lands make up approximately 75% of this total area. The Major waterfowl area for Nevada, Stillwater Wildlife Management Area and Stillwater Wildlife Management Refuge is located in the northern part of this area. It is a very popular and important recreational use region. Area is relatively free from federal environmental decisions with none of the sites having any constraints. When geothermal development is feasible in this area, conflicts will no doubt occur between recreation and development uses of land. Additional environmental studies may be necessary to resolve the conflict.

There are eight (8) sites in the area and two (2) are KGRAs: Soda Lakes-Upsal Hogback and Stillwater. Leasing activity at these KGRAs has been significant but, the greater activity has occured outside but adjacent to the KGRA boundary. Most interest has been shown by major companies who do have a few leases in the KGRAs and vicinity. Close to 95% of all the leasing activity for the area has occured on non-KGRA land by major companies. Most of this activity has been at Four and Eight Mile Flats, North Sands Springs Range, Lee Hot Springs, Carson Lake and Rainbow Mountain. Basically, every one of the eight (8) sites in the area have leasing activity. All sites are also within the U.S.G.S. Area Potential Prospectively.

Extensive geophysical survey and shallow temperature gradient holes work have been implied by the Notices of Intents which have been filed. All sites have been included.

EXPLANATION TO HOT-WATER CONVECTION SYSTEMS SHEETS

Footnotes

(1) Maximum surface temperature reported from a spring or fumarole.

(2) Predicted using chemical geothermometers, assuming last equilibration in the reservoir; assumes saturation of SiO_2 with respect to quartz, and no loss of Ca from calcite deposition.

(3) Assumed average reservoir temperature based on data presently available. Temperatures from Circular 726 and other sources. Temperatures in parentheses are highly subjective.

(4) From surface manifestations, geophysical data, well records, geologic inference and leasing activity. Assumes 1.5 km^2 if no data pertinent to size is available. Top assumed at depth of 1.5 km if no data available. Bottom assumed at 3 km depth for all convection systems. Calculated from assumed area and thickness.

(5) Calculated as product of assumed volume, volumetric specific heat of 0.6 $cal/cm^3°C$, and temperature in degrees C above 15°C.

(6) 0.02 for 150°-200°C
0.025 for 200°-250°C

(7) 25% Heat Content Recoverable as thermal energy at the surface; 1 Quad= 0.25×10^{18} cal.

HOT-WATER CONVECTION SYSTEMS IN AREA 18 .

Location	Temperatures °C			Reservoir Assumptions		Energy Potential		
Site	Surface (1)	Geochemical SiO_2 (2)	Geochemical Na-K-Ca (2)	Subsurface (3)	Volume km^3 (4)	Heat content 10^{18} cal (5)	Recovery Factor e_r (6)	Electrical Potential MW_e-30yrs.	Thermal Energy for Direct Use Quads (7)
Soda Lake-Upsal Hogback	90	165	161	165 (215)	30	3.6	0.025	400	
Soda Lake-Upsal Hogback	90			(215)	5	0.6			0.6
Stillwater	96	159	140	160 (215)	40	4.8	0.025	530	
Carson Lake	70			(185)	10	1.1	0.025	125	
Lee Hot Springs	91	173	162	175 (185)	10	1.1	0.025	125	
Eight Mile Flat	81			(185)	10	1.1	0.025	125	
Stillwater	96			(215)	10	1.2			1.2
Four Mile Flat	Hot								
North Sand Springs Range	ND								
Rainbow Mountain	ND								
TOTAL:								1305	1.8

Footnotes 1 thru 7-see Explanation Page

NEVADA GEOTHERMAL AREA 18 SCENARIO

AREA: 17

SITE CHARACTERISTICS:

SITE: CARSON SINK-ALKALI FLAT, WEST SIDE

Possible Subsequent Additions (MWe) and On Line Date:

50 MWe 1990
50 MWe 1992

POSTULATED SITE DEVELOPMENT SCHEDULE (FOR FIRST 25 MWe PLANT)

OPERATING ENTITIES	ACTIVITY	RECIPIENTS	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
BLM	Approve Notice of Intent-	Developer																								
USGS	Approve NOI & Drill Permit	Developer						—	—																	
BLM/Owner	Lease Land	Developer	(1)				—	—	—	—	—															
BLM	Process EIA/EIS	CEQ					—	—																		
County	Issue Land Use Permits	Developer									—															
Developer	Exploratory Drilling & Reservoir Evaluation											—	—													
Developer	Develop Utility Interest											—														
Developer & Utility	Feasibility Study												—												—	
Producer (Developer) & Utility	Financial Negotiations													—												
Producer	Site Selection													—												
Producer & Utility	Design													—	—	—										
Producer & Utility	Commitment to Development													△												
Producer & Utility	Prepare Master Development Plan	BLM, USGS													—	—										
Utility	Prepare Environmental Data Statement	BLM, FPC STATE, County													—											
BLM, FPC STATE, USGS	Certify Plant & Site Issue Permits	Producer & Utility														—	—									
USGS	Process EIA/EIS (Drilling)	CEQ														—										
FPC	Process EIA/EIS (Plant)	CEQ														—										
FPC	Process EIA/EIS (Transmission Line)	CEQ														—										
Producer	Development Drilling																	—	—							
Utility	Plant Construction																	—	—	—						
Utility	Install Transmission Line (40 km)																		—	—						

(1) Present and possibly any future environmental constraints and land status pattern can be a deterent in development. There are still over 34,000 acres in lease application. Only 10,800 acres have been leased. Have extended "Lease Land" by 2 years.

AREA 17

95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	100	100	50
						25	25	75	75	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125
														20	20	70	70	90	90	90	90	90	90	90	90

COMPOSITE POSTULATED SITE DEVELOPMENT SCHEDULE
FOR AREA 17

SITE NAME	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
Carson Sink-Alkali Flat, W. Side																			25	25	75	75	125	125	125
Carson Sink-Alkali Flat, E. Side																									
Lone Rock																									
TOTAL MWe:																									
TOTAL Quads:																									

20,50,100 = MWe (megawatts electric); electrical power generation.
.037,.04,.017 = Quads (0.252×10^{18} cal.); direct thermal utilization. Quads available for commercial utilization. It is unlikely that the energy developed at each site will be wholly utilized, or utilized in the optimum or most efficient manner.

References To Postulated Site Development Schedules And Non-Technical Components Of Areas.

References (indicated by parentheses and corresponding number)

1. Oral Communication:

2. Regional Environmental Analysis Record
   Geothermal oil/gas leasing (BLM) and maps

   a. Carson City District
      Pyramid District, 1975

   b. Winnemucca District
      Sonoma-Gerlach Resource Area
      Buffalo Hills Planning Unit
      1975

   c. Winnemucca District
      Deno, Paradise, Blue Wing and
      Sonoma Planning Units,
      1975

   d. Elko District,
      1975

   e. Battle Mountain District
      1976

   f. Tonopah Resource Area
      1975

   g. Fort Churchill-Clan Alpine Area,
      Carson City District, Nev., 1975

   h. Pine Nut-Walker Area,
      Carson City District, Nev. 1975

   i. Esmeralda Planning Unit,
      Esmeralda and Nye Counties, 1974

3. Lease Books (Nevada Team Data)
   Data obtained from BLM public records and maps.

4. "Intent to Conduct Geothermal Resource Exploration"
   (Filed with U.S.G.S.), (Maps and Folder) and maps.

5. Drilling and Resource Data Sheets.

6. Plan of Operation, Phillips Petroleum Company,
   March 1, 1978 - To drill 6 geothermal wells to 8000'.
   To determine the existence and commercial potential of geothermal resources.
   Estimating starting date - 6-78
   Estimated comp. date - 12-82

EXPLANATION FOR AREA SHEETS

ENVIRONMENT: Federal environmental decisions relating to availability of federal lands for geothermal resource leasing. All data taken from Environmental Assessment Records prepared by BLM.

CRIT. R.: Critical Restrictions. Restrictions to lessee, in addition to those restrictions covered in the Geothermal Resource Lease Application (Sec. 14 and 18).

EXCLUD. PEND.: Excluded from Leasing. Pending additional environmental studies.

EXCLUD.: Excluded from all leasing.

LAND STATUS: Geothermal leasing status on federal lands.

LSE. APLN.: Lease Application

CLOSED: Closed cases. Application never became lease. In theory the land is available for geothermal leasing.

GEO. SIM.: Geothermal Simultaneous Drawing. These applications became leases, then were terminated or relinquished by the lessee. These parcels are held for simultaneous drawing.

OPEN: Open - No leases presently recorded for site.

A.P.P.: Area Potential Prospectively. As outlined by U.S.G.S., possible geothermal resource areas.

OTHER or KGRA: KGRA - Known Geothermal Resource

OWNERSHIP INTEREST:

MAJOR: Major company interest or holdings.

MINOR: Minor company interest or holdings.

IND./INV.: Individual and/or investment group interest or holdings.

INTENTS: "Intent to Conduct Geothermal Resource Exploration" are filed with U.S.G.S.

GEO.: Geophysical work only. No Drilling (i.e.= Gravity, magnetotelluric and other surveys)

DRILL: Drilling of shallow temperature gradient holes.

OTHER: Any exploration work not included in above categories.

(NOTE: The filing of the Intent to conduct geothermal resource exploration Does Not imply the work was completed.)

AREA: 17

SITE	ENVIRONMENT			LAND STATUS							OWNERSHIP INTEREST			INTENTS			NOTES
	CRIT.R.	EXCLUD. PEND.	EXCLUD.	LSE. APLN.	CLOSED	LSE.	GEO SIM	OPEN	A.P.P.	OTHER or KGRA	MAJOR	MINOR	IND./ INV.	GEO.	DRILL.	OTHER	
Carson Sink-Alkali Flat, W. Side			X	X	X				X			X	X	X	X		Military Ord.
Carson Sink-Alkali Flat, E. Side			X	X	X				X			X	X	X	X		Military Ord.
Lone Rock			X	X	X				X			X	X	X	X		Military Ord.

General Statement to Non-Technical Components Section,
Area Scenarios

1. All observations for environmental, leasing and "Intents" are based on data gathered in 1977, which has not been corrected, adjusted or up-dated.

2. All environmental decisions are federal (BLM) as there are no localities in Nevada which require an environmental statement. Nevada has only 2 laws requiring such reports:

   a. Nevada Clean Air Act of 1971. Amended in 1973.

   b. Utility Environmental Protection Act, 1971.
   Amended 1973.
   Requires environmental statement for utility plant siting.

   Protection of environmental values is now explicitly and clearly a major criteria for BLM management activities. All BLM activities are governed by the "Federal Land Policy and Management Act".

3. Areas 15, 16, 17, 18, 19 grouped together make up a zone of Intensive and Extensive geothermal resource interests.

   A little over 1/2 of the total land in this zone is available for geothermal leasing, the remainder is covered by private indian reservation, Bureau of Reclamation withdrawals, wildlife management and refuge, state parks and military use lands. The zone contains 10 KGRAs.

   There has been intensive "Geophysical" and "Shallow Temperature Gradient Hole" interest indicated by numerous filings of "Intent to do Geothermal Resource Exploration" with U.S.G.S. To date we do not know how many of these projects were completed.

This zone does not have extensive environment decisions but some significant sites will be affected by such decisions. (i.e. Tahoe Basin Area and Carson Sink-Alkali Flat East and West)

There has been significant leasing in this zone, both within the KGRA's and its vicinity. The leasing interest is mostly by minor companies and individual and/or investment groups. Some sites showed 100% major company interest, such as Bell Flat, of which very few are still lease applications, the remainder closed cases.

This zone includes 1 of the 2 metropolitan localities in the state: Reno-Sparks - (should include Carson City) with many important communities, good to fair transportation arteries.

Economic Base: Tourism, Agriculture/Livestock, Warehousing. The growth in tourism and warehousing increases population energy needs.

Non-Technical Components For Area 17

Approximately 85% of this total area is covered by Military Ordinance, Bureau of Reclamation withdrawals and the familiar checkerboard pattern. Only, this time the pattern is created by alternating sections of Fallon Wildlife Management area and Bureau of Reclamation, and/or private lands, as well as some federal lands. All three (3) sites in this area are affected by the federal environmental decision for military ordinance, as well as the other aforementioned land status. This area also includes part of the Stillwater Wildlife Management area which represents Nevada's largest waterfowl location, and, therefore a major recreational area. When geothermal development becomes feasible for this area, no doubt conflict will develop between recreation and site development. Additional environmental studies and decisions may be necessary.

Presently there are no KGRAs in this area, but there has been considerable leasing activity. Approximately 50-50% of all such activity has occured at the Carson Sink-Alkali Flat East and West sites. About 80% of the total activity is still in lease application. Most of leasing interest has been by individuals and/or investment groups.

Present data shows very few Notices of Intent have been filed for this area. But what geophysical survey and shallow temperature gradient holes activity intended, has included the entire area. All sites are also included in U.S.G.S. Area Potential Prospectively.

EXPLANATION TO HOT-WATER CONVECTION SYSTEMS SHEETS

Footnotes

(1) Maximum surface temperature reported from a spring or fumarole.

(2) Predicted using chemical geothermometers, assuming last equilibration in the reservoir; assumes saturation of SiO_2 with respect to quartz, and no loss of Ca from calcite deposition.

(3) Assumed average reservoir temperature based on data presently available. Temperatures from Circular 726 and other sources. Temperatures in parentheses are highly subjective.

(4) From surface manifestations, geophysical data, well records, geologic inference and leasing activity. Assumes 1.5 km^2 if no data pertinent to size is available. Top assumed at depth of 1.5 km if no data available. Bottom assumed at 3 km depth for all convection systems. Calculated from assumed area and thickness.

(5) Calculated as product of assumed volume, volumetric specific heat of 0.6 $cal/cm^3°C$, and temperature in degrees C above 15°C.

(6) 0.02 for 150°-200°C
0.025 for 200°-250°C

(7) 25% Heat Content Recoverable as thermal energy at the surface; 1 Quad= 0.25×10^{18} cal.

HOT-WATER CONVECTION SYSTEMS IN AREA 17 .

Location	Temperatures °C			Reservoir Assumptions		Energy Potential		
Site	Surface (1)	Geochemical SiO_2 (2)	Geochemical Na-K-Ca (2)	Subsurface (3)	Volume km^3 (4)	Heat content 10^{18} cal (5)	Recovery Factor e_r (6)	Electrical Potential MW_e-30yrs.	Thermal Energy for Direct Use Quads (7)
Carson Sink-Alkali Flat, West Side	Hot			(200)	10	1.1	0.025	125	
Carson Sink-Alkali Flat, East Side	ND			(200)	10	1.1	0.025	125	
Lone Rock	ND			(185)	10	1.0	0.02	90	
TOTAL:								340	

Footnotes 1 thru 7-see Explanation Page

NEVADA GEOTHERMAL AREA 17 SCENARIO

AREA: 16

Possible Subsequent Additions
Quads and On Line Date:

SITE CHARACTERISTICS:

SITE: BRADY'S HOT SPRINGS (1)

POSTULATED SITE DEVELOPMENT SCHEDULE (FOR FIRST 0.04 QUAD DEVELOPMENT)

OPERATING ENTITIES	ACTIVITY	RECIPIENTS	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
BLM	Approve Notice of Intent-	Developer																								
USGS	Approve NOI & Drill Permit	Developer																								
BLM/Owner	Lease Land	Developer																								
BLM	Process EIA/EIS	CEQ																								
County	Issue Land Use Permits	Developer																								
Developer	Exploratory Drilling & Reservoir Evaluation																									
Developer	Develop User Interest																									
Developer & User	Feasibility Study			Completed																						
Producer (Developer) & User	Financial Negotiations																									
Producer	Site Selection																									
Producer & User	Design																									
Producer & User	Commitment to Development									△																
Producer & User	Prepare Master Development Plan	BLM, USGS																								
User	Prepare Environmental Data Statement	BLM, STATE, County																								
BLM, STATE, USGS	Issue Permits on Site	Producer & User																								
USGS	Process EIA/EIS (Drilling)	CEQ																								
Producer	Development Drilling																									
User	Plant Construction																									

(1) Dehydration/Processing plant on line-1978. Above based on this date.
DOE Loan Guarantee approved Oct. 14, 1977. Commitment to develop is based on this fact.

AREA: 16

SITE CHARACTERISTICS:

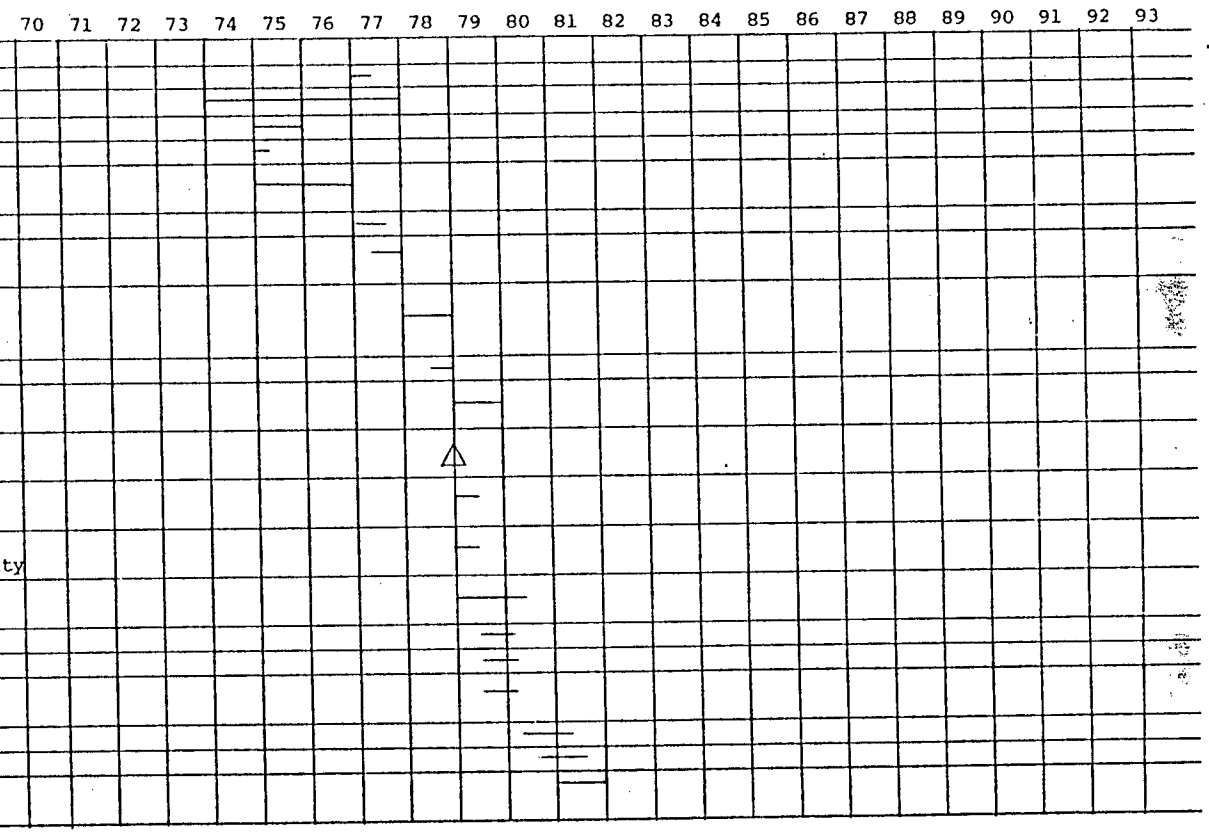
SITE: DESERT PEAK (1)

POSTULATED SITE DEVELOPMENT SCHEDULE (FOR FIRST 20 MWe PLANT)

Possible Subsequent Additions (MWe) and On Line Date:

50 MWe	1984	100 MWe	1992
50 MWe	1986	100 MWe	1994
100 MWe	1988	100 MWe	1996
100 Mwe	1990	45 MWe	1998

OPERATING ENTITIES	ACTIVITY	RECIPIENTS
BLM	Approve Notice of Intent-	Developer
USGS	Approve NOI & Drill Permit	Developer
BLM/Owner	Lease Land	Developer
BLM	Process EIA/EIS	CEQ
County	Issue Land Use Permits	Developer
Developer	Exploratory Drilling & Reservoir Evaluation	
Developer	Develop Utility Interest	
Developer & Utility	Feasibility Study	
Producer (Developer) & Utility	Financial Negotiations	
Producer	Site Selection	
Producer & Utility	Design	
Producer & Utility	Commitment to Development	
Producer & Utility	Prepare Master Development Plan	BLM, USGS
Utility	Prepare Environmental Data Statement	BLM, FPC STATE, County
BLM, FPC STATE, USGS	Certify Plant & Site Issue Permits	Producer & Utility
USGS	Process EIA/EIS (Drilling)	CEQ
FPC	Process EIA/EIS (Plant)	CEQ
FPC	Process EIA/EIS (Transmission Line)	CEQ
Producer	Development Drilling	
Utility	Plant Construction	
Utility	Install Transmission Line (40 km)	



(1) Private land

AREA 16

95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
520	620	620	665	665	665	665	665	665	665	665	665	665	665	665	665	665	645	645	595	595	495	495	395	395	295
.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04													
					25	25	75	75	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125
.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04					
										15	15	65	65	165	165	215	215	265	265	265	265	265	265	265	265
															25	25	75	75	125	125	125	125	125	125	125
15	15	65	65	165	165	215	215	265	265	265	265	265	265	265	265	265	265	265	265	265	265	265	265	265	265

COMPOSITE POSTULATED SITE DEVELOPMENT SCHEDULE
FOR AREA 16

SITE NAME	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
Desert Peak													20	20	70	70	120	120	220	220	320	320	420	420	520
Brady's Hot Springs									.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04
Huxley																									
Eagle Salt Works																	.04	.04	.04	.04	.04	.04	.04	.04	.04
Hot Springs Mountains																									
Hazen																									
Biddleman Spring																									
Brady's Hot Springs																									
TOTAL MWe:																									
TOTAL Quads:																									

20,50,100 = MWe (megawatts electric); electrical power generation.
.037,.04,.017 = Quads (0.252×10^{18} cal.); direct thermal utilization. Quads available for commercial utilization. It is unlikely that the energy developed at each site will be wholly utilized, or utilized in the optimum or most efficient manner.

References To Postulated Site Development Schedules And Non-Technical Components Of Areas.

References (indicated by parentheses and corresponding number)

1. Oral Communication:

2. Regional Environmental Analysis Record
   Geothermal oil/gas leasing (BLM) and maps

   a. Carson City District
      Pyramid District, 1975

   b. Winnemucca District
      Sonoma-Gerlach Resource Area
      Buffalo Hills Planning Unit
      1975

   c. Winnemucca District
      Deno, Paradise, Blue Wing and
      Sonoma Planning Units,
      1975

   d. Elko District,
      1975

   e. Battle Mountain District
      1976

   f. Tonopah Resource Area
      1975

   g. Fort Churchill-Clan Alpine Area,
      Carson City District, Nev., 1975

   h. Pine Nut-Walker Area,
      Carson City District, Nev. 1975

   i. Esmeralda Planning Unit,
      Esmeralda and Nye Counties, 1974

3. Lease Books (Nevada Team Data)
   Data obtained from BLM public records and maps.

4. "Intent to Conduct Geothermal Resource Exploration"
   (Filed with U.S.G.S.), (Maps and Folder) and maps.

5. Drilling and Resource Data Sheets.

6. Plan of Operation, Phillips Petroleum Company,
   March 1, 1978 - To drill 6 geothermal wells to 8000'.
   To determine the existence and commercial potential of geothermal resources.
   Estimating starting date - 6-78
   Estimated comp. date - 12-82

EXPLANATION FOR AREA SHEETS

ENVIRONMENT: Federal environmental decisions relating to availability of federal lands for geothermal resource leasing. All data taken from Environmental Assessment Records prepared by BLM.

CRIT. R.: Critical Restrictions. Restrictions to lessee, in addition to those restrictions covered in the Geothermal Resource Lease Application (Sec. 14 and 18).

EXCLUD. PEND.: Excluded from Leasing. Pending additional environmental studies.

EXCLUD.: Excluded from all leasing.

LAND STATUS: Geothermal leasing status on federal lands.

LSE. APLN.: Lease Application

CLOSED: Closed cases. Application never became lease. In theory the land is available for geothermal leasing.

GEO. SIM.: Geothermal Simultaneous Drawing. These applications became leases, then were terminated or relinquished by the lessee. These parcels are held for simultaneous drawing.

OPEN: Open - No leases presently recorded for site.

A.P.P.: Area Potential Prospectively. As outlined by U.S.G.S., possible geothermal resource areas.

OTHER or KGRA: KGRA - Known Geothermal Resource

OWNERSHIP INTEREST:

MAJOR: Major company interest or holdings.

MINOR: Minor company interest or holdings.

IND./INV.: Individual and/or investment group interest or holdings.

INTENTS: "Intent to Conduct Geothermal Resource Exploration" are filed with U.S.G.S.

GEO.: Geophysical work only. No Drilling (i.e.= Gravity, magnetotelluric and other surveys)

DRILL: Drilling of shallow temperature gradient holes.

OTHER: Any exploration work not included in above categories.

(NOTE: The filing of the Intent to conduct geothermal resource exploration Does Not imply the work was completed.)

AREA: 16

SITE	ENVIRONMENT			LAND STATUS							OWNERSHIP INTEREST			INTENTS			NOTES
	CRIT.R.	EXCLUD. PEND.	EXCLUD.	LSE. APLN.	CLOSED	LSE.	GEO SIM	OPEN	A.P.P.	OTHER or KGRA	MAJOR	MINOR	IND./ INV.	GEO.	DRILL.	OTHER	
Desert Peak				X	X				X		X	X	X	X	X		Some private land
Huxley				X	X				X			X		X			
Eagle Salt Works				X	X				X			X		X			
Hot Springs Mtns.				X	X				X			X		X			Bur. Rec. Wdwl
Hazen				X	X				X	KGRA	X		X				State Pr. land
Brady's Hot Springs				X	X				X	KGRA		X		X	X		Bur. Reclam.
Biddleman Spring									X								

General Statement to Non-Technical Components Section,
Area Scenarios

1. All observations for environmental, leasing and "Intents" are based on data gathered in 1977, which has not been corrected, adjusted or up-dated.

2. All environmental decisions are federal (BLM) as there are no localities in Nevada which require an environmental statement. Nevada has only 2 laws requiring such reports:

   a. Nevada Clean Air Act of 1971. Amended in 1973.

   b. Utility Environmental Protection Act, 1971.
   Amended 1973.
   Requires environmental statement for utility plant siting.

   Protection of environmental values is now explicitly and clearly a major criteria for BLM management activities. All BLM activities are governed by the "Federal Land Policy and Management Act".

3. Areas 15, 16, 17, 18, 19 grouped together make up a zone of Intensive and Extensive geothermal resource interests.

   A little over 1/2 of the total land in this zone is available for geothermal leasing, the remainder is covered by private indian reservation, Bureau of Reclamation withdrawals, wildlife management and refuge, state parks and military use lands. The zone contains 10 KGRAs.

   There has been intensive "Geophysical" and "Shallow Temperature Gradient Hole" interest indicated by numerous filings of "Intent to do Geothermal Resource Exploration" with U.S.G.S. To date we do not know how many of these projects were completed.

This zone does not have extensive environment decisions but some significant sites will be affected by such decisions. (i.e. Tahoe Basin Area and Carson Sink-Alkali Flat East and West)

There has been significant leasing in this zone, both within the KGRA's and its vicinity. The leasing interest is mostly by minor companies and individual and/or investment groups. Some sites showed 100% major company interest, such as Bell Flat, of which very few are still lease applications, the remainder closed cases.

This zone includes 1 of the 2 metropolitan localities in the state: Reno-Sparks - (should include Carson City) with many important communities, good to fair transportation arteries.

Economic Base: Tourism, Agriculture/Livestock, Warehousing. The growth in tourism and warehousing increases population energy needs.

Non-Technical Components For Area 16

Nearly 95% of the total area is taken by the checkerboard pattern of alternating federal and private lands, Indian Reservation and Bureau of Reclamation withdrawal. Only two (2) of the seven (7) sites in this area are on federal land: Huxley and Eagle Salt Works. The remaining five (5) sites are on one of the above noted land status. No federal environmental decisions affect this area.

There are two (2) KGRAs in the area. Brady's Hot Spring and Hazen. Both have had significant leasing activity with the majority of activity now in closed cases with few geothermal leases. Interest at both sites has been by both major and minor companies. Activity has also occured at four (4) other sites, but not a significant trend. The exception is at Huxley. This site is a non-KGRA but has 60% of its leasing activity now in geothermal leases. Biddleman Spring is the only site without leasing activity. All seven (7) sites in this area are included in U.S.G.S. Area Potential Prospectively.

Several Notices of Intent have been filed for the area with most interest for both geophysical survey and shallow temperature gradient holes concentrated at Brady's Hot Springs and Desert Peak.

The geothermal resources at the Desert Peak site are now being used in a newly completed food processing plant. The leases and plant site are on private property. The communities of Wadsworth and Fernley are about 30 miles from this new plant.

EXPLANATION TO HOT-WATER CONVECTION SYSTEMS SHEETS

Footnotes

(1) Maximum surface temperature reported from a spring or fumarole.

(2) Predicted using chemical geothermometers, assuming last equilibration in the reservoir; assumes saturation of SiO_2 with respect to quartz, and no loss of Ca from calcite deposition.

(3) Assumed average reservoir temperature based on data presently available. Temperatures from Circular 726 and other sources. Temperatures in parentheses are highly subjective.

(4) From surface manifestations, geophysical data, well records, geologic inference and leasing activity. Assumes 1.5 km^2 if no data pertinent to size is available. Top assumed at depth of 1.5 km if no data available. Bottom assumed at 3 km depth for all convection systems. Calculated from assumed area and thickness.

(5) Calculated as product of assumed volume, volumetric specific heat of 0.6 $cal/cm^3°C$, and temperature in degrees C above 15°C.

(6) 0.02 for 150°-200°C
0.025 for 200°-250°C

(7) 25% Heat Content Recoverable as thermal energy at the surface; 1 Quad= 0.25×10^{18} cal.

HOT-WATER CONVECTION SYSTEMS IN AREA 16 .

Location	Temperatures °C			Reservoir Assumptions		Energy Potential		
Site	Surface (1)	Geochemical SiO_2 (2)	Geochemical Na-K-Ca (2)	Subsurface (3)	Volume km^3 (4)	Heat content 10^{18} cal (5)	Recovery Factor e_r (6)	Electrical Potential MW_e-30yrs.	Thermal Energy for Direct Use Quads (7)
Desert Peak	ND			212 (215)	50	6.0	0.025	665	
Brady's Hot Springs	98	179		214 (215)	20	2.4	0.025	265	
Huxley	ND			(200)	10	1.1	0.025	125	
Eagle Salt Works	Hot			(215)	10	1.2			1.2
Hot Springs Mountains	ND			(215)	20	2.4	0.025	265	
Hazen	ND			132-(200)	10	1.1	0.025	125	
Biddlemen Spring	24								
Brady's Hot Springs	98			(215)	10	1.2			1.2
TOTAL:								1445	2.4

Footnotes 1 thru 7-see Explanation Page

NEVADA GEOTHERMAL AREA 16 SCENARIO

AREA: 15

SITE CHARACTERISTICS:

SITE: STEAMBOAT SPRING-HUFFAKER

Possible Subsequent Additions
Quads and On Line Date:

POSTULATED SITE DEVELOPMENT SCHEDULE (FOR FIRST .037 QUAD DEVELOPMENT)

OPERATING ENTITIES	ACTIVITY	RECIPIENTS	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
BLM	Approve Notice of Intent-	Developer							—	—																
USGS	Approve NOI & Drill Permit	Developer																								
BLM/Owner	Lease Land	Developer					—	—	—	—																
BLM	Process EIA/EIS	CEQ						—																		
County	Issue Land Use Permits	Developer									—															
Developer	Exploratory Drilling & Reservoir Evaluation										—	—														
Developer	Develop User Interest										—	—														
Developer & User	Feasibility Study											—														
Producer (Developer) & User	Financial Negotiations											—	—										—			
Producer	Site Selection											—														
Producer & User	Design												—													
Producer & User	Commitment to Development												△													
Producer & User	Prepare Master Development Plan	BLM, USGS											—													
User	Prepare Environmental Data Statement	BLM, STATE, County											—													
BLM, STATE, USGS	Issue Permits on Site	Producer & User												—												
USGS	Process EIA/EIS (Drilling)	CEQ												—												
Producer	Development Drilling														—											
User	Plant Construction														—											

AREA: 15

SITE CHARACTERISTICS:

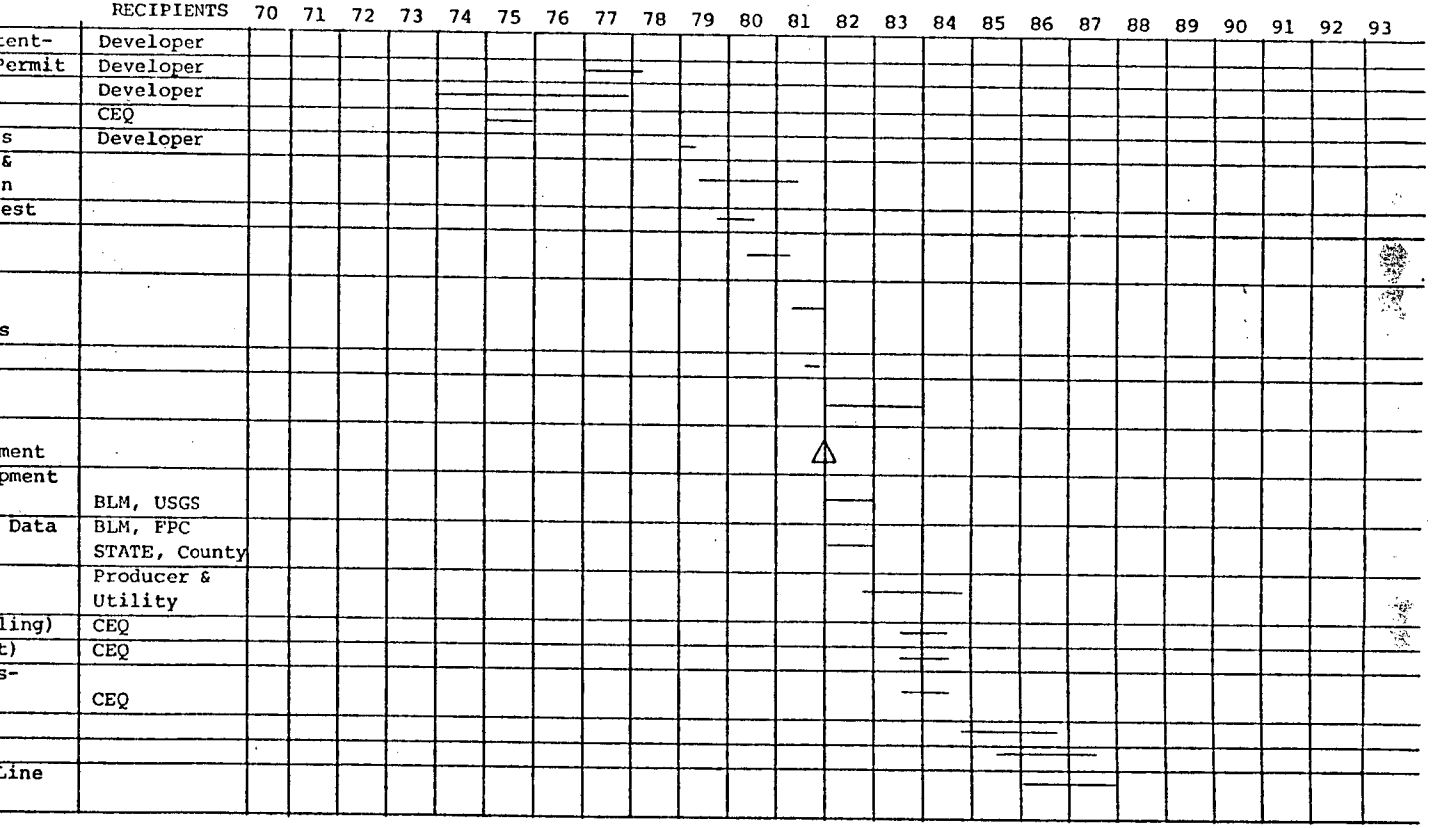
SITE: STEAMBOAT SPRING-HUFFAKER (1)

Possible Subsequent Additions (MWe) and On Line Date:

50 MWe 1991
100 MWe 1994
100 MWe 1997
50 MWe 2000
50 MWe 2003

POSTULATED SITE DEVELOPMENT SCHEDULE (FOR FIRST 50 MWe PLANT)

OPERATING ENTITIES	ACTIVITY	RECIPIENTS
BLM	Approve Notice of Intent-	Developer
USGS	Approve NOI & Drill Permit	Developer
BLM/Owner	Lease Land	Developer
BLM	Process EIA/EIS	CEQ
County	Issue Land Use Permits	Developer
Developer	Exploratory Drilling & Reservoir Evaluation	
Developer	Develop Utility Interest	
Developer & Utility	Feasibility Study	
Producer (Developer) & Utility	Financial Negotiations	
Producer	Site Selection	
Producer & Utility	Design	
Producer & Utility	Commitment to Development	
Producer & Utility	Prepare Master Development Plan	BLM, USGS
Utility	Prepare Environmental Data Statement	BLM, FPC STATE, County
BLM, FPC STATE, USGS	Certify Plant & Site Issue Permits	Producer & Utility
USGS	Process EIA/EIS (Drilling)	CEQ
FPC	Process EIA/EIS (Plant)	CEQ
FPC	Process EIA/EIS (Transmission Line)	CEQ
Producer	Development Drilling	
Utility	Plant Construction	
Utility	Install Transmission Line (40 km)	



(1) Federal/Private land. Area may have delays due to present recreational uses, known historic value and projected development for housing.

AREA 15

95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
200	200	300	300	300	350	350	350	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	350	350	350
.037	.037	.037	.037	.037	.037	.037	.037	.036	.036	.036	.036	036	.036	.036	.036	.036	.036								
.037	.037	.037	.037	.037	.037	.037	.037	.037	.037	.037	.037	037	.037	.037	.036	.036	.036	.036	.036	.036	.036	.036	.036	.036	
															25	25	25	75	75	75	75	75	75	75	75
.017	.017	.017	.017	.017	.017	.017	.017	.017	.017	.017	.017	.017	.017	.017	.017	.017	.016	.016	.016	.016	.016	.016	.016	.016	.016

COMPOSITE POSTULATED SITE DEVELOPMENT SCHEDULE
FOR AREA 15

SITE NAME	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
Steamboat Spring-Huffaker																			50	50	50	100	100	100	200
Steamboat Spring-Huffaker														.037	.037	.037	.037	.037	.037	.037	.037	.037	.037	.037	.037
Moana Spring-Lawton																					.037	.037	.037	.037	.037
Comstock Mining District																									
Washoe Valley																							.017	.017	.017
Hobo-Saratoga Springs																									
Carson H. Sps.-Pinyon Hills																									
Dayton																									
Lockwood																									
Spanish Springs																									
Walley's Hot Spring																									
Double Spring Flat																									
Deep Canyon																									
Crystal Bay																									
TOTAL MWe:																									
TOTAL Quads:																									

20,50,100 = MWe (megawatts electric); electrical power generation.
.037,.04,.017 = Quads (0.252×10^{18} cal.); direct thermal utilization. Quads available for commercial utilization. It is unlikely that the energy developed at each site will be wholly utilized, or utilized in the optimum or most efficient manner.

References To Postulated Site Development Schedules And Non-Technical Components Of Areas.

References (indicated by parentheses and corresponding number)

1. Oral Communication:

2. Regional Environmental Analysis Record
   Geothermal oil/gas leasing (BLM) and maps

   a. Carson City District
      Pyramid District, 1975

   b. Winnemucca District
      Sonoma-Gerlach Resource Area
      Buffalo Hills Planning Unit
      1975

   c. Winnemucca District
      Deno, Paradise, Blue Wing and
      Sonoma Planning Units,
      1975

   d. Elko District,
      1975

   e. Battle Mountain District
      1976

   f. Tonopah Resource Area
      1975

   g. Fort Churchill-Clan Alpine Area,
      Carson City District, Nev., 1975

   h. Pine Nut-Walker Area,
      Carson City District, Nev. 1975

   i. Esmeralda Planning Unit,
      Esmeralda and Nye Counties, 1974

3. Lease Books (Nevada Team Data)
   Data obtained from BLM public records and maps.

4. "Intent to Conduct Geothermal Resource Exploration"
   (Filed with U.S.G.S.), (Maps and Folder) and maps.

5. Drilling and Resource Data Sheets.

6. Plan of Operation, Phillips Petroleum Company,
   March 1, 1978 - To drill 6 geothermal wells to 8000'.
   To determine the existence and commercial potential of geothermal resources.
   Estimating starting date - 6-78
   Estimated comp. date - 12-82

EXPLANATION FOR AREA SHEETS

ENVIRONMENT: Federal environmental decisions relating to availability of federal lands for geothermal resource leasing. All data taken from Environmental Assessment Records prepared by BLM.

CRIT. R.: Critical Restrictions. Restrictions to lessee, in addition to those restrictions covered in the Geothermal Resource Lease Application (Sec. 14 and 18).

EXCLUD. PEND.: Excluded from Leasing. Pending additional environmental studies.

EXCLUD.: Excluded from all leasing.

LAND STATUS: Geothermal leasing status on federal lands.

LSE. APLN.: Lease Application

CLOSED: Closed cases. Application never became lease. In theory the land is available for geothermal leasing.

GEO. SIM.: Geothermal Simultaneous Drawing. These applications became leases, then were terminated or relinquished by the lessee. These parcels are held for simultaneous drawing.

OPEN: Open - No leases presently recorded for site.

A.P.P.: Area Potential Prospectively. As outlined by U.S.G.S., possible geothermal resource areas.

OTHER or KGRA: KGRA - Known Geothermal Resource

OWNERSHIP INTEREST:

MAJOR: Major company interest or holdings.

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IND./INV.: Individual and/or investment group interest or holdings.

INTENTS: "Intent to Conduct Geothermal Resource Exploration" are filed with U.S.G.S.

GEO.: Geophysical work only. No Drilling (i.e.= Gravity, magnetotelluric and other surveys)

DRILL: Drilling of shallow temperature gradient holes.

OTHER: Any exploration work not included in above categories.

(NOTE: The filing of the Intent to conduct geothermal resource exploration Does Not imply the work was completed.)

AREA: 15

SITE	ENVIRONMENT			LAND STATUS							OWNERSHIP INTEREST			INTENTS			NOTES
	CRIT.R.	EXCLUD. PEND.	EXCLUD.	LSE. APLN.	CLOSED	LSE.	GEO SIM	OPEN	A.P.P.	OTHER or KGRA	MAJOR	MINOR	IND./ INV.	GEO.	DRILL.	OTHER	
Steamboat Spring-Huffaker				X	X				X	KGRA	X	X		X			Some Private Land
Moana Sp.-Lawton				X	X				X	KGRA				X			Private
Comstock Mining District		X						X	X						X		Some Private Land
Deep Canyon								X	X	Private				X			Some Private Land
Spanish Springs				X	X				X		X	X			X		Some Private Land
Lockwood				X	X				X			X			X		Some Private Land
Walley's H. Sp.				X	X				X								
Washoe Valley				X	X				X		X						Some Private Land
Hobo-Saratoga Sps.					X			X	X								
Carson H. Sps.-Pinyon Hills					X			X	X								
Double Sp. Flat								X									
Crystal Bay			X					X		Private							& Nat'l. Forest
Dayton																	

General Statement to Non-Technical Components Section,

Area Scenarios

1. All observations for environmental, leasing and "Intents" are based on data gathered in 1977, which has not been corrected, adjusted or up-dated.

2. All environmental decisions are federal (BLM) as there are no localities in Nevada which require an environmental statement. Nevada has only 2 laws requiring such reports:

   a. Nevada Clean Air Act of 1971. Amended in 1973.

   b. Utility Environmental Protection Act, 1971.
   Amended 1973.
   Requires environmental statement for utility plant siting.

   Protection of environmental values is now explicitly and clearly a major criteria for BLM management activities. All BLM activities are governed by the "Federal Land Policy and Management Act".

3. Areas 15, 16, 17, 18, 19 grouped together make up a zone of Intensive and Extensive geothermal resource interests.

   A little over 1/2 of the total land in this zone is available for geothermal leasing, the remainder is covered by private indian reservation, Bureau of Reclamation withdrawals, wildlife management and refuge, state parks and military use lands. The zone contains 10 KGRAs.

   There has been intensive "Geophysical" and "Shallow Temperature Gradient Hole" interest indicated by numerous filings of "Intent to do Geothermal Resource Exploration" with U.S.G.S. To date we do not know how many of these projects were completed.

   This zone does not have extensive environment decisions but some significant sites will be affected by such decisions. (i.e. Tahoe Basin Area and Carson Sink-Alkali Flat East and West)

   There has been significant leasing in this zone, both within the KGRA's and its vicinity. The leasing interest is mostly by minor companies and individual and/or investment groups. Some sites showed 100% major company interest, such as Bell Flat, of which very few are still lease applications, the remainder closed cases.

   This zone includes 1 of the 2 metropolitan localities in the state: Reno-Sparks - (should include Carson City) with many important communities, good to fair transportation arteries.

   Economic Base: Tourism, Agriculture/Livestock, Warehousing. The growth in tourism and warehousing increases population energy needs.

Non-Technical Components For Area 15

Approximately 80% of the total area is under private Indian Trust, State Parks and National Forest land classification. Along the western side of this area, is part of the Tahoe Basin (Toiyable Nat'l Forest) which is excluded from leasing by a Federal environmental decision. One of the sites, Crystal Bay, is included in this region. Another site affected by federal environmental decision is the Comstock Mining District which is excluded from leasing because of historic places which are listed on the Register of Historic Places. There are a total of fourteen (14) sites in this area and all of the sites are located either on or adjacent to private property.

There has been significant leasing activity in the area with the most important interest at the two (2) KGRAs, Steamboat Spring-Huffaker and Moana Spring-Lawton sites. Both sites contain private property. Most of the activity on federal land at these sites are lease applications which never went to lease. Six (6) other sites have had leasing activity but all the leases are now closed cases.

Notices of Intents have been filed for the area, which most of the geophysical survey work centered in the Steamboat Spring-Huffaker and Moana Spring-Lawton sites, while most of the shallow temperature gradient hole activity was focused at Spanish Springs, Lockwood and Comstock Mining District sites.

Since most of the sites are located on private property, information is not easily available. Presently space heating and recreation are the two uses for the geothermal resource. The area also contains one of the two metropolitan regions in Nevada, Reno-Sparks. Growth is increasing as more land is removed from pasture and used for housing/retail/tourist development. Geothermal development will almost surely be in competition with the other entities for space.

EXPLANATION TO HOT-WATER CONVECTION SYSTEMS SHEETS

Footnotes

(1) Maximum surface temperature reported from a spring or fumarole.

(2) Predicted using chemical geothermometers, assuming last equilibration in the reservoir; assumes saturation of SiO_2 with respect to quartz, and no loss of Ca from calcite deposition.

(3) Assumed average reservoir temperature based on data presently available. Temperatures from Circular 726 and other sources. Temperatures in parentheses are highly subjective.

(4) From surface manifestations, geophysical data, well records, geologic inference and leasing activity. Assumes 1.5 km^2 if no data pertinent to size is available. Top assumed at depth of 1.5 km if no data available. Bottom assumed at 3 km depth for all convection systems. Calculated from assumed area and thickness.

(5) Calculated as product of assumed volume, volumetric specific heat of 0.6 $cal/cm^3°C$, and temperature in degrees C above 15°C.

(6) 0.02 for 150°-200°C
0.025 for 200°-250°C

(7) 25% Heat Content Recoverable as thermal energy at the surface; 1 Quad= 0.25×10^{18} cal.

HOT-WATER CONVECTION SYSTEMS IN AREA 15 .

Location	Temperatures °C			Reservoir Assumptions		Energy Potential		
Site	Surface (1)	Geochemical SiO_2 (2)	Geochemical Na-K-Ca (2)	Subsurface (3)	Volume km^3 (4)	Heat content 10^{18} cal (5)	Recovery Factor e_r (6)	Electrical Potential MW_e-30yrs.	Thermal Energy for Direct Use Quads (7)
Steamboat Spring-Huffaker	96	207	226	210 (215)	30	3.6	0.025	400	
Steamboat Spring-Huffaker	96			(60)	40	1.1			1.1
Moana Spring-Lawton	48			98-(60)	40	1.1			1.1
Comstock Mining District	ND			77-(155)	10	0.8	0.02	75	
Washoe Valley	53			(60)	20	0.5			0.5
Hobo-Saratoga Springs	50								
Carson Hot Sps.-Pinyon Hills	49								
Dayton	35-								
Lockwood	ND								
Spanish Springs	ND								
Walley's Hot Spring	71	109	85	110	2.25	0.1			
Double Spring Flat	21								
Deep Canyon	Hot								
Crystal Bay	60								
TOTAL:								475	2.7

Footnotes 1 thru 7-see Explanation Page

NEVADA GEOTHERMAL AREA 15 SCENARIO

AREA: 14

SITE CHARACTERISTICS:

SITE: SULPHUR HOT SPRINGS (1)

Possible Subsequent Additions (MWe) and On Line Date:

50 MWe	1991	50 MWe	1999
100 MWe	1993	50 MWe	2001
100 MWe	1995	20 MWe	2003
100 MWe	1997		

POSTULATED SITE DEVELOPMENT SCHEDULE (FOR FIRST 20 MWe PLANT)

OPERATING ENTITIES	ACTIVITY	RECIPIENTS	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
BLM	Approve Notice of Intent-	Developer																								
USGS	Approve NOI & Drill Permit	Developer	(2)																							
BLM/Owner	Lease Land	Developer																								
BLM	Process EIA/EIS	CEQ																								
County	Issue Land Use Permits	Developer																								
Developer	Exploratory Drilling & Reservoir Evaluation																									
Developer	Develop Utility Interest																									
Developer & Utility	Feasibility Study																									
Producer (Developer) & Utility	Financial Negotiations																									
Producer	Site Selection																									
Producer & Utility	Design																									
Producer & Utility	Commitment to Development															△										
Producer & Utility	Prepare Master Development Plan	BLM, USGS																								
Utility	Prepare Environmental Data Statement	BLM, FPC STATE, County																								
BLM, FPC STATE, USGS	Certify Plant & Site Issue Permits	Producer & Utility																								
USGS	Process EIA/EIS (Drilling)	CEQ																								
FPC	Process EIA/EIS (Plant)	CEQ																								
FPC	Process EIA/EIS (Transmission Line)	CEQ																								
Producer	Development Drilling																									
Utility	Plant Construction																									
Utility	Install Transmission Line (40 km)																									

(1) Sulphur Hot Springs located (by U.S.G.S.) as T31N/R59E Sec. 11-Now included in the Ruby Valley KGRA

(2) Drilling permits (Geophysical) and exploratory drilling may take longer due to some environmental restrictions even though there is some private property.

AREA 14

95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
270	270	370	370	420	420	470	470	490	490	490	490	490	490	490	490	490	490	490	490	490	490	490	490	470	470
										30	30	80	80	130	130	180	180	180	180	180	180	180	180	180	180
															20	20	70	70	120	120	170	170	220	220	245
																						30	30	80	80

COMPOSITE POSTULATED SITE DEVELOPMENT SCHEDULE
FOR AREA 14

SITE NAME	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
Sulphur Hot Springs																				20	20	70	70	170	170
Monte Neva Hot Springs																									
Ruby Lake																									
Cherry Creek Hot Springs																									
Collar and Elbow Spring																									
Dolly Varden																									
Ely-Lackawanna Hot Springs																									
North Spring Valley																									
Winchett Lake																									
Wood Hills																									
Hardy Creek																									
Buck Pass																									
Pancake Summit																									
McGill																									
Steptoe																									
Duck Creek																									
Becky Peak																									
Shellborne Pass																									
Pleasant Valley																									
Snake Range																									
TOTAL MWe:																									
TOTAL Quads:																									

20,50,100 = MWe (megawatts electric); electrical power generation.
.037,.04,.017 = Quads (0.252×10^{18} cal.); direct thermal utilization. Quads available for commercial utilization. It is unlikely that the energy developed at each site will be wholly utilized, or utilized in the optimum or most efficient manner.

References To Postulated Site Development Schedules And Non-Technical Components Of Areas.

References (indicated by parentheses and corresponding number)

1. Oral Communication:

2. Regional Environmental Analysis Record
   Geothermal oil/gas leasing (BLM) and maps

   a. Carson City District
      Pyramid District, 1975

   b. Winnemucca District
      Sonoma-Gerlach Resource Area
      Buffalo Hills Planning Unit
      1975

   c. Winnemucca District
      Deno, Paradise, Blue Wing and
      Sonoma Planning Units,
      1975

   d. Elko District,
      1975

   e. Battle Mountain District
      1976

   f. Tonopah Resource Area
      1975

   g. Fort Churchill-Clan Alpine Area,
      Carson City District, Nev., 1975

   h. Pine Nut-Walker Area,
      Carson City District, Nev. 1975

   i. Esmeralda Planning Unit,
      Esmeralda and Nye Counties, 1974

3. Lease Books (Nevada Team Data)
   Data obtained from BLM public records and maps.

4. "Intent to Conduct Geothermal Resource Exploration"
   (Filed with U.S.G.S.), (Maps and Folder) and maps.

5. Drilling and Resource Data Sheets.

6. Plan of Operation, Phillips Petroleum Company,
   March 1, 1978 - To drill 6 geothermal wells to 8000'.
   To determine the existence and commercial potential of
   geothermal resources.
   Estimating starting date - 6-78
   Estimated comp. date - 12-82

EXPLANATION FOR AREA SHEETS

ENVIRONMENT: Federal environmental decisions relating to availability of federal lands for geothermal resource leasing. All data taken from Environmental Assessment Records prepared by BLM.

CRIT. R.: Critical Restrictions. Restrictions to lessee, in addition to those restrictions covered in the Geothermal Resource Lease Application (Sec. 14 and 18).

EXCLUD. PEND.: Excluded from Leasing. Pending additional environmental studies.

EXCLUD.: Excluded from all leasing.

LAND STATUS: Geothermal leasing status on federal lands.

LSE. APLN.: Lease Application

CLOSED: Closed cases. Application never became lease. In theory the land is available for geothermal leasing.

GEO. SIM.: Geothermal Simultaneous Drawing. These applications became leases, then were terminated or relinquished by the lessee. These parcels are held for simultaneous drawing.

OPEN: Open - No leases presently recorded for site.

A.P.P.: Area Potential Prospectively. As outlined by U.S.G.S., possible geothermal resource areas.

OTHER or KGRA: KGRA - Known Geothermal Resource

OWNERSHIP INTEREST:

MAJOR: Major company interest or holdings.

MINOR: Minor company interest or holdings.

IND./INV.: Individual and/or investment group interest or holdings.

INTENTS: "Intent to Conduct Geothermal Resource Exploration" are filed with U.S.G.S.

GEO.: Geophysical work only. No Drilling (i.e.= Gravity, magnetotelluric and other surveys)

DRILL: Drilling of shallow temperature gradient holes.

OTHER: Any exploration work not included in above categories.

(NOTE: The filing of the Intent to conduct geothermal resource exploration Does Not imply the work was completed.)

AREA: 14

SITE	ENVIRONMENT			LAND STATUS							OWNERSHIP INTEREST			INTENTS			NOTES
	CRIT. R.	EXCLUD. PEND.	EXCLUD.	LSE. APLN.	CLOSED	LSE.	GEO SIM	OPEN	A.P.P.	OTHER OF KGRA	MAJOR	MINOR	IND./ INV.	GEO.	DRILL.	OTHER	
Monte Neva H.Sps.	X(Minor)					X			X	KGRA	X				X		Some Private Land
Sulphur Hot Spgs.	X			X	X	X			X	KGRA	X						Some Private Land
Steptoe	X							X	X								
Ruby Lake								X	X								Ruby L. Wild Ref.
Collar & Elbow Sp.								X	X								
Becky Peak								X	X								
Duck Creek				X					X		X						
North Sp. Valley								X	X								
McGill								X	X								Some Private Land
Ely-Lackawanna H. Springs								X	X								Some Private Land
Cherry Crk. H. Sps								X	X								
Shellborne Pass				X	X			X	X		X						Some Private Land
Dolly Varden				X	X						X						
Snake Range				X	X								X				
Winchett Lake								X									
Wood Hills								X									
Hardy Creek								X									
Buck Pass								X									
Pancake Summit								X									
Pleasant Valley								X									

General Statement to Non-Technical Components Section,
Area Scenarios

1. All observations for environmental, leasing and "Intents" are based on data gathered in 1977, which has not been corrected, adjusted or up-dated.

2. All environmental decisions are federal (BLM) as there are no localities in Nevada which require an environmental statement. Nevada has only 2 laws requiring such reports:

   a. Nevada Clean Air Act of 1971. Amended in 1973.

   b. Utility Environmental Protection Act, 1971.
   Amended 1973.
   Requires environmental statement for utility plant siting.

   Protection of environmental values is now explicitly and clearly a major criteria for BLM management activities. All BLM activities are governed by the "Federal Land Policy and Management Act".

3. Areas 15, 16, 17, 18, 19 grouped together make up a zone of Intensive and Extensive geothermal resource interests.

   A little over 1/2 of the total land in this zone is available for geothermal leasing, the remainder is covered by private indian reservation, Bureau of Reclamation withdrawals, wildlife management and refuge, state parks and military use lands. The zone contains 10 KGRAs.

   There has been intensive "Geophysical" and "Shallow Temperature Gradient Hole" interest indicated by numerous filings of "Intent to do Geothermal Resource Exploration" with U.S.G.S. To date we do not know how many of these projects were completed.

   This zone does not have extensive environment decisions but some significant sites will be affected by such decisions. (i.e. Tahoe Basin Area and Carson Sink-Alkali Flat East and West)

   There has been significant leasing in this zone, both within the KGRA's and its vicinity. The leasing interest is mostly by minor companies and individual and/or investment groups. Some sites showed 100% major company interest, such as Bell Flat, of which very few are still lease applications, the remainder closed cases.

   This zone includes 1 of the 2 metropolitan localities in the state: Reno-Sparks - (should include Carson City) with many important communities, good to fair transportation arteries.

   Economic Base: Tourism, Agriculture/Livestock, Warehousing. The growth in tourism and warehousing increases population energy needs.

Non-Technical Components For Area 14

Another large area containing twenty (20) presently identified sites. There are four (4) communities also within this area: Ely, East Ely, McGill and Ruth and all are located in the southern part of the area. About 40% of the total area is covered by federal environmental constraints but only three (3) sites: Sulphur Hot Springs (KGRA), Monte Neva Hot Springs (KGRA) and Steptoe sites are directly affected by the restrictions for seasonal occupancy. One (1) of the sites, Ruby Lake is located within the boundary of the Ruby Lake National Wildlife Refuge, which may require additional stipulations if interest is generated for this site.

Of the many sites in this area, only two (2) are KGRAs, as noted above. Both Monte Neva Hot Springs and Sulphur Hot Springs have had significant leasing activity, but most outside but adjacent to the KGRA boundaries. This may be accounted for by the presence of private land at both sites. About 95% of the activity at Monte Neva Hot Springs is now KGRA and is now in geothermal leases. Most activity at Sulphur Hot Springs are now closed cases. There has been activity at four (4) other sites Dolly Varden, Duck Creek, Snake Range and Shellborne Pass.

Very few Notices of Intents have been filed for the area. Monte Neva Hot Springs KGRA is only site included in any of the geophysical survey work.

EXPLANATION TO HOT-WATER CONVECTION SYSTEMS SHEETS

Footnotes

(1) Maximum surface temperature reported from a spring or fumarole.

(2) Predicted using chemical geothermometers, assuming last equilibration in the reservoir; assumes saturation of SiO_2 with respect to quartz, and no loss of Ca from calcite deposition.

(3) Assumed average reservoir temperature based on data presently available. Temperatures from Circular 726 and other sources. Temperatures in parentheses are highly subjective.

(4) From surface manifestations, geophysical data, well records, geologic inference and leasing activity. Assumes 1.5 km^2 if no data pertinent to size is available. Top assumed at depth of 1.5 km if no data available. Bottom assumed at 3 km depth for all convection systems. Calculated from assumed area and thickness.

(5) Calculated as product of assumed volume, volumetric specific heat of 0.6 $cal/cm^3°C$, and temperature in degrees C above 15°C.

(6) 0.02 for 150°-200°C
0.025 for 200°-250°C

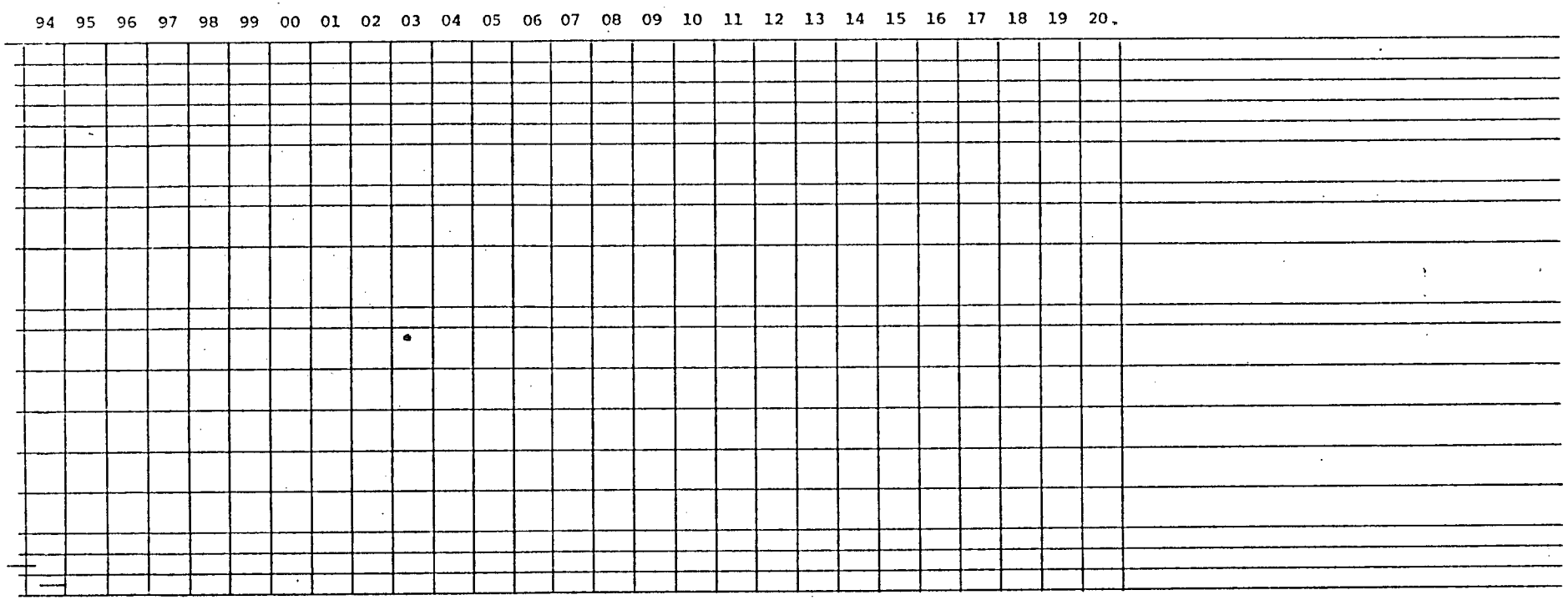
(7) 25% Heat Content Recoverable as thermal energy at the surface; 1 Quad= 0.25×10^{18} cal.

HOT-WATER CONVECTION SYSTEMS IN AREA 14 .

Location	Temperatures °C			Reservoir Assumptions		Energy Potential		
Site	Surface (1)	Geochemical SiO_2 (2)	Geochemical Na-K-Ca (2)	Subsurface (3)	Volume km^3 (4)	Heat content 10^{18} cal (5)	Recovery Factor e_r (6)	Electrical Potential MW_e-30yrs.	Thermal Energy for Direct Use Quads (7)
Sulphur Hot Springs	93			(200)	40	4.4	0.025	490	
Monte Neva Hot Springs	89			(185)	20	2.0	0.02	180	
Ruby Lake	65			(200)	20	2.2	0.025	245	
Cherry Creek Hot Springs	65			(170)	10	0.9	0.02	80	
Collar and Elbow Spring	33								
Dolly Varden	ND								
Ely-Lackawanna Hot Springs	35								
North Spring Valley	32								
Winchett Lake	Warm								
Wood Hills	30								
Hardy Creek	23								
Buck Pass	24-								
Pancake Summit	Hot								
McGill	29								
Steptoe	24								
Duck Creek	ND								
Becky Peak	28								
Shellborne Pass	25								
Pleasant Valley	Warm								
Snake Range	ND								
TOTAL:								995	

Footnotes 1 thru 7-see Explanation Page

NEVADA GEOTHERMAL AREA 14 SCENARIO


94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20

AREA: 13

Possible Subsequent Additions Quads and On Line Date:

SITE CHARACTERISTICS:

SITE: ELKO HOT SPRINGS (1)

POSTULATED SITE DEVELOPMENT SCHEDULE (FOR FIRST .007 QUAD DEVELOPMENT)

OPERATING ENTITIES	ACTIVITY	RECIPIENTS	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
BLM	Approve Notice of Intent-	Developer																			—					
USGS	Approve NOI & Drill Permit	Developer																								
BLM/Owner	Lease Land	Developer																				—	—			
BLM	Process EIA/EIS	CEQ	Completed																							
County	Issue Land Use Permits	Developer																					—			
Developer	Exploratory Drilling & Reservoir Evaluation																						—	—		
Developer	Develop User Interest																						—	—		
Developer & User	Feasibility Study																							—		
Producer(Developer) & User	Financial Negotiations																							—	—	
Producer	Site Selection																							—		
Producer & User	Design																								—	
Producer & User	Commitment to Development																								△	
Producer & User	Prepare Master Development Plan	BLM, USGS																							—	
User	Prepare Environmental Data Statement	BLM, STATE, County																								—
BLM, STATE, USGS	Issue Permits on Site	Producer & User																								—
USGS	Process EIA/EIS (Drilling)	CEQ																								—
Producer	Development Drilling																									
User	Plant Construction																									

(1) Elko Hot Springs KGRA-Located on and within a private land block, and, the KGRA includes a part of the town of Elko. Very little (about 900 acres) of KGRA are federal land. Presently no leases, no intents nor environmental constraints for this Site.

AREA: 13

SITE CHARACTERISTICS:

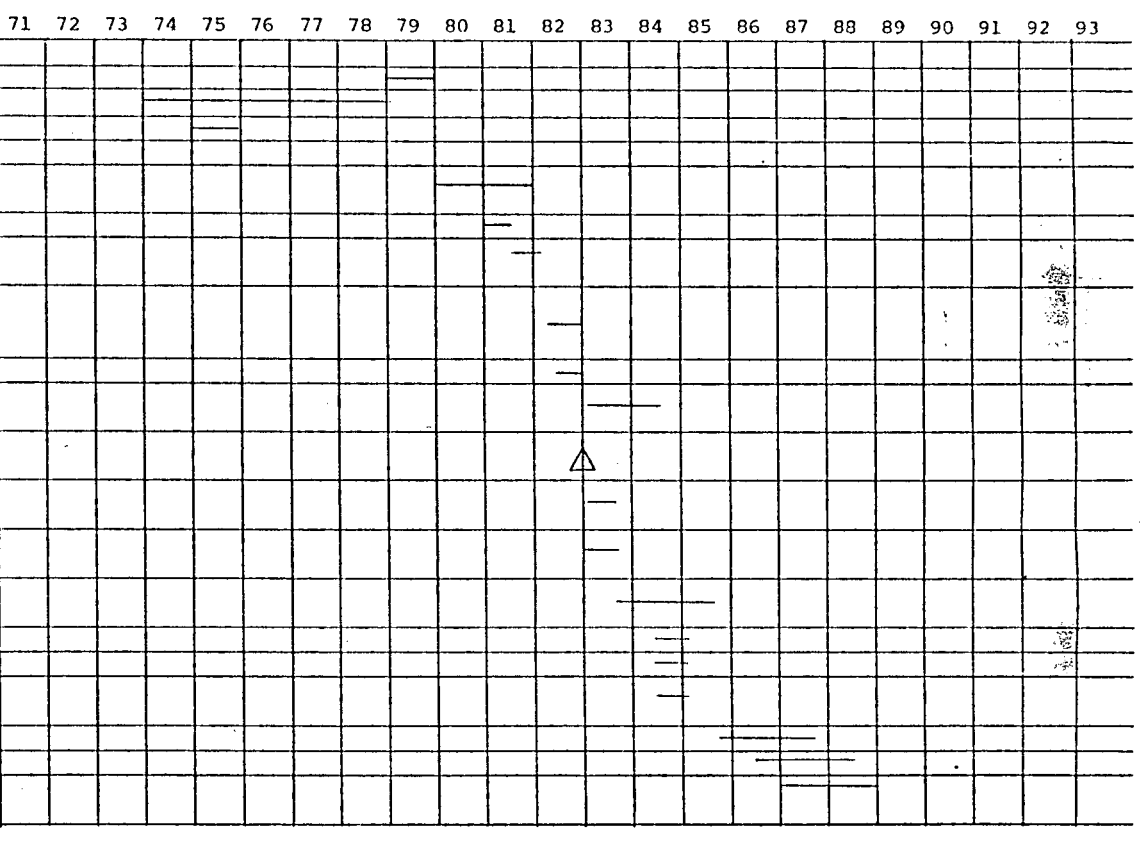
SITE: DARROUGH'S HOT SPRINGS

Possible Subsequent Additions (MWe) and On Line Date:

50 MWe 1991
20 MWe 1993

POSTULATED SITE DEVELOPMENT SCHEDULE (FOR FIRST 20 MWe PLANT)

OPERATING ENTITIES	ACTIVITY	RECIPIENTS
BLM	Approve Notice of Intent-	Developer
USGS	Approve NOI & Drill Permit	Developer (1)
BLM/Owner	Lease Land	Developer (2)
BLM	Process EIA/EIS	CEQ
County	Issue Land Use Permits	Developer
Developer	Exploratory Drilling & Reservoir Evaluation	
Developer	Develop Utility Interest	
Developer & Utility	Feasibility Study	
Producer (Developer) & Utility	Financial Negotiations	
Producer	Site Selection	
Producer & Utility	Design	
Producer & Utility	Commitment to Development	
Producer & Utility	Prepare Master Development Plan	BLM, USGS
Utility	Prepare Environmental Data Statement	BLM, FPC STATE, County
BLM, FPC STATE, USGS	Certify Plant & Site Issue Permits	Producer & Utility
USGS	Process EIA/EIS (Drilling)	CEQ
FPC	Process EIA/EIS (Plant)	CEQ
FPC	Process EIA/EIS (Transmission Line)	CEQ
Producer	Development Drilling	
Utility	Plant Construction	
Utility	Install Transmission Line (40 km)	



(1) Issue drilling permits extended to full year because of some environmental restrictions at Site.
(2) Darrough's Hot Sps. on private land. No leasing at KGRA Site-but leasing activity adjacent to Site, extended leasing 2 years more.

AREA 13

95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	70	70
.007	.007	.007	.007	.007	.007	.007	.007	.007	.007	.007	.007	.007	.007	.007	.007	.007	.007	.007	.007	.007	.007	.007	.007	.007	.007
							20	20	70	70	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90
																					20	20	70	70	90
													20	20	70	70	90	90	90	90	90	90	90	90	90
		20	20	70	70	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90
.004	.004	.004	.004	.004	.004	.004	.004	.004	.004	.003	.003	.003	.003	.003	.003	.003	.003	.003	.003	.003	.003	.003	.003	.003	.003

COMPOSITE POSTULATED SITE DEVELOPMENT SCHEDULE
FOR AREA 13

SITE NAME	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
Darrough's Hot Springs																				20	20	70	70	90	90
Elko Hot Springs																									
Walti Hot Springs																									
Bruffey's Hot Springs																									
Kolbe Hot Springs																									
Spenser Hot Spring																									
Carlin																									
Carlotti Ranch Springs																									
Vivian Siding																									
Bartine Hot Springs																									
Clipper Gap Canyon																									
Diana's Punch Bowl-Pott's Ranch																									
McLeod's Ranch Spring																									
Shipley Hot Springs																									
Mosquito Creek Ranch																									
Pine Creek																									
Diamond Valley																									
Cold Creek																									
Wildcat Canyon																									
Kingston																									
Santa Fe Creek																									
Tule Dam Spring																									
Diamond Mountains																									
Wilson Spring																									
Alkali Flat																									
TOTAL MWe:																									
TOTAL Quads:																									

20,50,100 = MWe (megawatts electric); electrical power generation.
.037,.04,.017 = Quads (0.252×10^{18} cal.); direct thermal utilization. Quads available for commercial utilization. It is unlikely that the energy developed at each site will be wholly utilized, or utilized in the optimum or most efficient manner.

References To Postulated Site Development Schedules And Non-Technical Components Of Areas.

References (indicated by parentheses and corresponding number)

1. Oral Communication:

2. Regional Environmental Analysis Record
   Geothermal oil/gas leasing (BLM) and maps

   a. Carson City District
      Pyramid District, 1975

   b. Winnemucca District
      Sonoma-Gerlach Resource Area
      Buffalo Hills Planning Unit
      1975

   c. Winnemucca District
      Deno, Paradise, Blue Wing and
      Sonoma Planning Units,
      1975

   d. Elko District,
      1975

   e. Battle Mountain District
      1976

   f. Tonopah Resource Area
      1975

   g. Fort Churchill-Clan Alpine Area,
      Carson City District, Nev., 1975

   h. Pine Nut-Walker Area,
      Carson City District, Nev. 1975

   i. Esmeralda Planning Unit,
      Esmeralda and Nye Counties, 1974

3. Lease Books (Nevada Team Data)
   Data obtained from BLM public records and maps.

4. "Intent to Conduct Geothermal Resource Exploration"
   (Filed with U.S.G.S.), (Maps and Folder) and maps.

5. Drilling and Resource Data Sheets.

6. Plan of Operation, Phillips Petroleum Company,
   March 1, 1978 - To drill 6 geothermal wells to 8000'.
   To determine the existence and commercial potential of geothermal resources.
   Estimating starting date - 6-78
   Estimated comp. date - 12-82

EXPLANATION FOR AREA SHEETS

ENVIRONMENT: Federal environmental decisions relating to availability of federal lands for geothermal resource leasing. All data taken from Environmental Assessment Records prepared by BLM.

CRIT. R.: Critical Restrictions. Restrictions to lessee, in addition to those restrictions covered in the Geothermal Resource Lease Application (Sec. 14 and 18).

EXCLUD. PEND.: Excluded from Leasing. Pending additional environmental studies.

EXCLUD.: Excluded from all leasing.

LAND STATUS: Geothermal leasing status on federal lands.

LSE. APLN.: Lease Application

CLOSED: Closed cases. Application never became lease. In theory the land is available for geothermal leasing.

GEO. SIM.: Geothermal Simultaneous Drawing. These applications became leases, then were terminated or relinquished by the lessee. These parcels are held for simultaneous drawing.

OPEN: Open - No leases presently recorded for site.

A.P.P.: Area Potential Prospectively. As outlined by U.S.G.S., possible geothermal resource areas.

OTHER or KGRA: KGRA - Known Geothermal Resource

OWNERSHIP INTEREST:

MAJOR: Major company interest or holdings.

MINOR: Minor company interest or holdings.

IND./INV.: Individual and/or investment group interest or holdings.

INTENTS: "Intent to Conduct Geothermal Resource Exploration" are filed with U.S.G.S.

GEO.: Geophysical work only. No Drilling (i.e.= Gravity, magnetotelluric and other surveys)

DRILL: Drilling of shallow temperature gradient holes.

OTHER: Any exploration work not included in above categories.

(NOTE: The filing of the Intent to conduct geothermal resource exploration Does Not imply the work was completed.)

AREA: 13

SITE	ENVIRONMENT			LAND STATUS							OWNERSHIP INTEREST			INTENTS			NOTES
	CRIT.R.	EXCLUD. PEND.	EXCLUD.	LSE. APLN.	CLOSED	LSE.	GEO SIM	OPEN	A.P.P.	OTHER OF KGRA	MAJOR	MINOR	IND./ INV.	GEO.	DRILL.	OTHER	
Walti Hot Springs				X	X	X	X		X		X						
Darrough's H.Sps.				X	X	X	X		X	KGRA	X						Some Private land
Spenser H. Spring				X	X				X		X	X					Stock Driveway
Kingston				X	X	X			X			X					
Wildcat Canyon				X	X				X			X					
Carlotti Ranch Sps	X							X	X								
Vivian Siding	X							X									
Bruffey's H.Sps.								X	X								
Elko Hot Springs								X	X	KGRA							Private Land
Klobe H. Springs								X	X								
Carlin								X									
Bartine Hot Sps.								X	X								
Clipper Gap Cany.								X	X								
Diana's Punch Bowl -Pott's Ranch								X	X								
McLeod's Ranch Sp.								X	X								
Mosquito Crk.Ranch								X									
Pine Creek								X									
Diamond Valley								X	X								
Cold Creek								X									
Santa Fe Creek								X	X								
Tule Dam Spring								X	X								
Diamond Mountains		X						X									
Wilson Spring								X									
Alkali Flat								X	X								
Shipley Hot Sps.								X	X								

General Statement to Non-Technical Components Section,
Area Scenarios

1. All observations for environmental, leasing and "Intents" are based on data gathered in 1977, which has not been corrected, adjusted or up-dated.

2. All environmental decisions are federal (BLM) as there are no localities in Nevada which require an environmental statement. Nevada has only 2 laws requiring such reports:

   a. Nevada Clean Air Act of 1971. Amended in 1973.

   b. Utility Environmental Protection Act, 1971.
   Amended 1973.
   Requires environmental statement for utility plant siting.

   Protection of environmental values is now explicitly and clearly a major criteria for BLM management activities. All BLM activities are governed by the "Federal Land Policy and Management Act".

3. Areas 15, 16, 17, 18, 19 grouped together make up a zone of Intensive and Extensive geothermal resource interests.

   A little over 1/2 of the total land in this zone is available for geothermal leasing, the remainder is covered by private indian reservation, Bureau of Reclamation withdrawals, wildlife management and refuge, state parks and military use lands. The zone contains 10 KGRAs.

   There has been intensive "Geophysical" and "Shallow Temperature Gradient Hole" interest indicated by numerous filings of "Intent to do Geothermal Resource Exploration" with U.S.G.S. To date we do not know how many of these projects were completed.

   This zone does not have extensive environment decisions but some significant sites will be affected by such decisions. (i.e. Tahoe Basin Area and Carson Sink-Alkali Flat East and West)

   There has been significant leasing in this zone, both within the KGRA's and its vicinity. The leasing interest is mostly by minor companies and individual and/or investment groups. Some sites showed 100% major company interest, such as Bell Flat, of which very few are still lease applications, the remainder closed cases.

   This zone includes 1 of the 2 metropolitan localities in the state: Reno-Sparks - (should include Carson City) with many important communities, good to fair transportation arteries.

   Economic Base: Tourism, Agriculture/Livestock, Warehousing. The growth in tourism and warehousing increases population energy needs.

Non-Technical Components For Area 13

A large area which presently has twenty-five (25) identified sites and three (3) important communities of: Eureka, Elko and Carlin. The northern 1/4 of the area is covered by the checkerboard pattern of alternating federal and private land sections, Indian Reservation and National Forest land. In the southern 1/4 of the area there is a significant amount of acreage in National Forest. Much of the area is covered by federal environmental constraints, only three (3) sites are directly affected: Carlotti Ranch Springs and Vivian Siding with seasonal occupancy restrictions and Diamond Mountains with no leasing pending additional environmental study decision.

The area has only two (2) KGRAs: Elko Hot Springs and Darrough's Hot Springs. Neither KGRA has any leasing activity within the KGRA boundary. The land status map indicates both sites are located on private property. Leasing activity has occured in the vicinity adjacent to both KGRAs. Very few leases, perhaps 25% for both sites. Four (4) other sites had some leasing activity (non-KGRAs), Walti Hot Springs with 98% of all activity as closed cases and geo sims; Spenser Hot Spring which is located within a stock driveway also indicates 98% activity in closed cases, remainder in lease; Kingston and Wildcat Canyon sites with minor activity.

Very few Notices of Intents have been filed for the area, and none for any of the sites.

EXPLANATION TO HOT-WATER CONVECTION SYSTEMS SHEETS

Footnotes

(1) Maximum surface temperature reported from a spring or fumarole.

(2) Predicted using chemical geothermometers, assuming last equilibration in the reservoir; assumes saturation of SiO_2 with respect to quartz, and no loss of Ca from calcite deposition.

(3) Assumed average reservoir temperature based on data presently available. Temperatures from Circular 726 and other sources. Temperatures in parentheses are highly subjective.

(4) From surface manifestations, geophysical data, well records, geologic inference and leasing activity. Assumes 1.5 km^2 if no data pertinent to size is available. Top assumed at depth of 1.5 km if no data available. Bottom assumed at 3 km depth for all convection systems. Calculated from assumed area and thickness.

(5) Calculated as product of assumed volume, volumetric specific heat of 0.6 $cal/cm^3°C$, and temperature in degrees C above 15°C.

(6) 0.02 for 150°-200°C
0.025 for 200°-250°C

(7) 25% Heat Content Recoverable as thermal energy at the surface; 1 Quad= 0.25×10^{18} cal.

HOT-WATER CONVECTION SYSTEMS IN AREA 13 .

Location	Temperatures °C			Reservoir Assumptions		Energy Potential		
Site	Surface (1)	Geochemical SiO_2 (2)	Geochemical Na-K-Ca (2)	Subsurface (3)	Volume km^3 (4)	Heat content 10^{18} cal (5)	Recovery Factor e_r (6)	Electrical Potential MW_e-30yrs.	Thermal Energy for Direct Use Quads (7)
Darrough's Hot Springs	97	136	127	140 (185)	10	1.0	0.02	90	
Elko Hot Springs	89	115	127	115 (185)	10	1.0			0.2
Walti Hot Springs	73	117	78	120 (185)	10	1.0	0.02	90	
Bruffey's Hot Springs	66			(185)	10	1.0	0.02	90	
Kolbe Hot Springs	70	129	72	130 (185)	10	1.0	0.02	90	
Spenser Hot Spring	96	123	210	125 (185)	10	1.0	0.02	90	
Carlin	Boiling?	119	81	120 (185)	10	1.0			0.1
Carlotti Ranch Springs	39								
Vivian Siding	37								
Bartine Hot Springs	41								
Clipper Gap Canyon	Hot								
Diana's Punch Bowl-Pott's Ranch	59								
McLeod's Ranch Spring	Hot								
Shipley Hot Springs	41								
Mosquito Creek Ranch	35								
Pine Creek	ND								
Diamond Valley	30								
Cold Creek	Warm								
Wildcat Canyon	ND								
Kingston	ND								
Santa Fe Creek	23-								
Tule Dam Spring	23-								
Diamond Mountains	24-								
Wilson Spring	Warm								
Alkali Flat	27								
TOTAL:								450	0.3

Footnotes 1 thru 7-see Explanation Page

NEVADA GEOTHERMAL AREA 13 SCENARIO

AREA: 12

SITE CHARACTERISTICS:

SITE: BEOWAWE GEYSERS

Possible Subsequent Additions (MWe) and On Line Date:

50 MWe	1988	100 MWe	1998	100 MWe	2008
100 MWe	1990	100 MWe	2000	100 MWe	2010
100 MWe	1992	100 MWe	2002	50 MWe	2012
100 MWe	1994	100 MWe	2004		
100 MWe	1996	100 MWe	2006		

POSTULATED SITE DEVELOPMENT SCHEDULE (FOR FIRST 20 MWe PLANT)

OPERATING ENTITIES	ACTIVITY	RECIPIENTS	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
BLM	Approve Notice of Intent-	Developer																								
USGS	Approve NOI & Drill Permit	Developer	(1)																							
BLM/Owner	Lease Land	Developer																								
BLM	Process EIA/EIS	CEQ																								
County	Issue Land Use Permits	Developer	(2)																							
Developer	Exploratory Drilling & Reservoir Evaluation		(2)																							
Developer	Develop Utility Interest		(2)																							
Developer & Utility	Feasibility Study		(2)																							
Producer (Developer) & Utility	Financial Negotiations																									
Producer	Site Selection																									
Producer & Utility	Design																									
Producer & Utility	Commitment to Development												△													
Producer & Utility	Prepare Master Development Plan	BLM, USGS																								
Utility	Prepare Environmental Data Statement	BLM, FPC STATE, County																								
BLM, FPC STATE, USGS	Certify Plant & Site Issue Permits	Producer & Utility																								
USGS	Process EIA/EIS (Drilling)	CEQ																								
FPC	Process EIA/EIS (Plant)	CEQ																								
FPC	Process EIA/EIS (Transmission Line)	CEQ																								
Producer	Development Drilling																									
Utility	Plant Construction																									
Utility	Install Transmission Line (40 km)																									

(1) Drilling activity in 1959, 1961, 1963, 1964, 1965.

(2) Assume completed because significant drilling/leasing activity by major companies and Sierra Pacific.

AREA 12

95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
370	470	470	570	570	670	670	770	770	870	870	970	970	1070	1070	1170	1170	1220	1220	1220	1220	1200	1200	1150	1150	1050
														20	20	70	70	90	90	90	90	90	90	90	90
																		30	30	80	80	130	130	180	180
																					20	20	70	70	90

COMPOSITE POSTULATED SITE DEVELOPMENT SCHEDULE
FOR AREA 12

SITE NAME	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
Beowawe Geysers																	20	20	70	70	170	170	270	270	370
Horseshoe Ranch Springs																									
Hot Springs Point																									
Duff Creek																									
Sheep Creek Range																									
TOTAL MWe:																									
TOTAL Quads:																									

20,50,100 = MWe (megawatts electric); electrical power generation.
.037,.04,.017 = Quads (0.252×10^{18} cal.); direct thermal utilization. Quads available for commercial utilization. It is unlikely that the energy developed at each site will be wholly utilized, or utilized in the optimum or most efficient manner.

References To Postulated Site Development Schedules And Non-Technical Components Of Areas.

References (indicated by parentheses and corresponding number)

1. Oral Communication:

2. Regional Environmental Analysis Record
   Geothermal oil/gas leasing (BLM) and maps

   a. Carson City District
      Pyramid District, 1975

   b. Winnemucca District
      Sonoma-Gerlach Resource Area
      Buffalo Hills Planning Unit
      1975

   c. Winnemucca District
      Deno, Paradise, Blue Wing and
      Sonoma Planning Units,
      1975

   d. Elko District,
      1975

   e. Battle Mountain District
      1976

   f. Tonopah Resource Area
      1975

   g. Fort Churchill-Clan Alpine Area,
      Carson City District, Nev., 1975

   h. Pine Nut-Walker Area,
      Carson City District, Nev. 1975

   i. Esmeralda Planning Unit,
      Esmeralda and Nye Counties, 1974

3. Lease Books (Nevada Team Data)
   Data obtained from BLM public records and maps.

4. "Intent to Conduct Geothermal Resource Exploration"
   (Filed with U.S.G.S.), (Maps and Folder) and maps.

5. Drilling and Resource Data Sheets.

6. Plan of Operation, Phillips Petroleum Company,
   March 1, 1978 - To drill 6 geothermal wells to 8000'.
   To determine the existence and commercial potential of geothermal resources.
   Estimating starting date - 6-78
   Estimated comp. date - 12-82

EXPLANATION FOR AREA SHEETS

ENVIRONMENT: Federal environmental decisions relating to availability of federal lands for geothermal resource leasing. All data taken from Environmental Assessment Records prepared by BLM.

CRIT. R.: Critical Restrictions. Restrictions to lessee, in addition to those restrictions covered in the Geothermal Resource Lease Application (Sec. 14 and 18).

EXCLUD. PEND.: Excluded from Leasing. Pending additional environmental studies.

EXCLUD.: Excluded from all leasing.

LAND STATUS: Geothermal leasing status on federal lands.

LSE. APLN.: Lease Application

CLOSED: Closed cases. Application never became lease. In theory the land is available for geothermal leasing.

GEO. SIM.: Geothermal Simultaneous Drawing. These applications became leases, then were terminated or relinquished by the lessee. These parcels are held for simultaneous drawing.

OPEN: Open - No leases presently recorded for site.

A.P.P.: Area Potential Prospectively. As outlined by U.S.G.S., possible geothermal resource areas.

OTHER or KGRA: KGRA - Known Geothermal Resource

OWNERSHIP INTEREST:

MAJOR: Major company interest or holdings.

MINOR: Minor company interest or holdings.

IND./INV.: Individual and/or investment group interest or holdings.

INTENTS: "Intent to Conduct Geothermal Resource Exploration" are filed with U.S.G.S.

GEO.: Geophysical work only. No Drilling (i.e.= Gravity, magnetotelluric and other surveys)

DRILL: Drilling of shallow temperature gradient holes.

OTHER: Any exploration work not included in above categories.

(NOTE: The filing of the Intent to conduct geothermal resource exploration Does Not imply the work was completed.)

AREA: 12

SITE	ENVIRONMENT			LAND STATUS							OWNERSHIP INTEREST			INTENTS			NOTES
	CRIT.R.	EXCLUD. PEND.	EXCLUD.	LSE. APLN.	CLOSED	LSE.	GEO SIM	OPEN	A.P.P.	OTHER or KGRA	MAJOR	MINOR	IND./ INV.	GEO.	DRILL.	OTHER	
Beowawe Geysers	X			X	X	X	X		X	KGRA				X	X		
Hot Springs Point	X			X	X	X	X		X	KGRA				X			
Horseshoe Ranch Sps.	X					X			X					X	X		
Duff Creek	X			X	X	X	X		X					X			
Sheep Crk. Range	X							X	X								

General Statement to Non-Technical Components Section,

Area Scenarios

1. All observations for environmental, leasing and "Intents" are based on data gathered in 1977, which has not been corrected, adjusted or up-dated.

2. All environmental decisions are federal (BLM) as there are no localities in Nevada which require an environmental statement. Nevada has only 2 laws requiring such reports:

   a. Nevada Clean Air Act of 1971. Amended in 1973.

   b. Utility Environmental Protection Act, 1971.
   Amended 1973.
   Requires environmental statement for utility plant siting.

   Protection of environmental values is now explicitly and clearly a major criteria for BLM management activities. All BLM activities are governed by the "Federal Land Policy and Management Act".

3. Areas 15, 16, 17, 18, 19 grouped together make up a zone of Intensive and Extensive geothermal resource interests.

   A little over 1/2 of the total land in this zone is available for geothermal leasing, the remainder is covered by private indian reservation, Bureau of Reclamation withdrawals, wildlife management and refuge, state parks and military use lands. The zone contains 10 KGRAs.

   There has been intensive "Geophysical" and "Shallow Temperature Gradient Hole" interest indicated by numerous filings of "Intent to do Geothermal Resource Exploration" with U.S.G.S. To date we do not know how many of these projects were completed.

This zone does not have extensive environment decisions but some significant sites will be affected by such decisions. (i.e. Tahoe Basin Area and Carson Sink-Alkali Flat East and West)

There has been significant leasing in this zone, both within the KGRA's and its vicinity. The leasing interest is mostly by minor companies and individual and/or investment groups. Some sites showed 100% major company interest, such as Bell Flat, of which very few are still lease applications, the remainder closed cases.

This zone includes 1 of the 2 metropolitan localities in the state: Reno-Sparks - (should include Carson City) with many important communities, good to fair transportation arteries.

Economic Base: Tourism, Agriculture/Livestock, Warehousing. The growth in tourism and warehousing increases population energy needs.

Non-Technical Components For Area 12

Nearly 75% of the total area is under the familiar checkerboard pattern of alternating federal and private sections of land. In addition, the Entire area is affected by the federal environmental constraint for birds of prey and deer habitat. The constraint allows leasing but entry is restricted during certain seasons and also includes surface disturbance stipulations. All of the five (5) sites identified for this area are located within the checkerboard pattern.

Beowawe Geysers, one of the two KGRAs in area 12, has been a thermal area of considerable interest. One of the first descriptions of Beowawe Geysers was first described in 1869 during the construction of the Central Pacific Railroad. Several natural geysers were observed around 1934. Intensive drilling took place from 1959 through 1964 which apparently led to the discontinuance of the geyser activity. Leasing activity has been significant at the Beowawe Geysers site and adjacent area, with almost 50% of the activity now in geothermal leases. Despite this site's location in the center of the checkerboard pattern, data indicates nearly 9000 acres are in geothermal lease outside KGRA boundary with approximately 11,183 acres within the KGRA. The other KGRA, Hot Springs Point has very few geothermal leases compared to the amount of activity now in Geo Sims. Horseshoe Ranch Springs and Duff Creek Range, both non-KGRAs, indicate some leasing activity, with both sites having several geothermal leases. All the sites within the area are located within U.S.G.S. Area Potential Prospectively.

There have been quite a number of Notices of Intents filed for the area with the concentration of interest at the Beowawe Geysers and Horseshoe Ranch Springs sites.

Although no major communities are located within this area, the area could be very important to two communities: Battle Mountain about 30 miles to the west and Elko about 70 miles to the east.

EXPLANATION TO HOT-WATER CONVECTION SYSTEMS SHEETS

Footnotes

(1) Maximum surface temperature reported from a spring or fumarole.

(2) Predicted using chemical geothermometers, assuming last equilibration in the reservoir; assumes saturation of SiO_2 with respect to quartz, and no loss of Ca from calcite deposition.

(3) Assumed average reservoir temperature based on data presently available. Temperatures from Circular 726 and other sources. Temperatures in parentheses are highly subjective.

(4) From surface manifestations, geophysical data, well records, geologic inference and leasing activity. Assumes 1.5 km^2 if no data pertinent to size is available. Top assumed at depth of 1.5 km if no data available. Bottom assumed at 3 km depth for all convection systems. Calculated from assumed area and thickness.

(5) Calculated as product of assumed volume, volumetric specific heat of 0.6 $cal/cm^3°C$, and temperature in degrees C above 15°C.

(6) 0.02 for 150°-200°C
0.025 for 200°-250°C

(7) 25% Heat Content Recoverable as thermal energy at the surface; 1 Quad= 0.25×10^{18} cal.

HOT-WATER CONVECTION SYSTEMS IN AREA 12 .

Location	Temperatures °C			Reservoir Assumptions		Energy Potential		
Site	Surface (1)	Geochemical SiO_2 (2)	Geochemical Na-K-Ca (2)	Subsurface (3)	Volume km^3 (4)	Heat content 10^{18} cal (5)	Recovery Factor e_r (6)	Electrical Potential MW_e-30yrs.	Thermal Energy for Direct Use Quads (7)
Beowawe Geysers	98	226	242	240 (245)	80	11.0	0.025	1220	
Horseshoe Ranch Springs	58			(185)	10	1.0	0.02	90	
Hot Springs Point	59	116	233	125 (185)	20	2.0	0.02	180	
Duff Creek	86			(185)	10	1.0	0.02	90	
Sheep Creek Range	Warm								
TOTAL:								1580	

Footnotes 1 thru 7-see Explanation Page

NEVADA GEOTHERMAL AREA 12 SCENARIO

AREA: 11

Possible Subsequent Additions
Quads and On Line Date:

SITE CHARACTERISTICS:

SITE: BATTLE MOUNTAIN

POSTULATED SITE DEVELOPMENT SCHEDULE (FOR FIRST .017 QUAD DEVELOPMENT)

OPERATING ENTITIES	ACTIVITY	RECIPIENTS	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
BLM	Approve Notice of Intent-	Developer																								
USGS	Approve NOI & Drill Permit	Developer						—	—																	
BLM/Owner	Lease Land	Developer	(1)						—																	
BLM	Process EIA/EIS	CEQ					—																			
County	Issue Land Use Permits	Developer										—														
Developer	Exploratory Drilling & Reservoir Evaluation		(2)										—													
Developer	Develop User Interest												—	—												
Developer & User	Feasibility Study													—												
Producer(Developer) & User	Financial Negotiations														—								—			
Producer	Site Selection														—											
Producer & User	Design															—										
Producer & User	Commitment to Development														△											
Producer & User	Prepare Master Development Plan	BLM, USGS													—											
User	Prepare Environmental Data Statement	BLM, STATE, County													—											
BLM, STATE, USGS	Issue Permits on Site	Producer & User														—										
USGS	Process EIA/EIS (Drilling)	CEQ														—										
Producer	Development Drilling																—									
User	Plant Construction																—	—								

(1) Acquired land-This acreage is still in Lease Appln.
(2) Exploratory drilling started late due to environmental restrictions and delay in leasing.

AREA 11

95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
.017	.017	.017	.017	.017	.017	.017	.017	.017	.017	.016	.016	.016	.016	.016	.016	.016	.016	.016	.016						
										20	20	70	70	120	120	170	170	220	220	245	245	245	245	245	245

COMPOSITE POSTULATED SITE DEVELOPMENT SCHEDULE
FOR AREA 11

SITE NAME	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
Battle Mountain																.017	.017	.017	.017	.017	.017	.017	.017	.017	.017
Smith Creek Valley																									
Chillis																									
Hot Springs Ranch																									
Mountain Springs Mine																									
Iowa Canyon Ranches																									
Wild Horse																									
Ranch Spring																									
Carico Lake																									
Edwards Creek Valley																									
Birchim Creek																									
Iron Tank Spring																									
Rayston Hills																									
TOTAL MWe:																									
TOTAL Quads:																									

20,50,100 = MWe (megawatts electric); electrical power generation.
.037,.04,.017 = Quads (0.252×10^{18} cal.); direct thermal utilization. Quads available for commercial utilization. It is unlikely that the energy developed at each site will be wholly utilized, or utilized in the optimum or most efficient manner.

References To Postulated Site Development Schedules
And Non-Technical Components Of Areas.

References (indicated by parentheses and corresponding number)

1. Oral Communication:

2. Regional Environmental Analysis Record
   Geothermal oil/gas leasing (BLM) and maps

   a. Carson City District
      Pyramid District, 1975

   b. Winnemucca District
      Sonoma-Gerlach Resource Area
      Buffalo Hills Planning Unit
      1975

   c. Winnemucca District
      Deno, Paradise, Blue Wing and
      Sonoma Planning Units,
      1975

   d. Elko District,
      1975

   e. Battle Mountain District
      1976

   f. Tonopah Resource Area
      1975

   g. Fort Churchill-Clan Alpine Area,
      Carson City District, Nev., 1975

   h. The Nut-Walker Area,
      Carson City District, Nev. 1975

   i. Esmeralda Planning Unit,
      Esmeralda and Nye Counties, 1974

3. Lease Books (Nevada Team Data)
   Data obtained from BLM public records and maps.

4. "Intent to Conduct Geothermal Resource Exploration"
   (Filed with U.S.G.S.), (Maps and Folder) and maps.

5. Drilling and Resource Data Sheets.

6. Plan of Operation, Phillips Petroleum Company,
   March 1, 1978 - To drill 6 geothermal wells to 8000'.
   To determine the existence and commercial potential of
   geothermal resources.
   Estimating starting date - 6-78
   Estimated comp. date - 12-82

EXPLANATION FOR AREA SHEETS

ENVIRONMENT: Federal environmental decisions relating to availability of federal lands for geothermal resource leasing. All data taken from Environmental Assessment Records prepared by BLM.

CRIT. R.: Critical Restrictions. Restrictions to lessee, in addition to those restrictions covered in the Geothermal Resource Lease Application (Sec. 14 and 18).

EXCLUD. PEND.: Excluded from Leasing. Pending additional environmental studies.

EXCLUD.: Excluded from all leasing.

LAND STATUS: Geothermal leasing status on federal lands.

LSE. APLN.: Lease Application

CLOSED: Closed cases. Application never became lease. In theory the land is available for geothermal leasing.

GEO. SIM.: Geothermal Simultaneous Drawing. These applications became leases, then were terminated or relinquished by the lessee. These parcels are held for simultaneous drawing.

OPEN: Open - No leases presently recorded for site.

A.P.P.: Area Potential Prospectively. As outlined by U.S.G.S., possible geothermal resource areas.

OTHER or KGRA: KGRA - Known Geothermal Resource

OWNERSHIP INTEREST:

MAJOR: Major company interest or holdings.

MINOR: Minor company interest or holdings.

IND./INV.: Individual and/or investment group interest or holdings.

INTENTS: "Intent to Conduct Geothermal Resource Exploration" are filed with U.S.G.S.

GEO.: Geophysical work only. No Drilling (i.e.= Gravity, magnetotelluric and other surveys)

DRILL: Drilling of shallow temperature gradient holes.

OTHER: Any exploration work not included in above categories.

(NOTE: The filing of the Intent to conduct geothermal resource exploration Does Not imply the work was completed.)

AREA: 11

SITE	ENVIRONMENT			LAND STATUS							OWNERSHIP INTEREST			INTENTS			NOTES
	CRIT.R.	EXCLUD. PEND.	EXCLUD.	LSE. APLN.	CLOSED	LSE.	GEO SIM	OPEN	A.P.P.	OTHER OR KGRA	MAJOR	MINOR	IND./ INV.	GEO.	DRILL.	OTHER	
Battle Mountain	X			X					X		X				X		
Wild Horse				X					X		X				X		
Smith Creek Valley				X	X	X	X		X		X	X					
Chillis								X	X		X						
Hot Springs Ranch						X			X		X						
Mtn. Spgs. Mine								X	X								
Iowa Cany.Ranches								X	X								
Ranch Spring								X	X								
Carico Lake								X									
Edwards Crk. V.																	
Birchim Creek		X						X	X								
Iron Tank Spring								X	X								
Rayston Hills																	

General Statement to Non-Technical Components Section,
Area Scenarios

1. All observations for environmental, leasing and "Intents" are based on data gathered in 1977, which has not been corrected, adjusted or up-dated.

2. All environmental decisions are federal (BLM) as there are no localities in Nevada which require an environmental statement. Nevada has only 2 laws requiring such reports:

   a. Nevada Clean Air Act of 1971. Amended in 1973.

   b. Utility Environmental Protection Act, 1971.
   Amended 1973.
   Requires environmental statement for utility plant siting.

   Protection of environmental values is now explicitly and clearly a major criteria for BLM management activities. All BLM activities are governed by the "Federal Land Policy and Management Act".

3. Areas 15, 16, 17, 18, 19 grouped together make up a zone of Intensive and Extensive geothermal resource interests.

   A little over 1/2 of the total land in this zone is available for geothermal leasing, the remainder is covered by private indian reservation, Bureau of Reclamation withdrawals, wildlife management and refuge, state parks and military use lands. The zone contains 10 KGRAs.

   There has been intensive "Geophysical" and "Shallow Temperature Gradient Hole" interest indicated by numerous filings of "Intent to do Geothermal Resource Exploration" with U.S.G.S. To date we do not know how many of these projects were completed.

This zone does not have extensive environment decisions but some significant sites will be affected by such decisions. (i.e. Tahoe Basin Area and Carson Sink-Alkali Flat East and West)

There has been significant leasing in this zone, both within the KGRA's and its vicinity. The leasing interest is mostly by minor companies and individual and/or investment groups. Some sites showed 100% major company interest, such as Bell Flat, of which very few are still lease applications, the remainder closed cases.

This zone includes 1 of the 2 metropolitan localities in the state: Reno-Sparks - (should include Carson City) with many important communities, good to fair transportation arteries.

Economic Base: Tourism, Agriculture/Livestock, Warehousing. The growth in tourism and warehousing increases population energy needs.

Non-Technical Components For Area 11

A large area containing thirteen (13) identified sites. Approximately 1/3 of the total area is under the status of private land, (a checkerboard pattern consisting of alternating sections of federal and private land), National Forest and some stock driveways.

The most significant site, Battle Mountain, is located entirely within a federal environmental constraint decision for birds of prey. Leasing is permitted with special stipulations for seasonal occupancy. Also, this site is located on land classified for Bureau of Reclamation withdrawal, and is surrounded by private land. These site characteristics indicate a possible problem of additional leasing, some access considerations and possible restraints for development.

Despite the land status problems for the Battle Mountain site there has been major company leasing activities. Approximately 90% of all activity is still in lease application. Three (3) other sites, have shown leasing activity: Wild Horse and Hot Springs Ranch which have shown significant activity by major companies with the former in lease applications and the latter in geothermal leases. The third site, Smith Creek Valley is now 100% Geo Sim status. Presently there are no KGRAs identified for this area. Most of the area is included in U.S.G.S. Area Potential Prospectively.

More than five (5) Notices of Intents have been filed for this area for both geophysical surveys and shallow temperature gradient holes. Concentration of interest has been at the Battle Mountain and Wild Horse sites.

EXPLANATION TO HOT-WATER CONVECTION SYSTEMS SHEETS

Footnotes

(1) Maximum surface temperature reported from a spring or fumarole.

(2) Predicted using chemical geothermometers, assuming last equilibration in the reservoir; assumes saturation of SiO_2 with respect to quartz, and no loss of Ca from calcite deposition.

(3) Assumed average reservoir temperature based on data presently available. Temperatures from Circular 726 and other sources. Temperatures in parentheses are highly subjective.

(4) From surface manifestations, geophysical data, well records, geologic inference and leasing activity. Assumes 1.5 km^2 if no data pertinent to size is available. Top assumed at depth of 1.5 km if no data available. Bottom assumed at 3 km depth for all convection systems. Calculated from assumed area and thickness.

(5) Calculated as product of assumed volume, volumetric specific heat of 0.6 $cal/cm^3°C$, and temperature in degrees C above 15°C.

(6) 0.02 for 150°-200°C
0.025 for 200°-250°C

(7) 25% Heat Content Recoverable as thermal energy at the surface; 1 Quad= 0.25×10^{18} cal.

HOT-WATER CONVECTION SYSTEMS IN AREA 11 .

Location	Temperatures °C				Reservoir Assumptions		Energy Potential		
Site	Surface (1)	Geochemical SiO_2 (2)	Geochemical Na-K-Ca (2)	Subsurface (3)	Volume km^3 (4)	Heat content 10^{18} cal (5)	Recovery Factor e_r (6)	Electrical Potential MW_e-30yrs.	Thermal Energy for Direct Use Quads (7)
Battle Mountain	Hot			(185)	5	0.5			0.5
Smith Creek Valley	86	143	157	160 (200)	20	2.2	0.025	245	
Chillis	39								
Hot Springs Ranch	53								
Mountain Springs Mine	43								
Iowa Canyon Ranches	39								
Wild Horse	ND								
Ranch Spring	28								
Carico Lake	22								
Edwards Creek Valley	24-								
Birchim Creek	ND								
Iron Tank Spring	29								
Rayston Hills	Warm								
TOTAL:								245	0.5

Footnotes 1 thru 7-see Explanation Page

NEVADA GEOTHERMAL AREA 11 SCENARIO

AREA: 10

SITE CHARACTERISTICS:

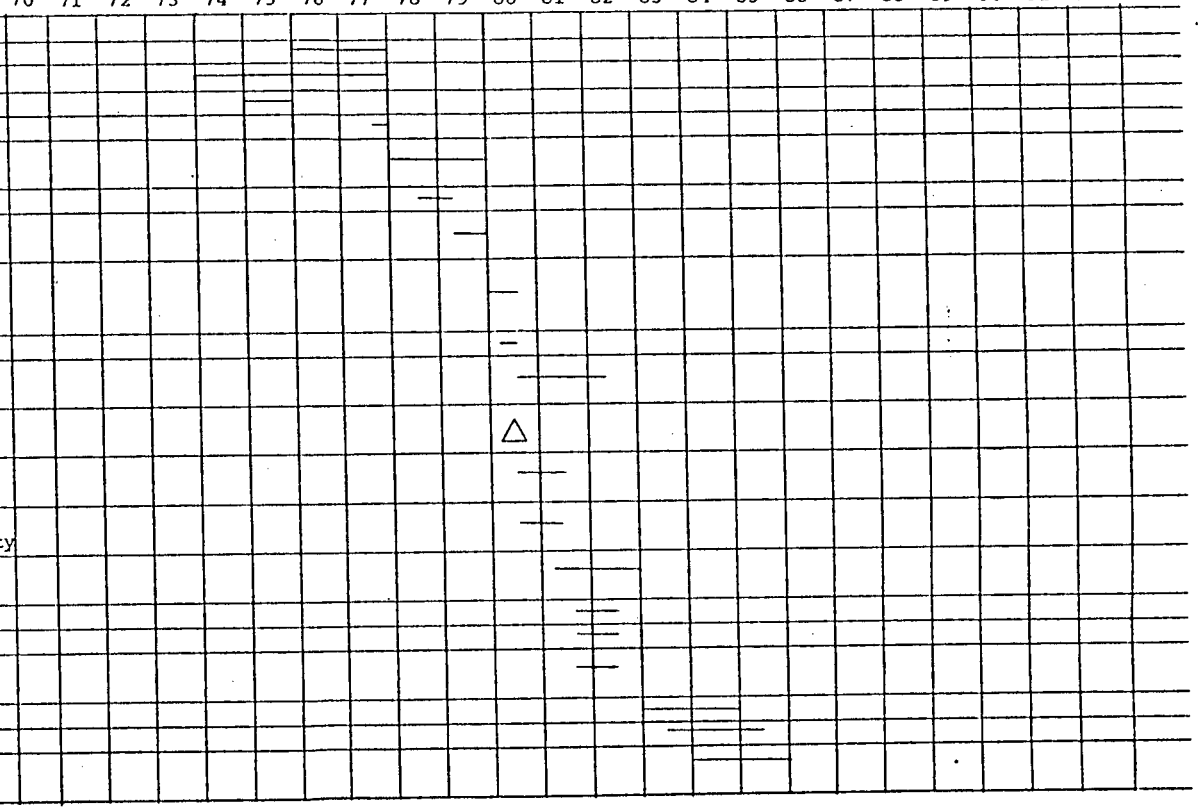
SITE: LEACH HOT SPRINGS

Possible Subsequent Additions (MWe) and On Line Date:

100 MWe	1987	100 MWe	1995
100 MWe	1989	100 MWe	1997
100 MWe	1991	50 MWe	1999
100 MWe	1993	50 MWe	2001

POSTULATED SITE DEVELOPMENT SCHEDULE (FOR FIRST 35 MWe PLANT)

OPERATING ENTITIES	ACTIVITY	RECIPIENTS
BLM	Approve Notice of Intent-	Developer
USGS	Approve NOI & Drill Permit	Developer
BLM/Owner	Lease Land	Developer
BLM	Process EIA/EIS	CEQ
County	Issue Land Use Permits	Developer
Developer	Exploratory Drilling & Reservoir Evaluation	
Developer	Develop Utility Interest	
Developer & Utility	Feasibility Study	
Producer (Developer) & Utility	Financial Negotiations	
Producer	Site Selection	
Producer & Utility	Design	
Producer & Utility	Commitment to Development	
Producer & Utility	Prepare Master Development Plan	BLM, USGS
Utility	Prepare Environmental Data Statement	BLM, FPC STATE, County
BLM, FPC STATE, USGS	Certify Plant & Site Issue Permits	Producer & Utility
USGS	Process EIA/EIS (Drilling)	CEQ
FPC	Process EIA/EIS (Plant)	CEQ
FPC	Process EIA/EIS (Transmission Line)	CEQ
Producer	Development Drilling	
Utility	Plant Construction	
Utility	Install Transmission Line (40 km)	



AREA 10

95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
535	535	635	635	685	685	735	735	735	735	735	735	735	735	735	735	735	735	735	735	700	700	600	600	500	500
										20	20	70	70	120	120	170	170	220	220	245	245	245	245	245	245

COMPOSITE POSTULATED SITE DEVELOPMENT SCHEDULE
FOR AREA 10

SITE NAME	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
Leach Hot Springs																35	35	135	135	235	235	335	335	435	435
New York Canyon Koalin Deposit																									
Kyle Hot Springs																									
Gold Mountain																									
Kent Spring																									
Dun Glen Creek																									
TOTAL MWe:																									
TOTAL Quads:																									

20,50,100 = MWe (megawatts electric); electrical power generation.
.037,.04,.017 = Quads (0.252×10^{18} cal.); direct thermal utilization. Quads available for commercial utilization. It is unlikely that the energy developed at each site will be wholly utilized, or utilized in the optimum or most efficient manner.

References To Postulated Site Development Schedules
And Non-Technical Components Of Areas.

References (indicated by parentheses and corresponding number)

1. Oral Communication:

2. Regional Environmental Analysis Record
   Geothermal oil/gas leasing (BLM) and maps

   a. Carson City District
      Pyramid District, 1975

   b. Winnemucca District
      Sonoma-Gerlach-Resource-Area
      Buffalo Hills Planning Unit
      1975

   c. Winnemucca District
      Deno, Paradise, Blue Wing and
      Sonoma Planning Units,
      1975

   d. Elko District,
      1975

   e. Battle Mountain District
      1976

   f. Tonopah Resource Area
      1975

   g. Fort Churchill-Clan Alpine Area,
      Carson City District, Nev., 1975

   h. Pine Nut-Walker Area,
      Carson City District, Nev. 1975

   i. Esmeralda Planning Unit,
      Esmeralda and Nye Counties, 1974

3. Lease Books (Nevada Team Data)
   Data obtained from BLM public records and maps.

4. "Intent to Conduct Geothermal Resource Exploration"
   (Filed with U.S.G.S.), (Maps and Folder) and maps.

5. Drilling and Resource Data Sheets.

6. Plan of Operation, Phillips Petroleum Company,
   March 1, 1978 - To drill 6 geothermal wells to 8000'.
   To determine the existence and commercial potential of geothermal resources.
   Estimating starting date - 6-78
   Estimated comp. date - 12-82

EXPLANATION FOR AREA SHEETS

ENVIRONMENT: Federal environmental decisions relating to availability of federal lands for geothermal resource leasing. All data taken from Environmental Assessment Records prepared by BLM.

CRIT. R.: Critical Restrictions. Restrictions to lessee, in addition to those restrictions covered in the Geothermal Resource Lease Application (Sec. 14 and 18).

EXCLUD. PEND.: Excluded from Leasing. Pending additional environmental studies.

EXCLUD.: Excluded from all leasing.

LAND STATUS: Geothermal leasing status on federal lands.

LSE. APLN.: Lease Application

CLOSED: Closed cases. Application never became lease. In theory the land is available for geothermal leasing.

GEO. SIM.: Geothermal Simultaneous Drawing. These applications became leases, then were terminated or relinquished by the lessee. These parcels are held for simultaneous drawing.

OPEN: Open - No leases presently recorded for site.

A.P.P.: Area Potential Prospectively. As outlined by U.S.G.S., possible geothermal resource areas.

OTHER or KGRA: KGRA - Known Geothermal Resource

OWNERSHIP INTEREST:

MAJOR: Major company interest or holdings.

MINOR: Minor company interest or holdings.

IND./INV.: Individual and/or investment group interest or holdings.

INTENTS: "Intent to Conduct Geothermal Resource Exploration" are filed with U.S.G.S.

GEO.: Geophysical work only. No Drilling (i.e.= Gravity, magnetotelluric and other surveys)

DRILL: Drilling of shallow temperature gradient holes.

OTHER: Any exploration work not included in above categories.

(NOTE: The filing of the Intent to conduct geothermal resource exploration Does Not imply the work was completed.)

AREA: 10

SITE	ENVIRONMENT			LAND STATUS							OWNERSHIP INTEREST			INTENTS			NOTES
	CRIT.R.	EXCLUD. PEND.	EXCLUD.	LSE. APLN.	CLOSED	LSE.	GEO SIM	OPEN	A.P.P.	OTHER or KGRA	MAJOR	MINOR	IND./ INV.	GEO.	DRILL.	OTHER	
Leach Hot Springs				X		X			X	KGRA	X			X			
Kyle Hot Springs				X	X				X	KGRA		X		X	X		
N.Y. Cany. Koalin Deposit								X	X								
Gold Mountain								X	X								
Kent Spring				X	X				X								

General Statement to Non-Technical Components Section,
Area Scenarios

1. All observations for environmental, leasing and "Intents" are based on data gathered in 1977, which has not been corrected, adjusted or up-dated.

2. All environmental decisions are federal (BLM) as there are no localities in Nevada which require an environmental statement. Nevada has only 2 laws requiring such reports:

   a. Nevada Clean Air Act of 1971. Amended in 1973.

   b. Utility Environmental Protection Act, 1971.
   Amended 1973.
   Requires environmental statement for utility plant siting.

   Protection of environmental values is now explicitly and clearly a major criteria for BLM management activities. All BLM activities are governed by the "Federal Land Policy and Management Act".

3. Areas 15, 16, 17, 18, 19 grouped together make up a zone of Intensive and Extensive geothermal resource interests.

   A little over 1/2 of the total land in this zone is available for geothermal leasing, the remainder is covered by private indian reservation, Bureau of Reclamation withdrawals, wildlife management and refuge, state parks and military use lands. The zone contains 10 KGRAs.

   There has been intensive "Geophysical" and "Shallow Temperature Gradient Hole" interest indicated by numerous filings of "Intent to do Geothermal Resource Exploration" with U.S.G.S. To date we do not know how many of these projects were completed.

This zone does not have extensive environment decisions but some significant sites will be affected by such decisions. (i.e. Tahoe Basin Area and Carson Sink-Alkali Flat East and West)

There has been significant leasing in this zone, both within the KGRA's and its vicinity. The leasing interest is mostly by minor companies and individual and/or investment groups. Some sites showed 100% major company interest, such as Bell Flat, of which very few are still lease applications, the remainder closed cases.

This zone includes 1 of the 2 metropolitan localities in the state: Reno-Sparks - (should include Carson City) with many important communities, good to fair transportation arteries.

Economic Base: Tourism, Agriculture/Livestock, Warehousing. The growth in tourism and warehousing increases population energy needs.

Non-Technical Components For Area 10

Approximately 50% of the total area is covered by the checkerboard pattern of alternating federal and private sections. This area is located about 125 miles from the Reno-Sparks metropolitan region. There are no direct environmental constraints for any of the five (5) sites in this area.

With 50% of the area in private land, there still has been significant leasing activity on federal lands. [illegible] activity has been in and around the two (2) KGRAs: Leach Hot Springs with about 75% of all applications now held as geothermal leases by major companies. The second KGRA, Kyle Hot Springs has had intense major company interest but All of the applications filed for this site and vicinity did not go to lease, but are now closed cases. There has been some leasing activity at Kent Springs where geothermal leases are presently shown.

There have been numerous Notices of Intents (10) filed for this area, with the focus of geophysical survey and shallow temperature gradient hole activity for Leach Hot Springs. All five (5) sites are within U.S.G.S. Area Potential Prospectively.

EXPLANATION TO HOT-WATER CONVECTION SYSTEMS SHEETS

Footnotes

(1) Maximum surface temperature reported from a spring or fumarole.

(2) Predicted using chemical geothermometers, assuming last equilibration in the reservoir; assumes saturation of SiO_2 with respect to quartz, and no loss of Ca from calcite deposition.

(3) Assumed average reservoir temperature based on data presently available. Temperatures from Circular 726 and other sources. Temperatures in parentheses are highly subjective.

(4) From surface manifestations, geophysical data, well records, geologic inference and leasing activity. Assumes 1.5 km^2 if no data pertinent to size is available. Top assumed at depth of 1.5 km if no data available. Bottom assumed at 3 km depth for all convection systems. Calculated from assumed area and thickness.

(5) Calculated as product of assumed volume, volumetric specific heat of 0.6 $cal/cm^3°C$, and temperature in degrees C above 15°C.

(6) 0.02 for 150°-200°C
0.025 for 200°-250°C

(7) 25% Heat Content Recoverable as thermal energy at the surface; 1 Quad= 0.25×10^{18} cal.

HOT-WATER CONVECTION SYSTEMS IN AREA 10 .

Location	Temperatures °C			Reservoir Assumptions		Energy Potential		
Site	Surface (1)	Geochemical SiO_2 (2)	Geochemical Na-K-Ca (2)	Subsurface (3)	Volume km^3 (4)	Heat content 10^{18} cal (5)	Recovery Factor e_r (6)	Electrical Potential MW_e-30yrs.	Thermal Energy for Direct Use Quads (7)
Leach Hot Springs	96	155	176	170 (200)	60	6.6	0.025	735	
New York Canyon Doalin Deposit	Hot								
Kyle Hot Springs	96	161	211	180 (200)	20	2.2	0.025	245	
Gold Mountain	24-								
Kent Spring	ND								
Dun Glen Creek	ND								
TOTAL:								980	

Footnotes 1 thru 7-see Explanation Page

NEVADA GEOTHERMAL AREA 10 SCENARIO

AREA: 9

Possible Subsequent Additions
Quads and On Line Date:

SITE CHARACTERISTICS:

SITE: GOLCONDA

POSTULATED SITE DEVELOPMENT SCHEDULE (FOR FIRST 0.07 QUAD DEVELOPMENT)

OPERATING ENTITIES	ACTIVITY	RECIPIENTS	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
BLM	Approve Notice of Intent-	Developer								—																
USGS	Approve NOI & Drill Permit	Developer											—													
BLM/Owner	Lease Land	Developer										—														
BLM	Process EIA/EIS	CEQ						—	—																	
County	Issue Land Use Permits	Developer											—													
Developer	Exploratory Drilling & Reservoir Evaluation													—												
Developer	Develop User Interest													—	—											
Developer & User	Feasibility Study														—											—
Producer (Developer) & User	Financial Negotiations															—										—
Producer	Site Selection															—										
Producer & User	Design																—									
Producer & User	Commitment to Development															△										
Producer & User	Prepare Master Development Plan	BLM, USGS															—									
User	Prepare Environmental Data Statement	BLM, STATE, County															—									
BLM, STATE, USGS	Issue Permits on Site	Producer & User																—								—
USGS	Process EIA/EIS (Drilling)	CEQ																—								
Producer	Development Drilling																		—							
User	Plant Construction																		—							

AREA 9

95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
.07	.07	.07	.07	.07	.07	.07	.07	.07	.07	.07	.07	.06	.06	.06	.06	.06	.06	.06	.06	.06	.06				
					20	20	70	70	120	120	170	170	220	220	245	245	245	245	245	245	245	245	245	245	245
																			20	20	70	70	90	90	90
		.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03
																							.005	.005	.005

COMPOSITE POSTULATED SITE DEVELOPMENT SCHEDULE
FOR AREA 9

SITE NAME	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
Golconda																		.07	.07	.07	.07	.07	.07	.07	.07
Hot Springs (Tipton) Ranch																									
Hot Pot																									
Sand Dunes																									
Winnemucca Mountain																									
Humboldt River																									
Brooks Hot Spring																									
Winnemucca																									
Lone Butte																									
TOTAL MWe:																									
TOTAL Quads:																									

20,50,100 = MWe (megawatts electric); electrical power generation.
.037,.04.017 = Quads (0.252×10^{18} cal.); direct thermal utilization. Quads available for commercial utilization. It is unlikely that the energy developed at each site will be wholly utilized, or utilized in the optimum or most efficient manner.

References To Postulated Site Development Schedules And Non-Technical Components Of Areas.

References (indicated by parentheses and corresponding number)

1. Oral Communication:

2. Regional Environmental Analysis Record
   Geothermal oil/gas leasing (BLM) and maps

   a. Carson City District
      Pyramid District, 1975

   b. Winnemucca District
      Sonoma-Gerlach Resource Area
      Buffalo Hills Planning Unit
      1975

   c. Winnemucca District
      Deno, Paradise, Blue Wing and
      Sonoma Planning Units,
      1975

   d. Elko District,
      1975

   e. Battle Mountain District
      1976

   f. Tonopah Resource Area
      1975

   g. Fort Churchill-Clan Alpine Area,
      Carson City District, Nev., 1975

   h. Pine Nut-Walker Area,
      Carson City District, Nev. 1975

   i. Esmeralda Planning Unit,
      Esmeralda and Nye Counties, 1974

3. Lease Books (Nevada Team Data)
   Data obtained from BLM public records and maps.

4. "Intent to Conduct Geothermal Resource Exploration"
   (Filed with U.S.G.S.), (Maps and Folder) and maps.

5. Drilling and Resource Data Sheets.

6. Plan of Operation, Phillips Petroleum Company,
   March 1, 1978 - To drill 6 geothermal wells to 8000'.
   To determine the existence and commercial potential of geothermal resources.
   Estimating starting date - 6-78
   Estimated comp. date - 12-82

EXPLANATION FOR AREA SHEETS

ENVIRONMENT: Federal environmental decisions relating to availability of federal lands for geothermal resource leasing. All data taken from Environmental Assessment Records prepared by BLM.

CRIT. R.: Critical Restrictions. Restrictions to lessee, in addition to those restrictions covered in the Geothermal Resource Lease Application (Sec. 14 and 18).

EXCLUD. PEND.: Excluded from Leasing. Pending additional environmental studies.

EXCLUD.: Excluded from all leasing.

LAND STATUS: Geothermal leasing status on federal lands.

LSE. APLN.: Lease Application

CLOSED: Closed cases. Application never became lease. In theory the land is available for geothermal leasing.

GEO. SIM.: Geothermal Simultaneous Drawing. These applications became leases, then were terminated or relinquished by the lessee. These parcels are held for simultaneous drawing.

OPEN: Open - No leases presently recorded for site.

A.P.P.: Area Potential Prospectively. As outlined by U.S.G.S., possible geothermal resource areas.

OTHER or KGRA: KGRA - Known Geothermal Resource

OWNERSHIP INTEREST:

MAJOR: Major company interest or holdings.

MINOR: Minor company interest or holdings.

IND./INV.: Individual and/or investment group interest or holdings.

INTENTS: "Intent to Conduct Geothermal Resource Exploration" are filed with U.S.G.S.

GEO.: Geophysical work only. No Drilling (i.e.= Gravity, magnetotelluric and other surveys)

DRILL: Drilling of shallow temperature gradient holes.

OTHER: Any exploration work not included in above categories.

(NOTE: The filing of the Intent to conduct geothermal resource exploration Does Not imply the work was completed.)

AREA: 9

SITE	ENVIRONMENT			LAND STATUS							OWNERSHIP INTEREST			INTENTS			NOTES
	CRIT.R.	EXCLUD. PEND.	EXCLUD.	LSE. APLN.	CLOSED	LSE.	GEO SIM	OPEN	A.P.P.	OTHER	MAJOR	MINOR	IND./ INV.	GEO.	DRILL.	OTHER	
Hot Springs (Tipton) Ranch				X	X				X			X		X			
Golconda								X	X								
Brooks Hot Spring		X						X	X					X			
Hot Pot								X	X						X		
Winnemucca								X	X						X		
Humboldt River								X	X								
Lone Butte								X	X								
Sand Dunes				X	X				X		X						
Winnemucca Mountain								X	X								

General Statement to Non-Technical Components Section,
Area Scenarios

1. All observations for environmental, leasing and "Intents" are based on data gathered in 1977, which has not been corrected, adjusted or up-dated.

2. All environmental decisions are federal (BLM) as there are no localities in Nevada which require an environmental statement. Nevada has only 2 laws requiring such reports:

   a. Nevada Clean Air Act of 1971. Amended in 1973.

   b. Utility Environmental Protection Act, 1971.
   Amended 1973.
   Requires environmental statement for utility plant siting.

   Protection of environmental values is now explicitly and clearly a major criteria for BLM management activities. All BLM activities are governed by the "Federal Land Policy and Management Act".

3. Areas 15, 16, 17, 18, 19 grouped together make up a zone of Intensive and Extensive geothermal resource interests.

   A little over 1/2 of the total land in this zone is available for geothermal leasing, the remainder is covered by private indian reservation, Bureau of Reclamation withdrawals, wildlife management and refuge, state parks and military use lands. The zone contains 10 KGRAs.

   There has been intensive "Geophysical" and "Shallow Temperature Gradient Hole" interest indicated by numerous filings of "Intent to do Geothermal Resource Exploration" with U.S.G.S. To date we do not know how many of these projects were completed.

This zone does not have extensive environment decisions but some significant sites will be affected by such decisions. (i.e. Tahoe Basin Area and Carson Sink-Alkali Flat East and West)

There has been significant leasing in this zone, both within the KGRA's and its vicinity. The leasing interest is mostly by minor companies and individual and/or investment groups. Some sites showed 100% major company interest, such as Bell Flat, of which very few are still lease applications, the remainder closed cases.

This zone includes 1 of the 2 metropolitan localities in the state: Reno-Sparks - (should include Carson City) with many important communities, good to fair transportation arteries.

Economic Base: Tourism, Agriculture/Livestock, Warehousing. The growth in tourism and warehousing increases population energy needs.

Non-Technical Components For Area 9

Close to 85% of the total area is covered by the well-known checkerboard pattern of alternating federal and private lands. Only one (1) of the nine (9) sites identified for this area: Brooks Hot Spring, is excluded from leasing by federal environment decisions. There are two (2) important communities in this area: Winnemucca and Golconda.

Presently there are no KGRAs in the area and leasing activity is not significant at this time. There are only two (2) sites with leasing activity: Hot Springs (Tipton) Ranch with closed cases and a few leases, and, Sand Dunes site with All activity now closed cases.

So far, only a few Notices of Intents are known for the area, focus has been at Hot Springs (Tipton) Ranch and Golconda sites.

EXPLANATION TO HOT-WATER CONVECTION SYSTEMS SHEETS

Footnotes

(1) Maximum surface temperature reported from a spring or fumarole.

(2) Predicted using chemical geothermometers, assuming last equilibration in the reservoir; assumes saturation of SiO_2 with respect to quartz, and no loss of Ca from calcite deposition.

(3) Assumed average reservoir temperature based on data presently available. Temperatures from Circular 726 and other sources. Temperatures in parentheses are highly subjective.

(4) From surface manifestations, geophysical data, well records, geologic inference and leasing activity. Assumes 1.5 km^2 if no data pertinent to size is available. Top assumed at depth of 1.5 km if no data available. Bottom assumed at 3 km depth for all convection systems. Calculated from assumed area and thickness.

(5) Calculated as product of assumed volume, volumetric specific heat of 0.6 $cal/cm^3°C$, and temperature in degrees C above 15°C.

(6) 0.02 for 150°-200°C
0.025 for 200°-250°C

(7) 25% Heat Content Recoverable as thermal energy at the surface; 1 Quad= 0.25×10^{18} cal.

HOT-WATER CONVECTION SYSTEMS IN AREA 9 .

Location	Temperatures °C			Reservoir Assumptions		Energy Potential		
Site	Surface (1)	Geochemical SiO_2 (2)	Geochemical Na-K-Ca (2)	Subsurface (3)	Volume km^3 (4)	Heat content 10^{18} cal (5)	Recovery Factor e_r (6)	Electrical Potential MW_e-30yrs.	Thermal Energy for Direct Use Quads (7)
Golconda	74	116	201	125 (185)	20	2.0	0.02		2.0
Hot Springs (Tipton) Ranch	85	150	180	180 (200)	20	2.2	0.025	245	
Hot Pot	58	125	195	125 (185)	10	1.0	0.02	90	
Sand Dunes	70			(185)	10	1.0			1.0
Winnemucca Mountain	34			(90)	5	0.15			0.15
Humboldt River	29								
Brooks Hot Spring	37								
Winnemucca	29								
Lone Butte	21								
TOTAL:								335	3.15

Footnotes 1 thru 7-see Explanation Page

NEVADA GEOTHERMAL AREA 9 SCENARIO

AREA: 8

SITE CHARACTERISTICS:

SITE: RYE PATCH

Possible Subsequent Additions (MWe) and On Line Date:

50 MWe	1988	100	1994
100 MWe	1990	100	1996
100 MWe	1992	50	1998

POSTULATED SITE DEVELOPMENT SCHEDULE (FOR FIRST 40 MWe PLANT)

OPERATING ENTITIES	ACTIVITY	RECIPIENTS	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
BLM	Approve Notice of Intent-	Developer																								
USGS	Approve NOI & Drill Permit	Developer																								
BLM/Owner	Lease Land	Developer	(1)																							
BLM	Process EIA/EIS	CEQ																								
County	Issue Land Use Permits	Developer																								
Developer	Exploratory Drilling & Reservoir Evaluation		(2)																							
Developer	Develop Utility Interest																									
Developer & Utility	Feasibility Study																									
Producer (Developer) & Utility	Financial Negotiations																									
Producer	Site Selection																									
Producer & Utility	Design																									
Producer & Utility	Commitment to Development													△												
Producer & Utility	Prepare Master Development Plan	BLM, USGS																								
Utility	Prepare Environmental Data Statement	BLM, FPC STATE, County																								
BLM, FPC STATE, USGS	Certify Plant & Site Issue Permits	Producer & Utility																								
USGS	Process EIA/EIS (Drilling)	CEQ																								
FPC	Process EIA/EIS (Plant)	CEQ																								
FPC	Process EIA/EIS (Transmission Line)	CEQ																								
Producer	Development Drilling																									
Utility	Plant Construction																									
Utility	Install Transmission Line (40 km)																									

(1) Some leasing on private land (see References Sheet, 2c)

(2) Dates per Phillip's Plan of Operation for 6-8000' Wells (see:6)

AREA 8

95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
390	490	490	540	540	540	540	540	540	540	540	540	540	540	540	540	540	540	540	540	540	500	500	450	450	350
					30	30	80	80	130	130	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180
													30	30	80	80	130	130	180	180	180	180	180	180	180

COMPOSITE POSTULATED SITE DEVELOPMENT SCHEDULE
FOR AREA 8

SITE NAME	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
Rye Patch																	40	40	90	90	190	190	290	290	390
Colado																									
South Eugene Mountains																									
TOTAL MWe:																									
TOTAL Quads:																									

20,50,100 = MWe (megawatts electric); electrical power generation.
.037, . . Quads (0.252 x 10^{18} cal.); direct thermal utilization. Quads available for commercial utilization. It is unlikely that the energy developed at each site will be wholly utilized, or utilized in the optimum or most efficient manner.

References To Postulated Site Development Schedules
And Non-Technical Components Of Areas.

References (indicated by parentheses and corresponding number)

1. Oral Communication:

2. Regional Environmental Analysis Record
   Geothermal oil/gas leasing (BLM) and maps

   a. Carson City District
      Pyramid District, 1975

   b. Winnemucca District
      Sonoma-Gerlach Resource Area
      Buffalo Hills Planning Unit
      1975

   c. Winnemucca District
      Deno, Paradise, Blue Wing and
      Sonoma Planning Units,
      1975

   d. Elko District,
      1975

   e. Battle Mountain District
      1976

   f. Tonopah Resource Area
      1975

   g. Fort Churchill-Clan Alpine Area,
      Carson City District, Nev., 1975

   h. Pine Nut-Walker Area,
      Carson City District, Nev. 1975

   i. Esmeralda Planning Unit,
      Esmeralda and Nye Counties, 1974

3. Lease Books (Nevada Team Data)
   Data obtained from BLM public records and maps.

4. "Intent to Conduct Geothermal Resource Exploration"
   (Filed with U.S.G.S.), (Maps and Folder) and maps.

5. Drilling and Resource Data Sheets.

6. Plan of Operation, Phillips Petroleum Company,
   March 1, 1978 - To drill 6 geothermal wells to 8000'.
   To determine the existence and commercial potential of
   geothermal resources.
   Estimating starting date - 6-78
   Estimated comp. date - 12-82

EXPLANATION FOR AREA SHEETS

ENVIRONMENT: Federal environmental decisions relating to availability of federal lands for geothermal resource leasing. All data taken from Environmental Assessment Records prepared by BLM.

CRIT. R.: Critical Restrictions. Restrictions to lessee, in addition to those restrictions covered in the Geothermal Resource Lease Application (Sec. 14 and 18).

EXCLUD. PEND.: Excluded from Leasing. Pending additional environmental studies.

EXCLUD.: Excluded from all leasing.

LAND STATUS: Geothermal leasing status on federal lands.

LSE. APLN.: Lease Application

CLOSED: Closed cases. Application never became lease. In theory the land is available for geothermal leasing.

GEO. SIM.: Geothermal Simultaneous Drawing. These applications became leases, then were terminated or relinquished by the lessee. These parcels are held for simultaneous drawing.

OPEN: Open - No leases presently recorded for site.

A.P.P.: Area Potential Prospectively. As outlined by U.S.G.S., possible geothermal resource areas.

OTHER or KGRA: KGRA - Known Geothermal Resource

OWNERSHIP INTEREST:

MAJOR: Major company interest or holdings.

MINOR: Minor company interest or holdings.

IND./INV.: Individual and/or investment group interest or holdings.

INTENTS: "Intent to Conduct Geothermal Resource Exploration" are filed with U.S.G.S.

GEO.: Geophysical work only. No Drilling (i.e.= Gravity, magnetotelluric and other surveys)

DRILL: Drilling of shallow temperature gradient holes.

OTHER: Any exploration work not included in above categories.

(NOTE: The filing of the Intent to conduct geothermal resource exploration Does Not imply the work was completed.)

AREA: 8

SITE	ENVIRONMENT			LAND STATUS							OWNERSHIP INTEREST			INTENTS			NOTES
	CRIT.R.	EXCLUD. PEND.	EXCLUD.	LSE. APLN.	CLOSED	LSE.	GEO SIM	OPEN	A.P.P.	OTHER	MAJOR	MINOR	IND./ INV.	GEO.	DRILL.	OTHER	
Rye Patch				X	X	X			X	KGRA	X			X	X		
Colado				X	X	X			X	KGRA	X			X			
South Eugene Mtns.						X					X						
Dun Glen Creek								X									

General Statement to Non-Technical Components Section,
Area Scenarios

1. All observations for environmental, leasing and "Intents" are based on data gathered in 1977, which has not been corrected, adjusted or up-dated.

2. All environmental decisions are federal (BLM) as there are no localities in Nevada which require an environmental statement. Nevada has only 2 laws requiring such reports:

   a. Nevada Clean Air Act of 1971. Amended in 1973.

   b. Utility Environmental Protection Act, 1971.
   Amended 1973.
   Requires environmental statement for utility plant siting.

   Protection of environmental values is now explicitly and clearly a major criteria for BLM management activities. All BLM activities are governed by the "Federal Land Policy and Management Act".

3. Areas 15, 16, 17, 18, 19 grouped together make up a zone of Intensive and Extensive geothermal resource interests.

   A little over 1/2 of the total land in this zone is available for geothermal leasing, the remainder is covered by private indian reservation, Bureau of Reclamation withdrawals, wildlife management and refuge, state parks and military use lands. The zone contains 10 KGRAs.

   There has been intensive "Geophysical" and "Shallow Temperature Gradient Hole" interest indicated by numerous filings of "Intent to do Geothermal Resource Exploration" with U.S.G.S. To date we do not know how many of these projects were completed.

This zone does not have extensive environment decisions but some significant sites will be affected by such decisions. (i.e. Tahoe Basin Area and Carson Sink-Alkali Flat East and West)

There has been significant leasing in this zone, both within the KGRA's and its vicinity. The leasing interest is mostly by minor companies and individual and/or investment groups. Some sites showed 100% major company interest, such as Bell Flat, of which very few are still lease applications, the remainder closed cases.

This zone includes 1 of the 2 metropolitan localities in the state: Reno-Sparks - (should include Carson City) with many important communities, good to fair transportation arteries.

Economic Base: Tourism, Agriculture/Livestock, Warehousing. The growth in tourism and warehousing increases population energy needs.

Non-Technical Components For Area 8

Approximately 90% of this area is covered by the familiar checkerboard pattern of alternating federal and private sections of land. The four (4) sites in this area are either located on or adjacent to private property, and the future availability of leaseable land for possible geothermal development may be of considerable importance. Federal environment constraints within the area do not directly affect any of the sites.

Leasing activity has occured at three (3) of the sites: Rye Patch KGRA with about 50% of its activity now in geothermal lease. The second site, Colado is also a KGRA with most all the activity now in closed cases. The third site, South Eugene Mountain has some geothermal leases. About 80% of the total leasing activity for this area has been conducted by major companies.

One (1) of the KGRAs, Colado is located about twelve (12) miles from the important community of Lovelock.

There have been four (4) Notices of Intents filed for the area with major focus in the Rye Patch-Colado zone for both geophysical survey and shallow temperature gradient holes.

A specific Plan of Operation has been filed by Phillips Petroleum Co. for their Federal leases at Rye Patch Reservoir area to drill six (6) geothermal wells to a depth of 2438 m (8000') plus or minus. All of the proposed geothermal wells are within a transportation and utility corridor.

EXPLANATION TO HOT-WATER CONVECTION SYSTEMS SHEETS

Footnotes

(1) Maximum surface temperature reported from a spring or fumarole.

(2) Predicted using chemical geothermometers, assuming last equilibration in the reservoir; assumes saturation of SiO_2 with respect to quartz, and no loss of Ca from calcite deposition.

(3) Assumed average reservoir temperature based on data presently available. Temperatures from Circular 726 and other sources. Temperatures in parentheses are highly subjective.

(4) From surface manifestations, geophysical data, well records, geologic inference and leasing activity. Assumes 1.5 km^2 if no data pertinent to size is available. Top assumed at depth of 1.5 km if no data available. Bottom assumed at 3 km depth for all convection systems. Calculated from assumed area and thickness.

(5) Calculated as product of assumed volume, volumetric specific heat of 0.6 $cal/cm^3°C$, and temperature in degrees C above 15°C.

(6) 0.02 for 150°-200°C
0.025 for 200°-250°C

(7) 25% Heat Content Recoverable as thermal energy at the surface; 1 Quad= 0.25×10^{18} cal.

AMS SHEET: LOVELOCK

NEVADA

SITE ID	SITE NAME	COUNTY	LATITUDE	LONGITUDE	TOWN-SHIP	RANGE	SEC-TION	RSVR** VOLUME (1)	--- TEMPERATURES IN DEGREES C --- SUB SURFACE	SURFACE	CS EST*	CS MEAS*
6033	FLY RANCH	616	40°48'40"N - 119°18'40"W	34N	23E	24	10	130°	94°		
	FLY RANCH, N.E.	614	40°54'00"N - 119°13'30"W	35N	24E	26	10		ND		
6022 6024	DOUBLE HOT SPRINGS-BLACK ROCK HOT SPS.	608	40°57'15"N - 119°00'00"W	35N	26E	3	60	150°	94°		
	SQUAW VALLEY	616	40°49'50"N - 119°31'55"W	34N	22E	18			ND		
	CHOLONA	614	40°50'55"N - 119°00'15"W	35N	26E	34	10		ND		
	SULPHUR	608	40°52'25"N - 118°42'20"W	35N	29E	35	10		ND		
	SAWMILL	616	40°42'30"N - 119°28'55"W	33N	22E	27			ND		
	LITTLE SAWMILL CANYON	616	40°41'00"N - 119°36'15"W	32N	21E	3			28°		
	GERLACH, N.E.	614	40°45'50"N - 119°15' 5"W	33N	24E	9	10		ND		
6028 6013	GERLACH	616	40°39'35"N - 119°21'20"W	32N	23E	15	30		98°		
6036 6035	TREGO	614	40°46'10"N - 119° 7'30"W	34N	25E	34	10	130°	86°		
	SOUTHERN EUGENE MTNS.	614	40°40'50"N - 118°13'40"W	33N	33E	35	20		ND		
	DUN GLEN CREEK	614	40°42'45"N - 118° 4'00"W	33N	35E	30			ND		
	NORTH FOX RANGE	616	40°35'35"N - 119°28'25"W	31N	22E	3			ND		
	SELENITE PEAK	614	40°34'55"N - 119°15'50"W	31N	24E	4			ND		
	BUFFALO CREEK	616	40°34'30"N - 119°43' 5"W	31N	20E	North Half			Warm		
	RYE PATCH	614	40°35'25"N - 118°16'50"W	31N	33E	4	60	182°	ND		
	SMOKE CREEK	616	40°28'10"N - 119°49'15"W	30N	19E	3			Warm		
	SO. SMOKE CRK. DESERT	616	40°19'45"N - 119°48'20"W	28N	19E	1	10		23°		
	SAND PASS	616	40°19'20"N - 119°54'00"W	28N	19E	6			Warm		

AMS SHEET: WELLS

NEVADA

SITE ID	SITE NAME	COUNTY	LATITUDE	LONGITUDE	TOWN-SHIP	RANGE	SEC-TION	RSVR** VOLUME (1)	SUB SURFACE	--- TEMPERATURES IN DEGREES C --- SURFACE	CS EST*	CS MEAS*
	TENNESSEE MOUNTAIN	605	41°52'50"N -	115°37'30"W	46N	56E	14			40°		
	JARBIDGE MOUNTAINS	605	41°52'15"N -	115°24'55"W	46N	58E	16?			27°		
	JACKPOT	605	41°57'40"N -	114°39'20"W	47N	65E	18			38°		
	SAN JACINTO RANCH SP.	605	41°52'10"N -	114°41'40"W	46N	64E	23			64°		
6061	GOOSE CREEK	605	41°10'00"N -	114° 5'00"W	46N	69E	1	2.25		43°		
	RIZZI RANCH HOT SP.	605	41°46'40"N -	115°55'30"W	45N	54E	20			41°		
6034	MINERAL HOT SPRINGS	605	41°47'10"N -	114°44'10"W	45N	64E	16	10	130°	60°		
6048	WILD HORSE HOT SP.	605	41°39'00"N -	115°46'20"W	43N	55E	4	2.25		54°		
	HOT CREEK SPRINGS	605	41°34'40"N -	115°10'55"W	43N	60E	32			68°		
	ROCK SPRING CREEK	605	41°34'25"N -	114°25'30"W	43N	67E	31			29°		
	WILKINS	605	41°25'10"N -	114°45'00"W	41N	64E	29			Hot		
	WINE CUP RANCH	605	41°24'00"N -	114°40'30"W	41N	64E	25			59°		
	THOUSAND SPRINGS	605	41° 6'50"N -	114° 9'20"W	40N	69E	10			96°?		
	GONCE CREEK	605	41°18' 5"N -	115°59' 5"W	39N	53E	2			ND		
	NORTH FORK	605	41°18' 5"N -	115°44'40"W	39N	55E	2			ND		
	MARY'S RIVER RANCH	605	41°13'40"N -	115°17'15"W	39N	59E	35			50°		
6027 6009	HUMBOLDT WELLS	605	41°11' 5"N -	115°00'00"W	38N	62E	17	20	140°	90°		
	WINTER CREEK	605	41° 3'45"N -	115°23'30"W	37N	58E	26			ND		
	CLOVER VALLEY	605	41° 3'35"N -	114°59'25"W	37N	62E	29			Warm		
	COBRE	605	41° 7'00"N -	114°22'50"W	37N	67E	3			77°		
	MULLIGAN CREEK	605	41°58'55"N -	114°22'40"W	47N	67E	9			30°		

AMS SHEET: MC DERMITT

NEVADA

SITE ID	SITE NAME	COUNTY	LATITUDE	LONGITUDE	TOWN-SHIP	RANGE	SEC-TION	RSVR** VOLUME(1)	SUB SURFACE	--- TEMPERATURES IN DEGREES C --- SURFACE	CS EST*	CS MEAS*
	CORDERO MERCURY MINE	608	41°55'40"N -	117°48'35"W	47N	37E	28	10		59°-		
	GOOSEY LAKE FLAT	608	41°46'20"N -	117°23'30"W	45N	41E	19			Hot		
	DEEP CRK.-SULPHUR CRK	605	41°37'00"N -	116°17'40"W	43N	50E	24			ND		
6045	THE HOT SPRINGS	608	41°25'20"N -	117°25'10"W	41N	41E	19	10	110°	59°		
	SOUTH FORK	608	41°27'40"N -	117° 7'10"W	41N	43E	4			ND		
6008	HOT SULPHUR SPRINGS	605	41°28'15"N -	116° 8'40"W	41N	52E	8	20		90°		
	BURNS CREEK	605	41°23'40"N -	116° 3'40"W	40N	53E	6			Warm		
	SAND DUNES	608	41° 6'30"N -	117°34'00"W	37N	39E	3	10		70°		
	MIDAS	605	41°13'10"N -	116°50'30"W	39N	45E	36			Hot		
	DRY CREEK MOUNTAIN	605	41°15'40"N -	116°21'35"W	39N	50E	18			47°		
	HOT LAKE	605	41° 8'40"N -	116°44'00"W	38N	46E	35			ND		
	WILLOW CRK. RESERVOIR	605	41°11'15"N -	116°30'30"W	38N	48E	11			ND		
	EVANS CREEK	608	41° 3'35"N -	117° 5'10"W	37N	43E	26			Hot		
	LONE BUTTE	608	41° 1'45"N -	117°19'25"W	36N	41E	2			21°		

AMS SHEET: VYA-Sheet #2

NEVADA

SITE ID	SITE NAME	COUNTY	LATITUDE	LONGITUDE	TOWN-SHIP	RANGE	SEC-TION	RSVR** VOLUME (1)	SUB SURFACE	--- TEMPERATURES IN DEGREES C --- SURFACE	CS EST*	CS MEAS*
	QUINN RIVER	608	41°25'15"N -	118° 3'30"W	41N	35E	20			27°		
	CAIN SPRINGS	608	41°15'20"N -	118°56'10"W	39N	27E	30			23°		
	SURPRISE VALLEY	616	41°10'30"N -	119°57'25"W	38N	18E	15	10		Hot		
	PARMAN	608	41° 7'15"N -	119° 7' 5"W	37N	25E	10			39°-		
	DONNELLY PEAK	608	41°00'20"N -	119°17'40"W	36N	24E	17			63°		
	MAC FAIRLANE'S	608	41° 3'00"N -	118°42'55"W	37N	29E	27	10		77°		

AMS SHEET: VV

APPENDIX O

NEVADA

SITE ID	SITE NAME	COUNTY	LATITUDE	LONGITUDE	TOWN-SHIP	RANGE	SEC-TION	RSVR** VOLUME (1)	SUB SURFACE	--- TEMPERATURES IN DEGREES C --- SURFACE	CS EST*	CS MEAS*
6058	BOG HOT SPRINGS	608	41°55'35"N - 118°48'10"W	46N	28E	18	10	115°	88°		
6016	BALTAZOR HOT SPRINGS	608	41°55'40"N - 118°42'35"W	46N	28E	26	10		93°		
	VIRGIN V. CAMPGROUND	608	41°52'15"N - 119°00'40"W	45N	26E	3			32°		
	MIDDLE LAKE	616	41°44'00"N - 119°47'10"W	44N	19E	13			28°		
	VIRGIN VALLEY	608	41°47'55"N - 119° 6'00"W	45N	25E	25			Warm		
	MC GEE MOUNTAIN	608	41°49'20"N - 118°49'00"W	45N	27E	24			55°-		
	LITTLE SAGE HEN SP.	608	41°49'45"N - 118°33'10"W	46N	30E	36			ND		
	JORDAN MEADOW MTN.	608	41°52'10"N - 118° 2'15"W	46N	35E	15			ND		
	FIVEMILE SPRING	608	41°00'55"N - 118°15'00"W	45N	33E	22			28°		
	FORTYNINE LAKE	616	41°35'15"N - 119°51'40"W	42N	19E	4			22°		
	GRIDLEY LAKE	608	41°45'25"N - 118°50'20"W	44N	27E	14			42°		
6029	HOWARD HOT SPRING	608	41°43'25"N - 118°30'10"W	44N	31E	4	10	130°	73°		
	BILK CREEK RESERVOIR	608	41°40'25"N - 118°26'40"W	44N	32E	19	10		57°		
	NINEMILE SUMMIT SP.	608	41°42'20"N - 118°15'15"W	44N	33E	10			26°		
6026	DYKE HOT SPRINGS	608	41°33'10"N - 118°33'40"W	43N	31E	31	20	140°	70°		
	QUINN RIVER CROSSING	608	41°31'45"N - 118°28'30"W	42N	31E	11			24°?		
	DEER CREEK PEAK	608	41°29'50"N - 118°26'00"W	42N	32E	19			21°		
	DE LONG SPRING	608	41°29'20"N - 118°17'50"W	42N	33E	29			26°		
6057	SOLDIER MEADOWS H.SPS	608	41°22'00"N - 119°13' 5"W	40N	24E	23	12	115°	54°		
6012	PINTO HOT SPRINGS	608	41°21'55"N - 118°47'35"W	40N	28E	21	10		94°		

APPENDIX O

RPPM DATA FILE - NEVADA
July 7, 1978

Inferred

AREA	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20		
1																								
2																								
3																								
4																								
5																								
6	.037	.037	.037	.037	.037	.037	.037	.037	.037	.037	.037	.036	.036	.036	.036	.036	.036	.036	.036	.036	.036	.036		
7																								
8																								
9	.11	.11	.11	.11	.11	.11	.11	.11	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09	.03	.035	.035	.035		
10																								
11	.017	.017	.017	.017	.017	.017	.016	.016	.016	.016	.016	.016	.016	.016	.016	.016								
12																								
13	.011	.011	.011	.011	.011	.011	.010	.010	.010	.010	.010	.010	.010	.010	.010	.010	.010	.010	.010	.010	.010	.010		
14																								
15	.091	.091	.091	.091	.090	.090	.090	.090	.090	.090	.090	.089	.089	.088	.052	.052	.052	.052	.052	.052	.052	.016		
16	.08	.08	.08	.08	.08	.08	.08	.08	.08	.04	.04	.04	.04	.04	.04	.04	.04							
17																								
18	.06	.06	.06	.06	.06	.06	.06	.06	.06	.06	.06	.06	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04		
19	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10	.09	.09	.09	.09	.09	.09	.09		
20	.06	.06	.06	.06	.06	.06	.06	.06	.06	.06	.06	.06	.06	.03	.03	.03	.03	.03	.03	.03	.02	.02		
21																								
22							.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03		
23					.02	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02		
24																								
25	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005			
26												.005	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005		
TOTAL	.571	.571	.571	.571	.590	.590	.618	.618	.598	.558	.558	.561	.541	.510	.474	.464	.448	.408	.348	.353	.343	.302		

APPENDIX C.

POSTULATED DEVELOPMENT SCHEDULE FOR NEVADA GEOTHERMAL AREAS

DIRECT THERMAL UTILIZATION (in Quads)

	Identified										Indicated					Inferred									
AREA	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	
1																									
2																									
3																									
4																									
5																									
6																.037	.037	.037	.037	.037	.037	.037	.037	.037	
7																									
8																									
9													.07	.07	.07	.07	.07	.07	.07	.07	.07	.07	.11	.11	
10																									
11											.017	.017	.017	.017	.017	.017	.017	.017	.017	.017	.017	.017	.017	.017	
12																									
13																					.011	.011	.011	.011	
14																									
15									.037	.037	.037	.037	.037	.037	.037	.074	.074	.091	.091	.091	.091	.091	.091	.091	
16				.04	.04	.04	.04	.04	.04	.04	.04	.08	.08	.08	.08	.08	.08	.08	.08	.08	.08	.08	.08	.08	
17																									
18							.02	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02	.06	
19																				.05	.10	.10	.10	.10	
20							.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.06	
21																									
22																									
23																									
24																									
25																.005	.005	.005	.005	.005	.005	.005	.005	.005	
26																									
TOTAL				.04	.04	.04	.09	.09	.127	.127	.144	.184	.254	.254	.254	.333	.333	.350	.350	.400	.461	.461	.501	.571	

Identified: Reservoir characteristics at least partially known from one or more deep test wells; economic or apparently economic.
Indicated: Used here as the probable to possible extension of an Identified reservoir.
Inferred: A possible resource which has not been tested by a deep well. It may, for example, be a site characterized by favorable geothermometry, temperature gradient holes, and geophysics; or it may be merely the site of a nondescript, moderately thermal spring or geothermal leasehold.

-Inferred

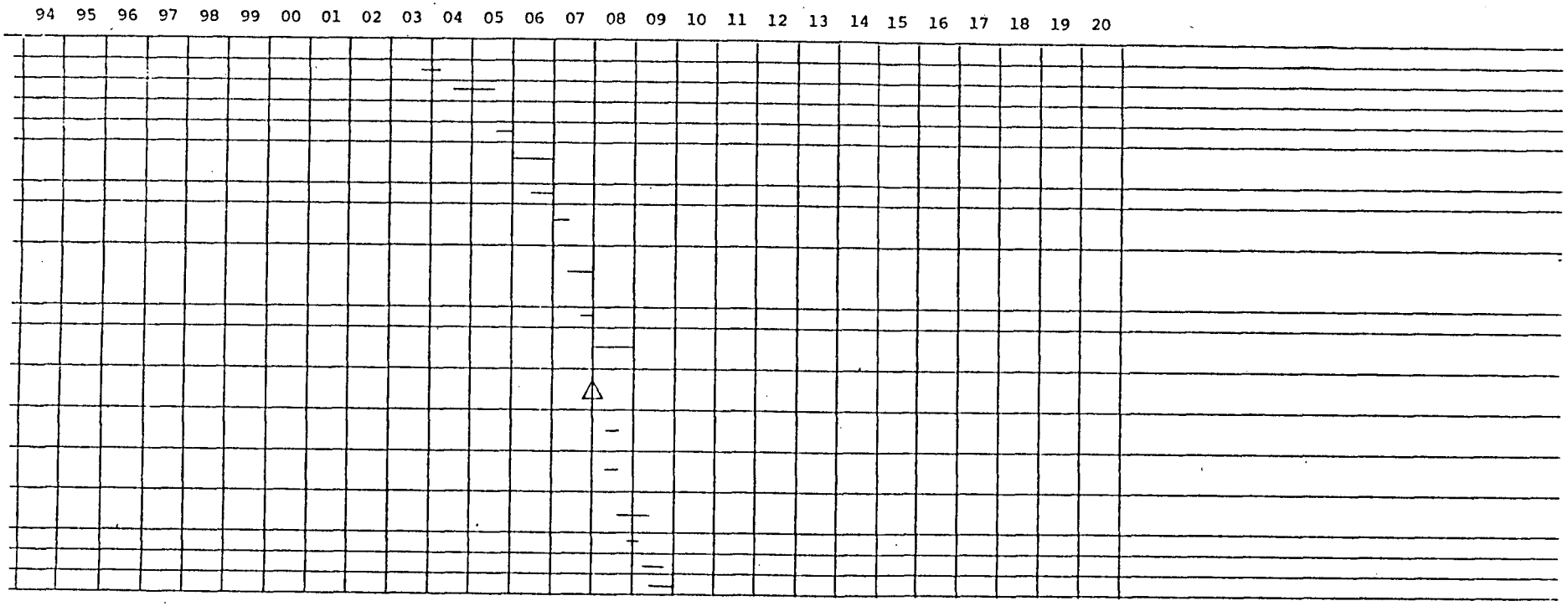
AREA	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	MWe in 2020
1	265	265	315	315	335	335	335	335	335	360	360	410	410	460	460	460	460	460	460	460
2	460	460	490	490	540	540	565	565	615	615	665	665	685	685	715	715	685	685	635	635
3	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	70	70	20	20
4	260	260	260	260	260	260	260	260	260	260	260	260	260	260	260	230	230	180	180	180
5	245	245	245	275	275	325	325	375	375	425	425	425	425	425	425	405	405	355	355	355
6	600	700	800	900	1000	1100	1200	1250	1320	1320	1420	1440	1480	1510	1580	1550	1620	1570	1590	1590
7	90	90	90	90	90	90	90	90	90	90	90	90	90	70	90	40	90	70	90	90
8	620	620	670	670	720	720	750	750	800	800	850	850	900	900	860	860	810	810	710	710
9	70	70	120	120	170	170	220	220	245	245	245	245	265	265	315	315	335	335	335	335
10	735	735	735	755	755	805	805	855	855	905	905	955	955	945	945	845	845	745	745	745
11				20	20	70	70	120	120	170	170	220	220	245	245	245	245	245	245	245
12	770	770	870	870	970	970	1070	1090	1190	1240	1290	1340	1340	1390	1390	1440	1440	1490	1410	1410
13	200	200	250	250	270	270	290	290	340	340	360	360	360	360	380	380	430	410	430	430
14	470	490	490	520	520	570	570	620	640	690	740	740	790	790	840	870	920	950	975	975
15	350	400	400	400	400	400	400	400	425	425	425	475	475	475	475	475	425	425	425	425
16	955	1005	1055	1070	1070	1120	1120	1220	1245	1295	1325	1375	1375	1375	1275	1275	1175	1175	1075	1075
17	150	200	200	250	250	250	250	270	270	320	320	340	340	340	340	340	315	315	265	265
18	880	880	930	955	955	1005	1005	1055	1055	1080	1080	1130	1130	1130	1155	1055	1105	1005	1055	1055
19	635	635	695	695	745	745	795	830	830	880	880	930	950	950	1000	980	1030	980	945	945
20	160	160	160	160	160	160	160	160	160	160	160	160	160	160	130	130	80	80	80	80
21	165	165	165	180	180	230	230	280	280	330	330	330	330	330	330	330	330	330	315	315
22																				
23	465	465	515	515	515	515	515	515	515	515	515	515	515	515	515	545	545	595	595	595
24	220	220	270	270	270	295	295	345	345	345	345	375	375	425	425	475	475	525	485	485
25																				
26																				
TOTAL	8,855	9,125	9,815	10,120	10,560	11,035	11,410	11,985	12,400	12,900	13,250	13,720	13,920	14,095	14,240	14,050	14,065	13,805	13,420	13,420

APPENDIX B.

POSTULATED DEVELOPMENT SCHEDULE FOR NEVADA GEOTHERMAL AREAS

ELECTRIC POWER GENERATION (in MWe)

| | | | | | - -Identified- - | | | - - - - - -Indicated- - - - - - | | | | | | - - - - - - - - - - - - Inferred- - - - - - - - - - - - -


94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20

AREA: 26

Possible Subsequent Additions
Quads and On Line Date:

SITE CHARACTERISTICS:

SITE: SARCOBATUS FLAT-BEATTY (1)

POSTULATED SITE DEVELOPMENT SCHEDULE (FOR FIRST .005 QUAD DEVELOPMENT)

OPERATING ENTITIES	ACTIVITY	RECIPIENTS	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
BLM	Approve Notice of Intent-	Developer																								
USGS	Approve NOI & Drill Permit	Developer																								
BLM/Owner	Lease Land	Developer																								
BLM	Process EIA/EIS	CEQ	Completed																							
County	Issue Land Use Permits	Developer																								
Developer	Exploratory Drilling & Reservoir Evaluation																									
Developer	Develop User Interest																									
Developer & User	Feasibility Study																									
Producer(Developer) & User	Financial Negotiations																									
Producer	Site Selection																									
Producer & User	Design																									
Producer & User	Commitment to Development																									
Producer & User	Prepare Master Development Plan	BLM, USGS																								
User	Prepare Environmental Data Statement	BLM, STATE, County																								
BLM, STATE, USGS	Issue Permits on Site	Producer & User																								
USGS	Process EIA/EIS (Drilling)	CEQ																								
Producer	Development Drilling																									
User	Plant Construction																									

(1) No leasing, No Intents, No federal environmental constraints for this Site. May be some private land.

AREA 26

95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
															.005	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005

COMPOSITE POSTULATED SITE DEVELOPMENT SCHEDULE
FOR AREA 26

SITE NAME	70	71	72	73	74	75	76	77	78	•79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
Sarcobatus Flat-Beatty																									
Ash Meadows																									
Jackass Flats																									
Boulder Junction-E. Las Vegas																									
Frenchman Flat																									
Moapa																									
Black Canyon																									
Steves Pass																									
Lathrop Wells																									
Desert Rock																									
Rock Valley																									
Scranton Well																									
Skeleton																									
Mt. Stirling																									
Point of Rocks Springs																									
Spotted Range																									
Sunrise Mountain																									
Muddy Mountains																									
Sixmile Spring																									
Jean Lake																									
Willow Spring																									
Davis Dam																									
TOTAL MWe:																									
TOTAL Quads:																									

20,50,100 = MWe (megawatts electric); electrical power generation.
.037,.04,.017 = Quads (0.252×10^{18} cal.); direct thermal utilization. Quads available for commercial utilization. It is unlikely that the energy developed at each site will be wholly utilized, or utilized in the optimum or most efficient manner.

References To Postulated Site Development Schedules
And Non-Technical Components Of Areas.

References (indicated by parentheses and corresponding number)

1. Oral Communication:

2. Regional Environmental Analysis Record
   Geothermal oil/gas leasing (BLM) and maps

   a. Carson City District
      Pyramid District, 1975

   b. Winnemucca District
      Sonoma-Gerlach Resource Area
      Buffalo Hills Planning Unit
      1975

   c. Winnemucca District
      Deno, Paradise, Blue Wing and
      Sonoma Planning Units,
      1975

   d. Elko District,
      1975

   e. Battle Mountain District
      1976

   f. Tonopah Resource Area
      1975

   g. Fort Churchill-Clan Alpine Area,
      Carson City District, Nev., 1975

   h. Pine Nut-Walker Area,
      Carson City District, Nev. 1975

   i. Esmeralda Planning Unit,
      Esmeralda and Nye Counties, 1974

3. Lease Books (Nevada Team Data)
   Data obtained from BLM public records and maps.

4. "Intent to Conduct Geothermal Resource Exploration"
   (Filed with U.S.G.S.), (Maps and Folder) and maps.

5. Drilling and Resource Data Sheets.

6. Plan of Operation, Phillips Petroleum Company,
   March 1, 1978 - To drill 6 geothermal wells to 8000'.
   To determine the existence and commercial potential of geothermal resources.
   Estimating starting date - 6-78
   Estimated comp. date - 12-82

EXPLANATION FOR AREA SHEETS

ENVIRONMENT: Federal environmental decisions relating to availability of federal lands for geothermal resource leasing. All data taken from Environmental Assessment Records prepared by BLM.

CRIT. R.: Critical Restrictions. Restrictions to lessee, in addition to those restrictions covered in the Geothermal Resource Lease Application (Sec. 14 and 18).

EXCLUD. PEND.: Excluded from Leasing. Pending additional environmental studies.

EXCLUD.: Excluded from all leasing.

LAND STATUS: Geothermal leasing status on federal lands.

LSE. APLN.: Lease Application

CLOSED: Closed cases. Application never became lease. In theory the land is available for geothermal leasing.

GEO. SIM.: Geothermal Simultaneous Drawing. These applications became leases, then were terminated or relinquished by the lessee. These parcels are held for simultaneous drawing.

OPEN: Open - No leases presently recorded for site.

A.P.P.: Area Potential Prospectively. As outlined by U.S.G.S., possible geothermal resource areas.

OTHER or KGRA: KGRA - Known Geothermal Resource

OWNERSHIP INTEREST:

MAJOR: Major company interest or holdings.

MINOR: Minor company interest or holdings.

IND./INV.: Individual and/or investment group interest or holdings.

INTENTS: "Intent to Conduct Geothermal Resource Exploration" are filed with U.S.G.S.

GEO.: Geophysical work only. No Drilling (i.e.= Gravity, magnetotelluric and other surveys)

DRILL: Drilling of shallow temperature gradient holes.

OTHER: Any exploration work not included in above categories.

(NOTE: The filing of the Intent to conduct geothermal resource exploration Does Not imply the work was completed.)

AREA: 26

SITE	ENVIRONMENT			LAND STATUS							OWNERSHIP INTEREST			INTENTS			NOTES
	CRIT.R.	EXCLUD. PEND.	EXCLUD.	LSE. APLN.	CLOSED	LSE.	GEO SIM	OPEN	A.P.P.	OTHER	MAJOR	MINOR	IND./ INV.	GEO.	DRILL.	OTHER	
Sarcobatus Flat-Beatty								X	X								
Ash Meadows	X							X	X								
Jackass Flats								X	X								
Boulder Junction-E. Las Vegas								X									
Frenchman Flat								X									
Moapa			X					X	X								
Black Canyon								X									
Steves Pass								X	X								
Lathrop Wells	X							X	X								
Desert Rock								X	X								
Scranton Well	X							X	X								
Skeleton								X	X								
Mt. Stirling								X	X								
Pt. of Rocks Springs	X							X	X								
Spotted Range								X									
Sunrise Mountain								X									
Muddy Mountains								X									
Sixmile Spring								X									
Jean Lake								X									
Willow Spring								X									
Davis Dam								X									
Rock Valley	X							X	X								

General Statement to Non-Technical Components Section,
Area Scenarios

1. All observations for environmental, leasing and "Intents" are based on data gathered in 1977, which has not been corrected, adjusted or up-dated.

2. All environmental decisions are federal (BLM) as there are no localities in Nevada which require an environmental statement. Nevada has only 2 laws requiring such reports:

   a. Nevada Clean Air Act of 1971. Amended in 1973.

   b. Utility Environmental Protection Act, 1971.
   Amended 1973.
   Requires environmental statement for utility plant siting.

   Protection of environmental values is now explicitly and clearly a major criteria for BLM management activities. All BLM activities are governed by the "Federal Land Policy and Management Act".

3. Areas 15, 16, 17, 18, 19 grouped together make up a zone of Intensive and Extensive geothermal resource interests.

   A little over 1/2 of the total land in this zone is available for geothermal leasing, the remainder is covered by private indian reservation, Bureau of Reclamation withdrawals, wildlife management and refuge, state parks and military use lands. The zone contains 10 KGRAs.

   There has been intensive "Geophysical" and "Shallow Temperature Gradient Hole" interest indicated by numerous filings of "Intent to do Geothermal Resource Exploration" with U.S.G.S. To date we do not know how many of these projects were completed.

This zone does not have extensive environment decisions but some significant sites will be affected by such decisions. (i.e. Tahoe Basin Area and Carson Sink-Alkali Flat East and West)

There has been significant leasing in this zone, both within the KGRA's and its vicinity. The leasing interest is mostly by minor companies and individual and/or investment groups. Some sites showed 100% major company interest, such as Bell Flat, of which very few are still lease applications, the remainder closed cases.

This zone includes 1 of the 2 metropolitan localities in the state: Reno-Sparks - (should include Carson City) with many important communities, good to fair transportation arteries.

Economic Base: Tourism, Agriculture/Livestock, Warehousing. The growth in tourism and warehousing increases population energy needs.

Non-Technical Components For Area 26

A large area in the southern part of Nevada which includes Clark county and the Las Vegas-Henderson metropolitan region. Approximately 35% of the area is within the Nevada Test Site, Desert National Wildlife Range and private property. Also, about 20% of the total area has some federal environmental constraints. Of the twenty-two (22) identified sites in the area, five (5) have critical restrictions which are for seasonal occupancy with leasing permitted. One (1) site, Moapa, has been excluded from leasing.

To date no leasing activity has occured at any of the sites, but over half of the sites are included in the U.S.G.S. designated Area Potential Prospectively.

There have been no Notices of Intents filed for any of the sites nor any part of this area.

EXPLANATION TO HOT-WATER CONVECTION SYSTEMS SHEETS

Footnotes

(1) Maximum surface temperature reported from a spring or fumarole.

(2) Predicted using chemical geothermometers, assuming last equilibration in the reservoir; assumes saturation of SiO_2 with respect to quartz, and no loss of Ca from calcite deposition.

(3) Assumed average reservoir temperature based on data presently available. Temperatures from Circular 726 and other sources. Temperatures in parentheses are highly subjective.

(4) From surface manifestations, geophysical data, well records, geologic inference and leasing activity. Assumes 1.5 km^2 if no data pertinent to size is available. Top assumed at depth of 1.5 km if no data available. Bottom assumed at 3 km depth for all convection systems. Calculated from assumed area and thickness.

(5) Calculated as product of assumed volume, volumetric specific heat of 0.6 $cal/cm^3°C$, and temperature in degrees C above 15°C.

(6) 0.02 for 150°-200°C
0.025 for 200°-250°C

(7) 25% Heat Content Recoverable as thermal energy at the surface; 1 Quad= 0.25×10^{18} cal.

HOT-WATER CONVECTION SYSTEMS IN AREA 26 .

Location	Temperatures °C			Reservoir Assumptions		Energy Potential		
Site	Surface (1)	Geochemical SiO_2 (2)	Geochemical Na-K-Ca (2)	Subsurface (3)	Volume km^3 (4)	Heat content 10^{18} cal (5)	Recovery Factor e_r (6)	Electrical Potential MW_e-30yrs.	Thermal Energy for Direct Use Quads (7)
Sarcobatus Flat-Beatty	43			(65)	5	0.15			0.15
Ash Meadows	34-								
Jackass Flats	36-								
Boulder [illegible] Las Vegas	41-								
Frenchman Flat	38-								
Moapa	32								
Black Canyon	63								
Steves Pass	29								
Lathrop Wells	28-								
Desert Rock	33-								
Rock Valley	27-								
Scranton Well	29-								
Skeleton	31-								
Mt. Stirling	28-								
Point of Rocks Springs	28-								
Spotted Range	27-								
Sunrise Mountain	29-								
Muddy Mountains	31								
Sixmile Spring	28?								
Jean Lake	27-								
Willow Spring	31								
Davis Dam	27								
TOTAL:									0.15

Footnotes 1 thru 7-see Explanation Page

NEVADA GEOTHERMAL AREA 26 SCENARIO

AREA: 25

Possible Subsequent Additions
Quads and On Line Date:

SITE CHARACTERISTICS:

SITE: CALIENTE (1)

POSTULATED SITE DEVELOPMENT SCHEDULE (FOR FIRST .005 QUAD DEVELOPMENT)

OPERATING ENTITIES	ACTIVITY	RECIPIENTS	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
BLM	Approve Notice of Intent-	Developer															—									
USGS	Approve NOI & Drill Permit	Developer																								
BLM/Owner	Lease Land	Developer															—	—								
BLM	Process EIA/EIS	CEQ	Completed																							
County	Issue Land Use Permits	Developer																—								
Developer	Exploratory Drilling & Reservoir Evaluation																		—	—						
Developer	Develop User Interest																		—							
Developer & User	Feasibility Study																			—						
Producer (Developer) & User	Financial Negotiations																			—						
Producer	Site Selection																			—						
Producer & User	Design																				—	—				
Producer & User	Commitment to Development																				△					
Producer & User	Prepare Master Development Plan	BLM, USGS																			—					
User	Prepare Environmental Data Statement	BLM, STATE, County																			—					
BLM, STATE, USGS	Issue Permits on Site	Producer & User																				—				
USGS	Process EIA/EIS (Drilling)	CEQ																				+				
Producer	Development Drilling																					—				
User	Plant Construction																						—			

(1) Caliente Hot Springs-No leasing, No Intents-No Federal environmental constraints, partially located on private property.

AREA 25

95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
.005	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005	.005	

COMPOSITE POSTULATED SITE DEVELOPMENT SCHEDULE
FOR AREA 25

SITE NAME	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
Caliente Hot Springs																					.005	.005	.005	.005	.005
Forest Moon Ranch																									
Moorman Spring																									
Williams Hot Springs																									
Ash Springs																									
Crystal Springs																									
Hiko Spring																									
Whipple Peak																									
Emigrant Springs																									
Preston																									
Schell Creek Range																									
Doyles Well																									
Granite Peak																									
Mount Grafton																									
Camp Valley Creek																									
Sand Spring Valley																									
Sand Spring Valley-West																									
Sand Spring Valley-South																									
Dry Valley																									
Panaca																									
TOTAL MWe:																									
TOTAL Quads:																									

20,50,100 = MWe (megawatts electric); electrical power generation.
.037,.04,.017 = Quads (0.252×10^{18} cal.); direct thermal utilization. Quads available for commercial utilization. It is unlikely that the energy developed at each site will be wholly utilized, or utilized in the optimum or most efficient manner.

References To Postulated Site Development Schedules
And Non-Technical Components Of Areas.

References (indicated by parentheses and corresponding number)

1. Oral Communication:

2. Regional Environmental Analysis Record
   Geothermal oil/gas leasing (BLM) and maps

   a. Carson City District
      Pyramid District, 1975

   b. Winnemucca District
      Sonoma-Gerlach Resource Area
      Buffalo Hills Planning Unit
      1975

   c. Winnemucca District
      Deno, Paradise, Blue Wing and
      Sonoma Planning Units,
      1975

   d. Elko District,
      1975

   e. Battle Mountain District
      1976

   f. Tonopah Resource Area
      1975

   g. Fort Churchill-Clan Alpine Area,
      Carson City District, Nev., 1975

   h. Pine Nut-Walker Area,
      Carson City District, Nev. 1975

   i. Esmeralda Planning Unit,
      Esmeralda and Nye Counties, 1974

3. Lease Books (Nevada Team Data)
   Data obtained from BLM public records and maps.

4. "Intent to Conduct Geothermal Resource Exploration"
   (Filed with U.S.G.S.), (Maps and Folder) and maps.

5. Drilling and Resource Data Sheets.

6. Plan of Operation, Phillips Petroleum Company,
   March 1, 1978 - To drill 6 geothermal wells to 8000'.
   To determine the existence and commercial potential of
   geothermal resources.
   Estimating starting date - 6-78
   Estimated comp. date - 12-82

EXPLANATION FOR AREA SHEETS

ENVIRONMENT: Federal environmental decisions relating to availability of federal lands for geothermal resource leasing. All data taken from Environmental Assessment Records prepared by BLM.

CRIT. R.: Critical Restrictions. Restrictions to lessee, in addition to those restrictions covered in the Geothermal Resource Lease Application (Sec. 14 and 18).

EXCLUD. PEND.: Excluded from Leasing. Pending additional environmental studies.

EXCLUD.: Excluded from all leasing.

LAND STATUS: Geothermal leasing status on federal lands.

LSE. APLN.: Lease Application

CLOSED: Closed cases. Application never became lease. In theory the land is available for geothermal leasing.

GEO. SIM.: Geothermal Simultaneous Drawing. These applications became leases, then were terminated or relinquished by the lessee. These parcels are held for simultaneous drawing.

OPEN: Open - No leases presently recorded for site.

A.P.P.: Area Potential Prospectively. As outlined by U.S.G.S., possible geothermal resource areas.

OTHER or KGRA: KGRA - Known Geothermal Resource

OWNERSHIP INTEREST:

MAJOR: Major company interest or holdings.

MINOR: Minor company interest or holdings.

IND./INV.: Individual and/or investment group interest or holdings.

INTENTS: "Intent to Conduct Geothermal Resource Exploration" are filed with U.S.G.S.

GEO.: Geophysical work only. No Drilling (i.e.= Gravity, magnetotelluric and other surveys)

DRILL: Drilling of shallow temperature gradient holes.

OTHER: Any exploration work not included in above categories.

(NOTE: The filing of the Intent to conduct geothermal resource exploration Does Not imply the work was completed.)

AREA: 25

SITE	ENVIRONMENT			LAND STATUS							OWNERSHIP INTEREST			INTENTS			NOTES
	CRIT. R.	EXCLUD. PEND.	EXCLUD.	LSE. APLN.	CLOSED	LSE.	GEO SIM	OPEN	A.P.P.	OTHER	MAJOR	MINOR	IND./ INV.	GEO.	DRILL.	OTHER	
Granite Peak				X	X								X				
Caliente Hot Springs								X	X								Some Private Ppty
Panaca								X	X								
Dry Valley								X									
Whipple Peak	X							X									
Emigrant Springs								X									
Preston								X									
Forest Moon Ranch	X							X	X								Some State & Priv.
Moorman Spring								X	X								
Williams Hot Springs								X									
Ash Springs								X	X								
Crystal Springs								X	X								
Hiko Spring	X							X	X								Some Private
Schell Crk. Range								X									
Doyles Well								X									
Mount Grafton	X							X									
Camp Valley Creek								X									
Sand Spring Valley								X									
Sand Sp. V.-West								X									
Sand Sp. V.-South								X									

General Statement to Non-Technical Components Section,
Area Scenarios

1. All observations for environmental, leasing and "Intents" are based on data gathered in 1977, which has not been corrected, adjusted or up-dated.

2. All environmental decisions are federal (BLM) as there are no localities in Nevada which require an environmental statement. Nevada has only 2 laws requiring such reports:

   a. Nevada Clean Air Act of 1971. Amended in 1973.

   b. Utility Environmental Protection Act, 1971.
   Amended 1973.
   Requires environmental statement for utility plant siting.

   Protection of environmental values is now explicitly and clearly a major criteria for BLM management activities. All BLM activities are governed by the "Federal Land Policy and Management Act".

3. Areas 15, 16, 17, 18, 19 grouped together make up a zone of Intensive and Extensive geothermal resource interests.

   A little over 1/2 of the total land in this zone is available for geothermal leasing, the remainder is covered by private indian reservation, Bureau of Reclamation withdrawals, wildlife management and refuge, state parks and military use lands. The zone contains 10 KGRAs.

   There has been intensive "Geophysical" and "Shallow Temperature Gradient Hole" interest indicated by numerous filings of "Intent to do Geothermal Resource Exploration" with U.S.G.S. To date we do not know how many of these projects were completed.

   This zone does not have extensive environment decisions but some significant sites will be affected by such decisions. (i.e. Tahoe Basin Area and Carson Sink-Alkali Flat East and West)

   There has been significant leasing in this zone, both within the KGRA's and its vicinity. The leasing interest is mostly by minor companies and individual and/or investment groups. Some sites showed 100% major company interest, such as Bell Flat, of which very few are still lease applications, the remainder closed cases.

   This zone includes 1 of the 2 metropolitan localities in the state: Reno-Sparks - (should include Carson City) with many important communities, good to fair transportation arteries.

   Economic Base: Tourism, Agriculture/Livestock, Warehousing. The growth in tourism and warehousing increases population energy needs.

Non-Technical Components For Area 25

Approximately 60% of the total area is covered by federal environmental constraints, which directly affect four (4) of the twenty (20) sites now identified in this area. Many of the remaining sites may have some affect because their locations are quite often adjacent to large areas with restrictions. Most of the decisions are for the protection of deer habitat and so are stipulations for seasonal occupancy. All restrictions permit leasing. The south 1/3 of the total area is covered by part of the Nellis Air Force Base, Gunnery Bombing Range and Desert National Wildlife Range.

There are no KGRAs in the area, and only one (1) site, Granite Peak, located in the Humboldt National Forest, has no current geothermal leases. All activity is in closed case status. All the activity was conducted by individuals and/or investment groups.

There have been no Notices of Intents filed for this area.

EXPLANATION TO HOT-WATER CONVECTION SYSTEMS SHEETS

Footnotes

(1) Maximum surface temperature reported from a spring or fumarole.

(2) Predicted using chemical geothermometers, assuming last equilibration in the reservoir; assumes saturation of SiO_2 with respect to quartz, and no loss of Ca from calcite deposition.

(3) Assumed average reservoir temperature based on data presently available. Temperatures from Circular 726 and other sources. Temperatures in parentheses are highly subjective.

(4) From surface manifestations, geophysical data, well records, geologic inference and leasing activity. Assumes 1.5 km^2 if no data pertinent to size is available. Top assumed at depth of 1.5 km if no data available. Bottom assumed at 3 km depth for all convection systems. Calculated from assumed area and thickness.

(5) Calculated as product of assumed volume, volumetric specific heat of 0.6 $cal/cm^3°C$, and temperature in degrees C above 15°C.

(6) 0.02 for 150°-200°C
0.025 for 200°-250°C

(7) 25% Heat Content Recoverable as thermal energy at the surface; 1 Quad= 0.25×10^{18} cal.

HOT-WATER CONVECTION SYSTEMS IN AREA 25 .

Location	Temperatures °C			Reservoir Assumptions		Energy Potential		
Site	Surface (1)	Geochemical SiO_2 (2)	Geochemical Na-K-Ca (2)	Subsurface (3)	Volume km^3 (4)	Heat content 10^{18} cal (5)	Recovery Factor e_r (6)	Electrical Potential MW_e-30yrs.	Thermal Energy for Direct Use Quads (7)
Caliente Hot Springs	57			(65)	5	0.15			0.15
Forest Moon Ranch	33								
Moorman Spring	38								
Williams Hot Springs	53								
Ash Springs	36								
Crystal Springs	32								
Hiko Spring	32								
Whipple Peak	24								
Emigrant Springs	21								
Preston	22-								
Schell Creek Range	Warm								
Doyles Well	24								
Granite Peak	ND								
Mount Grafton	21								
Camp Valley Creek	29								
Sand Spring Valley	30								
Sand Spring Valley-West	28-								
Sand Spring Valley-South	Warm								
Dry Valley	25-								
Panaca	32								
TOTAL:									0.15

Footnotes 1 thru 7-see Explanation Page

NEVADA GEOTHERMAL AREA 25 SCENARIO

AREA: 24

SITE CHARACTERISTICS:

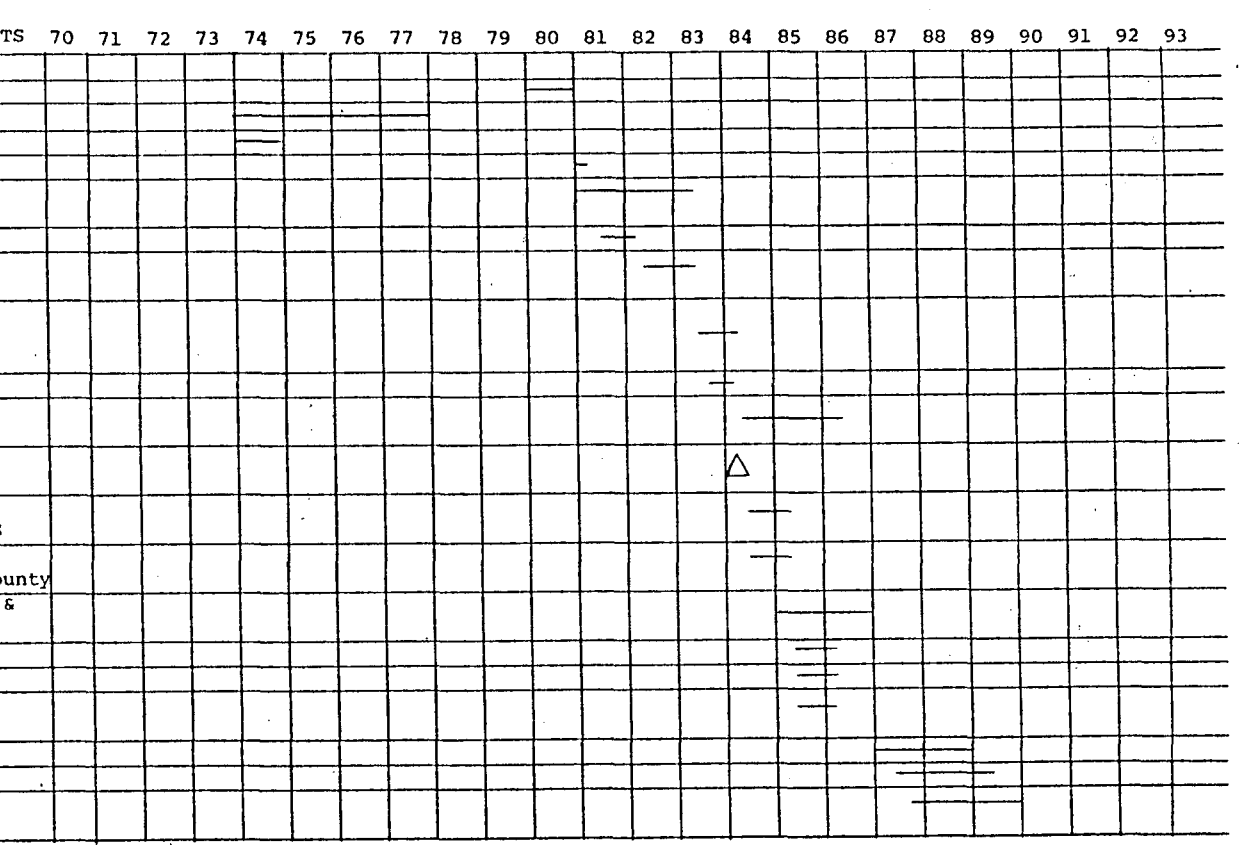
SITE: WARM SPRINGS

Possible Subsequent Additions (MWe) and On Line Date:

50 MWe 1992

POSTULATED SITE DEVELOPMENT SCHEDULE (FOR FIRST 40 MWe PLANT)

OPERATING ENTITIES	ACTIVITY	RECIPIENTS
BLM	Approve Notice of Intent-	Developer
USGS	Approve NOI & Drill Permit	Developer
BLM/Owner	Lease Land	Developer
BLM	Process EIA/EIS	CEQ
County	Issue Land Use Permits	Developer
Developer	Exploratory Drilling & Reservoir Evaluation	
Developer	Develop Utility Interest	
Developer & Utility	Feasibility Study	
Producer (Developer) & Utility	Financial Negotiations	
Producer	Site Selection	
Producer & Utility	Design	
Producer & Utility	Commitment to Development	
Producer & Utility	Prepare Master Development Plan	BLM, USGS
Utility	Prepare Environmental Data Statement	BLM, FPC STATE, County
BLM, FPC STATE, USGS	Certify Plant & Site Issue Permits	Producer & Utility
USGS	Process EIA/EIS (Drilling)	CEQ
FPC	Process EIA/EIS (Plant)	CEQ
FPC	Process EIA/EIS (Transmission Line)	CEQ
Producer	Development Drilling	
Utility	Plant Construction	
Utility	Install Transmission Line (40 km)	



AREA 24

95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	50
	40	40	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90
							40	40	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90
												25	25	75	75	75	75	75	75	75	75	75	75	75	75
																		30	30	80	80	130	130	180	180

COMPOSITE POSTULATED SITE DEVELOPMENT SCHEDULE
FOR AREA 24

SITE NAME	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
Warm Springs																					40	40	90	90	90
Railroad Valley-Pancake Range																									
Hot Creek Canyon																									
Hot Creek Valley																									
Lunar Crater																									
Big Spring																									
Little Fish Lake Valley																									
Duckwater																									
Railroad Valley-Eagle Springs																									
Bull Creek																									
Saulsbury Wash																									
Willow Creek																									
Pinon Peak																									
Reveille Mill																									
Coyote Hole Spring																									
TOTAL MWe:																									
TOTAL Quads:																									

20,50,100 = MWe (megawatts electric); electrical power generation.
.037,.04,.017 = Quads (0.252×10^{18} cal.); direct thermal utilization. Quads available for commercial utilization. It is unlikely that the energy developed at each site will be wholly utilized, or utilized in the optimum or most efficient manner.

References To Postulated Site Development Schedules
And Non-Technical Components Of Areas.

References (indicated by parentheses and corresponding number)

1. Oral Communication:

2. Regional Environmental Analysis Record
   Geothermal oil/gas leasing (BLM) and maps

   a. Carson City District
      Pyramid District, 1975

   b. Winnemucca District
      Sonoma-Gerlach Resource Area
      Buffalo Hills Planning Unit
      1975

   c. Winnemucca District
      Deno, Paradise, Blue Wing and
      Sonoma Planning Units,
      1975

   d. Elko District,
      1975

   e. Battle Mountain District
      1976

   f. Tonopah Resource Area
      1975

   g. Fort Churchill-Clan Alpine Area,
      Carson City District, Nev., 1975

   h. Pine Nut-Walker Area,
      Carson City District, Nev. 1975

   i. Esmeralda Planning Unit,
      Esmeralda and Nye Counties, 1974

3. Lease Books (Nevada Team Data)
   Data obtained from BLM public records and maps.

4. "Intent to Conduct Geothermal Resource Exploration"
   (Filed with U.S.G.S.), (Maps and Folder) and maps.

5. Drilling and Resource Data Sheets.

6. Plan of Operation, Phillips Petroleum Company,
   March 1, 1978 - To drill 6 geothermal wells to 8000'.
   To determine the existence and commercial potential of
   geothermal resources.
   Estimating starting date - 6-78
   Estimated comp. date - 12-82

2

EXPLANATION FOR AREA SHEETS

ENVIRONMENT: Federal environmental decisions relating to availability of federal lands for geothermal resource leasing. All data taken from Environmental Assessment Records prepared by BLM.

CRIT. R.: Critical Restrictions. Restrictions to lessee, in addition to those restrictions covered in the Geothermal Resource Lease Application (Sec. 14 and 18).

EXCLUD. PEND.: Excluded from Leasing. Pending additional environmental studies.

EXCLUD.: Excluded from all leasing.

LAND STATUS: Geothermal leasing status on federal lands.

LSE. APLN.: Lease Application

CLOSED: Closed cases. Application never became lease. In theory the land is available for geothermal leasing.

GEO. SIM.: Geothermal Simultaneous Drawing. These applications became leases, then were terminated or relinquished by the lessee. These parcels are held for simultaneous drawing.

OPEN: Open - No leases presently recorded for site.

A.P.P.: Area Potential Prospectively. As outlined by U.S.G.S., possible geothermal resource areas.

OTHER or KGRA: KGRA - Known Geothermal Resource

OWNERSHIP INTEREST:

MAJOR: Major company interest or holdings.

MINOR: Minor company interest or holdings.

IND./INV.: Individual and/or investment group interest or holdings.

INTENTS: "Intent to Conduct Geothermal Resource Exploration" are filed with U.S.G.S.

GEO.: Geophysical work only. No Drilling (i.e.= Gravity, magnetotelluric and other surveys)

DRILL: Drilling of shallow temperature gradient holes.

OTHER: Any exploration work not included in above categories.

(NOTE: The filing of the Intent to conduct geothermal resource exploration Does Not imply the work was completed.)

AREA: 24

SITE	ENVIRONMENT			LAND STATUS							OWNERSHIP INTEREST			INTENTS			NOTES
	CRIT.R.	EXCLUD. PEND.	EXCLUD.	LSE. APLN.	CLOSED	LSE.	GEO SIM	OPEN	A.P.P.	OTHER or KGRA	MAJOR	MINOR	IND./ INV.	GEO.	DRILL.	OTHER	
Saulsbury Wash	X							X									
Railroad V.-Eagle Sps	X								X								
Lunar Crater		X		X	X				X			X					
Warm Springs					X	X			X	KGRA	X						
Railroad V.-Pancake Range	X					X	X		X				X				
Hot Creek Canyon								X									
Hot Creek Valley								X	X								
Big Spring	X							X	X								
Duckwater								X									Ind. Reservation
Bull Creek								X									
Willow Creek								X									
Pinon Peak								X									
Reveille Mill								X									
Coyote Hole Spring								X	X								
Little Fish Lake V.								X									Some Private Land

General Statement to Non-Technical Components Section,

Area Scenarios

1. All observations for environmental, leasing and "Intents" are based on data gathered in 1977, which has not been corrected, adjusted or up-dated.

2. All environmental decisions are federal (BLM) as there are no localities in Nevada which require an environmental statement. Nevada has only 2 laws requiring such reports:

   a. Nevada Clean Air Act of 1971. Amended in 1973.

   b. Utility Environmental Protection Act, 1971.
   Amended 1973.
   Requires environmental statement for utility plant siting.

   Protection of environmental values is now explicitly and clearly a major criteria for BLM management activities. All BLM activities are governed by the "Federal Land Policy and Management Act".

3. Areas 15, 16, 17, 18, 19 grouped together make up a zone of Intensive and Extensive geothermal resource interests.

   A little over 1/2 of the total land in this zone is available for geothermal leasing, the remainder is covered by private indian reservation, Bureau of Reclamation withdrawals, wildlife management and refuge, state parks and military use lands. The zone contains 10 KGRAs.

   There has been intensive "Geophysical" and "Shallow Temperature Gradient Hole" interest indicated by numerous filings of "Intent to do Geothermal Resource Exploration" with U.S.G.S. To date we do not know how many of these projects were completed.

This zone does not have extensive environment decisions but some significant sites will be affected by such decisions. (i.e. Tahoe Basin Area and Carson Sink-Alkali Flat East and West)

There has been significant leasing in this zone, both within the KGRA's and its vicinity. The leasing interest is mostly by minor companies and individual and/or investment groups. Some sites showed 100% major company interest, such as Bell Flat, of which very few are still lease applications, the remainder closed cases.

This zone includes 1 of the 2 metropolitan localities in the state: Reno-Sparks - (should include Carson City) with many important communities, good to fair transportation arteries.

Economic Base: Tourism, Agriculture/Livestock, Warehousing. The growth in tourism and warehousing increases population energy needs.

Non-Technical Components For Area 24

The southern half of this area is covered by the Nellis Air Force Base and Nevada Test Site. Also, about 35% of the total area is covered by federal environmental constraints which includes five (5) of the fifteen (15) presently identified sites for the area. Only one (1) site, Lunar Crater has a no leasing decision, pending additional environmental studies. The other affected four (4) sites permit leasing with seasonal surface occupancy and live water stipulations.

There is one (1) designated KGRA in the area: Warm Springs which has had some leasing activity by major companies who presently have several geothermal leases. The only other leasing activity has occured at Lunar Crater with 100% of all activity now in closed cases (no leasing) and some activity at Railroad Valley-Pancake Range which are also closed cases.

Apparently there are no Notices of Intents filed for this area.

EXPLANATION TO HOT-WATER CONVECTION SYSTEMS SHEETS

Footnotes

(1) Maximum surface temperature reported from a spring or fumarole.

(2) Predicted using chemical geothermometers, assuming last equilibration in the reservoir; assumes saturation of SiO_2 with respect to quartz, and no loss of Ca from calcite deposition.

(3) Assumed average reservoir temperature based on data presently available. Temperatures from Circular 726 and other sources. Temperatures in parentheses are highly subjective.

(4) From surface manifestations, geophysical data, well records, geologic inference and leasing activity. Assumes 1.5 km^2 if no data pertinent to size is available. Top assumed at depth of 1.5 km if no data available. Bottom assumed at 3 km depth for all convection systems. Calculated from assumed area and thickness.

(5) Calculated as product of assumed volume, volumetric specific heat of 0.6 $cal/cm^3°C$, and temperature in degrees C above 15°C.

(6) 0.02 for 150°-200°C
0.025 for 200°-250°C

(7) 25% Heat Content Recoverable as thermal energy at the surface; 1 Quad= 0.25×10^{18} cal.

HOT-WATER CONVECTION SYSTEMS IN AREA 24 .

Location	Temperatures °C				Reservoir Assumptions		Energy Potential		
Site	Surface (1)	Geochemical SiO_2 (2)	Geochemical Na-K-Ca (2)	Subsurface (3)	Volume km^3 (4)	Heat content 10^{18} cal (5)	Recovery Factor e_r (6)	Electrical Potential MW_e-30yrs.	Thermal Energy for Direct Use Quads (7)
Warm Springs	63	111	192	125 (170)	10	0.9	0.02	90	
Railroad Valley-Pancake Range	71			(170)	10	0.9	0.02	90	
Hot Creek Canyon	82			(170)	10	0.9	0.07	90	
Hot Creek Valley	61			(155)	10	0.8	0.02	75	
Lunar Crater	ND			(185)	20	2.0	0.02	180	
Big Spring	37								
Little Fish Lake Valley	48								
Duckwater	34								
Railroad Valley-Eagle Springs	38-								
Bull Creek	Warm								
Saulsbury Wash	30								
Willow Creek	29								
Pinon Peak	26								
Reveille Mill	29								
Coyote Hole Spring	29								
TOTAL:								525	

Footnotes 1 thru 7-see Explanation Page

NEVADA GEOTHERMAL AREA 24 SCENARIO

AREA: 23

SITE CHARACTERISTICS:

SITE: FISH LAKE VALLEY

Possible Subsequent Additions (MWe) and On Line Date:

50 MWe 1993
50 MWe 1995
100 MWe 1997
100 MWe 1999
50 MWe 2001

POSTULATED SITE DEVELOPMENT SCHEDULE (FOR FIRST 40 MWe PLANT)

OPERATING ENTITIES	ACTIVITY	RECIPIENTS	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
BLM	Approve Notice of Intent-	Developer																								
USGS	Approve NOI & Drill Permit	Developer	(1)																							
BLM/Owner	Lease Land	Developer	(3)		(3)																					
BLM	Process EIA/EIS	CEQ	(2)																							
County	Issue Land Use Permits	Developer																								
Developer	Exploratory Drilling & Reservoir Evaluation																									
Developer	Develop Utility Interest																									
Developer & Utility	Feasibility Study																									
Producer (Developer) & Utility	Financial Negotiations																									
Producer	Site Selection																									
Producer & Utility	Design																									
Producer & Utility	Commitment to Development																△									
Producer & Utility	Prepare Master Development Plan	BLM, USGS																								
Utility	Prepare Environmental Data Statement	BLM, FPC STATE, County																								
BLM, FPC STATE, USGS	Certify Plant & Site Issue Permits	Producer & Utility																								
USGS	Process EIA/EIS (Drilling)	CEQ																								
FPC	Process EIA/EIS (Plant)	CEQ																								
FPC	Process EIA/EIS (Transmission Line)	CEQ																								
Producer	Development Drilling																									
Utility	Plant Construction																									
Utility	Install Transmission Line (40 km)																									

(1) No Intents.

(2) Detremental restrictions for this Site. (No surface occupancy). Each lease with Intents will have to be individually considered. This will add a significant amount of time to acquiring leases and doing geophysical work.

(3) Additional leasing may or may not be necessary. If additional lands for development are necessary other restrictions (Footnote 2) may prevent such acquisition.

AREA 23

95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
140	140	240	240	340	340	390	390	390	390	390	390	390	390	390	390	390	390	390	390	390	390	390	390	390	390
					25	25	75	75	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125
								.02	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02
																						30	30	80	80

COMPOSITE POSTULATED SITE DEVELOPMENT SCHEDULE
FOR AREA 23

SITE NAME	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
Fish Lake Valley																						40	40	90	90
Silver Peak Hot Springs																									
Silver Peak Hot Springs																									
Southern Clayton Valley																									
Basalt																									
Alkali Springs																									
Pearl Hot Springs																									
Gap Spring																									
Emigrant Peak																									
Mt. Diablo																									
Valcalda Spring																									
Tonopah Mining District																									
TOTAL MWe:																									
TOTAL Quads:																									

20,50,100 = MWe (megawatts electric); electrical power generation.
.037,.04,.017 = Quads (0.252×10^{18} cal.); direct thermal utilization. Quads available for commercial utilization. It is unlikely that the energy developed at each site will be wholly utilized, or utilized in the optimum or most efficient manner.

References To Postulated Site Development Schedules
And Non-Technical Components Of Areas.

References (indicated by parentheses and corresponding number)

1. Oral Communication:

2. Regional Environmental Analysis Record
   Geothermal oil/gas leasing (BLM) and maps

   a. Carson City District
      Pyramid District, 1975

   b. Winnemucca District
      Sonoma-Gerlach Resource Area
      Buffalo Hills Planning Unit
      1975

   c. Winnemucca District
      Deno, Paradise, Blue Wing and
      Sonoma Planning Units,
      1975

   d. Elko District,
      1975

   e. Battle Mountain District
      1976

   f. Tonopah Resource Area
      1975

   g. Fort Churchill-Clan Alpine Area,
      Carson City District, Nev., 1975

   h. Pine Nut-Walker Area,
      Carson City District, Nev. 1975

   i. Esmeralda Planning Unit,
      Esmeralda and Nye Counties, 1974

3. Lease Books (Nevada Team Data)
   Data obtained from BLM public records and maps.

4. "Intent to Conduct Geothermal Resource Exploration"
   (Filed with U.S.G.S.), (Maps and Folder) and maps.

5. Drilling and Resource Data Sheets.

6. Plan of Operation, Phillips Petroleum Company,
   March 1, 1978 - To drill 6 geothermal wells to 8000'.
   To determine the existence and commercial potential of
   geothermal resources.
   Estimating starting date - 6-78
   Estimated comp. date - 12-82

EXPLANATION FOR AREA SHEETS

ENVIRONMENT: Federal environmental decisions relating to availability of federal lands for geothermal resource leasing. All data taken from Environmental Assessment Records prepared by BLM.

CRIT. R.: Critical Restrictions. Restrictions to lessee, in addition to those restrictions covered in the Geothermal Resource Lease Application (Sec. 14 and 18).

EXCLUD. PEND.: Excluded from Leasing. Pending additional environmental studies.

EXCLUD.: Excluded from all leasing.

LAND STATUS: Geothermal leasing status on federal lands.

LSE. APLN.: Lease Application

CLOSED: Closed cases. Application never became lease. In theory the land is available for geothermal leasing.

GEO. SIM.: Geothermal Simultaneous Drawing. These applications became leases, then were terminated or relinquished by the lessee. These parcels are held for simultaneous drawing.

OPEN: Open - No leases presently recorded for site.

A.P.P.: Area Potential Prospectively. As outlined by U.S.G.S., possible geothermal resource areas.

OTHER or KGRA: KGRA - Known Geothermal Resource

OWNERSHIP INTEREST:

MAJOR: Major company interest or holdings.

MINOR: Minor company interest or holdings.

IND./INV.: Individual and/or investment group interest or holdings.

INTENTS: "Intent to Conduct Geothermal Resource Exploration" are filed with U.S.G.S.

GEO.: Geophysical work only. No Drilling (i.e.= Gravity, magnetotelluric and other surveys)

DRILL: Drilling of shallow temperature gradient holes.

OTHER: Any exploration work not included in above categories.

(NOTE: The filing of the Intent to conduct geothermal resource exploration Does Not imply the work was completed.)

AREA: 23

SITE	ENVIRONMENT			LAND STATUS							OWNERSHIP INTEREST			INTENTS			NOTES
	CRIT. R.	EXCLUD. PEND.	EXCLUD.	LSE. APLN.	CLOSED	LSE.	GEO SIM	OPEN	A.P.P.	OTHER or KGRA	MAJOR	MINOR	IND./ INV.	GEO.	DRILL.	OTHER	
Tonopah Min. District			X														Some Patented Land
Silver Peak H. Sps.				X	X				X	KGRA		X					
Fish Lake Valley	X					X			X			X					
Southern Clayton V.						X			X			X					
Mt. Diablo				X	X				X								
Valcalda Spring				X	X				X			X					
Basalt								X	X								Some Private Land
Alkali Springs																	
Pearl Hot Springs								X	X								
Gap Spring								X									
Emigrant Peak								X									

General Statement to Non-Technical Components Section,
Area Scenarios

1. All observations for environmental, leasing and "Intents" are based on data gathered in 1977, which has not been corrected, adjusted or up-dated.

2. All environmental decisions are federal (BLM) as there are no localities in Nevada which require an environmental statement. Nevada has only 2 laws requiring such reports:

   a. Nevada Clean Air Act of 1971. Amended in 1973.

   b. Utility Environmental Protection Act, 1971.
   Amended 1973.
   Requires environmental statement for utility plant siting.

   Protection of environmental values is now explicitly and clearly a major criteria for BLM management activities. All BLM activities are governed by the "Federal Land Policy and Management Act".

3. Areas 15, 16, 17, 18, 19 grouped together make up a zone of Intensive and Extensive geothermal resource interests.

   A little-over-1/2 of the total land in this zone is available for geothermal leasing, the remainder is covered by private indian reservation, Bureau of Reclamation withdrawals, wildlife management and refuge, state parks and military use lands. The zone contains 10 KGRAs.

   There has been intensive "Geophysical" and "Shallow Temperature Gradient Hole" interest indicated by numerous filings of "Intent to do Geothermal Resource Exploration" with U.S.G.S. To date we do not know how many of these projects were completed.

This zone does not have extensive environment decisions but some significant sites will be affected by such decisions. (i.e. Tahoe Basin Area and Carson Sink-Alkali Flat East and West)

There has been significant leasing in this zone, both within the KGRA's and its vicinity. The leasing interest is mostly by minor companies and individual and/or investment groups. Some sites showed 100% major company interest, such as Bell Flat, of which very few are still lease applications, the remainder closed cases.

This zone includes 1 of the 2 metropolitan localities in the state: Reno-Sparks - (should include Carson City) with many important communities, good to fair transportation arteries.

Economic Base: Tourism, Agriculture/Livestock, Warehousing. The growth in tourism and warehousing increases population energy needs.

Non-Technical Components For Area 23

Of the eleven (11) sites presently identified for this area, two (2) have federal environmental constraints. The first, Tonopah Mining District is excluded from leasing because of the historic value of the site. The second, Fish Lake Valley has a decision which permits leasing but no surface entry, this decision covers about 1/2 of the described site.

Five (5) sites in the area have shown impressive leasing activity, especially at Fish Lake Valley and Southern Clayton Valley sites which both have 50% of their activity now in geothermal leases. The one (1) KGRA, Silver Peak Hot Springs presently has no active leases, all activity now in closed cases. Looking at the Land Status Map for Nevada (1:500,000) shows that most of the sites are located in, or in the near vicinity of mining districts. About 98% of all leasing activity has been conducted by minor companies. All activity at Valcalda and Mt. Diablo sites are closed cases.

There have been no Notices of Intents filed for this area.

EXPLANATION TO HOT-WATER CONVECTION SYSTEMS SHEETS

Footnotes

(1) Maximum surface temperature reported from a spring or fumarole.

(2) Predicted using chemical geothermometers, assuming last equilibration in the reservoir; assumes saturation of SiO_2 with respect to quartz, and no loss of Ca from calcite deposition.

(3) Assumed average reservoir temperature based on data presently available. Temperatures from Circular 726 and other sources. Temperatures in parentheses are highly subjective.

(4) From surface manifestations, geophysical data, well records, geologic inference and leasing activity. Assumes 1.5 km^2 if no data pertinent to size is available. Top assumed at depth of 1.5 km if no data available. Bottom assumed at 3 km depth for all convection systems. Calculated from assumed area and thickness.

(5) Calculated as product of assumed volume, volumetric specific heat of 0.6 $cal/cm^3°C$, and temperature in degrees C above 15°C.

(6) 0.02 for 150°-200°C
0.025 for 200°-250°C

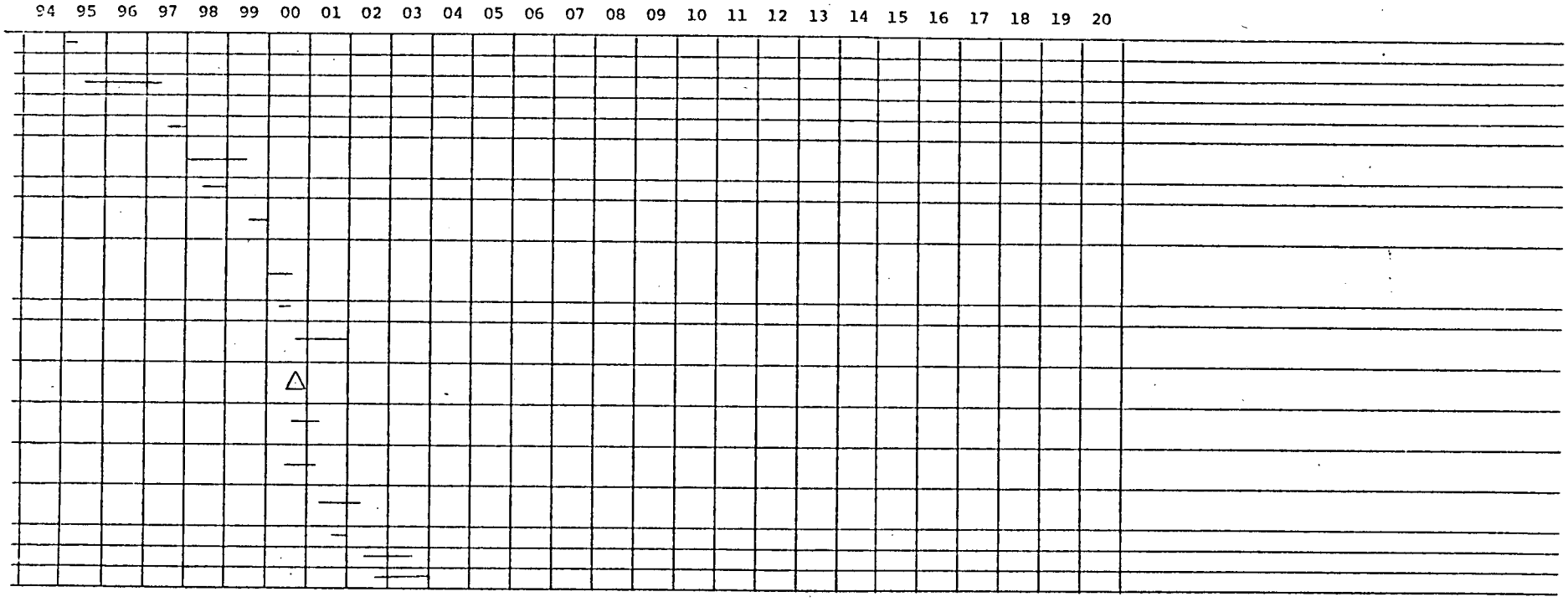
(7) 25% Heat Content Recoverable as thermal energy at the surface; 1 Quad= 0.25×10^{18} cal.

HOT-WATER CONVECTION SYSTEMS IN AREA 23 .

Location	Temperatures °C			Reservoir Assumptions		Energy Potential		
Site	Surface (1)	Geochemical SiO_2 (2)	Geochemical Na-K-Ca (2)	Subsurface (3)	Volume km^3 (4)	Heat content 10^{18} cal (5)	Recovery Factor e_r (6)	Electrical Potential MW_e-30yrs.	Thermal Energy for Direct Use Quads (7)
Fish Lake Valley	ND			253 (260)	20	2.9	0.03	390	
Silver Peak Hot Springs	48			(200)	10	1.1	0.025	125	
Silver Peak Hot Springs				(200)	5	0.6			0.6
Southern Clayton Valley	ND			(170)	10	0.9	0.02	80	
Basalt	45								
Alkali Springs	60								
Pearl Hot Springs	37								
Gap Spring	ND								
Emigrant Peak	27								
Mt. Diablo	Hot								
Valcalda Spring	ND								
Tonopah Mining District	ND								
TOTAL:								595	0.6

Footnotes 1 thru 7-see Explanation Page

NEVADA GEOTHERMAL AREA 23 SCENARIO


94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20

AREA: 22

Possible Subsequent Additions
Quads and On Line Date:

SITE CHARACTERISTICS:

SITE: SODAVILLE SPRINGS (1)

POSTULATED SITE DEVELOPMENT SCHEDULE (FOR FIRST 0.03 QUAD DEVELOPMENT)

OPERATING ENTITIES	ACTIVITY	RECIPIENTS	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
BLM	Approve Notice of Intent-	Developer																								
USGS	Approve NOI & Drill Permit	Developer																								
BLM/Owner	Lease Land	Developer																								
BLM	Process EIA/EIS	CEQ		Completed																						
County	Issue Land Use Permits	Developer																								
Developer	Exploratory Drilling & Reservoir Evaluation																									
Developer	Develop User Interest																									
Developer & User	Feasibility Study																									
Producer (Developer) & User	Financial Negotiations																									
Producer	Site Selection																									
Producer & User	Design																									
Producer & User	Commitment to Development																									
Producer & User	Prepare Master Development Plan	BLM, USGS																								
User	Prepare Environmental Data Statement	BLM, STATE, County																								
BLM, STATE, USGS	Issue Permits on Site	Producer & User																								
USGS	Process EIA/EIS (Drilling)	CEQ																								
Producer	Development Drilling																									
User	Plant Construction																									

(1) Greenhousing-Future-on line by 2005.

AREA 22

95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
										.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03

COMPOSITE POSTULATED SITE DEVELOPMENT SCHEDULE
FOR AREA 22

SITE NAME	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
Sodaville Springs																									
Aldrich Station																									
Whiskey Flat																									
Double Spring																									
Hawthorne																									
Soda Spring Valley																									
Huntoon Valley																									
Rhodes Salt Marsh																									
TOTAL MWe:																									
TOTAL Quads:																									

20,50,100 = MWe (megawatts electric); electrical power generation.
.037,.04,.017 = Quads (0.252×10^{18} cal.); direct thermal utilization. Quads available for commercial utilization. It is unlikely that the energy developed at each site will be wholly utilized, or utilized in the optimum or most efficient manner.

References To Postulated Site Development Schedules And Non-Technical Components Of Areas.

References (indicated by parentheses and corresponding number)

1. Oral Communication:

2. Regional Environmental Analysis Record
   Geothermal oil/gas leasing (BLM) and maps

   a. Carson City District
      Pyramid District, 1975

   b. Winnemucca District
      Sonoma-Gerlach Resource Area
      Buffalo Hills Planning Unit
      1975

   c. Winnemucca District
      Deno, Paradise, Blue Wing and
      Sonoma Planning Units,
      1975

   d. Elko District,
      1975

   e. Battle Mountain District
      1976

   f. Tonopah Resource Area
      1975

   g. Fort Churchill-Clan Alpine Area,
      Carson City District, Nev., 1975

   h. Pine Nut-Walker Area,
      Carson City District, Nev. 1975

   i. Esmeralda Planning Unit,
      Esmeralda and Nye Counties, 1974

3. Lease Books (Nevada Team Data)
   Data obtained from BLM public records and maps.

4. "Intent to Conduct Geothermal Resource Exploration"
   (Filed with U.S.G.S.), (Maps and Folder) and maps.

5. Drilling and Resource Data Sheets.

6. Plan of Operation, Phillips Petroleum Company,
   March 1, 1978 - To drill 6 geothermal wells to 8000'.
   To determine the existence and commercial potential of geothermal resources.
   Estimating starting date - 6-78
   Estimated comp. date - 12-82

EXPLANATION FOR AREA SHEETS

ENVIRONMENT: Federal environmental decisions relating to availability of federal lands for geothermal resource leasing. All data taken from Environmental Assessment Records prepared by BLM.

CRIT. R.: Critical Restrictions. Restrictions to lessee, in addition to those restrictions covered in the Geothermal Resource Lease Application (Sec. 14 and 18).

EXCLUD. PEND.: Excluded from Leasing. Pending additional environmental studies.

EXCLUD.: Excluded from all leasing.

LAND STATUS: Geothermal leasing status on federal lands.

LSE. APLN.: Lease Application

CLOSED: Closed cases. Application never became lease. In theory the land is available for geothermal leasing.

GEO. SIM.: Geothermal Simultaneous Drawing. These applications became leases, then were terminated or relinquished by the lessee. These parcels are held for simultaneous drawing.

OPEN: Open - No leases presently recorded for site.

A.P.P.: Area Potential Prospectively. As outlined by U.S.G.S., possible geothermal resource areas.

OTHER or KGRA: KGRA - Known Geothermal Resource

OWNERSHIP INTEREST:

MAJOR: Major company interest or holdings.

MINOR: Minor company interest or holdings.

IND./INV.: Individual and/or investment group interest or holdings.

INTENTS: "Intent to Conduct Geothermal Resource Exploration" are filed with U.S.G.S.

GEO.: Geophysical work only. No Drilling (i.e.= Gravity, magnetotelluric and other surveys)

DRILL: Drilling of shallow temperature gradient holes.

OTHER: Any exploration work not included in above categories.

(NOTE: The filing of the Intent to conduct geothermal resource exploration Does Not imply the work was completed.)

AREA: 22

SITE	ENVIRONMENT			LAND STATUS							OWNERSHIP INTEREST			INTENTS			NOTES
	CRIT.R.	EXCLUD. PEND.	EXCLUD.	LSE. APLN.	CLOSED	LSE.	GEO SIM	OPEN	A.P.P.	OTHER	MAJOR	MINOR	IND./ INV.	GEO.	DRILL.	OTHER	
Aldrich Station			X					X									
Sodaville Springs								X	X								
Whiskey Flat																	
Double Spring																	
Hawthorne								X									Private & Bur.Re.Wdl
Soda Spring Valley								X									
Huntoon Valley								X									
Rhodes Salt Marsh								X									

General Statement to Non-Technical Components Section,
Area Scenarios

1. All observations for environmental, leasing and "Intents" are based on data gathered in 1977, which has not been corrected, adjusted or up-dated.

2. All environmental decisions are federal (BLM) as there are no localities in Nevada which require an environmental statement. Nevada has only 2 laws requiring such reports:

   a. Nevada Clean Air Act of 1971. Amended in 1973.

   b. Utility Environmental Protection Act, 1971.
   Amended 1973.
   Requires environmental statement for utility plant siting.

   Protection of environmental values is now explicitly and clearly a major criteria for BLM management activities. All BLM activities are governed by the "Federal Land Policy and Management Act".

3. Areas 15, 16, 17, 18, 19 grouped together make up a zone of Intensive and Extensive geothermal resource interests.

   A little over 1/2 of the total land in this zone is available for geothermal leasing, the remainder is covered by private indian reservation, Bureau of Reclamation withdrawals, wildlife management and refuge, state parks and military use lands. The zone contains 10 KGRAs.

   There has been intensive "Geophysical" and "Shallow Temperature Gradient Hole" interest indicated by numerous filings of "Intent to do Geothermal Resource Exploration" with U.S.G.S. To date we do not know how many of these projects were completed.

This zone does not have extensive environment decisions but some significant sites will be affected by such decisions. (i.e. Tahoe Basin Area and Carson Sink-Alkali Flat East and West)

There has been significant leasing in this zone, both within the KGRA's and its vicinity. The leasing interest is mostly by minor companies and individual and/or investment groups. Some sites showed 100% major company interest, such as Bell Flat, of which very few are still lease applications, the remainder closed cases.

This zone includes 1 of the 2 metropolitan localities in the state: Reno-Sparks - (should include Carson City) with many important communities, good to fair transportation arteries.

Economic Base: Tourism, Agriculture/Livestock, Warehousing. The growth in tourism and warehousing increases population energy needs.

Non-Technical Components For Area 22

Almost 50% of the entire area is under the U.S. Naval Ammunition Depot, National Forest and Walker Lake Recreation Area. Only one (1) site, Aldrich Station has been affected by federal environmental constraints, which is an exclusion from leasing for recreational uses.

Although there are eight (8) sites identified for this area, there presently are no KGRAs nor is there any leasing activity at any of the sites. The sites appear to be on federal land with no apparent access problems.

No Notices of Intents have been filed, and, only one (1) site: Sodaville Springs is within the U.S.G.S. Area Potential Prospectively designation. This area has three (3) important communities: Babbit, Hawthorne and Mina.

EXPLANATION TO HOT-WATER CONVECTION SYSTEMS SHEETS

Footnotes

(1) Maximum surface temperature reported from a spring or fumarole.

(2) Predicted using chemical geothermometers, assuming last equilibration in the reservoir; assumes saturation of SiO_2 with respect to quartz, and no loss of Ca from calcite deposition.

(3) Assumed average reservoir temperature based on data presently available. Temperatures from Circular 726 and other sources. Temperatures in parentheses are highly subjective.

(4) From surface manifestations, geophysical data, well records, geologic inference and leasing activity. Assumes 1.5 km^2 if no data pertinent to size is available. Top assumed at depth of 1.5 km if no data available. Bottom assumed at 3 km depth for all convection systems. Calculated from assumed area and thickness.

(5) Calculated as product of assumed volume, volumetric specific heat of 0.6 $cal/cm^3°C$, and temperature in degrees C above 15°C.

(6) 0.02 for 150°-200°C
0.025 for 200°-250°C

(7) 25% Heat Content Recoverable as thermal energy at the surface; 1 Quad= 0.25×10^{18} cal.

HOT-WATER CONVECTION SYSTEMS IN AREA 22 .

Location	Temperatures °C			Reservoir Assumptions		Energy Potential		
Site	Surface (1)	Geochemical SiO_2 (2)	Geochemical Na-K-Ca (2)	Subsurface (3)	Volume km^3 (4)	Heat content 10^{18} cal (5)	Recovery Factor e_r (6)	Electrical Potential MW_e-30yrs.	Thermal Energy for Direct Use Quads (7)
Sodaville Springs	38			(140)	10	0.8			0.8
Aldrich Station	43								
Whiskey Flat	43								
Double Spring	21								
Hawthorne	26								
Soda Spring Valley	ND								
Huntoon Valley	ND								
Rhodes Salt Marsh	ND								
TOTAL:									0.8

Footnotes 1 thru 7-see Explanation Page

NEVADA GEOTHERMAL AREA 22 SCENARIO

AREA: 21

SITE CHARACTERISTICS:

SITE: DEAD HORSE WELLS-WEDELL SPRINGS

Possible Subsequent Additions (MWe) and On Line Date:

50 MWe 1992
50 MWe 1994
50 MWe 1996

POSTULATED SITE DEVELOPMENT SCHEDULE (FOR FIRST 15 MWe PLANT)

OPERATING ENTITIES	ACTIVITY	RECIPIENTS	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
BLM	Approve Notice of Intent-	Developer																								
USGS	Approve NOI & Drill Permit	Developer	(1)																							
BLM/Owner	Lease Land	Developer																								
BLM	Process EIA/EIS	CEQ																								
County	Issue Land Use Permits	Developer																								
Developer	Exploratory Drilling & Reservoir Evaluation																									
Developer	Develop Utility Interest																									
Developer & Utility	Feasibility Study																									
Producer (Developer) & Utility	Financial Negotiations																									
Producer	Site Selection																									
Producer & Utility	Design																									
Producer & Utility	Commitment to Development																△									
Producer & Utility	Prepare Master Development Plan	BLM, USGS																								
Utility	Prepare Environmental Data Statement	BLM, FPC STATE, County																								
BLM, FPC STATE, USGS	Certify Plant & Site Issue Permits	Producer & Utility																								
USGS	Process EIA/EIS (Drilling)	CEQ																								
FPC	Process EIA/EIS (Plant)	CEQ																								
FPC	Process EIA/EIS (Transmission Line)	CEQ																								
Producer	Development Drilling																									
Utility	Plant Construction																									
Utility	Install Transmission Line (40 km)																									

(1) No Intents filed-Project such work-start in 1979.

AREA 21

95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
115	165	165	165	165	165	165	165	165	165	165	165	165	165	165	165	165	165	165	165	165	165	165	165	165	150
										15	15	65	65	115	115	165	165	165	165	165	165	165	165	165	165

COMPOSITE POSTULATED SITE DEVELOPMENT SCHEDULE
FOR AREA 21

SITE NAME	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
Dead Horse Wells-Wedell Springs																					15	15	65	65	115
West Gabbs Valley																									
Downeyville																									
Kelly's Wells																									
South Clan Alpine Mountains																									
Bell Flat																									
Eagleville																									
TOTAL MWe:																									
TOTAL Quads:																									

20,50,100 = MWe (megawatts electric); electrical power generation.
.037,.04,.017 = Quads (0.252×10^{18} cal.); direct thermal utilization. Quads available for commercial utilization. It is unlikely that the energy developed at each site will be wholly utilized, or utilized in the optimum or most efficient manner.

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      Sonoma-Gerlach Resource Area
      Buffalo Hills Planning Unit
      1975

   c. Winnemucca District
      Deno, Paradise, Blue Wing and
      Sonoma Planning Units,
      1975

   d. Elko District,
      1975

   e. Battle Mountain District
      1976

   f. Tonopah Resource Area
      1975

   g. Fort Churchill-Clan Alpine Area,
      Carson City District, Nev., 1975

   h. Pine Nut-Walker Area,
      Carson City District, Nev. 1975

   i. Esmeralda Planning Unit,
      Esmeralda and Nye Counties, 1974

3. Lease Books (Nevada Team Data)
   Data obtained from BLM public records and maps.

4. "Intent to Conduct Geothermal Resource Exploration"
   (Filed with U.S.G.S.), (Maps and Folder) and maps.

5. Drilling and Resource Data Sheets.

6. Plan of Operation, Phillips Petroleum Company,
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   To determine the existence and commercial potential of geothermal resources.
   Estimating starting date - 6-78
   Estimated comp. date - 12-82

EXPLANATION FOR AREA SHEETS

ENVIRONMENT: Federal environmental decisions relating to availability of federal lands for geothermal resource leasing. All data taken from Environmental Assessment Records prepared by BLM.

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EXCLUD.: Excluded from all leasing.

LAND STATUS: Geothermal leasing status on federal lands.

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CLOSED: Closed cases. Application never became lease. In theory the land is available for geothermal leasing.

GEO. SIM.: Geothermal Simultaneous Drawing. These applications became leases, then were terminated or relinquished by the lessee. These parcels are held for simultaneous drawing.

OPEN: Open - No leases presently recorded for site.

A.P.P.: Area Potential Prospectively. As outlined by U.S.G.S., possible geothermal resource areas.

OTHER or KGRA: KGRA - Known Geothermal Resource

OWNERSHIP INTEREST:

MAJOR: Major company interest or holdings.

MINOR: Minor company interest or holdings.

IND./INV.: Individual and/or investment group interest or holdings.

INTENTS: "Intent to Conduct Geothermal Resource Exploration" are filed with U.S.G.S.

GEO.: Geophysical work only. No Drilling (i.e.= Gravity, magnetotelluric and other surveys)

DRILL: Drilling of shallow temperature gradient holes.

OTHER: Any exploration work not included in above categories.

(NOTE: The filing of the Intent to conduct geothermal resource exploration Does Not imply the work was completed.)

AREA: 21

SITE	ENVIRONMENT			LAND STATUS							OWNERSHIP INTEREST			INTENTS			NOTES
	CRIT.R.	EXCLUD. PEND.	EXCLUD.	LSE. APLN.	CLOSED	LSE.	GEO SIM	OPEN	A.P.P.	OTHER	MAJOR	MINOR	IND./ INV.	GEO.	DRILL.	OTHER	
Dead Horse Wells-Wedell Springs				X	X	X	X		X			X					
West Gabbs Valley				X	X	X			X			X					
Downeyville									X								
Kelly Wells									X								
Bell Flat					X				X		X			X			
Eagleville					X				X		X						
S. Clan Alpine Mtns.						X					X						

General Statement to Non-Technical Components Section,
Area Scenarios

1. All observations for environmental, leasing and "Intents" are based on data gathered in 1977, which has not been corrected, adjusted or up-dated.

2. All environmental decisions are federal (BLM) as there are no localities in Nevada which require an environmental statement. Nevada has only 2 laws requiring such reports:

   a. Nevada Clean Air Act of 1971. Amended in 1973.

   b. Utility Environmental Protection Act, 1971.
   Amended 1973.
   Requires environmental statement for utility plant siting.

   Protection of environmental values is now explicitly and clearly a major criteria for BLM management activities. All BLM activities are governed by the "Federal Land Policy and Management Act".

3. Areas 15, 16, 17, 18, 19 grouped together make up a zone of Intensive and Extensive geothermal resource interests.

   A little over 1/2 of the total land in this zone is available for geothermal leasing, the remainder is covered by private indian reservation, Bureau of Reclamation withdrawals, wildlife management and refuge, state parks and military use lands. The zone contains 10 KGRAs.

   There has been intensive "Geophysical" and "Shallow Temperature Gradient Hole" interest indicated by numerous filings of "Intent to do Geothermal Resource Exploration" with U.S.G.S. To date we do not know how many of these projects were completed.

This zone does not have extensive environment decisions but some significant sites will be affected by such decisions. (i.e. Tahoe Basin Area and Carson Sink-Alkali Flat East and West)

There has been significant leasing in this zone, both within the KGRA's and its vicinity. The leasing interest is mostly by minor companies and individual and/or investment groups. Some sites showed 100% major company interest, such as Bell Flat, of which very few are still lease applications, the remainder closed cases.

This zone includes 1 of the 2 metropolitan localities in the state: Reno-Sparks - (should include Carson City) with many important communities, good to fair transportation arteries.

Economic Base: Tourism, Agriculture/Livestock, Warehousing. The growth in tourism and warehousing increases population energy needs.

Non-Technical Components For Area 21

There are no federal environmental constraints for any of the sites within this area.

Presently seven (7) sites have been identified for this area with leasing activity at five (5) of the sites. None of the sites have been designated as KGRAs. West Gabbs Valley and Dead Horse Wells-Wedell Springs have about 25% of their activity in geothermal leases and another 25% in lease applications, the remainder closed cases. At Kelly Wells and Downeyville sites, 80% of their activity is now in geothermal lease. All activity at these four (4) sites has been conducted by minor companies. At the site of Bell Falt, 100% of the leasing activity never went to lease.

Although there seems to be intensive leasing activity in the area, and most of the sites are within the U.S.G.S. designation of Area Potential Prospectively, the number of Notices of Intents filed have been very insignificant. Some shallow temperature gradient holes were scheduled for a location just south of West Gabbs Valley.

EXPLANATION TO HOT-WATER CONVECTION SYSTEMS SHEETS

Footnotes

(1) Maximum surface temperature reported from a spring or fumarole.

(2) Predicted using chemical geothermometers, assuming last equilibration in the reservoir; assumes saturation of SiO_2 with respect to quartz, and no loss of Ca from calcite deposition.

(3) Assumed average reservoir temperature based on data presently available. Temperatures from Circular 726 and other sources. Temperatures in parentheses are highly subjective.

(4) From surface manifestations, geophysical data, well records, geologic inference and leasing activity. Assumes 1.5 km^2 if no data pertinent to size is available. Top assumed at depth of 1.5 km if no data available. Bottom assumed at 3 km depth for all convection systems. Calculated from assumed area and thickness.

(5) Calculated as product of assumed volume, volumetric specific heat of 0.6 $cal/cm^3°C$, and temperature in degrees C above 15°C.

(6) 0.02 for 150°-200°C
0.025 for 200°-250°C

(7) 25% Heat Content Recoverable as thermal energy at the surface; 1 Quad= 0.25×10^{18} cal.

HOT-WATER CONVECTION SYSTEMS IN AREA 21 .

Location	Temperatures °C			Reservoir Assumptions		Energy Potential		
Site	Surface (1)	Geochemical SiO_2 (2)	Geochemical Na-K-Ca (2)	Subsurface (3)	Volume km^3 (4)	Heat content 10^{18} cal (5)	Recovery Factor e_r (6)	Electrical Potential MW_e-30yrs.	Thermal Energy for Direct Use Quads (7)
Dead Horse Wells-Wedell Springs	67			(170)	20	1.9	0.02	165	
West Gabbs Valley	68-			(170)	20	1.9	0.02	165	
Downeyville	68								
Kelly's Wells	ND								
South Clan Alpine Mountains	ND								
Bell Flat	ND								
Eagleville	ND								
TOTAL:								330	

Footnotes 1 thru 7-see Explanation Page

NEVADA GEOTHERMAL AREA 21 SCENARIO

AMS SHEET: LOVELOCK-Sheet #2

NEVADA

SITE ID	SITE NAME	COUNTY	LATITUDE	LONGITUDE	TOWN-SHIP	RANGE	SEC-TION	RSVR** VOLUME (1)	SUB SURFACE	--- TEMPERATURES IN DEGREES C --- SURFACE	CS EST*	CS MEAS*
6004	SAN EMIDIO DESERT	616	40°24'15"N -	119°27'10"W	29N	23E	6	20		53°-		
	GOLD MOUNTAIN	614	40°20'25"N -	118° 8'15"W	29N	34E	34			24°-		
	NORTH WINNEMUCCA LAKE	616	40°15'25"N -	119°22'35"W	28N	23E	34			86°		
	COLADO	614	40°15'00"N -	118°22' 5"W	28N	32E	34			68°-		
	FISH SPRINGS	616	40° 6'50"N -	119°53'50"W	26N	19E	29			23°		
6021	THE NEEDLES ROCKS	616	40° 8'50"N -	119°40'45"W	26N	20E	1	20	145°	98°		
	NUGENT SPRINGS	616	40° 8' 5"N -	119°23'15"W	26N	23E	10			ND		

AMS SHEET: WINNEMUCCA

NEVADA

SITE ID	SITE NAME	COUNTY	LATITUDE	LONGITUDE	TOWN-SHIP	RANGE	SEC-TION	RSVR** VOLUME (1)	SUB SURFACE	--- TEMPERATURES IN DEGREES C --- SURFACE	CS EST*	CS MEAS*
	HUMBOLDT RIVER	608	40°53'00"N - 117°56'10"W	35N	36E	28			29°		
	WINNEMUCCA	608	40°57' 5"N - 117°42'30"W	36N	38E	33			29°		
6039	GOLCONDA	608	40°57'25"N - 117°29'30"W	36N	40E	32	20	125°	74°		
	BROOKS HOT SPRING	608	40°49'45"N - 117°18'20"W	34N	41E	12			37°		
6032	HOT POT	608	40°55'10"N - 117° 6'20"W	35N	43E	11	10	125°	58°		
	RANCH SPRING	609	40°55'35"N - 116°53'45"W	35N	45E	10			28°		
6010	HOT SPRINGS (TIPTON) RANCH	608	40°45'00"N - 117°28'40"W	33N	40E	5	20	180°	85°		
6014	LEACH HOT SPRINGS	614	40° 6'20"N - 117°38'45"W	32N	38E	36	60	170°	96°		
	KENT SPRING	614	40°38'50"N - 117°13'45"W	32N	40E	16			ND		
	TIMBER CANYON	609	40°34'35"N - 117°13'30"W	31N	42E	11			24°		
	BATTLE MOUNTAIN	609	40°39'40"N - 116°52'15"W	32N	45E	11	5		Hot		
	SHEEP CREEK RANGE	609	40°44'50"N - 116°41'45"W	33N	47E	8			Warm		
6001	BEOWAWE GEYSERS	609/607	40°33'50"N - 116°35'20"W	31N	48E	17	80	240°	98°		
	VIVIAN SIDING	605	40°45'00"N - 116° 2'10"W	33N	53E	8			37°		
6051	CARLIN	605	40°41'40"N - 116° 8'10"W	33N	52E	33	10	120°	Boiling?		
	HORSESHOE RANCH SPS.	607	40°36'50"N - 116°28'10"W	32N	49E	32	10		58°		
	PINE CREEK	607	40°35'25"N - 116° 9'10"W	31N	52E	7			ND		
6006	KYLE HOT SPRINGS	614	40°24'20"N - 117°53'00"W	29N	36E	12	20	180°	96°		
	DRY LAKE	614	40°24'00"N - 117°24'50"W	29N	41E	7			Warm		
	NEEDLE PEAK	614	40°20'25"N - 117°27'10"W	28N	40E	2			ND		

AMS SHEET: WINNEMUCCA-Sheet #2

NEVADA

SITE ID	SITE NAME	COUNTY	LATITUDE	LONGITUDE	TOWN-SHIP	RANGE	SEC-TION	RSVR** VOLUME(1)	--- TEMPERATURES IN DEGREES C --- SUB SURFACE	SURFACE	CS EST*	CS MEAS*
6031	BUFFALO VALLEY H. SPS.	609	40°22'15"N -	117°19'20"W	29N	41E	23	15	130°	79°		
	MOUNTAIN SPRINGS MINE	609	40°18'35"N -	117° 4'00"W	28N	44E	7			43°		
6038	HOT SPRINGS POINT	607	40°24'25"N -	116°31'50"W	29N	48E	11	20	125°	59°		
	DUFF CREEK	607	40°19'00"N -	116°25'55"W	28N	49E	10	10		86°		
	CARLOTTI RANCH SPS.	605/607	40°19' 5"N -	116° 3'10"W	28N	52E	13			39°		
	BRUFFEY'S HOT SPS.	607	40°13' 5"N -	116° 4'40"W	27N	52E	14	10		66°		
	N.Y. CANYON KAOLIN DEPOSIT	614	40° 3' 5"N -	117°59'55"W	25N	35E	12			Hot		
6043	SCU HOT SPRINGS	614	40° 5'15"N -	117°44' 5"W	26N	38E	29	15	115°	93°		
6007	JERSEY VALLEY	614	40°1o'45"N -	117°29'45"W	27N	40E	33	15	185°	57°		
	MC COY SPRINGS	614	40° 4'55"N -	117°36'20"W	26N	39E	33	15		49°		
6042	HYDER HOT SPRING	614	40° 1'15"N -	117°42'40"W	25N	38E	28	15		79°		
6047	HOT SPRINGS RANCH	609	40°11'50"N -	117° 6'00"W	27N	43E	23	2.25		53°		
	[illegible]IS	609	40°11'20"N -	116°47'30"W	27N	46E	27			39°		
	CARICO LAKE	609	40° 7'45"N -	116°53'00"W	26N	45E	15			22°		
	DIAMOND VALLEY	607	40° 4'50"N -	116° 1'35"W	25N	53E	5			30°		
	WINNEMUCCA MOUNTAIN	608	41°00'00"N -	117° 1'15"W	36N	37E	13			34°		

AMS SHEET: ELKO

NEVADA

SITE ID	SITE NAME	COUNTY	LATITUDE	LONGITUDE	TOWN-SHIP	RANGE	SEC-TION	RSVR** VOLUME (1)	SUB SURFACE	--- TEMPERATURES IN DEGREES C --- SURFACE	CS EST*	CS MEAS*
6044	ELKO HOT SPRINGS	605	40°49'10"N -	115°46'50"W	34N	55E	21	10	115°	89°		
	COLD CREEK	605	40°47'15"N -	115°21'35"W	34N	59E	31			Warm		
	WINCHETT LAKE	605	40°58'10"N -	115° 1'15"W	36N	62E	30			Warm		
	WOOD HILLS	605	40°57' 5"N -	114°45'00"W	36N	64E	33			30°		
	HARDY CREEK	605	40°58'40"N -	114°30'00"W	36N	66E	28			23°		
6005	SULPHUR HOT SPRINGS	605	40°35'10"N -	115°17' 5"W	31N	59E	11	40		93°		
	DOLLY VARDEN	605	40°37'45"N -	114°26'40"W	32N	67E	30			ND		
6053	RUBY LAKE	605	40°15'00"N -	115°24'10"W	27N	58E	2	20		65°		
	COLLAR & ELBOW SPRING	617	40° 5'00"N -	114°39'00"W	26N	65E	33			33°		

AMS SHEET: RENO

NEVADA

SITE ID	SITE NAME	COUNTY	LATITUDE	LONGITUDE	TOWN-SHIP	RANGE	SEC-TION	RSVR** VOLUME (1)	SUB SURFACE	SURFACE	CS EST*	CS MEAS*
									--- TEMPERATURES IN DEGREES C ---			
	ANAHO ISLAND	616	39°56' 4"N - 119°30'20"W		24N	22E	53	10		49°		
	DOGSKIN MOUNTAIN	616	39°50'25"N - 119°43'40"W		23N	20E	22			Hot		
	WARM SPRINGS VALLEY	616	39°48'15"N - 119°38'45"W		22N	21E	5			43°		
	NORTH VALLEY	602	39°53'20"N - 119° 9'25"W		23N	25E	3			ND		
	HUXLEY	602	39°51'10"N - 118°47'20"W		23N	28E	24	10		ND		
	CARSON SINK-ALKALI FLAT, (WEST SIDE)	602	39°48'10"N - 118°31'30"W		22N	31E	5	10	Hot	ND		
	LONE ROCK	602	39°55'20"N - 118°18'00"W		24N	33E	29	10		ND		
	DIXIE COMSTOCK MINE-HUMBOLDT MARSH	602	39°51'45"N - 118°00'50"W		23N	35E	14	15		Hot		
6023	DIXIE HOT SPRINGS	602	39°48'00"N - 118° 3'40"W		22N	35E	5	20	150°	72°		
6002	BRADY'S HOT SPRINGS	602	39°47'00"N - 119°00'55"W		22N	26E	12	30	214°	98°		
	DESERT PEAK	602	39°00'20"N - 118°57'35"W		22N	27E	21	50	212°	ND		
	EAGLE SALT WORKS	602	39°44'00"N - 119° 1'30"W		22N	26E	35	10		Hot		
	HOT SPRINGS MOUNTAINS	602	39°41'10"N - 118°56'20"W		21N	27E	15	20		ND		
	CARSON SINK-ALKALI FLAT, (EAST SIDE)	602	39°47'00"N - 118°19'30"W		22N	32E	12	10		ND		
	SPANISH SPRINGS	616	39°34'15"N - 119°42'20"W		20N	20E	26			ND		
	LOCKWOOD	616	39°41'15"N - 119°41'20"W		19N	20E	12			ND		
6015	HAZEN	611	39°36'10"N - 119° 6'30"W		20N	26E	18	10		ND		
6017	SODA LAKE-UPSAL HOGBACK	602	39°32'50"N - 118°51' 5"W		19N	28E	5	35	165°	90°		
6018	STILLWATER	602	39° 1'00"N - 118°33'50"W		19N	30E	13	50	160°	96°		
	IXL	602	39°41'00"N - 118° 6'55"W		21N	34E	23	15		24°?		

AMS SHEET: RENO-Sheet #2

NEVADA

SITE ID	SITE NAME	COUNTY	LATITUDE	LONGITUDE	TOWN-SHIP	RANGE	SEC-TION	RSVR** VOLUME (1)	SUB SURFACE	--- TEMPERATURES IN DEGREES C --- SURFACE	CS EST*	CS MEAS*
	DEEP CANYON	616	39°26'10"N - 120°00'00"W		18N	18E	7			Hot		
	MOANA SPRING-LAWTON	616	39°29'50"N - 119°48'35"W		19N	19E	25	40		48°		
6003	STEAMBOAT SPRING-HUFFAKER	616	39°23'10"N - 119°44'30"W		18N	20E	23	70	210°	96°		
	BIDDLEMAN SPRING	615	39°29'35"N - 119°25'00"W		19N	23E	20			24°		
	TABLE MOUNTAIN	602	39°28'50"N - 118°16'45"W		19N	33E	29			ND		
	PIROUETTE MOUNTAIN	602	39°30'20"N - 118° 8'50"W		19N	34E	22			ND		
	RAINBOW MOUNTAIN	602	39°25'50"N - 118°31'25"W		18N	31E	17			ND		
	SO. STILLWATER RANGE	602	39°23'20"N - 118°23'00"W		18N	32E	34			ND		
	FAIRVIEW VALLEY	602	39°23'15"N - 118°16'20"W		18N	33E	27			ND		
	CRYSTAL BAY	616	39°15'10"N - 120°00'00"W		16N	18E	18			60°		
6059	WASHOE VALLEY	616	39°17' 5"N - 119°50'25"W		16N	19E	3	20		53°		
	COMSTOCK MINING DISTRICT	611	39°17'50"N - 119°38'20"W		17N	21E	29	10		ND		
	DAYTON	611	39°16'10"N - 119°34'10"W		16N	21E	12			35°-		
	CHURCHILL VALLEY	611	39°15'55"N - 119° 3'20"W		16N	26E	10			ND		
	CARSON LAKE	602	39°21'20"N - 118°39'10"W		17N	30E	7	10	70°			
	CARSON HOT SPRINGS-PINYON HILLS	601	39°10'45"N - 119°44' 5"W		15N	20E	9			49°		
	HOBO-SARATOGA SPS.	604	39° 4'25"N - 119°45'35"W		14N	20E	17			50°		
6020	WABUSKA HOT SPRINGS	611	39° 9'40"N - 119°11'15"W		15N	25E	16	20	155°	97°		
	CARSON HILL	611	39° 4'50"N - 119°16'20"W		14N	24E	14			ND		
6011	LEE HOT SPRINGS	602	39°12'40"N - 118°43'25"W		16N	29E	34	10	175°	91°		

2

AMS SHEET: RENO-Sheet #3

NEVADA

SITE ID	SITE NAME	COUNTY	LATITUDE	LONGITUDE	TOWN-SHIP	RANGE	SEC-TION	RSVR** VOLUME (1)	SUB SURFACE	--- TEMPERATURES IN DEGREES C --- SURFACE	CS EST*	CS MEAS*
	EIGHT MILE FLAT	602	39°19'35"N -	118°32'20"W	17N	30E	19	10		81°		
	FOUR MILE FLAT	602	39°16'15"N -	118°27'40"W	16N	32E	1			Hot		
	NORTH SAND SPS.RANGE	602	39°17'10"N -	118°22'25"W	16N	32E	3			ND		
	BELL FLAT	602	39° 6'40"N -	118° 5'25"W	14N	34E	1			ND		
	EAGLEVILLE	612	39°00'20"N -	118°12'10"W	13N	33E	12			ND		

AMS SHEET: MILLETT

NEVADA

SITE ID	SITE NAME	COUNTY	LATITUDE	LONGITUDE	TOWN-SHIP	RANGE	SEC-TION	RSVR** VOLUME(1)	SUB SURFACE	--- TEMPERATURES IN DEGREES C --- SURFACE	CS EST*	CS MEAS*
	IRON TANK SPRING	602	39°33'20"N -	117°25'45"W	20N	40E	36			29°		
	WILD HORSE	602	39°50'55"N -	117°30'00"W	23N	40E	20			ND		
	SENATOR	602	39°57'10"N -	117°52'55"W	24N	36E	1	15		Boiling		
	MT. GRANT	602	39°40'50"N -	117°53'30"W	21N	36E	23			ND		
	EDWARDS CREEK VALLEY	602	39°37'25"N -	117°44'50"W	20N	38E	6			24°-		
	IOWA CANYON RANCHES	609	39°55'10"N -	117° 7'40"W	24N	43E	27			39°		
	SANTA FE CREEK	609	39°14'15"N -	116°13'55"W	16N	44E	24			23°-		
6052	WALTI HOT SPRINGS	609/607	39°55'00"N -	116°37'20"W	24N	48E	30	10	120°	73°		
	SHIPLEY HOT SPRINGS	607	39°58'25"N -	116° 3'30"W	24N	52E	23			41°		
	NORTHERN CLAN ALPINE MOUNTAINS	602	39°49'00"N -	117°50'35"W	23N	37E	32			ND		
	TULE DAM SPRING	607	39°50'10"N -	116° 3'55"W	23N	52E	36			23°-		
	BARTINE HOT SPRINGS	607	39°34'00"N -	116°22'10"W	19N	50E	5			41°		
6040	KLOBE HOT SPRINGS	607	39°24'45"N -	116°20'45"W	18N	50E	28	10	130°	70°		
	SOUTH CLAN ALPINE MOUNTAINS	602	39°25'30"N -	117°59'30"W	18N	35E	13			ND		
6019	SMITH CREEK VALLEY	609	39°18'40"N -	117°32'20"W	17N	39E	25	20	160°	86°		
	BIRCHIM CREEK	609	39°18'25"N -	117°25'40"W	17N	40E	35			ND		
6037	SPENSER HOT SPRING	609	39°19'45"N -	116°51'40"W	17N	45E	13	10	125°	96°		
	CLIPPER GAP CANYON	609	39°14'40"N -	116°52'55"W	16N	45E	14			Hot		
	KINGSTON	613	39° 9'20"N -	116°59'10"W	15N	44E	14			ND		
	WILDCAT CANYON	613	39° 5'45"N -	117° 2'55"W	14N	44E	5			ND		

AMS SHEET: MILLETT-Sheet #2

NEVADA

--- TEMPERATURES IN DEGREES C ---

SITE ID	SITE NAME	COUNTY	LATITUDE	LONGITUDE	TOWN-SHIP	RANGE	SEC-TION	RSVR** VOLUME (1)	SUB SURFACE	SURFACE	CS EST*	CS MEAS*
	MC LEOD'S RANCH SP.	613	39° 1'30"N -	117° 8'10"W	14N	43E	34			Hot		
6056 6060	DIANA'S PUNCH BOWL-POTTS RANCH	613	39° 3'40"N -	116°39' 5'W	14N	47E	11	2.25		59°		

AMS SHEET: ELY

NEVADA

SITE ID	SITE NAME	COUNTY	LATITUDE	LONGITUDE	TOWN-SHIP	RANGE	SEC-TION	RSVR** VOLUME (1)	SUB SURFACE	--- TEMPERATURES IN DEGREES C --- SURFACE	CS EST*	CS MEAS*
	DIAMOND MOUNTAINS	607	39°54' 5"N -	115°52' 5"W	23N	54E	3			24°-		
	BUCK PASS	617	39°48'40"N -	115°36'35"W	22N	56E	1			24°-		
	DUCK CREEK	617	39°57'00"N -	114°45'30"W	24N	64E	17			ND		
6030	CHERRY CRK. HOT SPS.	617	39°53'10"N -	114°53'40"W	23N	63E	7	10		65°		
	BECKY PEAK	617	39°55' 5"N -	114°39'40"W	24N	65E	31			28°		
	SHELLBORNE PASS	617	39°47'30"N -	114°40'20"W	22N	65E	7			25°		
	NORTH SPRING VALLEY	617	39°49'45"N -	114°32'55"W	23N	66E	31			32°		
6050	MONTE NEVA HOT SPS.	617	39°40'00"N -	114°48'25"W	21N	63E	24	20		89°		
	PLEASANT VALLEY	617	39°40'55"N -	114° 4'30"W	21N	70E	21?			Warm		
	PANCAKE SUMMIT	617	39°25'55"N -	115°40'10"W	18N	56E	16			Hot		
	STEPTOE	617	39°32'20"N -	114°54'35"W	19N	63E	8			24°		
	MC GILL	617	39°26'00"N -	114°46'00"W	18N	64E	16			29°		
	ELY-LACKAWANNA HOT SPRINGS	617	39°16'50"N -	114°52'20"W	16N	63E	3			35°		
	SNAKE RANGE	617	39°20'20"N -	114°20'00"W	17N	68E	16			ND		
	BULL CREEK	617	39° 3'55"N -	115°38'30"W	14N	56E	23			Warm		

AMS SHEET: WALKER LAKE

NEVADA

SITE ID	SITE NAME	COUNTY	LATITUDE	LONGITUDE	TOWN-SHIP	RANGE	SEC-TION	RSVR** VOLUME (1)	SUB SURFACE	--- TEMPERATURES IN DEGREES C --- SURFACE	CS EST*	CS MEAS*
6054	WALLEY'S HOT SPRING	604	38°58'45"N - 119°50'00"W	13N	19E	22	2.25	110°	71°		
	BUCKSKIN RANGE	611	38°57'45"N - 119°22'20"W	13N	23E	26			28°		
6055	HIND'S HOT SPRINGS	611	38°54'00"N - 119°24'50"W	12N	23E	16	10	105°	67°		
	MOUNT WILSON	611	38°51'45"N - 119°10'35"W	12N	25E	34			Hot		
	DOUBLE SPRING	612	38°58'00"N - 118°41'25"W	13N	29E	25			21°		
	WEST GABBS VALLEY	613	38°54'40"N - 118° 5'25"W	12N	34E	12	20		68°-		
	DOUBLE SPRING FLAT	604	38°47'50"N - 119°38'25"W	11N	21E	20			21°		
	WELLINGTON	611/604	38°45'00"N - 119°22'10"W	10N	23E	2			67°		
	WILSON HOT SPRINGS	611	38°46'45"N - 119° 9'45"W	11N	25E	34	10		Hot		
	DEAD HORSE WELLS-WEDELL SPRINGS	612	38°54'45"N - 118°18'15"W	12N	33E	17	20		67°		
	ALDRICH STATION	611	38°29'25"N - 118°58'00"W	7N	27E	4			43°		
	HAWTHORNE	612	38°31'10"N - 118°38'10"W	8N	30E	27			26°		
	SODA SPRING VALLEY	612	38°32'50"N - 118°23'40"W	8N	32E	14			ND		
	WHISKEY FLAT	612	38°17'00"N - 118°34'20"W	5N	31E	19			43°		
6046	SODAVILLE SPRINGS	612	38°20'35"N - 118° 6'20"W	6N	35E	29	10		38		
	RHODES SALT MARSH	612	38°16'45"N - 118° 4'35"W	5N	35E	22			ND		
	HUNTOON VALLEY	612	38° 7'45"N - 118°34'00"W	3N	31E	7			ND		

AMS SHEET: TONOPAH

NEVADA

SITE ID	SITE NAME	COUNTY	LATITUDE	LONGITUDE	TOWN-SHIP	RANGE	SEC-TION	RSVR** VOLUME(1)	SUB SURFACE	--- TEMPERATURES IN DEGREES C --- SURFACE	CS EST*	CS MEAS*
	DOWNEYVILLE	613	38°55'10"N - 117°51'15"W	12N	36E	21			68°		
	KELLY'S WELLS	613	38°48'10"N - 117°57'10"W	11N	36E	18			ND		
	ALKALI FLAT	613	38°58'30"N - 117° 2'40"W	13N	44E	21			27°		
6025	DARROUGH'S HOT SPS.	613	38°49'25"N - 117°11' 5"W	11N	43E	7	10	140°	97°		
	MOSQUITO CRK. RANCH	613	38°49'30"N - 116°43'35"W	11N	47E	6			35°		
	LITTLE FISH LAKE V.	613	38°41'50"N - 116°26' 5"W	10N	49E	14			48°		
	HOT CREEK CANYON	613	38°31'50"N - 116°24'15"W	8N	49E	25	10		82°		
	HOT CREEK VALLEY	613	38°26'10"N - 116°16'40"W	7N	51E	30	10		61°		
	RAYSON HILLS	613	38°26' 5"N - 117°29'30"W	7N	40E	28			Warm		
	WILSON SPRING	613	38°25'25"N - 117°15'00"W	7N	42E	34?			Warm		
	PINON PEAK	613	38°20'20"N - 116°39'25"W	6N	47E	36			26°		
	LUNAR CRATER	613	38°23'20"N - 116° 4'20"W	6N	52E	13	20		ND		
	TONOPAH MINING DISTR.	613	38° 4'10"N - 117°13'10"W	3N	42E	35			ND		
	SAULSBURY WASH	613	38°15'15"N - 116°49'30"W	5N	46E	28			30°		
6041	WARM SPRINGS	613	38°11'30"N - 116°22'25"W	4N	50E	20	10	125°	63°		
	WILLOW CREEK	613	38° 1'35"N - 116°41'00"W	2N	47E	14			29°		

AMS SHEET: LUND

NEVADA

SITE ID	SITE NAME	COUNTY	LATITUDE	LONGITUDE	TOWN-SHIP	RANGE	SEC-TION	RSVR** VOLUME (1)	SUB SURFACE	--- TEMPERATURES IN DEGREES C --- SURFACE	CS EST*	CS MEAS*
	DUCKWATER	613	38°56'10"N -	115°41'45"W	12N	56E	5			34°		
	WILLIAMS HOT SPRINGS	617	38°57'15"N -	115°13'55"W	13N	60E	33			53°		
	PRESTON	617	38°55'35"N -	115° 5'00"W	12N	61E	12			22°-		
	DOYLES WELL	617	38°56'25"N -	114°25' 5"W	12N	67E	2			24°-		
	SCHELL CREEK RANGE	617	38°48'15"N -	114°40'10"W	11N	65E	22?			Warm		
	GRANITE PEAK	617	38°49'10"N -	114°13'35"W	11N	69E	16			ND		
	BIG SPRING	613	38°33'20"N -	115°46'10"W	8N	55E	15			37°		
	RAILROAD VALLEY-EAGLE SPRINGS	613	38°34'10"N -	115°31'55"W	8N	57E	11			38°-		
	MOORMAN SPRING	613	38°35'45"N -	115° 8'25"W	9N	61E	32			38°		
	EMIGRANT SPRINGS	613	38°37'25"N -	115° 3'10"W	9N	62E	19			21°		
	MOUNT GRAFTON	610	38°39'10"N -	114°37'50"W	9N	65E	12			21°		
	RAILROAD VALLEY-PANCAKE RANGE	613	38°27'55"N -	115°47'25"W	7N	55E	16	10		71°		
	COYOTE HOLE SPRING	613	38°23'20"N -	115°52' 5"W	6N	54E	14			29°		
	WHIPPLE PEAK	613	38°25'40"N -	115° 1'30"W	7N	62E	32			24°		
	FOREST MOON RANCH	613	38°23'00"N -	115° 9'15"W	6N	61E	18			33°		
	CAMP VALLEY CREEK	610	38°17'30"N -	114°15'50"W	5N	69E	17			29°		

AMS SHEET: MARIPOSA

NEVADA

SITE ID	SITE NAME	COUNTY	LATITUDE	LONGITUDE	TOWN-SHIP	RANGE	SEC-TION	RSVR** VOLUME(1)	SUB SURFACE	--- TEMPERATURES IN DEGREES C --- SURFACE	CS EST*	CS MEAS*
	BASALT	612	37°59'10"N	118°19'10"W	2N	33E	32			45°		

AMS SHEET: GOLDFIELD

NEVADA

SITE ID	SITE NAME	COUNTY	LATITUDE	LONGITUDE	TOWN-SHIP	RANGE	SEC-TION	RSVR** VOLUME (1)	SUB SURFACE	--- TEMPERATURES IN DEGREES C --- SURFACE	CS EST*	CS MEAS*
	EMIGRANT PEAK	606	37°57'50"N -	117°48'15"W	1N	37E	1			27°-		
	GAP SPRING	606	37°56'40"N -	117°58'40"W	1N	36E	7			ND		
	MT. DIABLO	606	37°54'30"N -	117°40'20"W	1N	39E	29			Hot		
	FISH LAKE VALLEY	606	37°51'30"N -	117°58'50"W	1S	36E	16	20	253°?	ND		
	VALCALDA SPRING	606	37°48'35"N -	117°46'55"W	1S	38E	32			ND		
	SILVER PEAK HOT SPS.	606	37°45'30"N -	117°37'50"W	2S	39E	15	15		48°		
	PEARL HOT SPRINGS	606	37°49'30"N -	117°29'00"W	1S	40E	25			37°		
	ALKALI SPRINGS	606	37°49'40"N -	117°20'25"W	1S	41E	26			60°		
	SOUTHERN CLAYTON V.	606	37°39'45"N -	117°43'50"W	3S	38E	23	10		ND		
	REVEILLE MILL	613	38°00'15"N -	116°23'20"W	2N	50E	28			29°		

AMS SHEET: CALIENTE

NEVADA

SITE ID	SITE NAME	COUNTY	LATITUDE	LONGITUDE	TOWN-SHIP	RANGE	SEC-TION	RSVR** VOLUME (1)	SUB SURFACE	--- TEMPERATURES IN DEGREES C --- SURFACE	CS EST*	CS MEAS*
	DRY VALLEY	610	37°54' 5"N -	114°14'25"W	1N	69E	34			25°-		
	SAND SPRING VALLEY	610	37°44'15"N -	115°45'00"W	2S	55E	26			30°		
	SAND SP. VALLEY WEST	610	37°40'20"N -	115°49'35"W	3S	55E	19			28°-		
	SAND SP. VALLEY SOUTH	610	37°37'40"N -	115°48'40"W	4S	55E	5			Warm		
	HIKO SPRING	610	37°35'10"N -	115°14'00"W	4S	60E	22			32°		
	CRYSTAL SPRINGS	610	37°31'50"N -	115°14'00"W	5S	60E	10			32°		
	ASH SPRINGS	610	37°27'30"N -	115°10'55"W	5S	60E	36			36°		
	CALIENTE HOT SPRINGS	610	37°37'10"N -	114°30'00"W	4S	67E	8	5		57°-		
	PANACA	610	37°48'20"N -	114°22'40"W	2S	68E	4			32°		

AMS SHEET: DEATH VALLEY

NEVADA

SITE ID	SITE NAME	COUNTY	LATITUDE	LONGITUDE	TOWN-SHIP	RANGE	SEC-TION	RSVR** VOLUME(1)	SUB SURFACE	--- TEMPERATURES IN DEGREES C --- SURFACE	CS EST*	CS MEAS*
	SARCOBATUS FLAT-BEATTY	613	36°57'40"N -	116°43'10"W	11S	47E	21	5		43°		
	STEVES PASS	613	36°46'00"N -	116°41'25"W	13S	47E	35			29°		
	JACKASS FLATS	613	36°46'30"N -	116°17' 5"W	13S	51E	31			36°-		
	LATHROP WELLS	613	36°38'50"N -	116°25'15"W	15S	49E	14			28°-		
	DESERT ROCK	613	36°35'30"N -	116° 2' 5"W	16S	53E	4			33°-		
	ROCK VALLEY	613	36°33'15"N -	116°30'00"W	16S	49E	18			27°-		
	SCRANTON WELL	613	36°30' 5"N -	116°27'40"W	17S	49E	4			29°-		
	SKELETON	613	36°32'20"N -	116°13'45"W	16S	51E	27			31°-		
	MT. STIRLING	613	36°29'10"N -	116° 9'10"W	17S	52E	8			28°-		
	ASH MEADOWS	613	36°25'45"N -	116°17'25"W	17S	50E	36			34°-		
	POINT OF ROCKS SPS.	613	36°26'00"N -	116°12'00"W	17S	51E	35			28°-		

AMS SHEET: LAS VEGAS

NEVADA

SITE ID	SITE NAME	COUNTY	LATITUDE	LONGITUDE	TOWN-SHIP	RANGE	SEC-TION	RSVR** VOLUME (1)	SUB SURFACE	--- TEMPERATURES IN DEGREES C --- SURFACE	CS EST*	CS MEAS*
	FRENCHMAN FLAT	603	36°48'50"N -	115°51'45"W	13S	54E	-			38°-		
	SPOTTED RANGE	603	36°35'35"N -	115°51'10"W	16S	54E	1			27°-		
	MOAPA	603	36°43'10"N -	114°43'20"W	14S	65E	16			32°		
	MUDDY MOUNTAINS	603	36°22'35"N -	114°19'55"W	18S	67E	12			31°		
	SIXMILE SPRING	613	36°12'30"N -	115°59'00"W	20S	53E	14			28°?		
	SUNRISE MOUNTAIN	603	36°15'00"N -	115°00'00"W	19S	62E	36			29°-		
	BOULDER JUNCTION-EAST LAS VEGAS	603	36° 2'15"N -	115° 9'40"W	22S	61E	16			41°-		

AMS SHEET: KINGMAN

NEVADA

SITE ID	SITE NAME	COUNTY	LATITUDE	LONGITUDE	TOWN-SHIP	RANGE	SEC-TION	RSVR** VOLUME (1)	SUB SURFACE	--- TEMPERATURES IN DEGREES C --- SURFACE	CS EST*	CS MEAS*
	BLACK CANYON	603	35°58'20"N -	114°44'30"W	23S	65E	8			63°		
	JEAN LAKE	603	35°46'40"N -	115°12'55"W	25S	60E	13			27°-		
	WILLOW SPRING	603	35°15'15"N -	114°42'40"W	31S	65E	15			31°		
	DAVIS DAM	603	35°11'25"N -	114°35'00"W	32S	66E	12			27°		

SITE SCENARIOS FOR THE STATE OF NEW MEXICO

POSTULATED SITE DEVELOPMENT SCHEDULE
ANIMAS VALLEY

WBS 7002

OPERATING ENTITIES	ACTIVITY	1977	1978	1979	1980	1981	1982	1983	1984	1986	1990	1995	2000	2020
Developer	Conducts casual reconnaissance exploration	—	—											
BLM, State	Leases Land	—	—	—										
USGS	Makes environment assessment	. 1975												
USGS, State	Approves plan of operation and issues permit to explore	—	—	—										
Developer	Conducts geophsical work and drills T.G. holes	—	—	—										
USGS	Makes EA for drilling deep exploratory wells			—	—									
USGS, State	Gives permission to drill				.									
Developer	Drill deep exploratory wells				—	—								
Developer	Conducts Feasibility Study					—	—							
Developer	Water rights application with State Engineer					—								
USGS	Makes EA for development						—	—						
	Gives permission to develop						.							
Developer	Drills development wells and runs production tests						—	—	—					
PSC	Certifies plant and site							—						
	Issue permits								.					
USGS	Approves plan of operation for production							—	—					

POSTULATED SITE DEVELOPMENT SCHEDULE
ANIMAS VALLEY

WBS 7002

OPERATING ENTITIES	ACTIVITY	1977	1978	1979	1980	1981	1982	1983	1984	1986	1990	1995	2000	2020
Utility	Obtains R.O.W. for Power Line								——					
Utility	Plant Construction								——	——				
Utility	Puts power on line										20 MW Δ——	10MW Δ	——	——

POSTULATED SITE DEVELOPMENT SCHEDULE
KILBOURNE HOLE

WBS 7004

OPERATING ENTITIES	ACTIVITY	1977	1978	1979	1980	1981	1982	1983	1984	1986	1990	1995	2000	2020
Developer	Conducts casual reconnaissance exploration	—	—											
BLM, State	Leases Land	—												
USGS	Makes Environment Assessment	—												
USGS, State	Approves Plan of Operation and issues permit to explore		—	—										
Developer	Conducts geophsical work and drills T.G. holes		—	—										
USGS	Makes EA for drilling deep exploratory wells			—	—									
USGS, State	Gives permission to drill			—										
Developer	Drills deep exploratory well			—	—	—								
Developer	Conducts Feasibility Study				—	—								
Developer	Water rights application with State Engineer				—									
USGS	Makes EA for development				—	—								
	Gives permission to develop					—								
Developer	Drills production wells and runs tests					—	—	—						
PSC	Certifies plant and site							—						
	Issue permits							—						
USGS	Approves plan of operation for production							—						
Utility	Obtains R.O.W. for Power Line							—						

POSTULATED SITE DEVELOPMENT SCHEDULE
KILBOURNE HOLE

WBS 7004

OPERATING ENTITIES	ACTIVITY	1977	1978	1979	1980	1981	1982	1983	1984	1986	1990	1995	2000	2020
Utility	Plant Construction													
Utility	Puts power on line									10 MW	25MW	50 MW		

POSTULATED SITE DEVELOPMENT SCHEDULE
RADIUM SPRINGS

WBS 7008

OPERATING ENTITIES	ACTIVITY	1977	1978	1979	1980	1981	1982	1983	1984	1986	1990	1995	2000	2020
Developer	Conducts casual reconnaissance exploration	—	—											
BLM, State	Leases Land	—												
USGS	Makes Environment Assessment	—												
USGS, State	Approves Plan of Operation and issues permit to explore		—											
Developer	Conducts geophsical work and drills T.G. holes		—	—										
USGS	Makes EA for drilling deep exploratory wells			—										
USGS, State	Gives permission to drill			—										
Developer	Drills deep exploratory well			—	—									
Developer	Conducts Feasibility Study			—	—									
Developer	Water rights application with State Engineer				—									
USGS	Makes EA for development				—	—								
	Gives permission to develop					—								
Developer	Drills development wells and runs production tests					—	—	—						
PSC	Certifies plant and site						—	—						
	Issue permits							—						
USGS	Approves plan of operation for production							—						

POSTULATED SITE DEVELOPMENT SCHEDULE
RADIUM SPRINGS

WBS 7008

OPERATING ENTITIES	ACTIVITY	1977	1978	1979	1980	1981	1982	1983	1984	1986	1990	1995	2000	2020
Utility	Obtains R.O.W. for Powerline							—						
Utility	Plant Construction								——	——				
Utility	Puts power on line									——	——	——	——	

POSTULATED SITE DEVELOPMENT SCHEDULE
SOCORRO

WBS 7055

OPERATING ENTITIES	ACTIVITY	1977	1978	1979	1980	1981	1982	1983	1984	1986	1990	1995	2000	2020
Developer	Conducts casual reconnaissance exploration		—											
BLM, State	Leases Land		—											
USGS	Makes Environment Assessment		—											
USGS, State	Approves Plan of Operation and issues permit to explore		—											
Developer	Conducts geophsical work and drills T.G. holes		—											
USGS	Makes EA for drilling deep exploratory wells			—										
USGS, State	Gives permission to drill			•										
Developer	Drills deep exploratory well			—	—									
Developer	Conducts Feasibility Study			—	—	—								
Developer	Water rights application with State Engineer				—									
USGS	Makes EA for development				—	—								
	Gives permission to develop					•								
Developer	Drills development wells and runs production tests					—	—	—						
USGS	Approves plan of operation						—							
Developer/User	District Heating System Installed							—						
Developer/User	Space Heating on line							•						

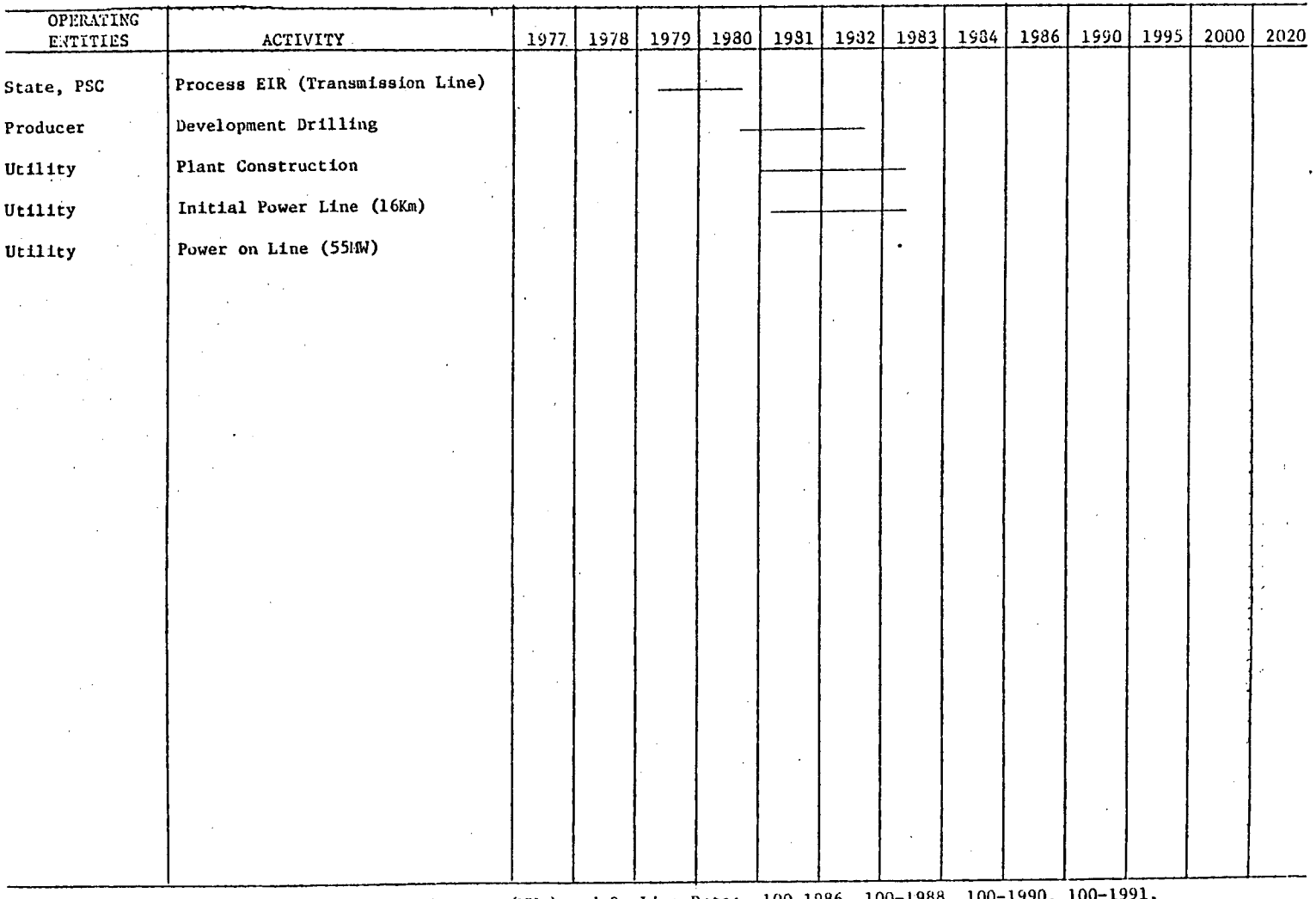
POSTULATED SITE DEVELOPMENT SCHEDULE
VALLES CALDERA

WBS 7001

OPERATING ENTITIES	ACTIVITY	1977	1978	1979	1980	1981	1982	1983	1984	1986	1990	1995	2000	2020
State, Owner County	Issue Permits -- Exploration, Drilling of T.G. holes													
Owner, State	Lease Land													
Developer	Preliminary Geophsical Exploration		COMPLETED											
Developer	Exploratory Drilling and Reservoir Evaluation													
Developer	Develop Utility Interest													
Developer & Utility	Feasibility Study													
Developer & Utility	Financial Negotiations	——	——											
Developer & Utility	Prepare and submit proposal to DOE	——												
Developer & Utility	Site Selection		—											
Developer & Utility	Design		——	——										
Developer & Utility	Commitment to Development		•											
Developer & Utility	Prepare Environmental Data Statement		——											
State, PSC	Certify Plant & Site, Issue Permits			——	——									
State	Process EIR (Drilling)			——	——									
State, PSC	Process EIR (Plant)			——	——									

POSTULATED SITE DEVELOPMENT SCHEDULE
VALLES CALDERA

WBS 7001



Possible Subsequent Additions (MWe) and On Line Date: 100-1986, 100-1988, 100-1990, 100-1991, 100-1992, 100-1993, 100-1994, 100-1995, 100-1996, 100-1997, 100-1998, 100-1999

Composite Scenarios for Direct Utilization of Geothermal Resources in New Mexico

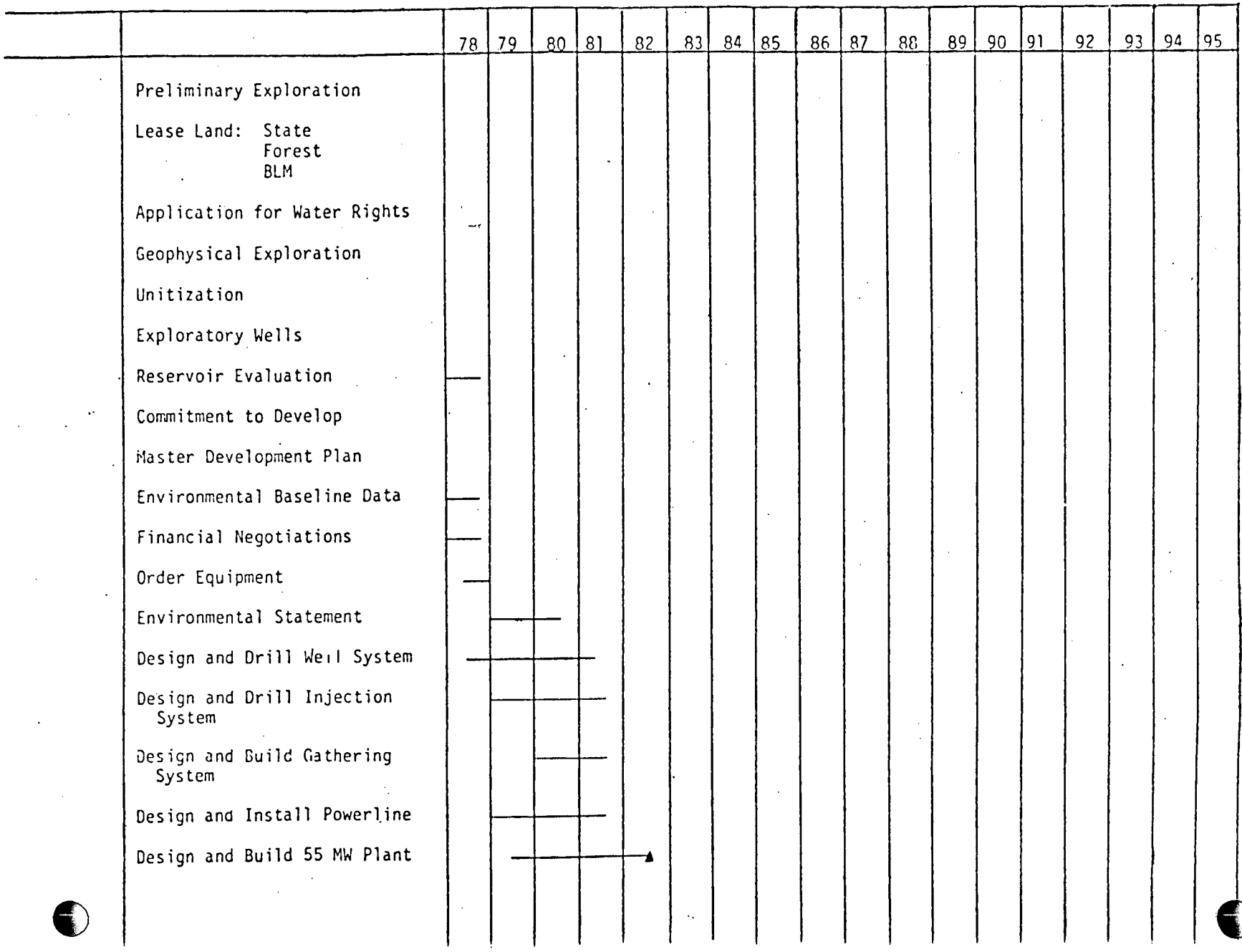
Site and Activity	Total MWth	78	80	82	84	86	88	90	92	94	96	98	2000	02	04	06	08	10	12	14	16	18
Socorro Spg. (Campus heating	30					10	20	30	30	30	30	30	30	30	30	30	30	30	30	30	30	20
Kilbourne Hole (Las Alturas & Anthony; Space Heating, Crop Drying, etc.,)	50					20	40	50	50	50	50	50	50	50	50	50	50	50	50	50	50	30
Radium Spg. (Green houses, Crop dehydration)	50					20		50	50	50	50	50	50	50	50	50	50	50	50	50	50	30
Jemez Spg. (Space heating, Agriculture)	60	3	3	3	23	43	60	60	60	60	60	60	60	60	60	60	60	60	57	57	37	17
T or C (Space heating, recreation)	30	2	2	2	30	30	30	30	30	30	30	30	30	30	30	30	30	30	28	28	28	
San Ysidro (Space heating)	20						20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Animas (Space heating, green houses)	40	2	2	22	40	40	40	40	40	40	40	40	40	40	40	40	40	40	38	38	18	
Albuquerque	50					20	40	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Cumulative Total		7	7	27	93	193	290	330	330	330	330	330	330	330	330	330	330	330	323	323	313	237

Composite Scenarios for Geothermal Power Generation in New Mexico

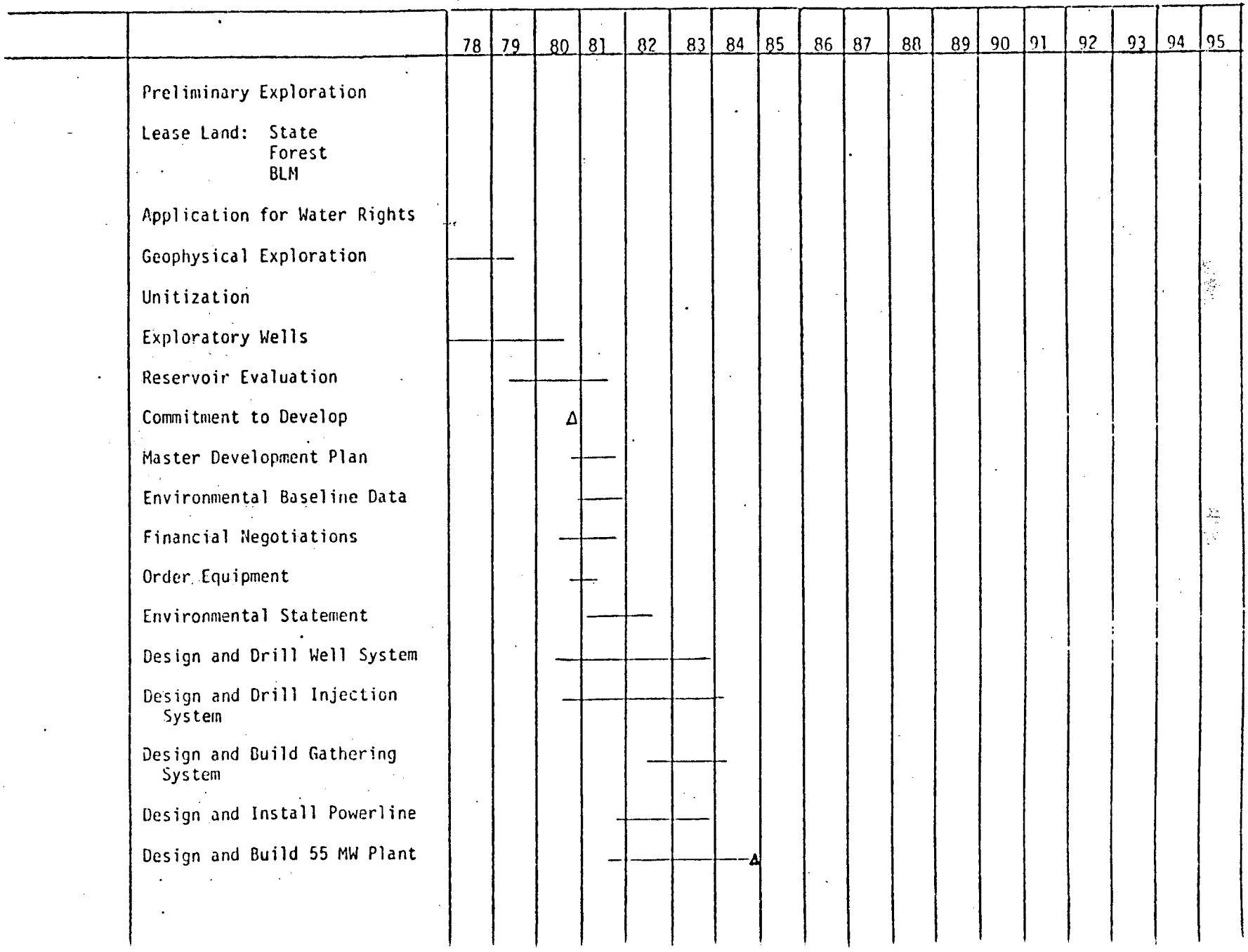
Site	Total MWe	80	82	84	86	88	90	92	94	96	98	2000	02	04	06	08	10	12
Animas	100				20	20	100	100	100	100	100	100	100	100	100	100	100	100
Kilbourne	50				10	25	50	50	50	50	50	50	50	50	50	50	50	50
Lower San Francisco	20						15	20	20	20	20	20	20	20	20	20	20	20
Radium Spring	30					5	30	30	30	30	30	30	30	30	30	30	30	30
Valles Caldera	2000		50	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500
Cumulative Total			50	100	230	350	595	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700

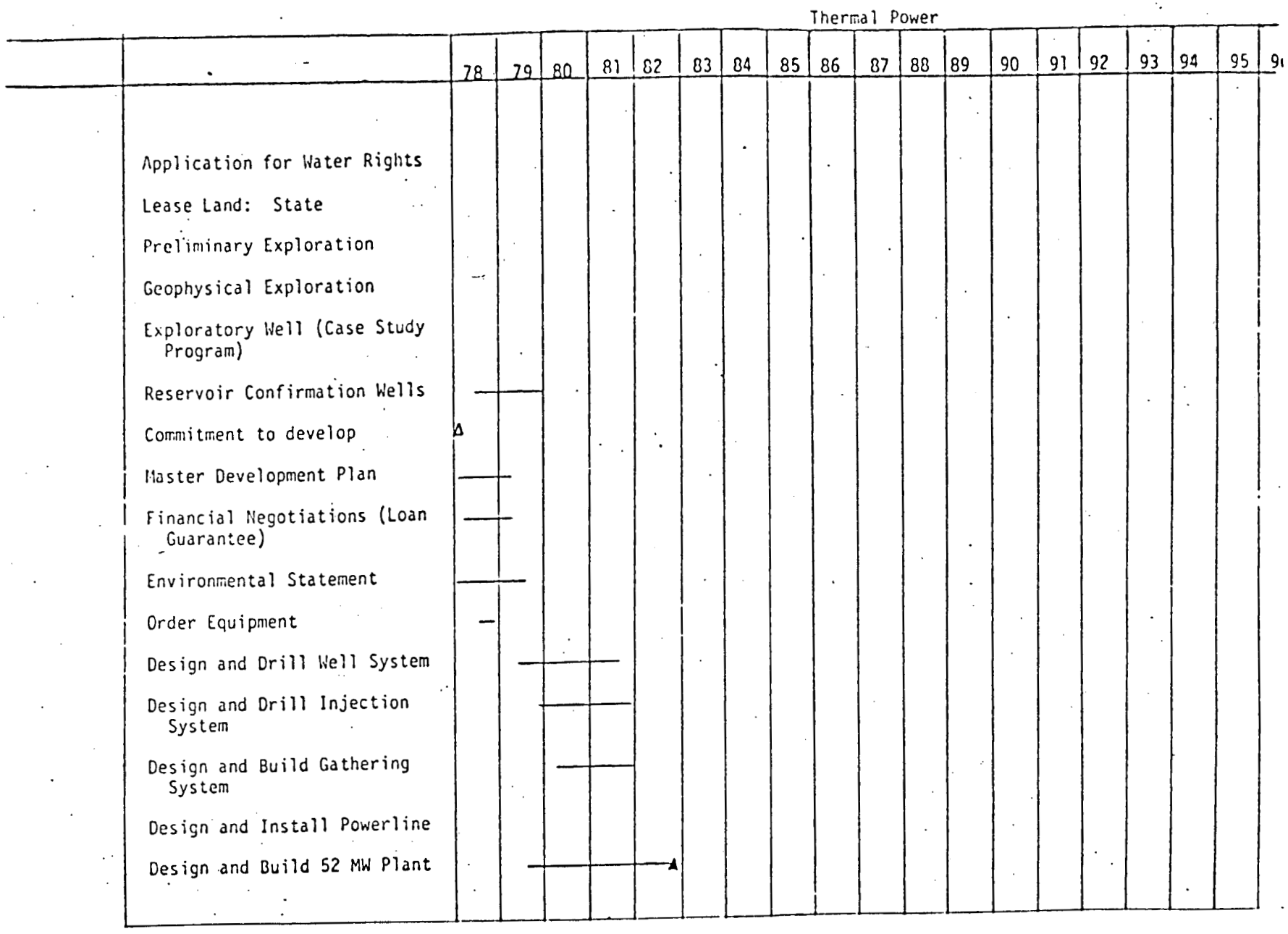
SITE SCENARIOS FOR THE STATE OF UTAH

Possible Development Forecast: Roosevelt Prospect (Phillips Petroleum Co.)



Possible Development Forecast: Cove Fort/Sulphurdale (Union Oil Co.)




Thermal Power
78
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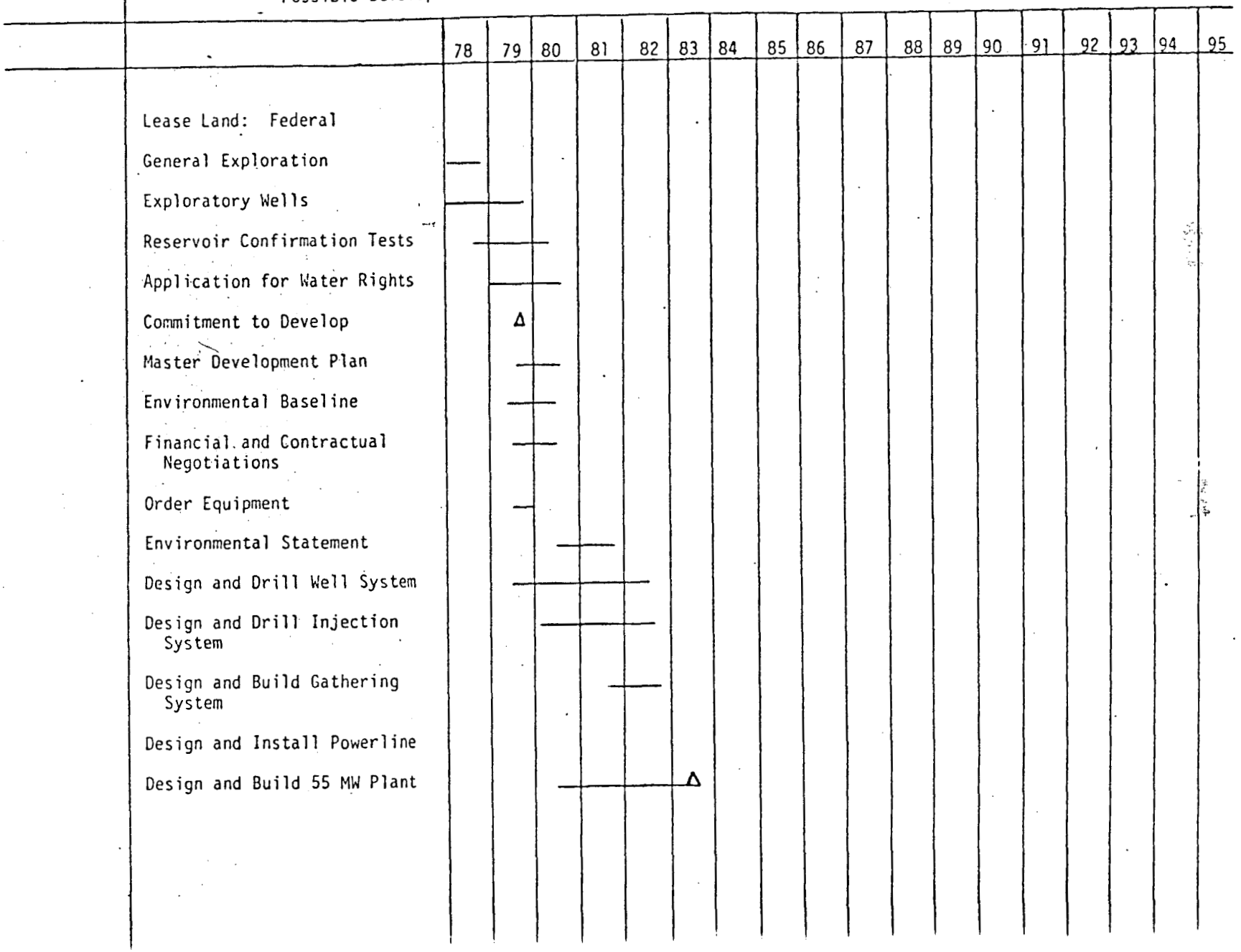
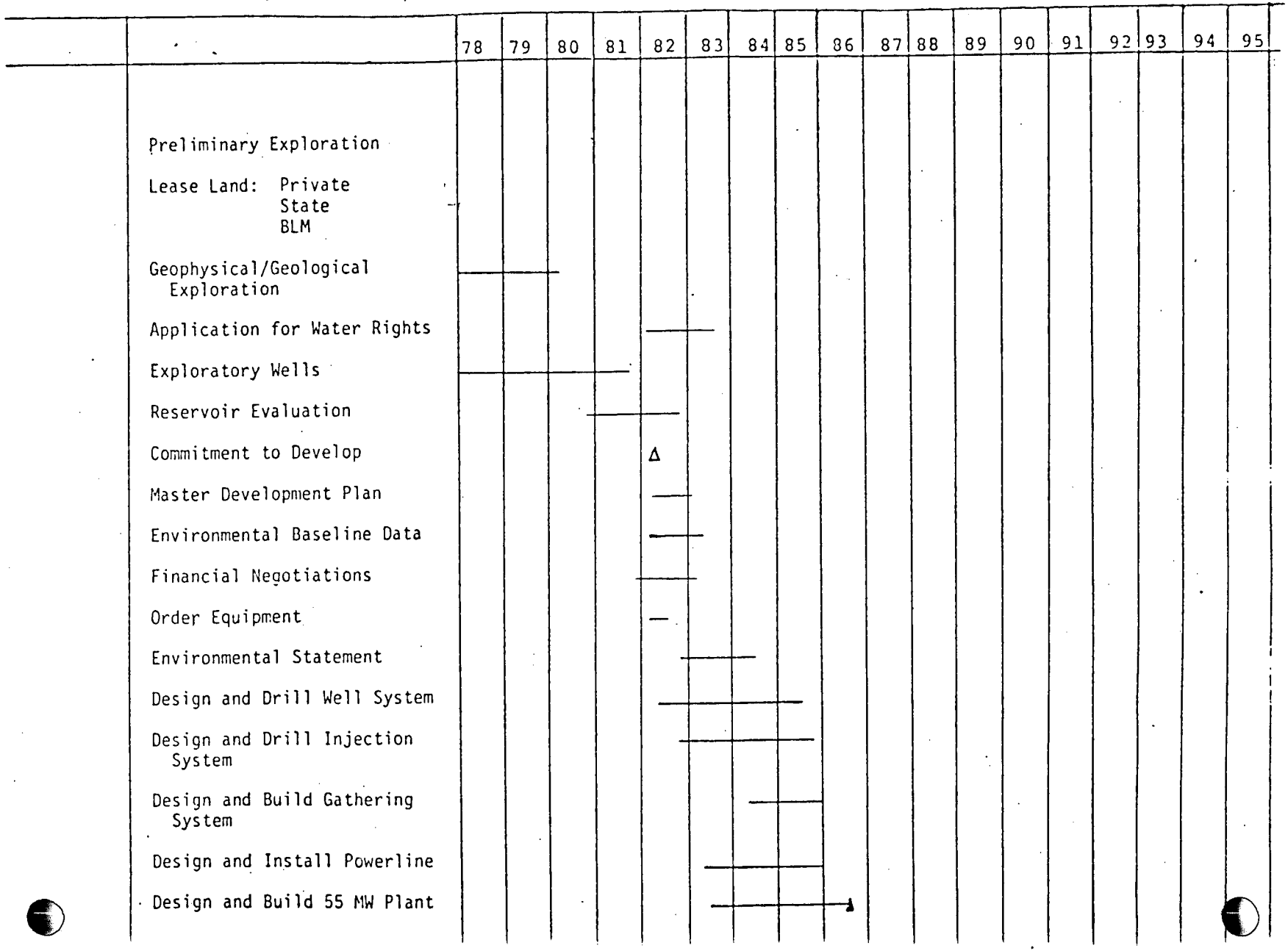
Application for Water Rights
Lease Land: State
Preliminary Exploration
Geophysical Exploration
Exploratory Well (Case Study Program)
Reservoir Confirmation Wells
Commitment to develop
Master Development Plan
Financial Negotiations (Loan Guarantee)
Environmental Statement
Order Equipment
Design and Drill Well System
Design and Drill Injection System
Design and Build Gathering System
Design and Install Powerline
Design and Build 52 MW Plant

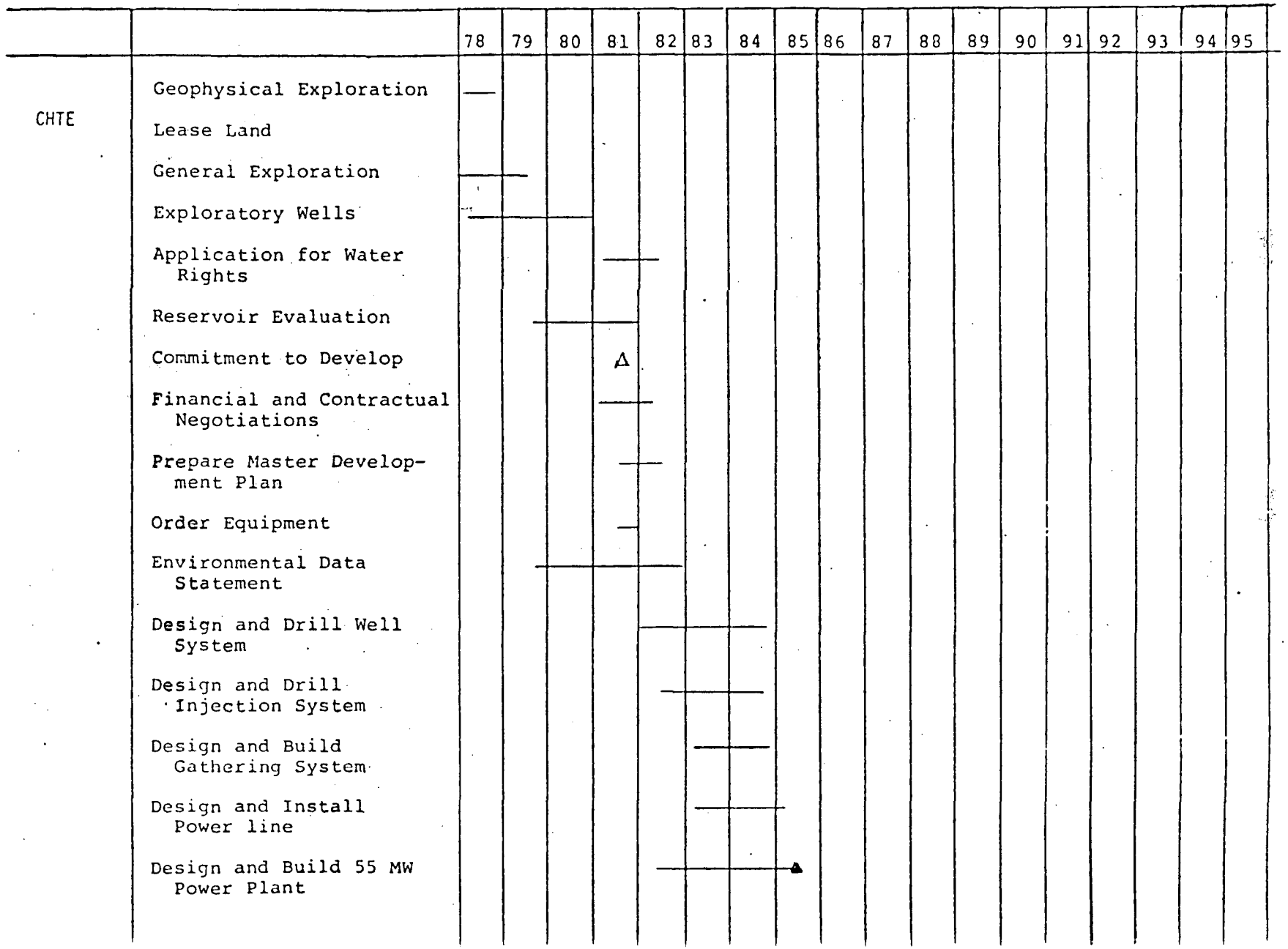
Possible Development Forecast: Roosevelt Prospect (Getty Oil Co.)



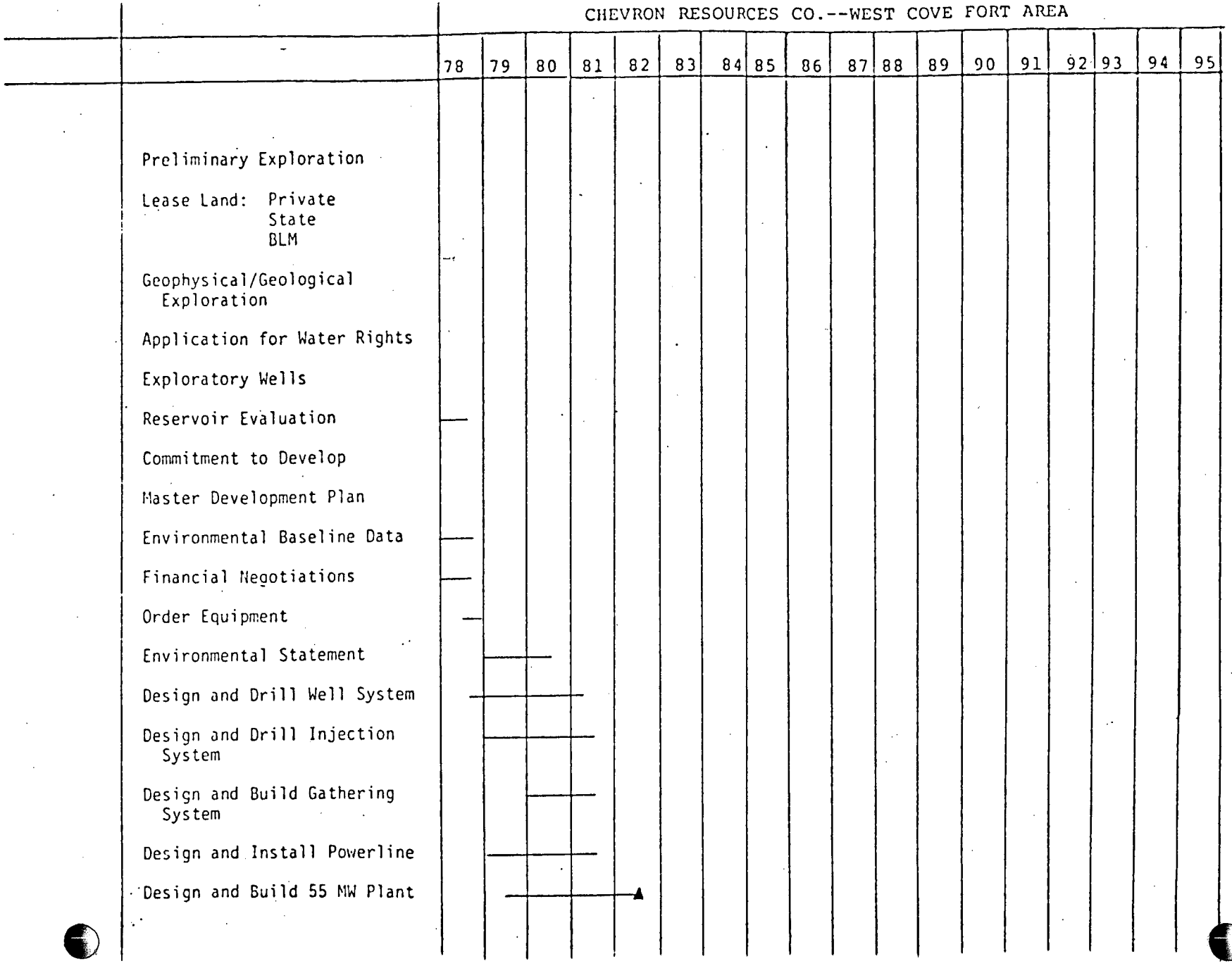
Possible Development Forecast: Thermo Prospect (Republic Geothermal, Inc.)



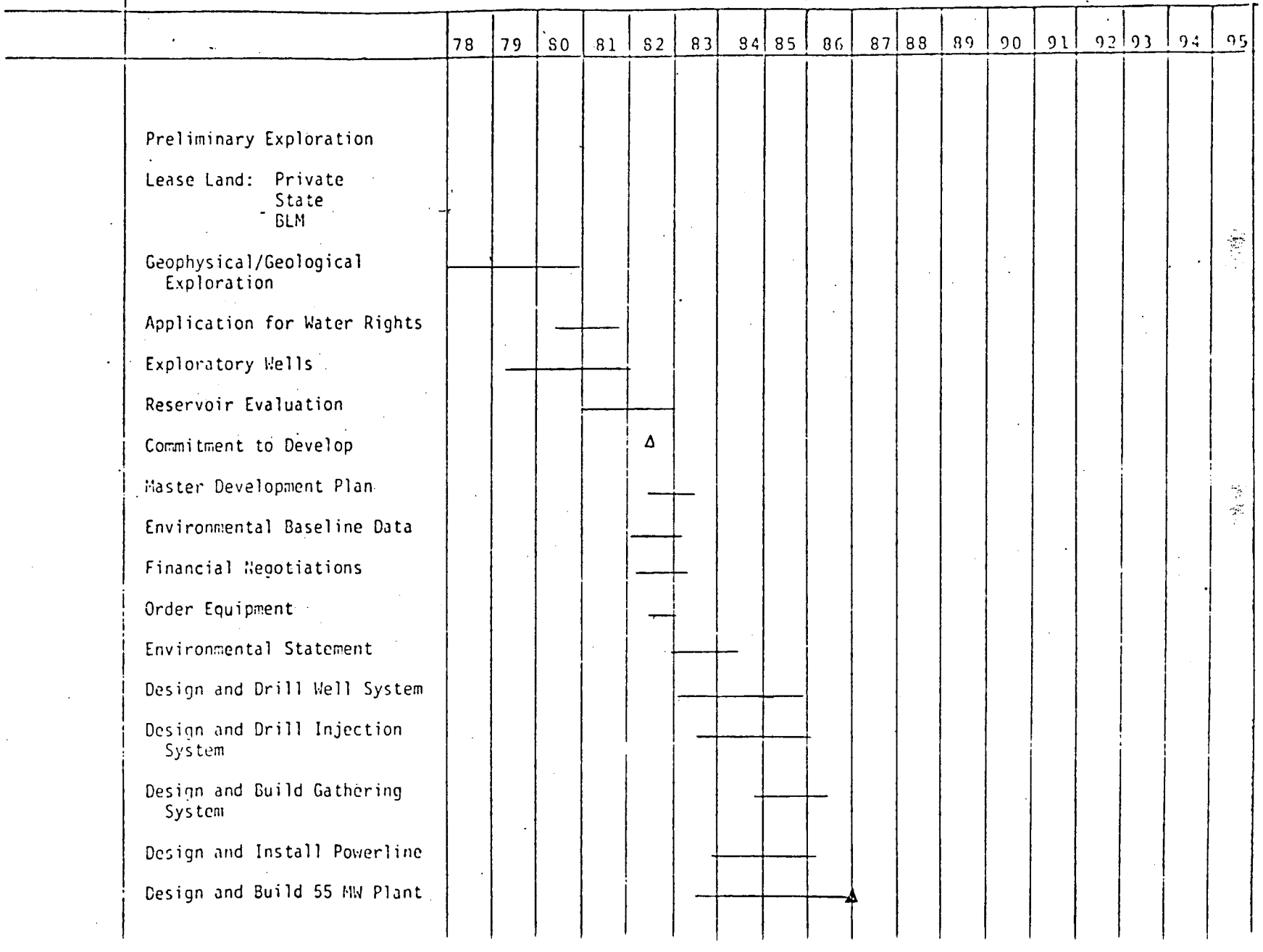
Possible Development Forecast: North Cove Fort Prospect (Caroline Hunt Trust Estate)



CHEVRON RESOURCES CO.--WEST COVE FORT AREA



Possible Development Forecast: West Cove Fort Area (AMAX Exploration, Inc.)



AGGREGATED SCENARIO--DIRECT UTILIZATION OF GEOTHERMAL RESOURCES IN UTAH

	Tot. MWt	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99
Monroe/Red Hill/Johnson	85		1	1	1	2	2	3	4	2	2	1	1	1	1		1		1		1		1
Crystal H. S.	43	1	1	2	4	2	2	1	1	1	1	1		1		1		1		1		1	
Wasatch/Beck's/Hobo	65			1	3	5	10	15	5	5	5	2	2	1	1	1	1		1		1		1
Midway	11			1	2	1	1	1		1		1		1		1		1					
Ogden/Hooper/Utah/Hill AFB	95			2	3	5	10	10	10	7	5	5	3	2	2	2	2	2	1	1	1	1	
Meadow/Hatton	45						1	2	4	10	10	3	2	2	1	1	1	1		1		1	
Joseph H. S.	45						1	2	4	4	2	2	1	1	1	1	1		1		1		1
New Castle	45*					1	1	2	4	7	10	8	4	2	1	1		1		1		1	
Cove Fort (Sulphurdale)	400*							2	4	7	10	10	10	5	5	3	3	3	3	3	3	2	2
Thermo	200*									1	2	4	10	10	10	5	5	3	3	3	3	3	2
Tintic	100*					2	2	2	4	4	5	5	4	3	3	3	3	3	3	3	3	2	2
Beryl	100*					2	4	10	15	10	5	5	5	4	3	3	3	3	2	2	2	2	2
Abraham	100*						1	1	2	6	10	10	5	4	4	3	3	3	3	3	2	2	2
West Cove Fort	100*								2	2	6	10	10	10	5	3	3	2	2	2	2	2	2
Black Rock Desert	100*								2	2	6	10	10	10	5	3	3	2	2	2	2	2	2
Veyo	10			1	1	2	2	1	1	1	1												
LaVerkin	10				1	1	2	2	1	1	1	1											
Crystal (Madsen's) H. S.	27					1	1	2	4	2	2	1	1		1		1		1		1		1
Other Areas	200*						1	2	4	4	4	6	6	4	4	2	2	2	2	2	2	2	2
Total for Year		1	2	8	15	24	41	58	71	76	86	83	68	61	47	38	32	29	25	24	24	21	20
Cumulative Total		1	3	11	26	50	91	149	220	296	382	465	533	594	641	679	711	740	765	789	813	834	854

Continued

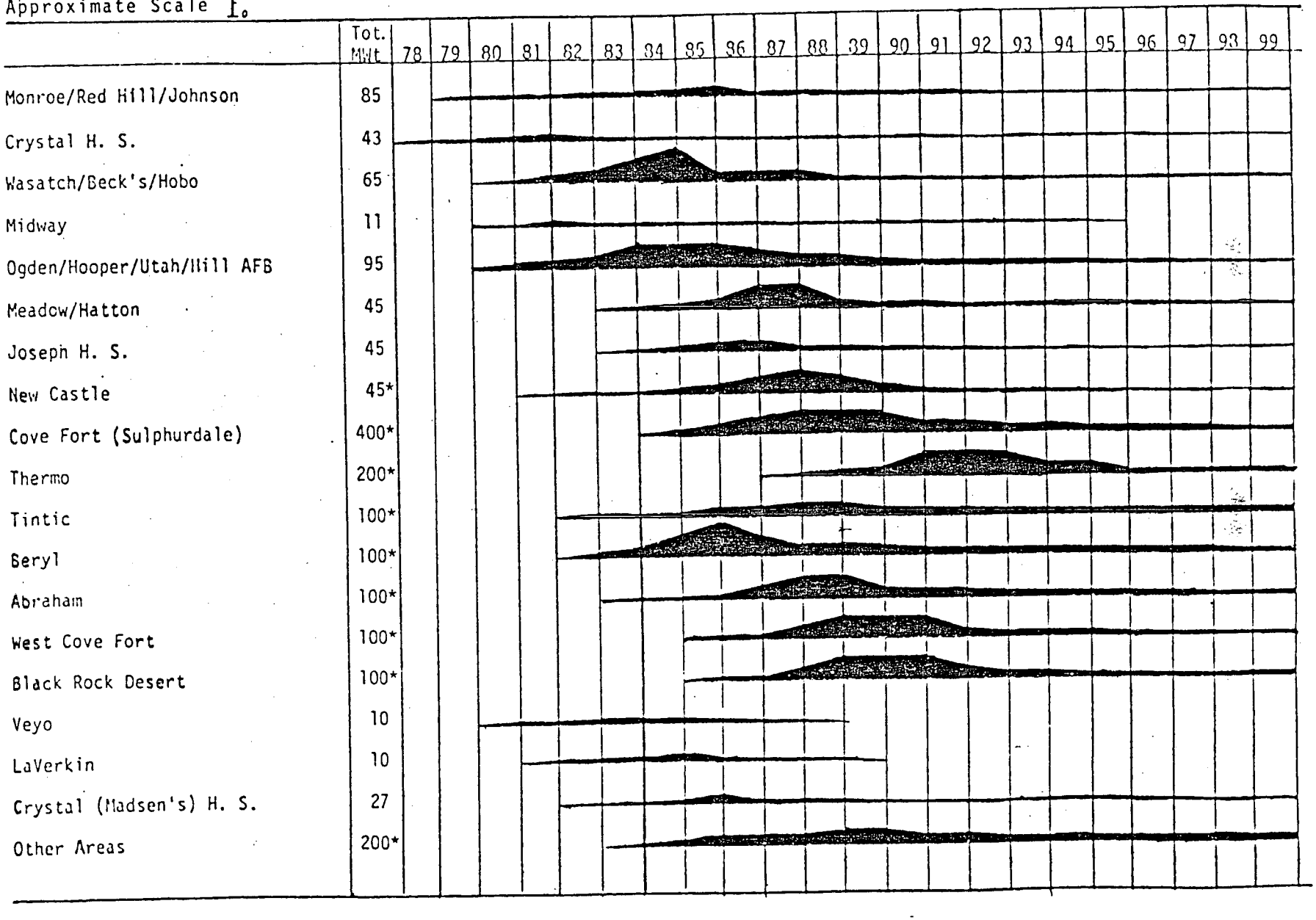
	Tot. MWt	2000	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
Monroe/Red Hill/Johnson	85		1		1		1		1		1		1		1		1		1		1	
Crystal H. S.	43	1		1		1		1		1		1		1		1		1		1		1
Wasatch/Beck's/Hobo	65		1		1		1		1													
Midway	11																					
Ogden/Hooper/Utah/Hill AFB	95	1		1		1		1		1		1		1		1		1		1		1
Meadow/Hatton	45	1		1		1		1		1												
Joseph H. S.	45		1		1		1		1		1		1		1		1		1		1	
New Castle	45*	1																				
Cove Fort (Sulphurdale)	400*	2	2	2	1	1	1	1	1	1	1	1		1		1		1		1		
Thermo	200*	2	1	1	1	1	1		1		1		1		1		1		1		1	
Tintic	100*	2	1	1	1	1		1		1		1		1		1		1		1		1
Beryl	100*	1	1	1	1	1	1	1	1		1		1		1		1		1		1	
Abraham	100*	2	2	1	1	1	1	1		1		1		1		1		1		1		1
West Cove Fort	100*	2	2	1	1	1	1	1	1		1		1		1		1		1		1	
Black Rock Desert	100*	2	2	1	1	1	1	1		1		1		1		1		1		1		1
Veyo	10																					
LaVerkin	10																					
Crystal (Madsen's) H. S.	27		1		1		1		1		1		1		1		1					
Other Areas	200*	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Total for Year		19	17	13	13	12	12	11	10	9	9	8	8	8	8	8	8	8	7	8	7	8
Cumulative Total		873	890	903	916	928	940	951	961	970	979	987	995	1003	1011	1019	1027	1035	1042	1050	1057	1065

Aggregated Scenario--Electrical Production from Geothermal Resources in Utah

	tot. MWe	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	2000	01	02	03
Roosevelt Prospect	400			50		50		50		50		100		100											
Cove Fort Sulphurdale	200					50		50		50		50													
West Cove Fort	200						50		50		50		50												
North Cove Fort	200						50		50		50		50												
Thermo	100							50		50															
Other Areas (Sevier Lake, Black Rock Desert, Delta Area	200								50		50		50	50											
TOTAL FOR YEAR				50		100	100	150	150	150	150	150	150	150											
CUMULATIVE TOTAL				50		150	250	400	550	700	850	1000	1150	1300											

Postulated Geothermal Direct Use Development Profile for Utah
(New development each year, MWt)

Approximate Scale I_0^{10MWt}



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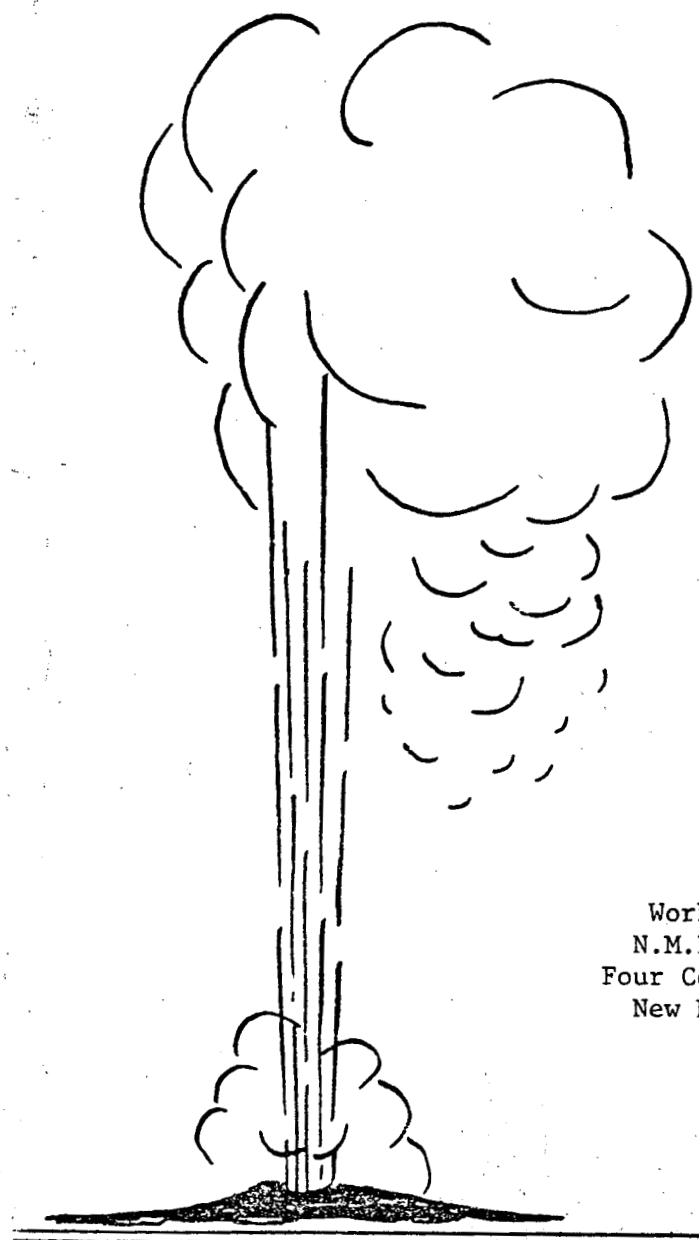

POTENTIAL OF GEOTHERMAL ENERGY IN ARIZONA

Appendix 6 of

REGIONAL OPERATIONS RESEARCH PROGRAM
FOR DEVELOPMENT OF GEOTHERMAL ENERGY
IN THE SOUTHWEST UNITED STATES

Final Technical Report
June 1977 to August 1978

Arizona Solar Energy
Research Commission
Frank Mancini
W. R. Hahman, Sr.
Don H. White
David Wolfe

January 1979

Work Performed under DOE Contract No. EG-77-S043992
N.M.Energy and Minerals Department Project No. 76-262
Four Corners Regional Commission Contract No. 672-066-075
New Mexico State University Sub-Contract No. 3104-X4

New Mexico Energy Institute at
New Mexico State University
Las Cruces, New Mexico 88003

U. S. DEPARTMENT OF ENERGY
Geothermal Energy

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TABLE OF CONTENTS

		Page
	I. INTRODUCTION	1
A.	PROJECT ORGANIZATION	1
	1. Coordination and Monitoring of Arizona Team Efforts	1
	2. Collection of Arizona Geological and Geothermal Data	1
	3. Preparation of Arizona's Geothermal Utilization Scenarios	1
B.	OBJECTIVES OF THE PROJECT	2
C.	RELATED ORIENTATION INFORMATION	5
	II. GEOTHERMAL RESOURCES IN ARIZONA	9
A.	RULES, REGULATIONS AND INSTITUTIONAL ASPECTS	9
	1. Established Executive Offices	9
	2. Agencies Related to Geothermal Development	9
	3. Organization of the State Legislature	11
	4. Legislature Which May be Considered by Future Sessions	11
B.	LEASING PROCEDURES	13
	1. Leasing of State Lands	13
	2. Leasing of Federal Lands	15
	3. Leasing of Private Lands	18
	4. Leasing of Indian Lands	18
	5. Creating Incentives	18
	6. Pertinent Recent Court Cases and Impacts	18
C.	GEOTHERMAL RESOURCE DATA	19
	1. Practical Experience and Geothermal Exploration in Arizona	19
	2. Introduction to the Arizona Geology	19
	3. Details on the Geology of Arizona	25
	4. Preliminary Map of Geothermal Energy Resources of Arizona	27
	5. Geothermal Energy Available for Development	30
	6. Assessment of Geothermal Resources in Arizona	30
	7. Geothermal Leasing and Drilling Activity in Arizona	39
	8. Known Geothermal Resource Areas (KGRA's)	49

TABLE OF CONTENTS CONTINUED

Page

III. ARIZONA DATA BASE 50

A. DATA BASE AND PHYSICAL RESOURCES 50

B. ENERGY USE IN ARIZONA 50

C. ARIZONA'S WATER SITUATION. 62

IV. GEOTHERMAL USE SCENARIOS. 70

A. INTRODUCTION 70

1. Preliminary Evaluation 70
2. Potential Constraints and Advantages 71

B. DETAILS ON THE SCENARIOS 75

1. Geothermal Use Scenarios for Arizona 78
   - No. 1 Space cooling for an industrial complex (Case Study: Electronic firm in Phoenix) 78
   - No. 2 District heating and cooling (Case study: Retirement community outside Phoenix). 86
   - No. 3 New Communities 90
   - No. 4 New industries 93
   - No. 5 Energy storage for heat pump systems. 93
   - No. 6 Central Arizona Project/Peak Power 94
   - No. 7 Wind energy/geothermal energy/energy storage 94
   - No. 8 Hot igneous rock and power plant. 95
   - No. 9 Coal mining operations 95
   - No. 10 Preheating/sulfur removal in coal field power plants. . . 95
   - No. 11 Solution mining 96
   - No. 12 Hot water for conventional mining 97
   - No. 13 Hot mines 98
   - No. 14 Salt production 98
   - No. 15 Desalination 98
   - No. 16 Biosalinity agriculture 104
   - No. 17 Greenhouse/hydroponics 104
   - No. 18 Irrigation pumping (Case Study: Hyder Valley area) . . .105
   - No. 19 Crop drying 107
   - No. 20 Kiln drying of lumber 108
   - No. 21 Lettuce chilling. 108
   - No. 22 Sugar beet plant 109

TABLE OF CONTENTS CONTINUED

Page

V. ANALYSIS OF GEOTHERMAL POTENTIAL 114

A. SURVEY OF CURRENT NON-ELECTRIC APPLICATIONS OF GEOTHERMAL ENERGY . . 114

B. ECONOMIC ASPECTS 117

1. Pricing of Geothermal Energy in Arizona. 117
2. The Economics of Geothermal Energy Compared to that of Fossil Fuels 118

VI. INTERACTION WITH STATE GROUPS 130

A. EXPLORATION OF INDUSTRIAL POTENTIAL USERS IN ARIZONA FOR GEOTHERMAL ENERGY 130

B. PROPOSED ARIZONA WORKSHOP - AUGUST 1978 134

VII. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS. 136

A. SUMMARY 136

B. CONCLUSIONS. 136

C. RECOMMENDATIONS. 137

1. Second Year on Current Project 137
2. Exploratory Drilling in Arizona. 138
3. Interaction with Local Groups 138
4. Department of Energy Assistance 139

VIII. APPENDIX 1 - PARTIAL LITERATURE SURVEY. 140

LIST OF TABLES

Table		Page
1	ELECTRICITY GENERATING CAPACITY FROM GEOTHERMAL RESOURCES	7
2	LIST OF HOT SPRINGS IN ARIZONA	21
3	ESTIMATED GEOTHERMAL ENERGY AT VARIOUS AREAS IN ARIZONA	31
4	HIGH TEMPERATURE GEOTHERMAL RESOURCES (>150°C)	32
5	INTERMEDIATE TEMPERATURE GEOTHERMAL RESOURCES (90-150°C)	33
6	LOW TEMPERATURE GEOTHERMAL RESOURCES (20-90°C)	34
7	INFORMATION ON GEOTHERMAL LOCATIONS IN THE STATE OF ARIZONA	36
8	ARIZONA LAND OWNERSHIP AND ADMINISTRATION BY COUNTY	57
9	ARIZONA GROSS ENERGY INPUTS - SUPPLY SOURCES BY USER CLASS 1975	66
10	SUMMARY - ARIZONA GROSS ENERGY CONSUMPTION IN 1975	67
11	ARIZONA TOTAL ENERGY CONSUMPTION 1960-1975	68
12	ARIZONA ENERGY CONSUMPTION BY FUEL SOURCES 1960-1975	69
13	GEOTHERMAL ENERGY POTENTIAL USES IN ARIZONA	72
14	LIST OF SCENARIOS DISCUSSED IN THIS REPORT	73
15	GENERALIZED IMPEDIMENTS AND ADVANTAGES TO USE OF GEOTHERMAL ENERGY	74
16	CATEGORIES OF POTENTIAL GEOTHERMAL USERS IN ARIZONA	76
17	COLLECTION OF ARIZONA BACKGROUND DATA	77
18	ESTIMATED COST OF PROJECT - SCENARIO #1	83
19	ESTIMATED USES OF PROCESS STEAM AT VARIOUS TEMPERATURES IN INDUSTRIAL SECTORS	115
20	ANALYSIS OF ENERGY ALTERNATIVES	119
21	FOSSIL FUEL AND GEOTHERMAL PRICE PROJECTIONS	123
22	POTENTIAL RECOVERABLE ENERGY FROM GEOTHERMAL RESOURCES IN THE U.S.	124
23	FOOTAGE COSTS FOR GEOTHERMAL DRILLING AS A FUNCTION OF ROCK TYPE AND WELL DEPTH	126

LIST OF TABLES CONT

Table		Page
24	FACTORS WHICH DETERMINE PENETRATION RATE.	127
25	DRILLING AND COMPLETION COSTS AT THE GEYSERS.	129
26	LIST OF COMPANIES WHICH WERE ASKED ABOUT ENERGY USE AND POTENTIAL GEOTHERMAL ENERGY APPLICATION	131
27	TENTATIVE ARIZONA WORKSHOP PROGRAM - AUGUST 1978.	135

LIST OF FIGURES

Figures		Page
1	TEMPERATURE RANGES FOR DIFFERENT GEOTHERMAL USES	8
2	GENERAL ORGANIZATION CHART OF THE ARIZONA STATE LEGISLATURE	12
3	COMPETITIVE BIDDING PROCESS FOR THE LEASING OF FEDERAL (NON-INDIAN) LANDS FOR GEOTHERMAL DEVELOPMENT	16
4	NON-COMPETITIVE LEASING PROCESS FOR FEDERAL (NON-INDIAN) LANDS FOR GEOTHERMAL DEVELOPMENT	17
5	GEOLOGIC MAP AND CROSS SECTIONS OF ARIZONA	23
6	PRELIMINARY MAP OF GEOTHERMAL ENERGY RESOURCES OF ARIZONA	28
7	LOCATION MAP FOR AREAS OF ARIZONA REFERRED TO IN THIS REPORT	38
8	GEOTHERMAL LAND STATUS OF MARICOPA COUNTY, ARIZONA, AS OF APRIL, 1978	41
9	GEOTHERMAL LAND STATUS OF PIMA AND SANTA CRUZ COUNTIES, ARIZONA, AS OF APRIL 1978	42
10	GEOTHERMAL LAND STATUS OF GRAHAM AND GREENLEE COUNTIES, ARIZONA AS OF APRIL 1978	43
11	GEOTHERMAL LAND STATUS OF MOHAVE COUNTY, ARIZONA AS OF APRIL 1978	44
12	GEOTHERMAL LAND STATUS OF COCHISE COUNTY, ARIZONA, AS OF APRIL 1978	45
13	GEOTHERMAL LAND STATUS OF PINAL COUNTY, ARIZONA, AS OF APRIL 1978	46
14	GEOTHERMAL STATUS OF YUMA COUNTY, ARIZONA, AS OF APRIL 1978	47
15	POPULATION DISTRIBUTION IN ARIZONA	51
16	LOGGING AND SAWMILL OPERATIONS IN ARIZONA	52
17	COLORADO RIVER DISCHARGE MEAN FLOW 1951-1960	53
18	AVERAGE GROUND WATER LEVEL IN SELECTED BASINS AND AREAS	54
19	CROP DISTRIBUTION AND IRRIGATED AREAS	55
20	CENTRAL ARIZONA PROJECT	56

LIST OF FIGURES CONTINUED

Figures		Page
21	LAND OWNERSHIP BY LOCATION.	58
22	COPPER MINES AND SULFURIC ACID PLANTS IN ARIZONA	59
23	VARIOUS MINERAL DEPOSITS IN ARIZONA	60
24	POWER SOURCES IN ARIZONA	61
25	DAILY ELECTRIC PEAKS IN ARIZONA	63
26	SEASONAL PEAK ELECTRIC LOADS IN ARIZONA	64
27	ARIZONA TOTAL ENERGY CONSUMPTION.	65
28	SPACE COOLING PROJECT - FEDERAL LANDS	79
29	INLET AND OUTLET CONDITIONS FOR THE HEAT EXCHANGER.	81
30	DISTRICT HEATING AND COOLING - PRIVATE LAND	87
31	SCHEMATIC REPRESENTATION OF DISTRICT HEATING AND COOLING SYSTEM	89
32	DESALINATION PROJECT - INDIAN LANDS	100
33	IRRIGATION PUMPING/PEAK POWER -STATE LAND	106
34	SUGAR PLANT OUTSIDE PHOENIX - PRIVATE LAND.	110
35	FUEL PRICE PROJECTION COMPARISONS OF CASCADED 300°F AND 350°F GEOTHERMAL SYSTEMS TO FOSSIL FUELS	113
36	ESTIMATED HEATING ENERGY USE IN SELECTED 25°C TEMPERATURE RANGES	116
37	FOSSIL FUEL PRICE PROJECTIONS	120
38	PROJECTIONS OF COST OF POWER PRODUCTION	121
39	AVERAGE U.S. PETROLEUM AND GEOTHERMAL WELL COSTS	125

POTENTIAL OF GEOTHERMAL ENERGY IN ARIZONA

a part of

Arizona Participation in Regional Operations Research for the Development of Geothermal Energy, Southwest United States

Final Report for the period June 12, 1977 - June 11, 1978

I. INTRODUCTION

A. PROJECT ORGANIZATION

The State of Arizona is participating in a geothermal energy development and planning project for the Southwestern U.S.A., sponsored by the Department of Energy and the Four Corners Regional Development Commission. Some of the costs have been shared by the State of New Mexico and the New Mexico Energy Institute, but also others (e.g., the University of Arizona for the participation by the State of Arizona). The study is being directed and coordinated by the New Mexico Energy Institute at New Mexico State University, with participation by the States of Arizona, Colorado, Nevada, New Mexico and Utah.

1. Coordination and Monitoring of Arizona Team Efforts

The Arizona Solar Energy Research Commission in the State of Arizona is the state coordinator and serves as coordinator on policies and as monitor of the Arizona State Team efforts. It has subcontracted most of the work to the Bureau of Geology and Mineral Technology, University of Arizona as outlined below. It also has provided input of institutional and other State of Arizona data as time permitted.

2. Collection of Arizona Geological and Geothermal Data

The Bureau of Geology and Mineral Technology, Geological Survey Branch, University of Arizona, had the responsibility of supplying the scientific and technical information to the project. In particular this includes the compilation of regional geological data, district or area geological data and site geological data concerning geothermal energy potential in the State of Arizona. The data generated was to be used to compile the data for the New Mexico Energy Institute's scenario program for geothermal energy evaluation in the State of Arizona.

3. Preparation of Arizona's Geothermal Utilization Scenarios

The Department of Chemical Engineering, University of Arizona was to make a series of process evaluations and was to prepare preliminary block process diagrams, depicting scenarios for the utilization of geothermal

energy in the State of Arizona. A list of all suggested uses would be compiled and maintained, but the major effort would concentrate upon industries in the agricultural, industrial and municipal sectors of the State.

B. OBJECTIVES OF THE PROJECT

The detailed objective and research plan was outlined in the original two-volume proposal submitted to DOE and the Four Corners Regional Development Commission, coordinated by the New Mexico Energy Institute. The following is a summary of those objectives:

1. To Provide the State of Arizona with a viable option which, if exercised, should lead to an environmentally acceptable time-phased commercial development of geothermal energy.

2. To be effective, the program must address local and regional problems.

3. Adopt a mission-oriented approach, having as its goal the acceleration of geothermal energy in commercial applications.

4. Solicit and include local input from interested parties in the state.

5. Develop use scenarios for the time-phased application of geothermal resources, based on the previous objectives.

6. Perform an economic analysis with energy alternatives to ascertain whether a distinct economic advantage exists for geothermal development.

7. Project estimates of electric power costs for geothermal applications and alternatives or conventional sources and these projections should consider alternative actions (i.e. technological improvement, tax incentives or loan guarantees) and their impact.

8. Identify potential regional contributions to the national energy goal.

9. Identify the type, magnitude and scheduling of public action.

Meeting these objectives was to involve conducting an operations research and systems analysis in sufficient breadth and depth to support the formulation of realistic detailed scenarios for the development and commerical utilization of the several geothermal energy resources in the region, considering both electric and non-electric applications of geothermal energy and identifying potential uses and users of the resources, prospective utilization cycles and required development time scales. In developing the scenarios it was considered to have the active participation of industry, state and local governments and the local communities. This study was to include a preliminary analysis of the scenarios to identify impediments to their realization and recommendations for public actions.

In carrying out this project, the following were to be included:

1. Data Pertaining to the Geothermal Energy Resource Base

   a. Location, properties and expected magnitude of all known geothermal resource areas (KGRA's) in the region.

   b. Location, properties and expected magnitude of all potential geothermal resource areas (PGRA's) in the region.

   c. Assessment of the state of knowledge concerning the amount and locations of geothermal energy resources in the region.

   d. Land ownership of all KGRA's and PGRA's (Federal, State, County, Private, Other).

   e. Leases presently applied for.

   f. Exploration and assessment activities completed and in progress.

   g. Information available or inferrable concerning industry plans for exploration, assessment, development, or production.

2. Data Pertaining to Utilization of the Resource

   a. Present usage and users, and their distribution geographically and with respect to transportation, raw materials, labor markets, and other infrastructural elements necessary for successful industrial, agricultural or commercial activities.

   b. Present plans or ongoing projects for new or expanded usage such as new housing developments, industrial expansion or translocated industries.

   c. Present projections for growth in energy consumption in the region through the year 2020, broken down by state, location and type of consumption.

   d. Projections of the availability and cost of alternate energy sources.

   e. Growth plans for prospective energy users (electric and nonelectric).

   f. Prospective users (electric and nonelectric). Their present energy sources and projected availability of those sources through 2020.

3. Data Pertaining to Legal and Institutional Factors

   a. Existing laws which affect the development process (Federal, State, Local).

   b. Regulatory bodies which impact on geothermal enterprises and their specific charters.

   c. Present policies of these bodies.

   d. Business practices, policies and relationships of industrial entities which may significantly affect the potential for utilization of geothermal energy resources.

e. Applicable environmental standards (Federal, State, local).

f. Existing community attitudes and attitudes of those who purport to represent the community (e.g. action groups).

g. Existing land-use plans.

h. Existing water-use plans and water availability.

i. Socio-economic conditions at each prospective site.

4. Data Pertaining to the Economics of Resource Exploitation

a. Major cost factors in exploration and assessment.

b. Major cost factors in field development.

c. Major cost factors in utilization.

d. Tax policies (Federal, State, Local).

e. Capital costs - by industry.

f. Capital amortization policies.

5. Data Pertaining to Technology Development

a. Ongoing federal and non-federal programs and target dates for technology readiness.

6. Data Pertaining to Regional Industry Status

a. Capital position - by industry.

b. Manpower availability.

c. Equipment availability.

As used here the term scenario refers to a reasonable statement of what could be achieved in bringing geothermal power, both electric and non-electric, "on-line". By this definition the scenario is not a projection or prediction of what is likely to happen based on past and present conditions and present programs for geothermal development but it involves positive actions which must be taken by the private and public sectors in order for the scenario to materialize.

For each scenario the following things were to be prepared.

1. A tentative development schedule for each site.

2. A schedule of required decisions by each participant in the development, including approval decisions by regulatory bodies.

3. Delineation of specific existing impediments to each required favorable decision.

4. Analyses of the possible federal or state programs which could enhance the probability of achieving timely development.

The regional program progress will be based on a recognition of the fact that a series of activities must be carried out in order for a geothermal energy resource to progress from an undiscovered resource status to a productive energy utilization status. Included in these activities are geological and geophysical exploration, reservoir assessment and evaluation, reservoir development, plant design and plant construction. Quantitative measures of the resources involved in each of these activities or phases of development can be useful gross indicators of progress in regional geothermal energy resource development.

Several comments regarding these objectives were also made at the start of the project with respect to the State of Arizona as follows:

1. Due to a lack of geological field data on a state-wide basis for geothermal energy, there must be much speculative data provided for the operations research scenarios.

2. Since many persons within the State, as well as many in the other participating states believe that much of the operations research program is getting the "cart before the horse", i.e. "hard data" are needed before some of the scenarios can have real meaning, it was anticipated that (a) educated guesses could be made to supply the data requests and at the same time, (b) major effort would be devoted to collecting the Arizona geological geothermal data and preparing the Arizona utilization scenarios, so that such know-how could be established for the potentialities of geothermal energy in Arizona.

3. Since in the regional scenario preparation, the interpretation of highly specialized geological data must by necessity at times be interpreted by non-geological groups, it was anticipated and desired that members of the Arizona team must interact and review certain aspects of the resulting scenarios. Moreover one should interest as many people and institutions as possible in order to ensure the feasibility and success of geothermal energy when and if developed.

C. RELATED ORIENTATION INFORMATION

In order to have the appropriate background on geothermal energy and also to understand better the potential uses of geothermal energy in Arizona we conducted a literature survey on the present uses of geothermal energy in other places in the U.S.A. and throughout the world. Geothermal energy has already been successfully utilized in many places such as Italy, New Zealand, Iceland, Japan, Soviet Union and the United States, especially in the Geyser region of California. If not for the cheap oil and gas, geothermal energy would have been much more advanced.

So far the main emphasis on use of geothermal energy was on electrical power production where steam was available with secondary

consideration to district space heating. Some 1360 MW of power plants are already available in the world and additional power plants of some 600 MW total are in construction. The geothermal power in the U.S.A. is presently around 600 MW and it will be doubled in the next few years. Table 1 shows the electricity generating capacity in the world and the projections for this century. Relatively few other uses of geothermal energy can be found in the literature. A brief summary of the 78 relevant references found in the literature as well as the list of these references are given in Appendix 1 of this report.

It is also interesting to note that geothermal energy is being used and promoted in developed countries and it has great advantages for the non-developed countries. First, it reduces the need for expensive oil and second, smaller power units can be constructed in the range of 15-50 MW, which are average loads for small and medium size communities. For the above reasons geothermal energy if available, might be the preferred energy resource in remote areas of well developed countries. In the past, geothermal water has been used for health purposes spas and for the recovery of chemicals from the brines. These along with other domestic and industrial uses are being considered for wider application.

Geothermal energy is commonly compared with solar energy especially with regard to the low grade heat and low heat density. However, geothermal energy currently has more potential since it is a constant heat supply and needs no heat storage as in the case of solar energy source.

Finally, geothermal energy at temperature levels of up to 250°C is quite feasible to obtain and is available in large quantities and therefore the use of this low grade temperature in the form of heat is a major consideration in this study. Since most of the industrial energy use is indeed in this range of temperature and in fact most of the heat used is at even lower temperatures than 200°C, the geothermal energy is applicable in a wide variety of areas. The list of industries for which low grade heat is required could be very long. The range of temperature needed by the various users is given in Figure 1.

TABLE 1 (*)

ELECTRICITY GENERATING CAPACITY
FROM GEOTHERMAL RESOURCES

	1976 Installed Capacity (MW)	1985 Estimated Capacity (MW)	2000 Estimated Capacity (MW)
United States	522	6,000	20,000
Italy	421	800	-
New Zealand	202	400	1,400
Japan	70	2,000	50,000
Mexico	78.5	400-1,400	1,500-20,000
Soviet Union	5.7	-	-
Iceland	2.5	150	500
Turkey	0.5	400	1,000
Canada	-	10	-
Costa Rica	-	100	-
El Salvador	60	180	-
Guatemala	-	100	-
Honduras	-	100	-
Nicaragua	-	150-200	300-400
Panama	-	60	-
Argentina	-	20	-
Portugal	-	30	100
Spain	-	25	200
Kenya	-	30	60-90
Indonesia	-	30-100	500-6,000
Philippines	-	300	-
Taiwan	-	50	200
Totals	1,362.2	11,335-12,475	14,775-100,000

(*) Meidav, T. et al, 1977, An update of World Geothermal Energy Development, J. Geothermal Energy, Vol. 5, No. 5, p. 34.

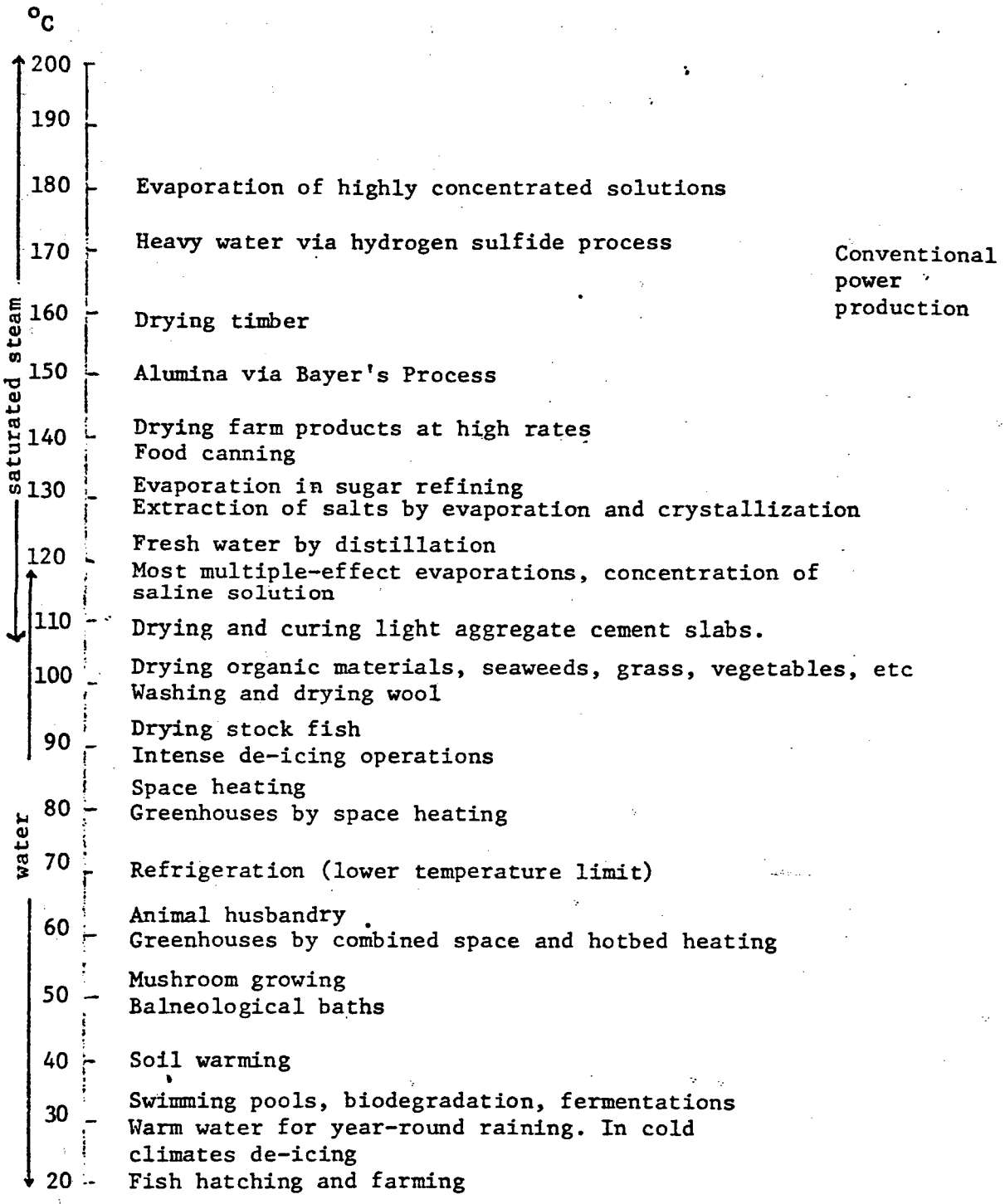

FIGURE 1: TEMPERATURE RANGES FOR DIFFERENT GEOTHERMAL USES (*)

(*) Reistad, G.M., 1975, a. Analysis of potential non-electric applications of geothermal energy and their place in the national economy; Livermore, California, Lawrence Livermore Lab., UCRL51747.

II. GEOTHERMAL RESOURCES IN ARIZONA

A. RULES, REGULATIONS AND INSTITUTIONAL ASPECTS

One of the major problems involved in geothermal energy exploration and use is the compliance with many rules and regulations, both state and federal. What follows is our attempt to outline the various State of Arizona governmental agencies which are involved in the development and use of geothermal energy. Recent legislations in the State affecting geothermal use development are also summarized. Also provided are the various State and federal leasing practices and requirements. It is hoped that this summary will help a potential developer in meeting the various state and federal requirements in an efficient and timely manner.

1. Established Executive Offices

Arizona lacks an executive office which deals exclusively with geothermal development. However, the State Land Department has exclusive lease rights to State trust lands and the Oil and Gas Conservation Commission has exclusive statewide regulatory authority. By virtue of Senate Bill 1018 in 1975, and a subsequent amendment in 1977, House Bill 2062, the Arizona Solar Energy Research Commission was created and empowered to coordinate and encourage the support of all solar and advanced alternate (including geothermal) energy systems research. As provided by law, ASERC shall:

"Encourage efforts by research institutions, local government institutions and home builders in obtaining technical and financial support from the federal government for their activities in solar and advanced alternate energy systems". (Senate Bill 1018 - A.R.S. s 41-574 #3).

ASERC plans to assume a lead role in providing information and research leading to increased geothermal production that is harmonious to the environment.

2. Agencies Related to Geothermal Development

In Arizona state government there are three agencies which include geothermal development as a part of their responsibility: i) Oil & Gas Conservation Commission, ii) Arizona Solar Energy Research Commission, iii) The Arizona State Land Department.

i) The Oil and Gas Conservation Commission regulates the development of oil, natural gas, and geothermal resources within the state and serves as technical consultant to resource developers throughout the state. As provided by law, "the Commission shall so supervise the drilling, operation, maintenance and abandonment of geothermal resource wells as to encourage the greatest ultimate

economic recovery of geothermal resources, to prevent damage to and waste from underground geothermal reservoirs, to prevent damage to or contamination of any waters of the state or any formation productive or potentially productive of fossil fuels or helium gas, and to prevent the discharge of any fluids or gases or disposition of substances harmful to the environment by reasons of drilling, operation, maintenance, or abandonment of geothermal resource wells." (A.R.S. § 27-652).

The Oil and Gas Conservation Commission consists of six members of which five are appointed by the Governor with Senate consent. The State Land Commission serves as an ex-officio member. The terms for appointed members are five years.

ii) The Arizona Solar Energy Research Commission (ASERC) collects, analyzes, and provides information and data relating to solar energy technology and other non-polluting renewable energy sources. ASERC cooperates with all federal agencies involved in solar and advanced energy (including geothermal) technology development. The Arizona Solar Energy Research Commission has seventeen members. At the present time the Commission is comprised of the Chairman of the Arizona Power Authority, six representatives from Arizona's three state universities, eight representatives of the business and industrial sectors, and as ex-officio members, the President of the Arizona Senate and the Speaker of the House of Representatives. New legislation provides three year terms.

iii) The Arizona State Land Department is responsible for the planning, development and protection of all forests and natural resources located on state lands. In its administration of the 9.6 million acres of state trust lands (13% of land in Arizona), the Department among other duties, is authorized to:

i. Create long range plans for the exchange, lease, or the sale of state lands (A.R.S. 37-102);

ii. Exercise the power of eminent domain (A.R.S. 37-461);

iii. Officially represent the state in any matter between state and federal government concerning public lands (A.R.S. 37-102);

iv. Engage in many activities administratively relating to the control and supervision of the lands and waters of the state (A.R.S. 37-102, 37-132).

In addition, new legislation (Chapter 87, House Bill 2257, 33rd Legislature) provides that the State Land Department may lease state lands for geothermal development. Regulations pursuant to this law are in the process of being developed by the Department.

3. Organization of the State Legislature

i) Legislature Committees having Prime Responsibility for Geothermal Development and Regulation: A general organization chart of the Arizona State Legislature is shown in Figure 2. The 14 standing committees in the House and the 10 committees in the Senate serve as major forums for the deliberations on the bills. The key committee for geothermal matters in the House is the 15-member Natural Resources Committee, while the Senate has a 9-member committee on Natural Resources and Environment.

ii) Legislative Committees having Oversight Responsibility for Geothermal Development and Regulation: No legislative committee in Arizona is specifically charged with responsibility for oversight of geothermal development and regulation. However, some oversight is carried out as part of the annual appropriations process of the appropriations committees of both houses, and by the Joint Legislative Budget Committee.

4. Legislation Which May be Considered by Future Sessions

i) Dates of the next Legislative session: The Arizona State Legislature convenes on the second Monday in January each year. For this session, the starting date is January 9, 1978. The last day for submission of bills is 36 days after the start of the first session, and 29 days after the start of the second session. As 1978 marks the meeting of the second session of the Thirty-third Legislature, the last day for submission of bills is February 7, 1978.

ii) Anticipated topics/needed Legislation: It appears unlikely that legislation relating to geothermal development will be introduced in Arizona in 1978. Considerable effort went into the preparation of House Bill 2257, passed in 1977, and detailed regulations to implement the leasing provisions are presently being drafted by the State Land Department. It is likely that most interested groups will wait to see how the new laws and regulations will work before mounting a campaign for changes.

There are at least four provisions which may be examined when the time for changes arrives. One concerns the constitutional provision for competitive bids when the Arizona State Land Department sells "products of the land". A 1950 constitutional amendment exempted oil and gas exploration leases from this provision, in order to stimulate exploration and discovery. Some think a similar amendment would be appropriate for geothermal development, especially since many of the provisions of the law are parallel for geothermal and oil/gas resources.

Another need may be further clarification to distinguish geothermal water resources from other water. A criterion of 80°C was part of the original House Bill 2257 last year, but the provision was struck.

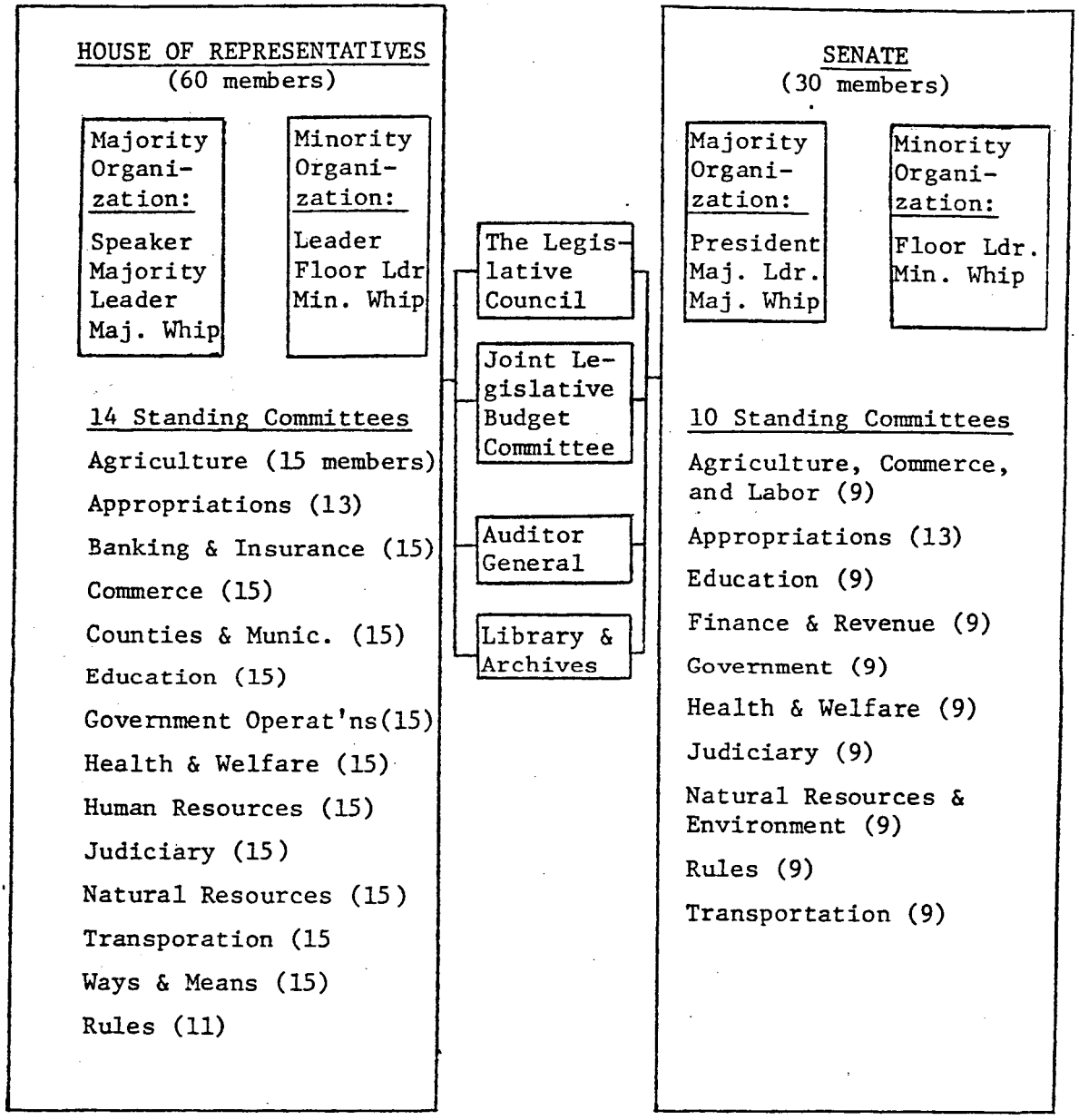

FIGURE 2 : GENERAL ORGANIZATION CHART OF THE ARIZONA STATE LEGISLATURE (*)

(*)Staff members are attached to most of the subdivisions of the Legislature, but are not shown here for the sake of simplicity.

Opponents of this measure pointed out the limitations which would be placed on low temperature resource development by the temperature restriction. Additional criterian needs to be incorporated to make regulation and administration more predictable.

A third item of consideration may be the granting of tax breaks to those industries or residences who either develop or use geothermal energy to alleviate their dependency on oil and natural gas. Legislation granting tax credits and exemptions to those users of solar energy has been enacted this year by the First Regular Session of the Thirty-third Arizona Legislature. *

Finally, a provision to retain State ownership of geothermal rights on State/private land trades could be added.

B. LEASING PROCEDURES

1. Leasing of State Lands

i) Geothermal leases may be initiated by either of two methods, each of which require a competitive bid sale process:

   a. The Land Department may designate likely resource areas which they wish to lease.

   b. An individual or company may apply for a lease on a given tract of state land.

ii) State Land Department reviews proposals, and if they are satisfactory, a notice of availability for lease is published for 10 weeks.

iii) The lease is awarded to the highest qualified bidder with payment of the first year's rental.

Arizona has recently enacted legislation that provides and sets procedures for the leasing of state lands for geothermal resources development. The major provisions of this stature, Chapter 87, House Bill 2257, * are as follows:

i) The State Land Department shall determine and designate known geothermal resource areas (KGRA) into which the lands shall be divided in "reasonably compact" tracts for leasing purposes.

ii) A notice of availability for lease is then published for 10 weeks in Statewide newspapers and publications.

* (H.B. 2068 - Solar Energy tax credit: H.B. 2063 - Solar Energy devices tax exemption)

iii) Upon receipt of an application to lease any state lands (which shall include a description of the land, name and address of applicant, and a $25 filing fee), the Land Department shall offer the tract(s) for lease to the highest and best bidder. The Department shall publish a call for bids. (The State Land Commissioner reserves the right to reject any or all bids).

iv) Bidding shall be on a basis of highest first year's bonus to be paid to the State Land Department at the time of declaration of the highest and best bidder.

v) The State Land Department shall determine the royalty which shall not be less than 12½% of the gross value of the resource at the well head.

vi) The State Land Department shall determine annual rental which shall be not less than $1 per acre for each year the lease is in effect.

vii) The lease shall be for a primary term of 10 years with 2 year extensions on active drilling sites.

viii) There may not be more than 2,560 acres included in any one lease.

ix) Requests to enter into unit operations or pools so as to expedite geothermal resource development must have the approval of the State Land Department.

x) Practices that delay the discovery or development of geothermal resources are illegal.

The State Land Department is given the power to enact regulations that are not explicitly written in this legislation. As mentioned before under "Organization of State Government", regulations pursuant to this law are in the process of being developed by the Department.

The primary unanswered questions in terms of legal procedures which must be initiated are at the state level. After completion of the leasing agreements, two general areas within the State of Arizona's legal requirements must be clarified:

a. Determine legal requirements for exploratory drilling with respect to:
    1. County permits, studies, hearings, and/or certifications.
    2. State permits, studies, hearings, and/or certifications.

b. Determine legal requirements for development of geothermal sources with respect to:
    1. County permits, studies, hearings, and/or certifications.
    2. State permits, studies, hearings, and/or certifications.

New rules and regulations were recently published for the Oil and Gas Conservation Commission and the State Land Department (Articles 2 and 22 - Geothermal Resources).

2. Leasing of Federal Lands

i) U.S. Department of Interior serves as the lead agency. This department's Bureau of Land Management (BLM) controls all federal land-geothermal leasing.

ii) The USDA Forest Services, the Fish and Wildlife Service, and the U.S. Geological Survey join in the preparation of environmental assessments.

iii) There are two basic leasing processes on Federal lands. The choice of which is used depends on whether the land in question is in a "Known Geothermal Resource Area" (KGRA). A KGRA is defined as "an area in which the geology, nearby discoveries, competitive interest, or other indicia would, in the opinion of the secretary, engender a belief in men who are experienced in the subject matter that the prospects for extraction of geothermal steam or associated geothermal steam or associated geothermal resources are good enough to warrant expenditures of money for that purpose."*

In other words, KGRAs would be delineated by geological information available to USGS, or by the overlap of several lease applications.

a. If an area up for lease is part of a KGRA, it is subject to competitive bidding as shown in Figure 3. This process consists of:

1. Applicant initiates lease request.
2. BLM forwards this to USGS.
3. USGS analyzes request to determine that it qualifies as a KGRA.
4. Surface management agencies assess the environment impact.
5. If acceptable, BLM publishes a request for competitive bidding.
6. Either no bid or best bid is awarded the lease.

b. If an area up for lease is not part of a KGRA, it is subject to the non-competitive leasing process as shown in Figure 4:

1. Applicant initiates request.
2. BLM forwards this to USGS
3. USGS analyzes requests to determine that the area is not a KGRA.
4. BLM reviews and forwards to appropriate land management agencies.
5. Surface management agencies assess the environmental impact.

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* Title 43 CFR Part 3000 section 3200.0-5(k)

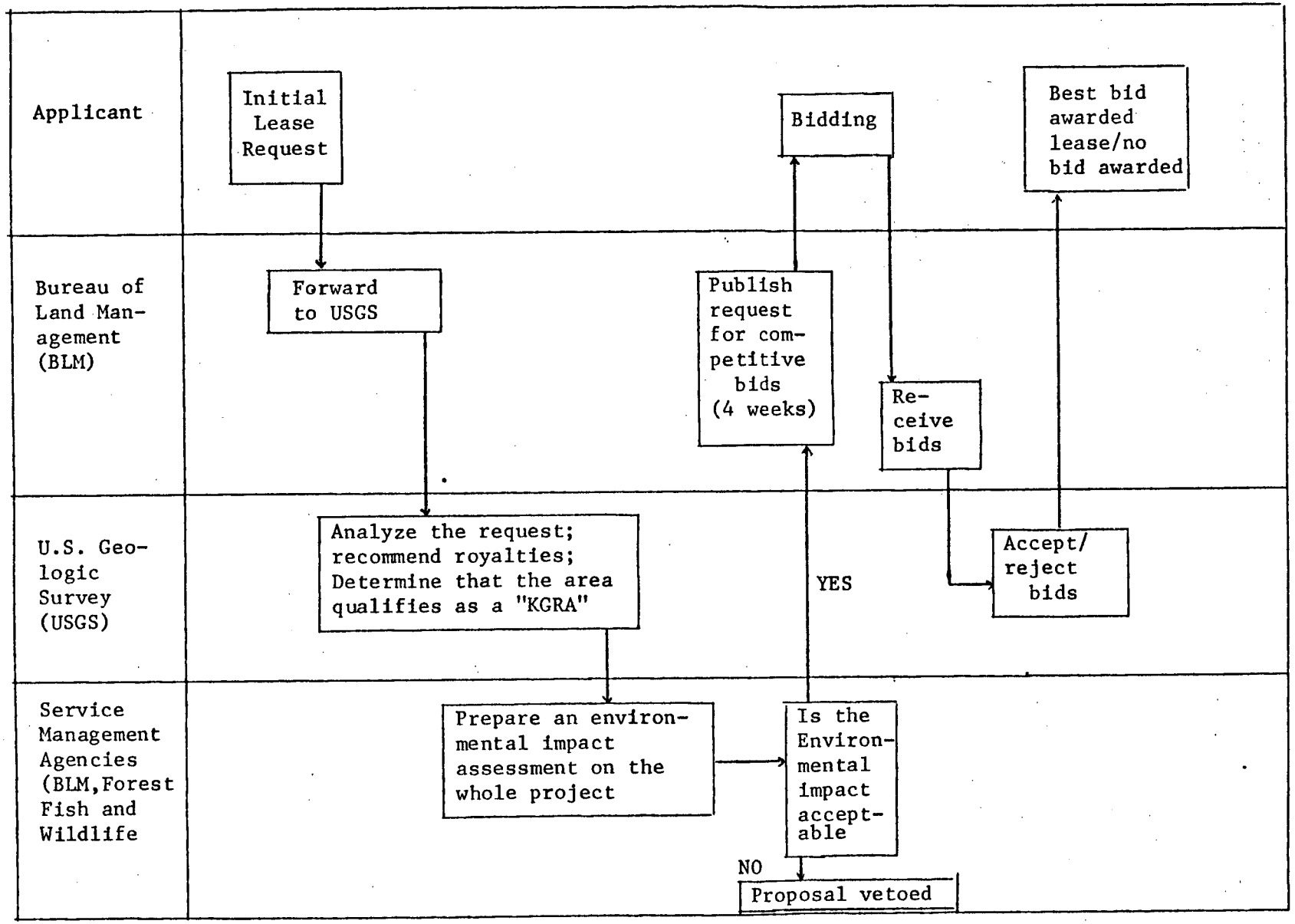


FIGURE 3: COMPETITIVE BIDDING PROCESS FOR THE LEASING OF FEDERAL (NON-INDIAN) LANDS FOR GEOTHERMAL DEVELOPMENT

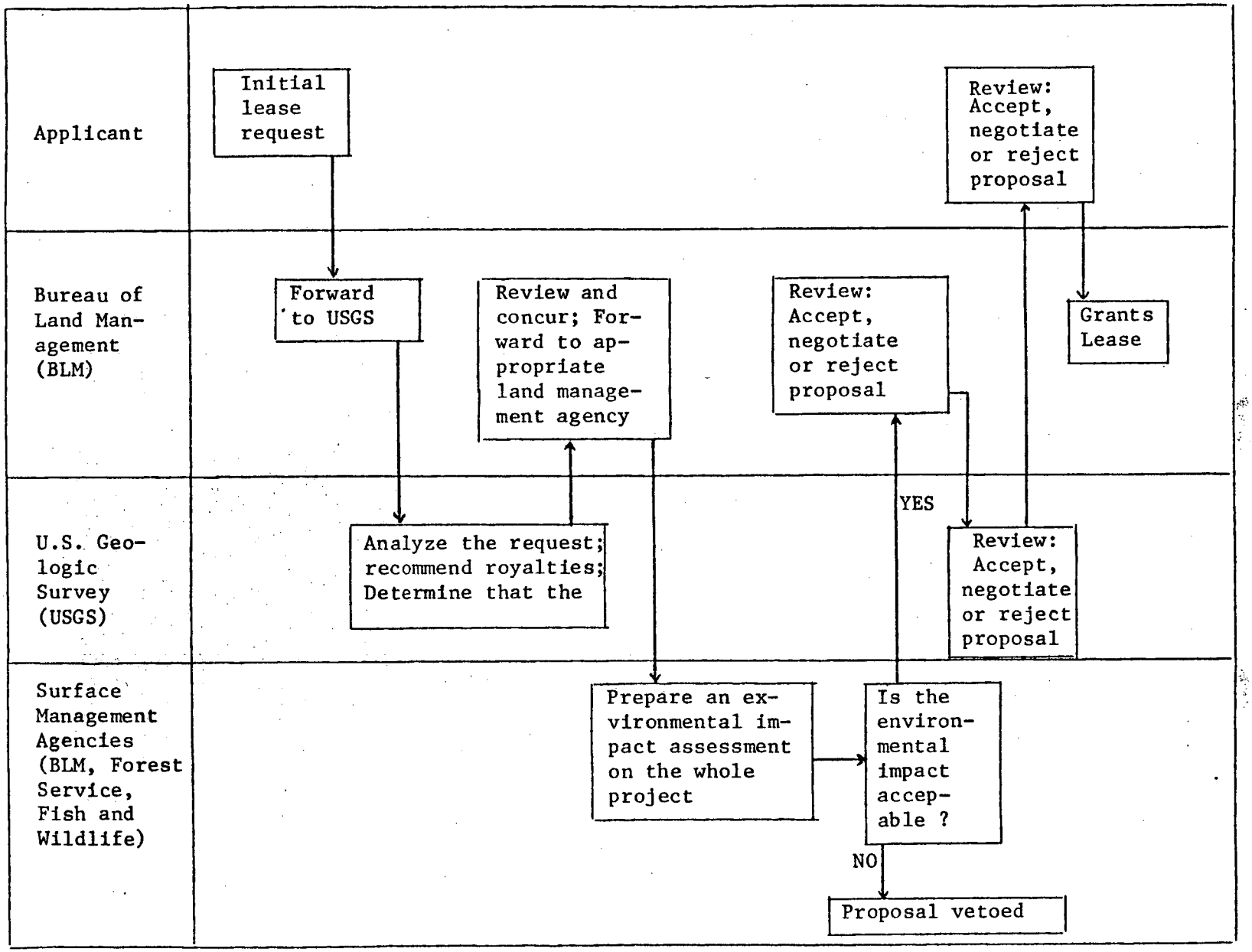


FIGURE 4: NON-COMPETITIVE LEASING PROCESS FOR FEDERAL (NON-INDIAN) LANDS FOR GEOTHERMAL DEVELOPMENT

6. BLM reviews and accepts, negotiates, or rejects proposals.
7. USGS reviews and accepts, negotiates, or rejects proposals.
8. Applicant reviews and accepts, negotiates, or rejects proposals.
9. Lease is granted or not granted.

3. Leasing of Private Lands

There are no state regulations pertaining to the leasing of private lands for geothermal development. However, the Oil and Gas Conservation Commission supervises all "drilling, operation, maintenance and abandonment of geothermal resource wells". A proposed geothermal drilling operation must apply to the Oil and Gas Conservation Commission for a drilling permit. This requirement applies to State, Federal, Indian or private land. It is possible that both the Oil and Gas Commission and the State Land Department could be involved in the cooperative development of a geothermal resource pool.

4. Leasing of Indian Land

Actions that relate to trust resources on federal lands ultimately rest with the Secretary of the Department of the Interior. Accordingly, the leasing of Indian lands for geothermal development has been assigned to the Bureau of Indian Affairs (BIA), and U.S. Geological Survey (USGS). The BIA provides technical and administrative assistance to the Indian Tribe in bid publication, lease contract review, and operations monitoring. USGS evaluates any environmental assessment or impact statement and also provides similar technical assistance. In addition, the USGS has enforcement authority in operation compliance of resource development. Various guidelines for development, however, such as royalties and leasing terms, are left to the Tribe to initiate, giving them a fair degree of flexibility.

5. Creating Incentives

Presently, there are no explicit state enacted incentives for geothermal development. However, the several state agencies which provide technical and administrative assistance, see their actions as indirect inducement techniques. Such mechanisms include the simplification of drilling regulations, inter-agency cooperation with respect to unitization and pooling of resources, and cooperation in monitoring, reporting, and evaluating geothermal resource potential.

6. Pertinent Recent Court Cases and Impacts

There have been no recent court cases in Arizona which relate to geothermal resources. However, sources at the Arizona Oil and Gas Commission cite the case of U.S. v. Union Oil, opinion number 74--1574 of the Ninth Circuit Court of Appeals, as significant. The case is presently before the U.S. Supreme Court.

C. GEOTHERMAL RESOURCE DATA

1. Practical Experience with Geothermal Exploration in Arizona

There has been a limited amount of exploration for geothermal energy in Arizona. In order to learn from that experience, we approached a few companies which were involved in this exploration and asked them for their remarks regarding the problems encountered. Very few replied to our letters of inquiry; therefore we cannot present a full picture of that experience. However, we shall present at least some of the remarks received due to their immediate relevance to our work.

One company which deals with the drilling process suggested that a single department should deal with the issuing of permits even if many agencies have to give their approval. Another company stated it is virtually impossible to document the various problems and experiences they have encountered in geothermal exploration and development, and offered to discuss this with us at a later stage. However, a third company did give us some interesting replies to our questions as follows:

> As far as geothermal exploration in Arizona is concerned, like geological, hydrological, geochemical and geophysical aspects, there were no significant institutional problems and most of those involved were actually very cooperative.

However, as far as the site-specific phase is concerned, companies basically concentrated on private land because the delay encountered in filing for prospective geothermal leases on BLM administered land is outrageous. The most interesting reply, however, was that they deliberately stay away from any known geothermal resource area (KGRA) because of time delays and the usually unworkable lease arrangements required for these areas. We believe presenting even these few remarks to be worthwhile.

From past experience with mineral leasing and development the situation that developers fear most is dealing with the regulations and bureaucracy, not the law. That is why the law should be completely clear and simple if we want a fast development of geothermal energy.

2. Introduction to the Arizona Geology

The paucity of activity in the area of geothermal energy in the State of Arizona quite probably has been caused by institutional impediments and the desert environment.

With the passage of Arizona House Bill 2257, providing for the leasing of state lands for geothermal resources, by both the Arizona House and Senate and approval by the Governor on May 23, 1977, the Arizona State Land Department is now able to accept geothermal lease

requests for state lands. The rules and regulations for these leases and other geothermal activities have already been discussed.

The desert environment and receding water tables in Arizona have tended to mask potential geothermal sites. However, there are over 40 hot or warm springs currently mapped in the state. The majority of these known thermal springs are situated in the desert environment of the Arizona Basin and Range physiographic province. A detailed list of these hot springs is given in Table 2.

With the advent of agriculture, numerous irrigation wells drilled in the Phoenix, Casa Grande, Tucson, Florence, Safford and Yuma areas were/are thermal wells. These wells indicate considerable potential for geothermal energy resources. The outcrops of Tertiary and Quaternary igneous rocks shown on the geologic map of Arizona (Fig. 5) further indicate considerable potential target areas in the state. In southern Apache County, south of St. Johns, is a large Tertiary-Quaternary quiet volcanic field (lavender colored on map). This field has potential for both low and high temperature (+200°C) hydrothermal resources as well as potential for hot dry rock.

The San Bernardino volcanic field lies in the southeast corner of Cochise County. This volcanic field, Quaternary in age, has considerable potential for low and high temperature hydrothermal resources as well as for hot dry rock. The igneous extrusive and intrusive rocks fringing Yavapai County and in the Flagstaff area, Coconino County, also present excellent areas for exploration for low to high temperature hydrothermal resources and hot dry rock.

The Quaternary and Quaternary-Tertiary volcanic (igneous extrusive) rocks of Yuma, Maricopa and Western Pima counties again present excellent areas in which to seek geothermal resources. In fact, currently, progressing thermal gradient studies in the areas cited above further indicate the potential that these extrusive and intrusive igneous rocks have to be associated with geothermal resources.

The geologic map and cross-sections of Arizona (Fig. 5) have large areas in the southwest half of the state colored pale yellow and designated QTs in the explanation. This color and designation indicate areas of very young sediments and valley fill. In fact, some of these deep valleys in time past have been enclosed evaporite basins and now contain large quantities of buried salt and anhydrite (1,2). When the mineral anhydrite alters to the mineral gypsum the chemical reaction is exothermic (evolves heat). Possibly some of the warm waters in these deep sediment filled valleys may be attributed to this heat source (3). However, it is more probable that most warm waters in these intermountain valleys result from the deep percolation of water along faults, the warm water then rising and mixing with subsurface or possibly surface waters. Also the possible existence of unexposed, intrusive igneous rocks in these sedimentary basins must not be overlooked. There are young igneous intrusive and extrusive rocks exposed in the mountains bounding these deep sediment filled valleys.

TABLE 2

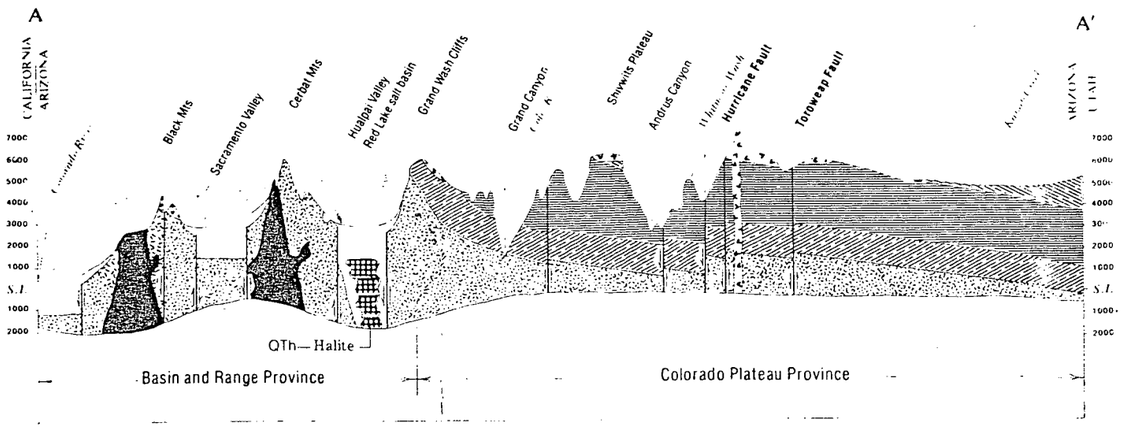
LIST OF HOT SPRINGS IN ARIZONA

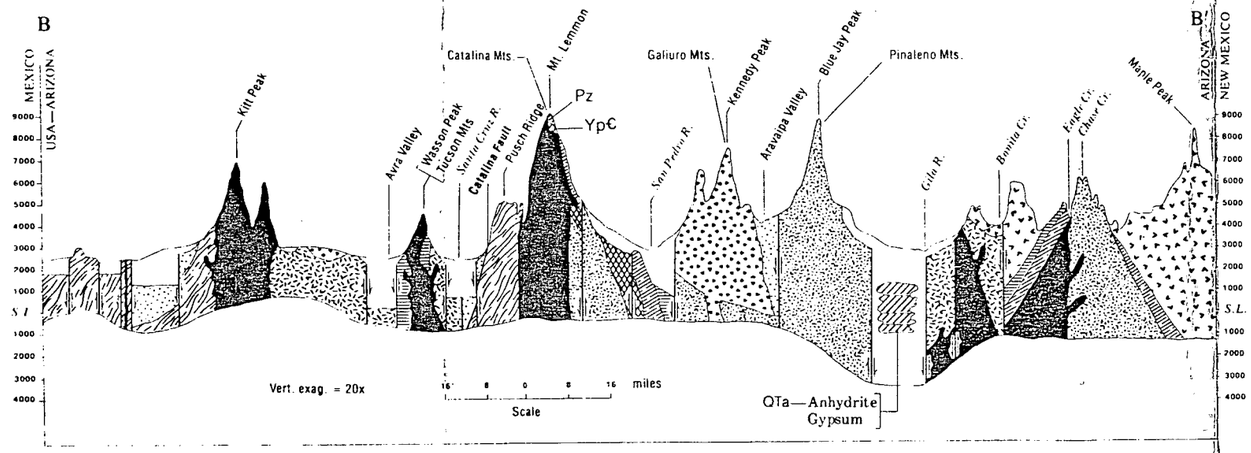
Hot Springs	Temp.	Township	Lat.	Long.
*Pioneer Spring	33°C	T2S R15E Sec 33	110°51.6'	33°12.6'N
*Lava Springs	32°C	T32N R7W Sec 6	113°05.4'W	36°12.0'N
Coffers Hot Springs	36°C	T16N R13W Sec 36	113°35.4'	34°40.8'N
Pakon Spring (Reported 38)	28°C	T35N R16W Sec 24	113°57.4'W	36°24.9'N
Quitobaquito (Reported 32)	26.5°C	T17S R7W Sec 18 SE 1/4	113°1.4W	31°57.5'N
Castle Hot Springs	50°C	T8N R1W Sec 34 SW 1/4 SW 1/4	112°21.7'W	34°59.0'N
Radium Hot Spring (Dry)	60°C	T8S R18W Sec 12 SW 1/4 SW 1/4	114°4.2'W	32°44.4'N
Indian Hot Springs	50°C	T5S R24E Sec 17 NE 1/4	109°54.0'W	33°0.1'N
Gillard Hot Springs	82°C	T5S R29E Sec 27 NE 1/4 NE 1/4	109°20.9'W	32°58.4'N
*Grapevine Spring	33°C	T5S R25E Sec 9 SE 1/4	109°51.6'W	33°1.2'N
*Spring	33°C	T5S R25E Sec 17	109°58.8'W	32°59.8'N
*Spring	34.5°C	T30N R23W	114°54'	35°42'
Aqua Caliente Hot Spring	32°C	T13S,R16E Sec 20 SW 1/4 SE 1/4	110°43.8'W	32°16.9'N
Aqua Caliente Hot Spring(Dry)	32°C	T20S R13E Sec 13 NE 1/4 NW 1/4	110°57.8'W	31°41.7'N
Verde Hot Spring	41°C	T11N R6E Sec 3 NW 1/4	111°42.5'W	34°21.3'N
Aqua Caliente Springs (Dry)	39°C	T5S R10W Sec 19 NE 1/4 NE 1/4	113°19.4'W	31°59.1'N
*Spring	37°C	T3S R16E Sec 1	110°42.0'W	33°10.2'N
Hookers Hot Spring	54.5°C	T13S R16E Sec 6 NE 1/4 NE 1/4	110°14.3'W	32°20.2'N
Clifton Hot Springs	61.0°C	T4S R30E Sec 18 SW 1/4 SE 1/4	109°17.8'W	33°4.8'N
Eagle Creek Hot Spring	42.0°C	T4S R28E Sec 35 NE 1/4 NW 1/4	109°26.4'W	33°2.9'N
Little Hanna Creek	55.5°C	T1N R31E Sec 29 SE 1/4 NE 1/4	109°10.8'w	33°22.8'N

TABLE 2 Cont...

Warm Spring	31.5°C	T4S R23E Sec 21 NE 1/4 SE 1/4	109°59.0'	33°4.3'N
Warm Spring Near Indian Hot Springs	33.0°C	T5S R24E Sec 17 NE 1/4 SE 1/4	109°54.0'	33°0.0'N
Very Small Spring or Seep Near Clifton	44.8°C	T4S R30E Sec 19 SW 1/4 NE 1/4	109°17.9'W	33°4.2'N
Warm Spring Near Hooker Hot Springs	32.5°C	T12S R21E Sec 31 NE 1/4 SW 1/4	110°14.4'W	32°20.9'N
Coolidge Dam Hot Springs	36.6°C	T3S R18E Sec. 17 SW 1/4 SE 1/4	110°31.7'W	33°10.3'N
Mescal Warm Springs	29.1°C	T3S R17E Sec 20 SW 1/4 NW 1/4	110°38.2W	33°9.3'N
Hoover Dam Hot Springs	42.2°C	T22S R65E Sec 29 SW 1/4	114°44.7'W	36°0.6'N
Warm Springs Bronco Gulch	30.0°C	T1N R20E Sec 12	110°12.7'N	33°26.4'N
Warm Spring	28.3°C	T18N R13W Sec 25 NW 1/4 SE 1/4	113°36.6'W	34°55.0'N
Honkey Spring	28.3°C	T21S R16E Sec 3 SW 1/4	110°42.2'W	31°38.1'N
Warm Spring	26.0°C	T5S R19E Sec 23 SE 1/4	110°22.5'W	32°59.o'N
*Colorado Pool	Warm	T36N R5E	111°51.6'W	36°31.8'N
*Chalk Mountain	Warm		111°45.0'W	34°5.4'N
*Roosevelt Dam	Warm		111°11.4'W	33°42.0'N
*Little Boiling	Warm		109°34.8'W	33°12.0'N
*Arsenic Cave	Warm		109°49.2'W	33°19.8'N
*Aravaipa	32.2°C	T5S R19E Sec 35	110°22.8'W	32°58.8'N
*Salt Spring	28.3°C		110°40.8'W	33°48.0'N
*Soda	Warm		111°46.8'W	34°38.4'N

* Stands for Rumored Hot Springs - have not been found or have not been field checked.





EXPLANATION

SEDIMENTARY AND VOLCANIC ROCKS

QTs — Quaternary and upper Tertiary (Upper Miocene-Pliocene) sedimentary rocks, mostly unconsolidated; includes scarce lava and silicic tuff

Ts — Middle Tertiary (Miocene and Oligocene) sedimentary rocks; locally include lava and tuff

Ks — Cretaceous sedimentary rocks

JRs — Jurassic and Triassic sedimentary rocks

QTh QTa — *Evaporites*
QTh—Halite
QTa—Anhydrite
Gypsum

QTv — Quaternary and upper Tertiary volcanic rocks, mostly basaltic in composition

Tv — Middle Tertiary volcanic rocks of silicic to basaltic composition; includes related intrusive rocks

TMzv — Lower Tertiary to Triassic volcanic rocks; includes some sedimentary rocks

PPs — Permian and Pennsylvanian sedimentary rocks; shown only on Colorado Plateau

MC Pz — Mississippian through Cambrian sedimentary rocks on Colorado Plateau; all Paleozoic sedimentary rocks in Basin and Range province

YpC — Younger Precambrian sedimentary rocks and intrusive diabase

OpC — Older Precambrian rocks of all types, including schist, gneiss, and fine- to coarse-grained igneous intrusive rocks

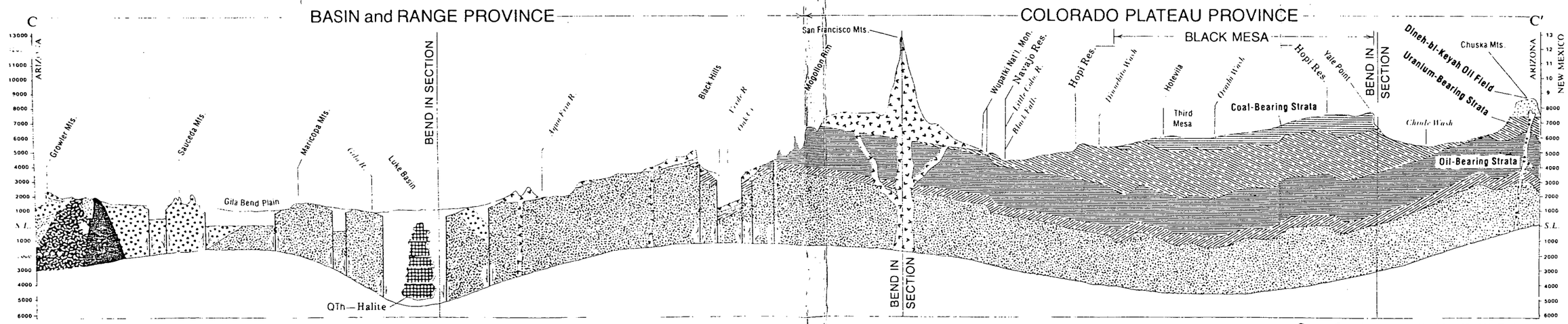
CENOZOIC
MESOZOIC
PALEOZOIC
PRECAMBRIAN

OTHER: METAMORPHIC AND INTRUSIVE IGNEOUS ROCKS

Tku — Tertiary and Upper Cretaceous intrusive igneous rocks

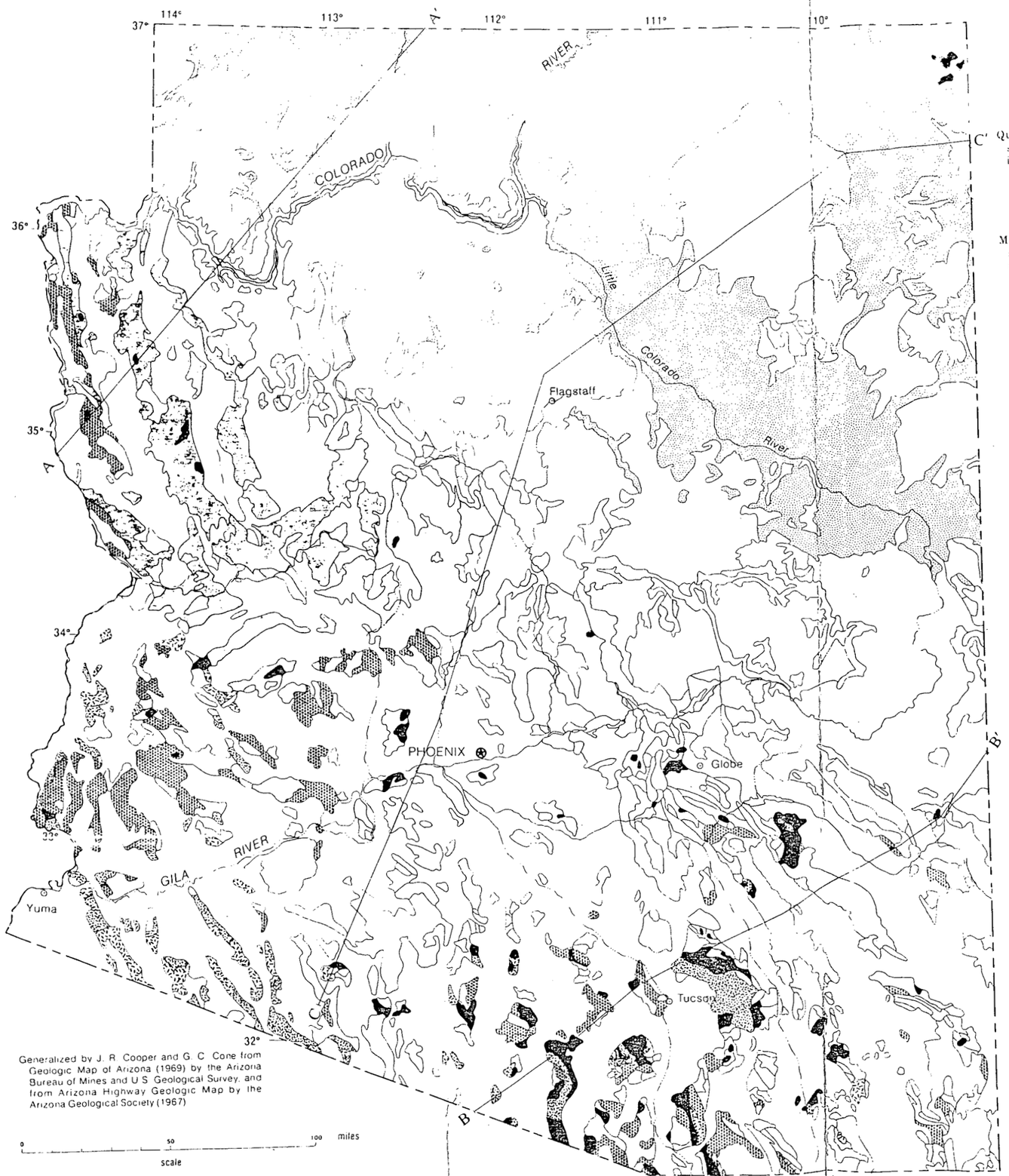
TMz — Post-Paleozoic gneiss and schist

KR — Mid-Cretaceous to Triassic intrusive igneous rocks



Cross-Sections compiled by H. W. Peirce

FIGURE 5: GEOLOGIC MAP AND CROSS SECTION OF ARIZONA



Generalized by J. R. Cooper and G. C. Cone from Geologic Map of Arizona (1969) by the Arizona Bureau of Mines and U.S. Geological Survey, and from Arizona Highway Geologic Map by the Arizona Geological Society (1967)

EXPLANATION

SEDIMENTARY AND VOLCANIC ROCKS

QTs

Quaternary and upper Tertiary (Pliocene) sedimentary rocks, mostly unconsolidated; includes scarce lava and silicic tuff

Ts

Middle Tertiary (Miocene and Oligocene) sedimentary rocks; locally include lava and tuff

Ks

Cretaceous sedimentary rocks

JRs

Jurassic and Triassic sedimentary rocks

Mesozoic sedimentary rocks

PPs

Permian and Pennsylvanian sedimentary rocks; shown only on Colorado Plateau

M€ / Pz

Mississippian through Cambrian sedimentary rocks on Colorado Plateau; all Paleozoic sedimentary rocks in Basin and Range province

Yp€

Younger Precambrian sedimentary rocks and intrusive diabase

Op€

Older Precambrian rocks of all types, including schist, gneiss, and fine- to coarse-grained igneous intrusive rocks

QTv

Quaternary and upper Tertiary volcanic rocks, mostly basaltic in composition

Tv

Middle Tertiary volcanic rocks of silicic to basaltic composition; includes related intrusive rocks

Lower Tertiary to Triassic volcanic rocks; includes some sedimentary rocks

CENOZOIC

MESOZOIC

PALEOZOIC

PRECAMBRIAN

OTHER METAMORPHIC AND INTRUSIVE IGNEOUS ROCKS

Tertiary and Upper Cretaceous intrusive igneous rocks

Post-Paleozoic gneiss and schist

Mid-Cretaceous to Triassic intrusive igneous rocks

GEOLOGIC MAP and CROSS-SECTIONS of ARIZONA

Therefore as demonstrated above, Arizona has high potential for the existence of geothermal energy resources. However, the potential is not obvious and considerable grass roots exploration work remains to be done.

1. Peirce, H.W., 1974, thick evaporites in the basin and range providence - Arizona: 4th Symposium on salt, Northern Ohio Geol. Society, Cleveland, p. 47-55.

2. Peirce, H.W., 1976, Tectonic significance of basin and range thick evaporite deposits: Arizona Geological Society Digest, Volume X, March; p. 325-339.

3. Gerlach, T., Norton, D., DeCook, K.I., and Sumner, J.S., 1975, Geothermal Water Resources in Arizona: Feasbility Study, University of Arizona U.S. Department of the Interior.

For purposes of categorizing use scenarios for use by the Core Team, site-specific scenarios geothermal resources were to be defined as follows:

Category I: "Sites for which active development work is being pursued by geothermal developers for electric energy or by other parties for non-electric (e.g. space-heating) applications". There is no current activity in this category in Arizona.

Category II: "Sites for which some activity is occurring (e.g. leasing, drilling, temperature gradient holes, etc)., but for which sufficient information is not yet available to construct specific scenarios."

Geothermal leasing activity is discussed below.

Category III: "Sites of minimal activity with essentially no substantive information to base quantity of resource or timetable for development."

Based upon data obtained from regional geologic reconnaissance, thermal springs, wells, and geochemical temperature indicators the following areas have been designated for further work.

a. Springerville - St. Johns area, Apache County, Arizona
b. Clifton - Morenci - Safford area, Greenlee and Graham Counties, Arizona
c. San Bernardino Valley area, Cochise County, Arizona.
d. Castle Hot Springs, Yavapai County, Arizona

The initial programs in these areas consisted of detailed geologic mapping, geophysical evaluations including heat flow measurements, water sampling and analyses and age dating of selected lithologic units.

The geological exploration and evaluation resulted in educated guesses concerning geothermal resources, temperatures, and availability for use in scenarios at various locations.

3. Details on the Geology of Arizona

The State of Arizona may be divided into two physiographic provinces, the Colorado Plateau in the northeast part of the state and the basin and range in the southwest part of the state. There is a transition zone between the two provinces. The complex lithologies and overall structure of the basin and range province are the result of a long history of tectonic activity that commenced during Precambrian times over one billion years ago. The physical features visible today, north and northwest trending mountain ranges and sediment-filled intermontane basins, are the result of complex tectonic activity that commenced approximately 14 million years ago and may have continued to the present in some places.

The Colorado plateau, when compared to the basin and range, is tectonically stable. The land forms that characterize this province are broad plains, plateaus, buttes and mesas. These features have been formed by differential errosion of resistant and nonresistant sedimentary rocks.*

i) Hydrothermal Geothermal Systems

In Arizona, indications of hydrothermal geothermal systems are represented by natural thermal springs and drilled wells. Thermal springs and wells are widely distributed throughout the state but are most abundant in the basin and range transition zone. The possible explanation for this relative concentration of geothermal areas follows: 1. deep circulation of meteoric water through the intense, complex fracture systems of the basin and range and transition zones; 2. igneous rock intrusions, again along fractures or zones of weakness, not exposed at the surface; 3. a combination of the prior two possibilities; 4. heat generated by radiogenic decay of radioactive elements in igneous rocks; 5. Gerlack et al** have suggested the exothermic reaction resulting from the hydration of anhydrite in the evaporation sequences of sediments that occur in some of the intermontane basins.

The paucity of thermal springs and wells, especially wells, in the Arizona section of the Colorado Plateau could be the result of lack of observation. However, the paucity most likely is the result of the plateau's relatively low heat flow.

Hydrothermal resources suitable for electrical generation are expected to be encountered in several areas around the state. These favorable areas have been determined by use of geochemical thermometers indicating projected

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* Arizona Geological Society, 1967, Arizona Highway Geologic Map, M.E. Cooley, compilier.

** Gerlack, T., Norton, D., DeCook, K.J. and Sumner, J.S., 1975, Geothermal Water Resources in Arizona: Feasibility Study, U.S. Dept. of Interior, Office of Water Resources Research.

reservoir temperatures calculated from chemical analyses of water from wells and springs. The favorable areas are the San Bernardino Valley, Clifton-Morenci-Safford, Springerville-St. Johns, Flagstaff, Phoenix, and the Hyder Valley area. Additional exploration is expected to locate other areas favorable for electrical generation from hydrothermal resources.

Hahman, Stone and Witcher*, in their preliminary map compilation of the geothermal energy resources of Arizona, showed both high temperature and low to moderate temperature areas. Most of the favorable areas on this map are situated in the Basin and Range physiographic province. Preliminary investigations seem to indicate that low to moderate temperature geothermal energy will be available for the use of most of the populated areas in the Arizona Basin and range province. The current major uses of low to moderate temperature geothermal resources are in space heating, cooling and agribusiness.

ii) Hot Dry Rock

Arizona has considerable potential for hot dry rock geothermal energy for use in electrical generation, space heating and cooling, agribusiness, etc. Technology's advancement rate will determine the practicality of developing this energy source in Arizona.

Byerly and Stolt**, in their article on the Curie point isotherm in northern and central Arizona, define a rather broad zone through central Arizona where the Curie point is less than 10 km and often less than 5 km below the land surface. The Curie point, that temperature at which magnetic materials lose their magnetic properties, of magnetite is 575°C***. Therefore, if the Curie point is at 5 km one might reasonably expect to have a temperature of approximately 575°C at that depth. The zone where the Curie point is within 5 km of the surface would be a much more favorable zone in which to look for hot dry rock and/or hydrothermal resources associated with young, concealed, silicic, intrusive rocks than a section where the Curie point is at a depth of 20 or 30 km.

In conclusion, Arizona has considerable potential for geothermal energy resources. The geological manifestations of these resources are often very subtle. However, these geothermal resources, for both electric and nonelectric uses, can be located and developed through prudent, integrated programs involving geology, geophysics and geochemistry.

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* Hahman, Sr., W.R., Stone, C. and Witcher, J.C., 1978, Preliminary Map, Geothermal Energy Resources of Arizona, Bureau of Geology and Mineral Technology, Tucson, Arizona.

** Byerly, P.E. and Stolt, R.H., 1977, An Attempt to Define the Curie Point Isotherm in Northern and Central Arizona, Geophysics, Vol 42, No. 7, p. 1394-1400

*** Telford, W.M., Geldart, L.P., Sheriff, R.E. and Keys, D.A., 1976, Applied Geophysics, Cambridge University Press, New York.

4. Preliminary Map of Geothermal Energy Resources of Arizona

During the first year of Arizona DOE/DGE contract, an attempt was made to compile data relevant to geothermal energy in the State of Arizona. As part of this program the Arizona Oil and Gas Conservation Commission was commissioned to prepare a map, scale 1:1,000,000, constructed from their files and published reports on the geothermal energy of Arizona.* Another part of the program was the construction of a lineament map, scale 1:1,000,000 prepared from Landsat imagery by Dr. Larry Lepley**. Dr. Chandler Swanberg furnished the data, contained in New Mexico Energy Institute report number 6, to the Arizona program.*** Therefore, the majority of the information had already been compiled when the U.S. Department of Energy, Division of Geothermal Energy requested the publication of a preliminary map (Fig. 6) on the geothermal energy resources of the state.

The Arizona Bureau of Mines**** had published a map of the outcrops of Quaternary igneous rocks, scale 1:1,000,000 in 1962 and of cinder cones, scale 1:500,000 in 1969. In these two instances all that was necessary was an updating of the material.

Dr. Paul Damon and his associates***** of the Laboratory of Isotope Geochemistry, University of Arizona, Tucson, were kind enough to revise the 1962 map from their extensive age date files. Drafter Dan Dwyer revised the cinder cone map and drafted, registered and stripped the 10 plates for the printing company.

The cooperation of all parties associated with this map is gratefully acknowledged and greatly appreciated. Without the contributors' efforts, the map in its present form would have been impossible to construct.

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* Druitt, C.E. and Conley, J.N., Geothermal Areas, Arizona Oil & Gas Conservation Commission, August 1977.

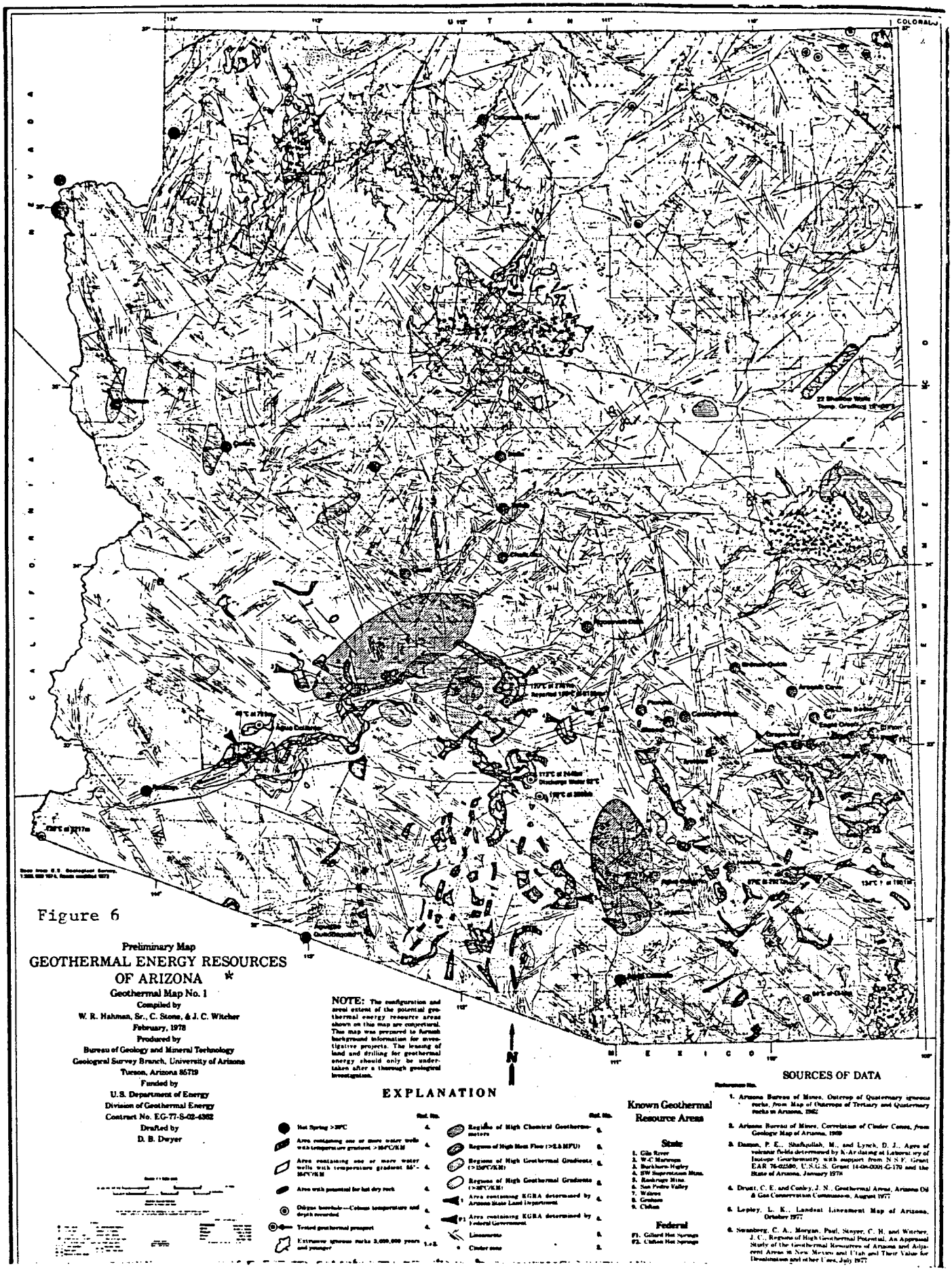
** Lepley, L.K., Landsat Lineament Map of Arizona, October 1977.

*** Swanberg, C.A., Morgan, Paul, Stoyer, C.H. and Witcher, J.C. Regions of High Geothermal Potential, An Appraisal Study of the Geothermal Resources of Arizona and Adjacent Areas in New Mexico and Utah and Their Value for Desalination and other Uses, July 1977.

**** Arizona Bureau of Mines, Outcrop of Quaternary Igneous rocks, from Map of Outcrops of Tertiary and Quaternary rocks in Arizona, 1962.

***** Arizona Bureau of Mines, Correlation of Cinder Cones, from Geologic Map of Arizona, 1969.

****** Damon, P.E., Shafiqullah, M., and Lynch, D.J., Ages of volcanic fields determined by K-Ar dating at Laboratory of Isotope Geochemistry with support from NSF Grant EAR 76-02590, U.S.G.S. Grant 14-18-0001-G-170 and the State of Arizona, January 1978.



(*) Reduced copy. For large colored map refer to Bureau of Geology and Mineral Technology. Geological Survey Branch, University of Arizona.

i) Discussion

The following interpretative comments are preliminary in nature and should be treated as such.

The areas of favorable geothermal energy potential shown on the map appear concentrated in the southern half of the state. This concentration is apparent because of the greater population density and mineral exploration activity which has generated considerable knowledge of the Basin and Range physiographic province.

Dr. Chandler Swanberg et al., in NMEI number 6, Figure 9, has computed the mean of observed temperatures for wells and springs from both the Colorado Plateau and the Basin and Range physiographic provinces of southwestern United States. The mean temperature for the Colorado Plateau is 16.1°C and for the Basin and Range 26.2°C. Therefore, any well or spring in the Colorado Plateau of Arizona having a temperature in excess of 20°C would be considered anomalous. In the Basin and Range of Arizona any well or spring having a temperature in excess of 30°C would be considered anomalous.

Lepley's lineament study presents some interesting conjectures when analyzed with the other data on the map. It does appear that the northeast (N 40° - 60°C) striking lineaments have a significant relationship with areas of high geothermal energy potential. Field observations in the volcanic field immediately west of Springerville, Arizona tend to support the importance of this northeast direction. Cinder cones appear to be alligned along relict fissure vents striking N 40° - 45° E.

Another apparently important lineament direction is N 40° - 45° W. Favorable geothermal energy areas seem to occur in the vicinity of the intersections of the northeast and northwest lineaments. While this association could well be fortuitous, the geothermal anomalies could well result from more favorable ground preparation of the basement complex. These intersections could have numerous, deeply penetrating fractures extending considerable distances into the earth's crust. The ground water in the intermontane basins could circulate to great depths along these fractures, become heated and rise along these fractures. This action would cause a turnover of the water in the aquifers creating a convection cell or cells similar to the Tucson basin cell.*

ii) Conclusion

This map is the initial attempt to present the knowledge to date on the geothermal energy potential of the State of Arizona.

Thermal gradients calculated from single temperatures in shallow wells have the highest chances for error and may not extend to depth. However, these calculations do point out where the shallow-depth hot water is located.

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* J.C. Witcher, Personal Communication (1978).

Water geochemical geothermometers are reasonably accurate at designating the minimum range of the geothermal reservoir temperatures. The reason it is the minimum temperature is that mixing of non-thermal water with thermal water often occurs prior to the water reaching the sample site.

Measured thermal gradients should be considered the most accurate. Temperature measurements, using a very accurate thermistor probe, are generally taken every five meters from the surface down. Approximately eight readings, over an extended time period, are taken at one downhole station if it is in air. Only one reading is necessary per downhole station if there is fluid in the hole.

It should be noted that the configuration and areal extent of the potential geothermal energy resource areas shown on this map are conjectural. This map was prepared to furnish background information for investigative projects. The leasing of land and drilling for geothermal energy should only be undertaken after a thorough geological investigation.

5. Geothermal Energy Available for Development

For the purpose of this study, Arizona has been divided into 12 geothermally favorable areas. These twelve areas, with rather nebulous boundaries, are as follows: San Bernardino Valley area, Clifton-Morenci-Safford area, Kingman area, Yuma area, Hyder Valley area, Tucson area, Springerville area, Flagstaff area, Willcox area, Palo Verde area, Pinacate volcanic field area and the Phoenix area.

In order to commence this exercise certain assumptions must be made, the major assumptions being that there is geothermal energy available for development and that the conditions for development are favorable. Preliminary investigations indicate favorable geothermal potential in all the above areas; however, there are no proven reservoirs or reserves. Therefore, all energy estimates given in Table 3 are merely best guesses in light of present information and will be subject to change as more data/information becomes available.

The estimated energy in the twelve areas as given in Table 3 has been constructed from a proven, probable and inferred standpoint assuming present technology and with some hot dry rock development. Advancement in exploration, development and generating (energy conversion) technology will of course greatly increase the megawatts of electricity on line.

6. Assessment of Geothermal Resources in Arizona

An assessment of the geothermal resources in Arizona, ranked by temperature (Tables 4,5 and 6) was prepared by Dr. Chandler A. Swanberg of the Department of Earth Sciences, New Mexico State University, Las Cruces. A similar assessment ranked by geographic location (Table 7) was prepared by the Geothermal Group of the Arizona Bureau of Geology and Mineral Technology.

TABLE 3

ESTIMATED GEOTHERMAL ENERGY AT VARIOUS AREAS IN ARIZONA

Electric Power Generation

Area	Proven	Probable	Inferred
1. San Bernardino Valley	0 MW	50 MW	500 MW
2. Clifton-Morenci-Safford	0 MW	50 MW	500 MW
3. Springerville	0 MW	100 MW	500 MW
4. Flagstaff	0 MW	100 MW	1000 MW
5. Kingman	0 MW	25 MW	100 MW
6. Yuma	0 MW	50 MW	50 MW
7. Hyder Valley	0 MW	50 MW	500 MW
8. Tucson	0 MW	10 MW	50 MW
9. Phoenix	0 MW	50 MW	500 MW
10. Willcox	0 MW	25 MW	100 MW
11. Palo Verde	0 MW	25 MW	100 MW
12. Pinacate Volcanic Field	0 MW	100 MW	500 MW
TOTAL	0 MW	635 MW	4450 MW

Non-electric power-space heating, cooling, agriculture is estimated at 1.5 times total electric power generation for the state.

Non-Electric Power

	Proven	Probable	Inferred
Total electric power x 1.5	0 MW	635 MW	4450 MW
	0 MW	952.5 MW	6675 MW
Grand Total	0 MW	1587.5 MW	11,125 MW

TABLE 4

HIGH TEMPERATURE GEOTHERMAL RESOURCES (>150°C)

NAME	LAT.	LONG.	MEASURED SUBSURFACE TEMPERATURE (°C)
Confirmed			
Chandler	33 17.1	111 41.2	184
Prospects			ESTIMATED SUBSURFACE TEMPERATURE (°C)
Clifton H.S.	33 4.2	109 17.9	160
Verde H.S.	34 21.5	111 42.5	150

Potential for Discovery - Areas having groundwaters whose chemical geotemperatures exceed 150°C

San Bernardino Basalt Area	31.4	109.4
Springerville	34.1	109.3
St. Johns	34.4	109.4
Joseph City	34.8	110.4
Flagstaff	35.1	111.9
Oatman	35.0	114.4
Weaver Park	34.4	112.9
Rancoras Plain	33.5	113.7
Rainbow Valley	33.2	112.5
Phoenix	33.4	112.0
San Simon*	32.2	109.3
Yuma*	32.5	114.8

Potential for Discovery - Areas having shallow boreholes whose temperature gradients exceed 150°C/km

Number of Prospects	Aggregate Area
73	2200 km^2

Potential for Discovery - Quaternary Volcanics

Number of Prospects	Aggregate Area
50	11,100 km^2 (C.P. = 9800 km^2, B&R = 1300 km^2)

* Measured temperature 130 - 140°C. See also intermediate temperature geothermal resources confirmed.

TABLE 5

INTERMEDIATE TEMPERATURE GEOTHERMAL RESOURCES (90-150°C)

NAME/AREA	LAT.	LONG	MEASURED* SUBSURFACE TEMPERATURE (°C)
Confirmed			
San Simon	32.2	109.3	134
Yuma	32.5	114.8	138
Prospects			ESTIMATED SUBSURFACE TEMPERATURE (°C)
Gillard H.S.	32 58.4	109 20.9	140
Eagle Creek H.S.	32 2.9	109 26.4	130
Coolidge H.S.	33 10.3	110 31.7	120
Coffers H.S.	34 41.6	113 34.5	120
Cat Tank	32 43.8	109 22.7	115
Javelina Peak	32 31.4	109 25.6	110
Safford Area	32 50.7	109 33.6	110
Indian H.S.	33 0.2	109 54.0	105
Castle H.S.	33 59.0	112 21.7	105

Potential for Discovery - Areas having shallow boreholes whose temperature gradients fall between 36 and 150°C/km

Number of Prospects	Aggregate Area	
-100	36-150°C/km	4900 km^2
	55-150°C/km	6000 km^2

Potential for Discovery - Cenozoic Volcanics

Nearly 20% of the total land surface area of Arizona is covered by Cenozoic volcanic rocks and therefore should be considered as potential areas for geothermal discoveries.

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* Numerous other wells in Arizona have reported gradients in the 90-150°C/km range but have been omitted from this table because the inferred temperature gradient is not sufficiently above normal to constitute a geothermal anomaly. See low temperature resources confirmed.

TABLE 6

LOW TEMPERATURE GEOTHERMAL RESOURCES (20-90°C)

NAME/AREA	LAT.	LONG.	MEASURED TEMPERATURE °C
Confirmed			
Littleton	32.1	110.9	147 * @ 3830m
Casa Grande (North)	32.9	111.5	113 * @ 2440m
Casa Grande (South)	32.8	111.5	110 * @ 3095m
Willcox	32.3	109.9	87 * @ 2027m
Whitewater	31.5	109.8	64 * @ 1510m
Coolidge Area	32 54.2	111 34.0	61
Radium SP.	32 44.4	114 4.2	>50
Hooker's H.S.	32 20.2	110 14.3	53
Buckhorn Area	33 25	111 42.2	49
Hyder Valley	33.1	113.3	49 * @ 789m
Agua Caliente	32 59.6	113 18.3	46
Artesia H.W.	32 43.1	109 42.5	44
Mt. Graham	32 51.8	109 44.9	44
Lucats Spa	32 44.7	109 44.7	42
Palomas Mts.	33 0.0	113 30.5	42
Branon Mtn.	33 6.7	113 24.5	39
Theba	32 55.9	112 45.1	38
Bowie	32 19.1	109 29.0	36
Mobil Area	33 12.2	112 21.9	35
Artesia Area	32 41.0	109 42.3	33
Warm Sp.	33 4.3	109 59.0	42
Hoover Dam Sp.	36.0	114.8	~40
Cottonwood Sp.	36.5	114.0	warm
Lava Sp.	36.2	113.1	warm
Colorado Pool	36.5	111.9	warm
Prescott Sp.	34.6	112.6	warm
Soda Sp.	34.7	111.7	warm
Chalk Mtn. Sp.	34.1	111.7	warm
Roosevelt Dam Sp.	33.6	111.2	warm
Bronco Culch Sp.	33.4	110.2	warm
Mescal Sp.	33.2	110.6	warm
Pioneer Sp.	33.2	110.8	warm
Arsenic Cave Sp.	33.3	109.8	warm
Little Boiling Sp.	33.2	109.6	warm
Graperine Sp.	33.0	109.8	warm
Agua Caliente	32.3	110.7	warm
Agua Caliente	31.8	111.0	warm

Prospects - Water Temperatures in excess of 20°C

In Arizona the entire Basin and Range province which includes roughly ½ the total land surface of the state should be considered to be a low temperature geothermal prospect. The mean water temperature of the Basin and Range is 26°C.

TABLE 6 CONT

Potential for Discovery

The entire Basin and Range province and roughly 1/3 of the Colorado Plateau in Arizona (~60-70% of the entire state) have some type of evidence suggesting the presence of low temperature geothermal resources.

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* High temperatures reflect the depth of the well. The inferred temperature gradient is not sufficiently above normal to constitute a geothermal anomaly.

TABLE 7 INFORMATION ON GEOTHERMAL LOCATIONS IN THE STATE OF ARIZONA*

No.	Location	Type of Ownership	Type of Geot. Energy	Depth (km)	Tempt. Range (°C)	Subsidence w/reinjection	Salinity of Source (PPM)	Heat Resv. (Quads)	Envtal Impact	Radius of location (miles)
1	Kingman	Federal & State	HDTF & HDR	2	HDTF: 50° HDR: 200°	Almost	3500	5	Significant	10
2	Flagstaff	Federal State & Indian	HDTF & HDR	1	HDTF: 60° HDR: 210°	Almost none	3000	20	"	20
3	Springer-ville (St Johns)	Federal & State	HDTF & HDR	1	HDTF: 55° HDR: 210°	Almost none	2500	10	Slightly Significant	15
4	Clifton-Morenci-Safford	Federal State & Indian	HDTF & HDR	1	HDTF: 110° HDR: 205°	Possible in Safford	4000	11	Significant	15
5	Willcox	Federal & State	HDTF	0.81	HDTF: 50-80° HDR: 150-200°	Possible	3000	5	"	10
6	Tucson	Federal State & Indian	HDTF	0.5-2	HDTF: 60-90°	Slightly Possible	2000	11	"	15
7	Phoenix	Federal & State	HDTF	0.5-2	HDTF: 80-120°	Slightly Possible	2000	20	"	20
8	Palo Verde	Federal & State	HDTF & HDR	0.5-2	HDTF: 54° HDR: 205°	Almost none	1000	2	"	5
9	Hyder Valley	Federal & State	HDTF & HDR	0.5-2	HDTF: 55° HDR: 209°	Possible	2500	20	"	15
10	Yuma	Federal State & Indian	HDTF	1.2	HDTF: 150-180°	Possible	3500	2	Slightly Significant	5
11	San Ber-nardino	Federal & State	HDTF & HDR	0.5-1	HDTF: 150-200° HDR: 205°	Possible in some areas	2500	2	"	5
12	Pinacate	Federal & State	HDTF & HDR	0.5-1	HDTF: 150-180° HDR: 200°	Possible in some areas	2500	2	"	5

* Most of the figures given in this table are approximate
HDTF: Hydrothermal fluid, HDR: Hot Dry Rock

For Tables 4-6, Swanberg states that the geothermal resources of Arizona have been "divided into high temperature (>150°C) (Table 4), intermediate temperature (90 - 150°C) (Table 5), and low temperature (20 - 90°C) (Table 6), with further modifications to determine the reliability of the assessment. The "confirmed" category includes only those geothermal areas whose subsurface temperatures have been verified by drilling. The "prospect" category includes those areas which have thermal waters (hot springs and wells) whose chemical constituents suggest a much higher subsurface temperature than can be measured at the surface. The "potential for discovery" category includes those areas which appear promising on the basis of various geological, geophysical, geochemical criteria but for which little or no detailed information is currently available. In preparing the following tables, we have utilized all geothermal data currently available although we have relied heavily upon the geothermal compilation works of Swanberg at al. * and Hahman et al. **.

Table 7 presents the resource assessment on the basis of the 12 most favorable locations in Arizona. The table includes land ownership, type of resource, environmental considerations, estimated heat reserve and other pertinent data. Fig. 7 is a map of Arizona showing counties and the locations of each of the 12 areas. The heat reserves in Table 7 were calculated as follows:

In order to estimate the heat energy in a geothermal reservoir in Quads; we will use the following equation,

$$H = \frac{\pi \cdot D^2 \cdot d \cdot Cp \cdot \Delta T \cdot \rho}{4} \times \frac{(5280)^3}{10^{15}} \qquad \text{(i)}$$

where:

π = 3.1416
H = potential amount of heat energy in reservoir (in Quads)
D = diameter of geothermal resource area (in miles)
d = depth (in miles)
Cp = specific heat of rock
ΔT = temperature drop by source
ρ = density of rock (in lb/ft^3)

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* Swanberg, C.A., Morgan, Paul, Stoyer, C.H., and Witcher, J.C., Regions of High Geothermal Potential, An Appraisal Study of the Geothermal Resources of Arizona and Adjacent Areas in New Mexico and Utah and their value for Desalination and other Uses, NMEI Report No. 6, July, 1977

** Hahman, Sr., W.R., Stone, C. and Witcher, J.C. 1978, Preliminary Map - Geothermal Energy Resources of Arizona, Bureau of Geology and Mineral Technology, Tucson, Arizona

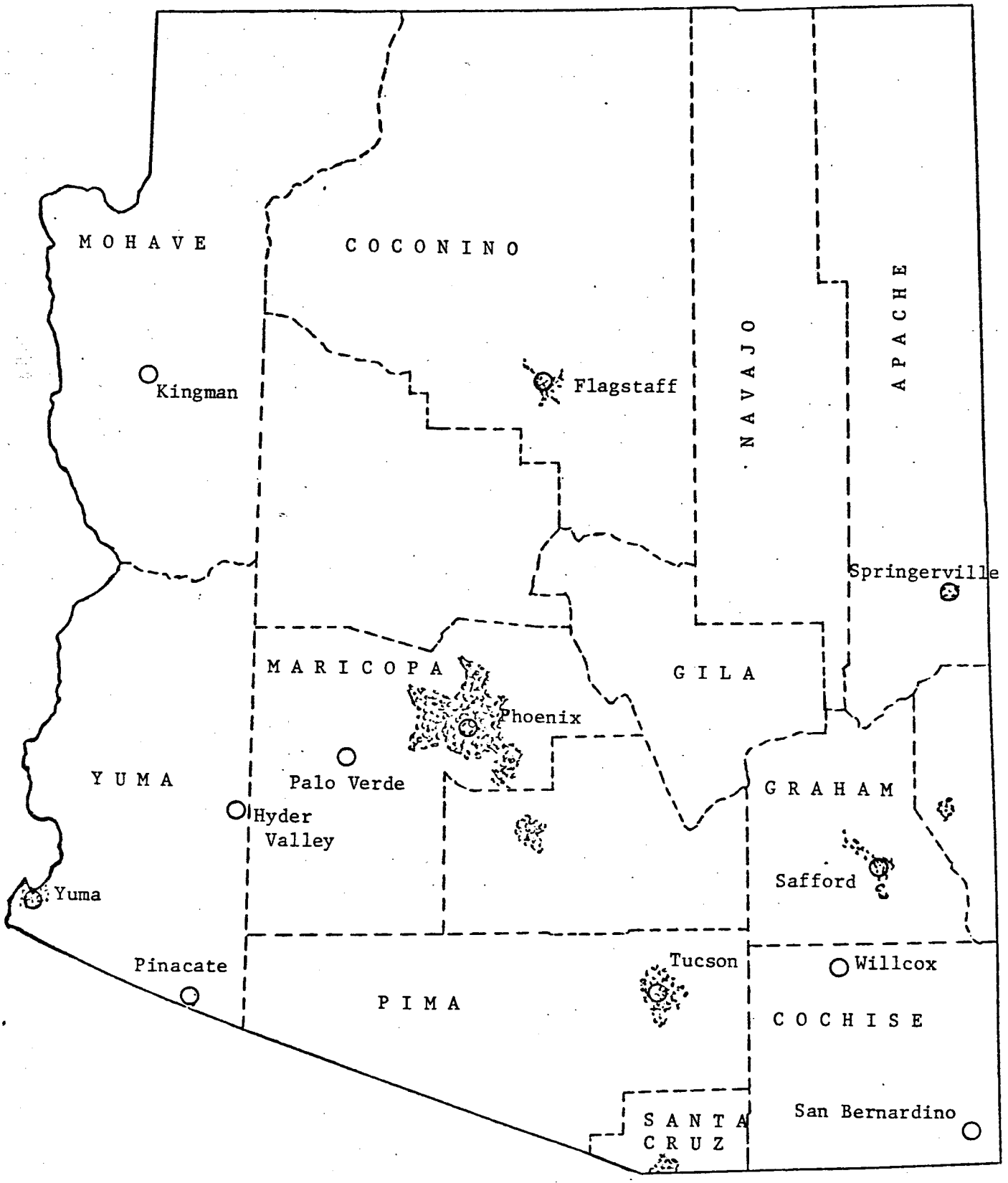


FIGURE 7: LOCATION MAP FOR AREAS OF ARIZONA REFERRED TO IN THIS REPORT

Conversion factors,
5280 = conversion factor from miles to feet
10^{15} = conversion factors from BTU to Quads

To illustrate how this equation is used; let us calculate an estimate for the heat energy in the Kingman area.

Assume that:

D = 20 miles
d = 0.25 miles
Cp= 0.2 BTU/lb ^{o}F
$\Delta T = 10^{o}F$
$\rho = 200$ lb/ft^3

$$H \text{ (in Quads)} = \frac{\pi(20)^2 (0.25) (0.2) (10) (200) (5280)^3}{(4) (10^{15})}$$

$$H = 4.62 \text{ Quads} \approx 5 \text{ Quads}$$

Thus the heat energy in the geothermal resource reservoir was estimated using equation (i). All the amounts of heat energy for the twelve areas in Table 10 were estimated in the same way.

7. Geothermal Leasing and Drilling Activity in Arizona

i. Leasing

Leasing activity has increased significantly on both state and federal lands in Arizona during the past year (see Figures 8-14). Several lease applications and two Notices of Intent to Conduct Geothermal Resource Exploration Operations have been filed at various Bureau of Land Management (BLM) Arizona district offices. On the state level one lease renewal and one new lease application were filed with the State Land Department.

Reed Nix of Nix Drilling Company, Globe, Arizona, obtained a lease on state land T5S R24E S16 in November, 1972, to drill a geothermal test hole. Drilling commenced April 23, 1974, and continues to the present. In November, 1977, Nix applied for a two year lease extension, but the extension was not granted by the State Land Department. Four individuals jointly applied for a geothermal lease on state land on the Hassayampa Plain, T5N R6W S36 and T4N R6W S2, in March, 1978. Upon receipt of such applications the State Land Department must advertise for competitive bidding for ten weeks. Lease issuance is currently pending action by the BLM, which is conducting an environmental study of surrounding federal land.

The BLM Safford District Office reported on seven older noncompetitive geothermal lease applications on federal lands in the Clifton area, within townships T4-6S R28-30E. Dates and applicants are unknown; however, four of the leases were granted to Phillips Petroleum Company, Del Mar, California,

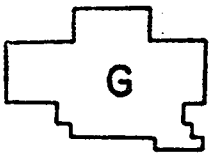
LEGEND FOR THE FOLLOWING FIGURES (8 - 14)



Federal Geothermal Resources Lease Application



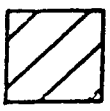
Federal Notice of Intent to Conduct Geothermal Resources Exploration Operations



Gillard Hot Springs; Federal Known Geothermal Resource Area (K G R A)



Clifton Hot Springs; Federal Known Geothermal Resource Area (K G R A)



State of Arizona Designated Known Geothermal Resource Area (K G R A)

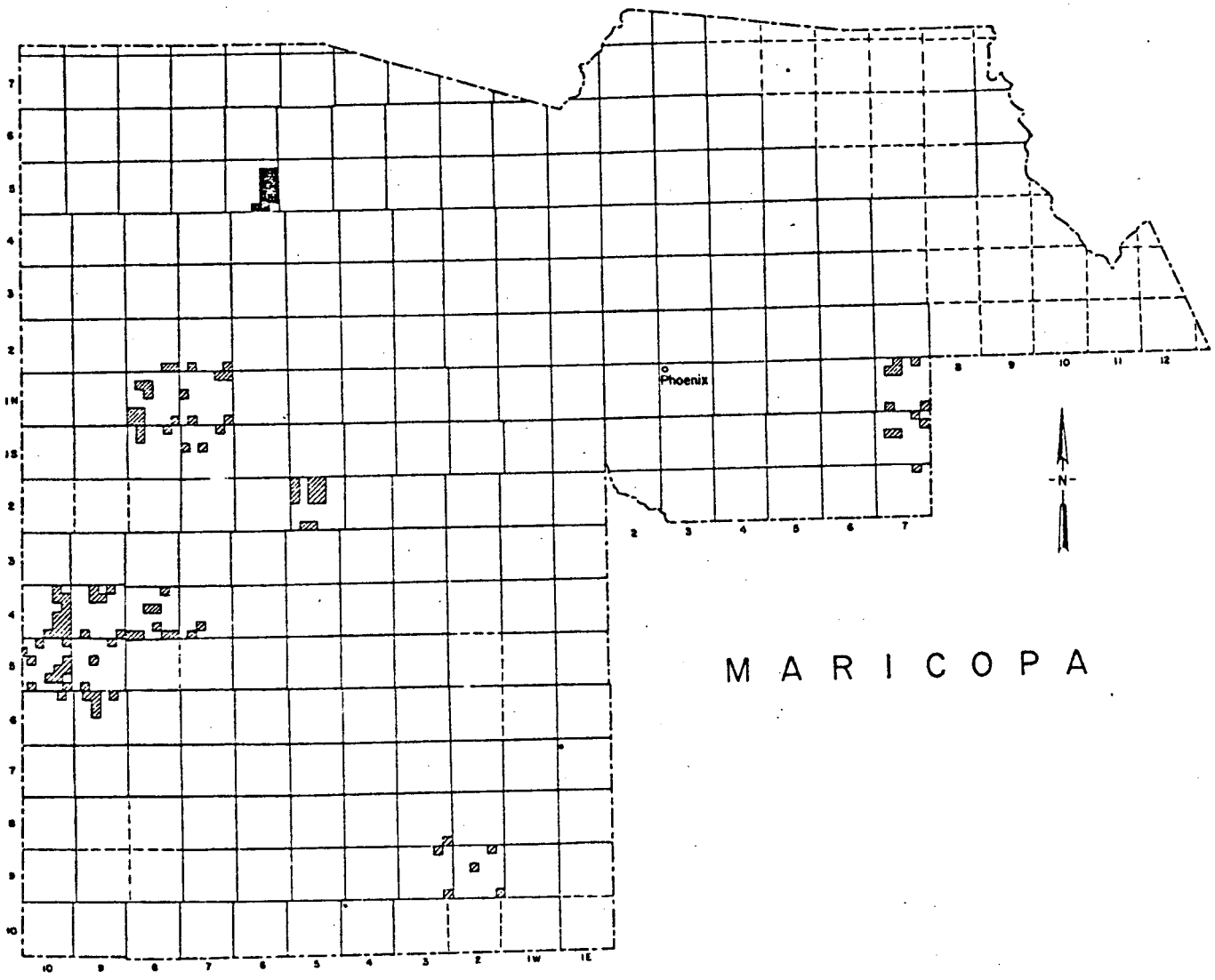


FIGURE 8: GEOTHERMAL LAND STATUS OF MARICOPA COUNTY, ARIZONA, AS OF APRIL 1978. SEE LEGEND.

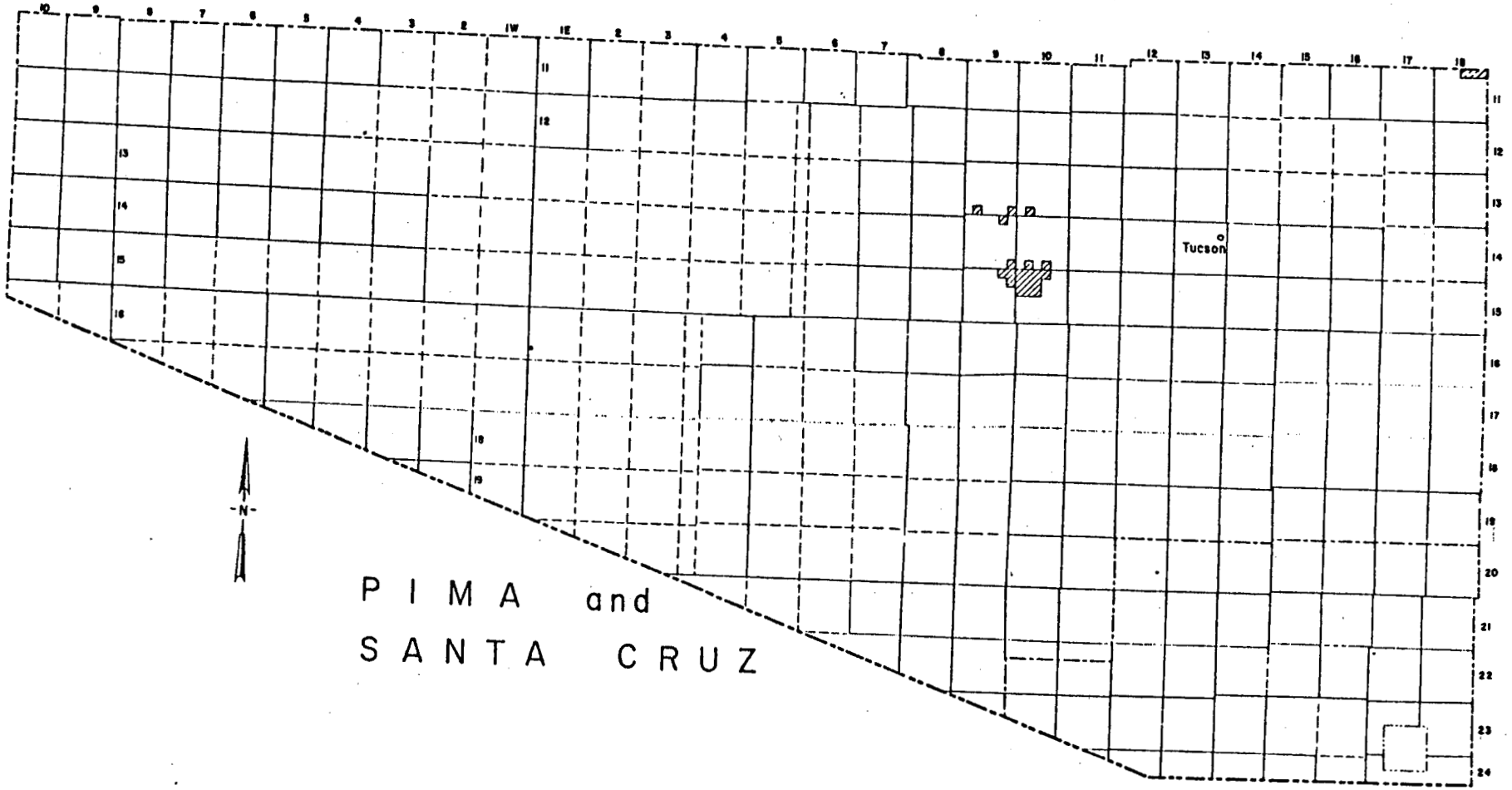


FIGURE 9: GEOTHERMAL LAND STATUS OF PIMA AND SANTA CRUZ COUNTIES, ARIZONA, AS OF APRIL, 1978. SEE LEGEND.

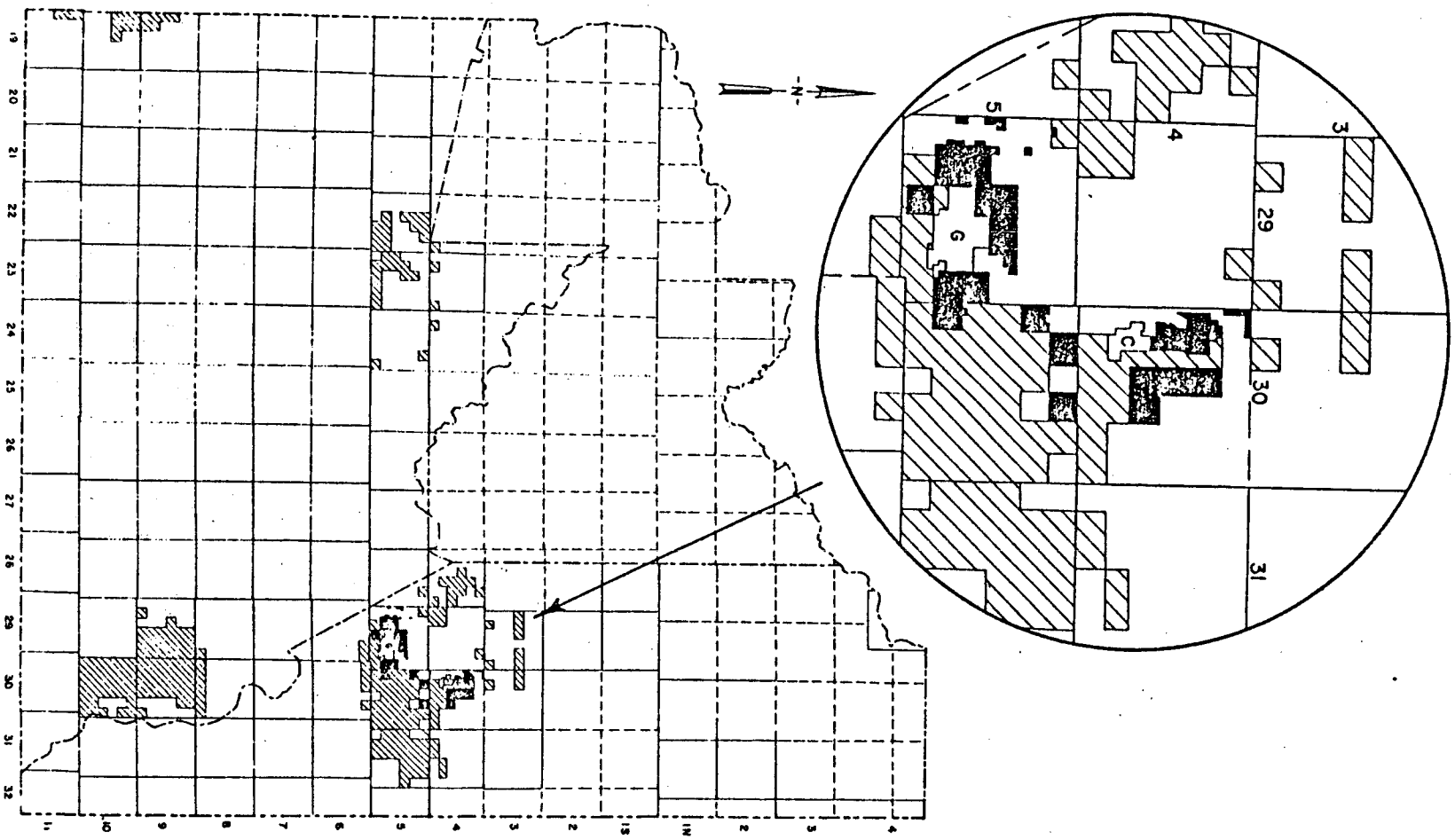


FIGURE 10: GEOTHERMAL LAND STATUS OF GRAHAM AND GREENLEE COUNTIES, ARIZONA, AS OF APRIL, 1978. SEE LEGEND

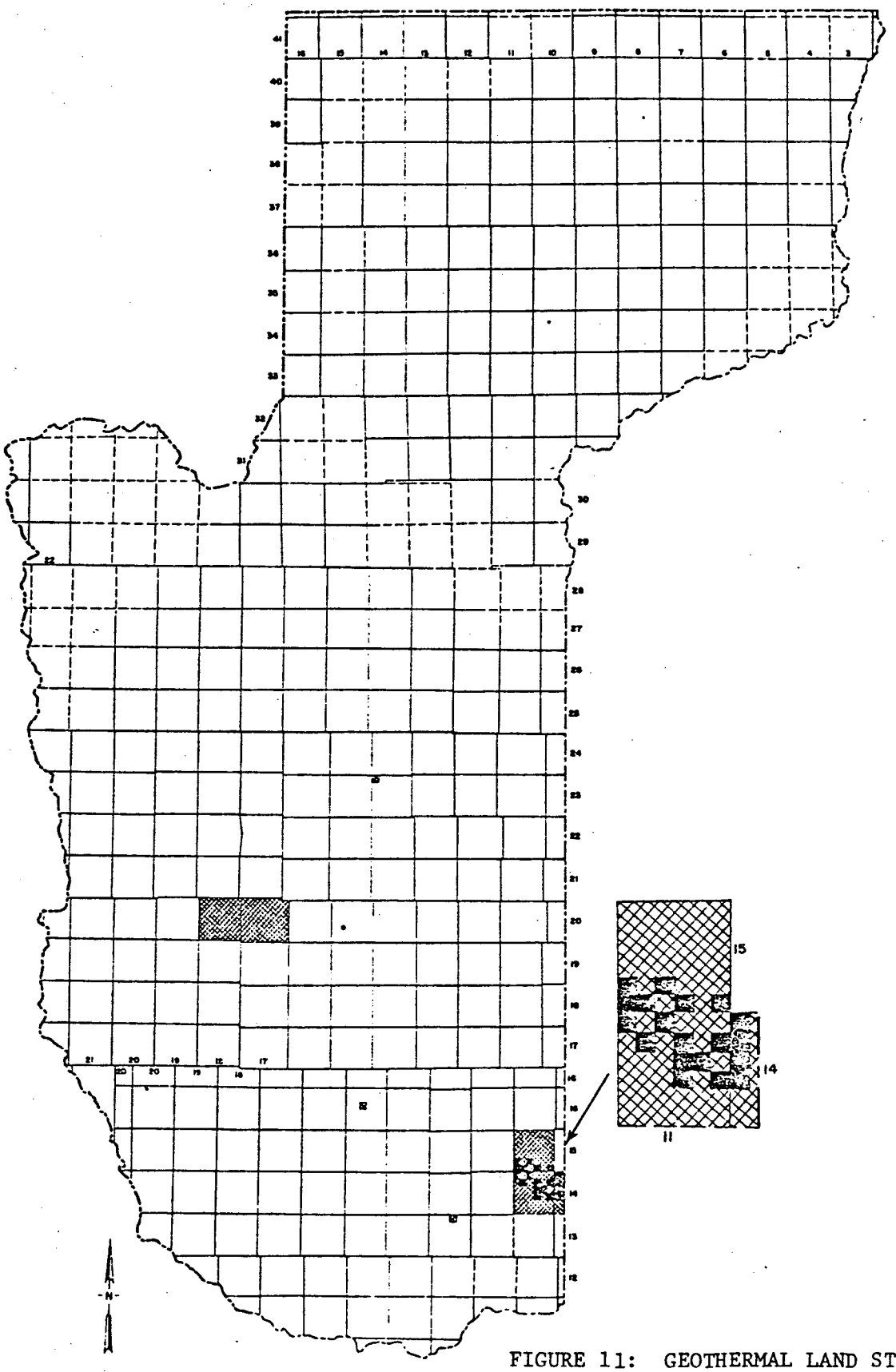


FIGURE 11: GEOTHERMAL LAND STATUS OF MOHAVE COUNTY, ARIZONA, AS OF APRIL, 1978. SEE LEGEND.

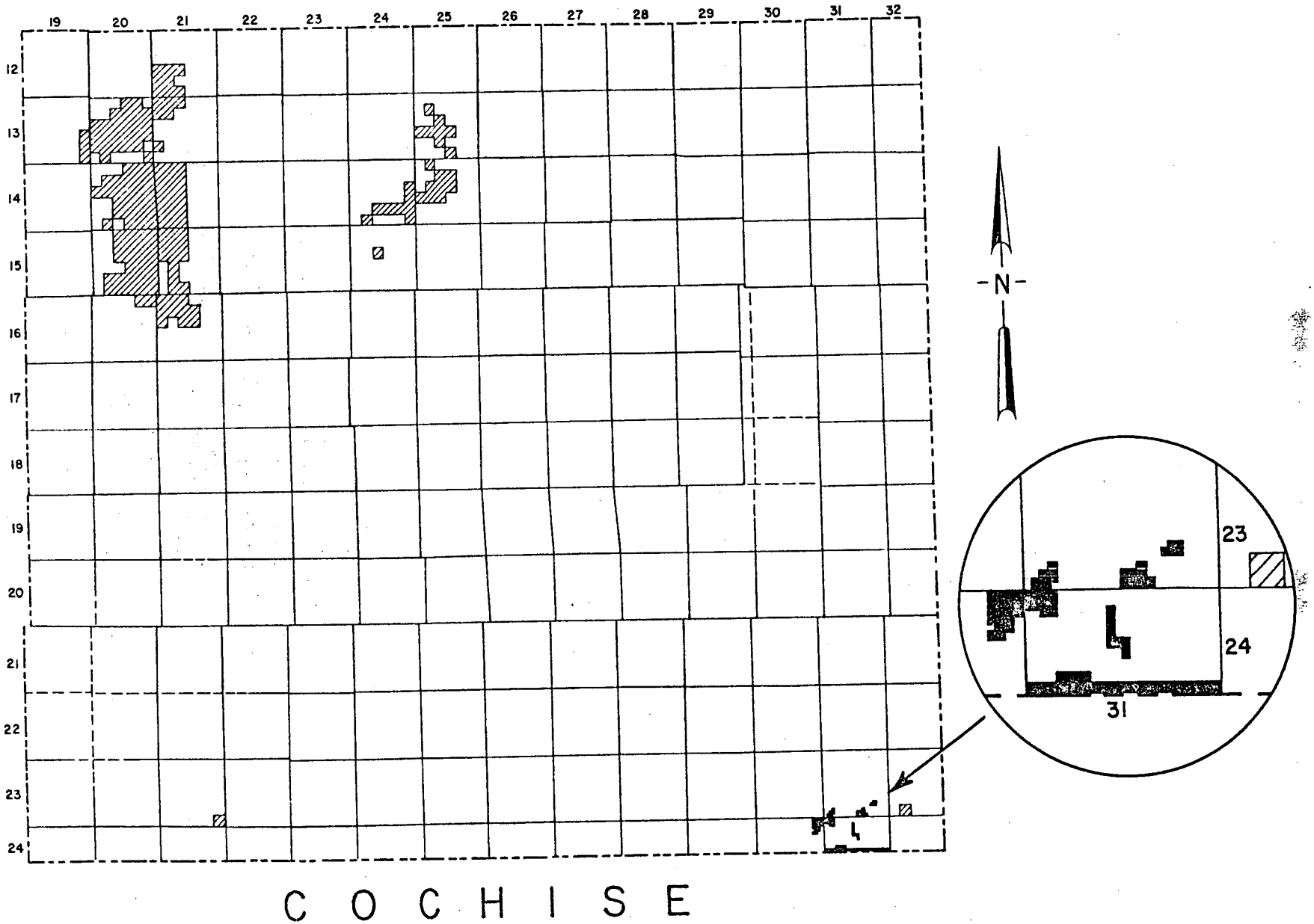


FIGURE 12: GEOTHERMAL LAND STATUS OF COCHISE COUNTY, ARIZONA AS OF APRIL 1978. SEE LEGEND.

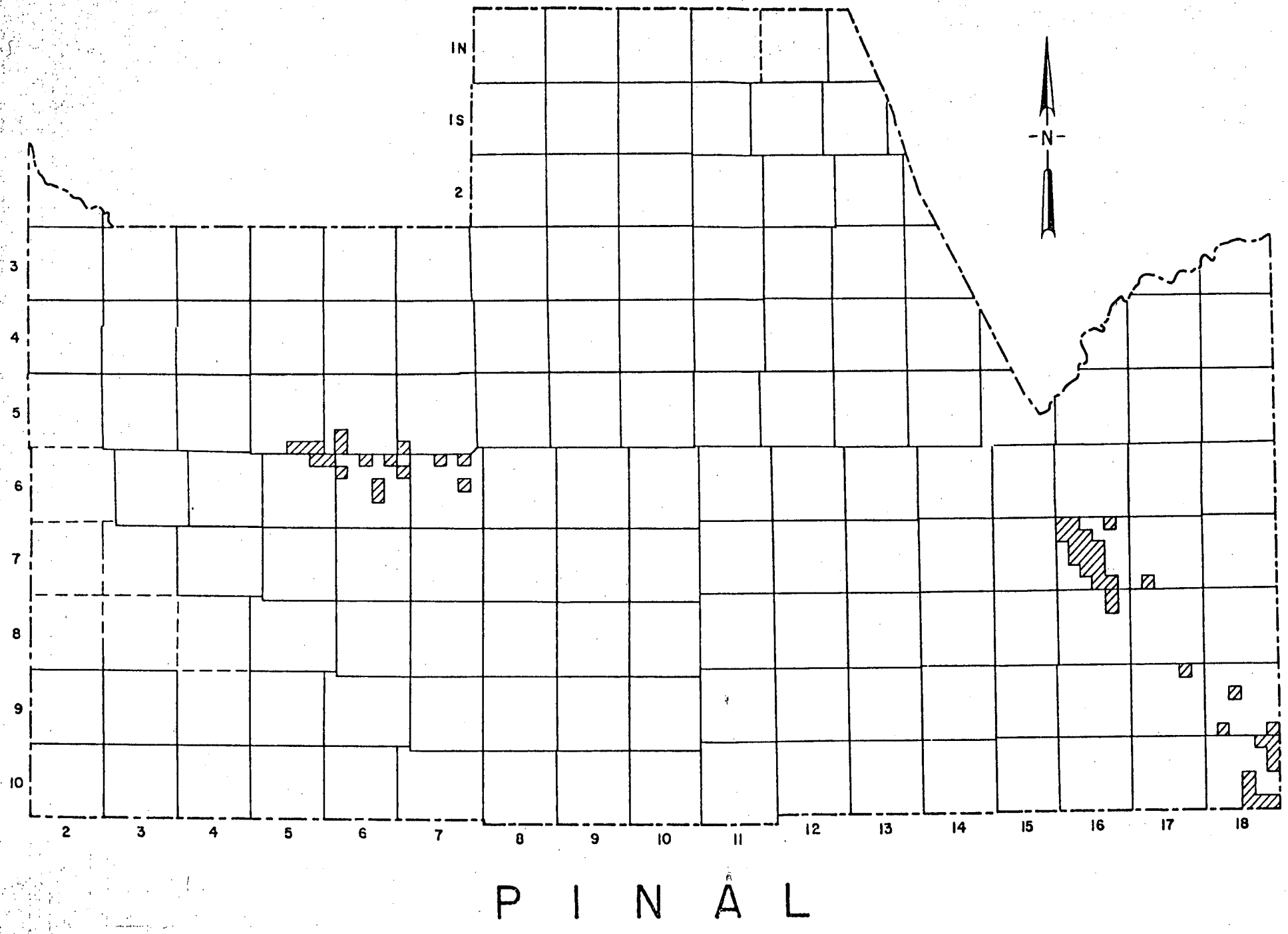


FIGURE 13: GEOTHERMAL LAND STATUS OF PINAL COUNTY, ARIZONA AS OF APRIL, 1978. SEE LEGEND

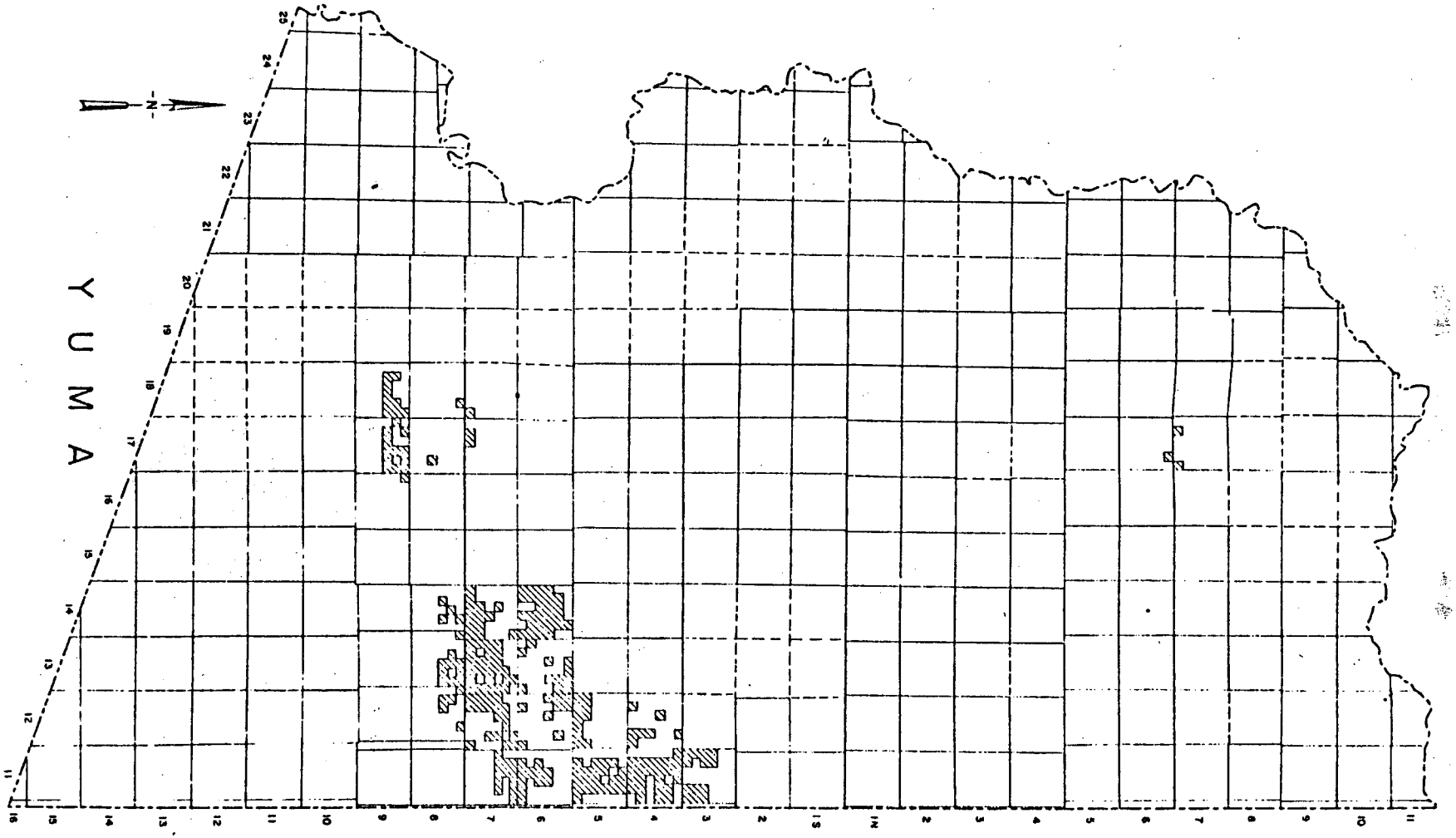


FIGURE 14: GEOTHERMAL STATUS OF YUMA COUNTY, ARIZONA AS OF APRIL, 1978. SEE LEGEND

on July 1, 1975. All of the applications may have been filed by Phillips as all sections are in proximity.

Geothermal leasing of federal land during the past year has been even more active than in former years. The BLM Kingman Resource Area Office reported receiving two Notices of Intent, one from the U.S. Geological Survey, Menlo Park, California, to drill five shallow (400 ft) heat flow holes in the Kingman district (see drilling section, below) and a second from Cyprus Georesearch of Los Angeles, California, to conduct three geophysical surveys in each of two areas: T20N R17-18W near Kingman and T15N R11W and T14N R10-11W south of Wickieup. The Kingman BLM office also received a geothermal lease application from a Utah lease broker for 20 sections south of Wickieup in townships T14-15N R10-11W. The lease applications are pending completion of an environmental assessment of the area.

On other federal lands, geothermal lease applications were filed in September and October, 1977 by Chevron U.S.A. Inc., Denver, Colorado for land near the San Francisco Peaks. Chevron applied for 56,091.6 acres within the township T21-25N R7-9E, but in December 1977, they withdrew applications on 8,558.77 of those acres. The status of these applications is currently unknown but probably is pending an environmental assessment.

Southland Royalty Company, Fort Worth, Texas applied for geothermal leases on 2,899.23 acres of federal land in San Bernardino Valley within the townships T23S R31E and T24S R30-31E. The applications were filed in December, 1977 and action is pending an environmental assessment of the area by the BLM Safford District Office.

On January 1, 1977 the BLM Phoenix District Office granted a geothermal lease to Gary and Frances Smith for federal land on the Hassayampa Plain, specifically T5N R6W S25. This section is continguous to land under application from the State Land Department by four individuals mentioned above, two of whom are also Gary and Frances Smith.

ii. Drilling Activity

Three deep geothermal test wells have been drilled in the state to date, with limited success. Two of these wells were drilled in 1973 by Geothermal Kinetics Systems, Phoenix, Arizona near Chandler. The well locations are T2S R6E S1 NE SE and T2S R6E S1 SE NE. Amax Exploration, Inc., Denver, Colorado, drilled the third well near Eloy, T7S R8E S8 SE SW, in 1974. The fourth geothermal test well is that mentioned above, being drilled by the Nix Drilling Company.

In March, 1978, the U.S. Geological Survey, as mentioned above, began drilling five shallow (400 ft) heat flow holes in the Kingman area. It is the intention of the U.S.G.S. to drill a total of 50 shallow heat flow holes throughout southern Arizona during 1978, for geothermal exploration. It is also anticipated that the Bureau of Reclamation will fund a drilling program in the Springerville area for shallow (500 ft) heat flow holes during 1979 with additional and possibly deeper holes in the Clifton area.

8. Known Geothermal Resource Areas (KGRA's)

Figures 8-14 also illustrate areas of state and federal land classified as Known Geothermal Resource Areas (KGRA's) by either a state or federal agency. Both of the federal KGRA's, Clifton and Gillard, were automatically designated by federal regulation, on the basis of overlapping geothermal lease applications. All state KGRA's, on the other hand, were so classified at the discretion of the State Land Department.

Both the federal government and the State Land Department have the authority to classify land under their jurisdiction as a KGRA solely on the basis of its being "an area in which the geology, nearby discoveries, competitive interests, and other indicators would, in the opinion of the Department (or Secretary, DOI for federal land), engender a belief in the men who are experienced in the subject matter that the prospects for the extraction of geothermal resources are good enough to warrant expenditures of money for that purpose." This rather arbitrary discretion is seen as a potential problem by many working in the field of exploration and development of low- to moderate-temperature, direct utilization geothermal energy.

The problem of low-temperature geothermal energy and the KGRA process was addressed recently in a report to Dr. Donald Elmer, DOE/DGE, by Kaufman and Laughlin*. This report, along with the way the Department of the Interior is claiming public lands valuable for geothermal steam and amounted geothermal resources, is given in Appendix III. In brief, the report points out the problem of subjecting development of low-temperature, direct utilization geothermal energy resources to the same restrictive regulations governing the development of high temperature resources. The extended time frame and the excessive costs involved in bringing low-temperature geothermal on line create impediments to its development which can seldom be surmounted by the small communities and businesses most likely to use and to benefit from such alternate energy sources.

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* Kaufman, E.L. and Laughlin, A.W., Report by Geological Research group G-6 Los Alamos Scientific Laboratory, Los Alamos, New Mexico

III. ARIZONA DATA BASE

A. DATA BASE AND PHYSICAL RESOURCES

Arizona is the sixth largest state in the nation, yet its population is only 2.35 million. Moreover, Phoenix and Tucson comprise 70% of the populace (Figure 15). Elevation ranges from about sea level (at Yuma) to over 12,000 feet near Flagstaff. Consequently, large areas of low population density are exploited by the agricultural and lumber industries, (Figs 16,19). Geothermal resources may be developed to augment existing power sources for these and other industries statewide. Water is necessary to support most of these industries; here Arizona's aridity poses serious problems. Fig 18 shows the depth to ground water in wells for various sedimentary basins statewide. While there is a water shortage, a project to augment existing supplies has begun. The Central Arizona Project will import Colorado River water to Phoenix via aqueducts (Fig.20) and even as far south as Tucson.

Land ownership is divided between Forest Service. BLM, private, public, Federal, State, Indian and military reservations (Fig. 21). Ownership is a paramount importance in the initial evaluation of a geothermal resource, in that some parties are dealt with more cooperatively than others, with respect to both time and investment capital. Private land is generally the most advisable land type on which to develop a geothermal resource. Percent ownership by type is given in Table 8.

Arizona is heavy in cattle feed lots and agriculture, importing cattle from Texas, Mexico, and Colorado and exporting the meat to California. That is a big business, being the 7th largest State in such activities.

Lastly, Arizona is blessed with many mineral deposits and large quantities of by-product sulfuric acid (Figs. 22, 23). Several geothermal use scenarios involving solution mining are being developed. It is too soon to say much about their potential until more technical facts are assembled and evaluated. However, it could turn out to be the most important non-electrical application of geothermal energy in Arizona.

B. ENERGY USE IN ARIZONA

Because of the low population of the state, Arizona's energy distribution is dissimilar to that of most other states. Natural gas lines cross the state and gasoline is pipelined from Los Angeles and El Paso (Fig. 24). Power production is scattered and many rural areas do not have power. The dependence upon remote markets for fossil fuels for transportation further emphasizes the lack of local sources of crude oil (Fig. 24). Arizona does have coal reserves and there are several large coal power plants including one served by coal slurry pipeline as shown in Fig. 24. Transportation as well as commerical and residential heating and cooling comprise the bulk of energy used in Arizona. As shown in Table 10, 37.2%

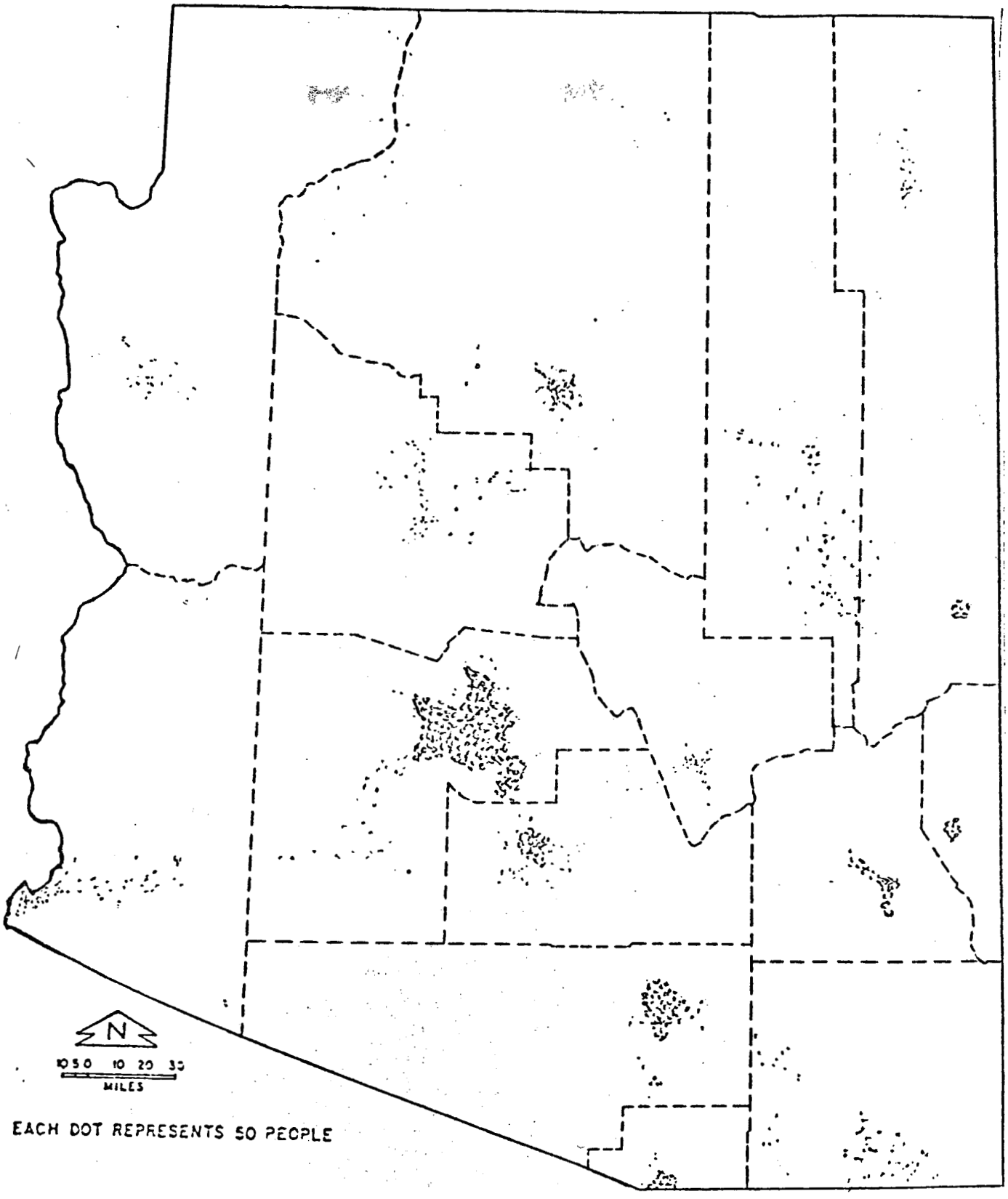
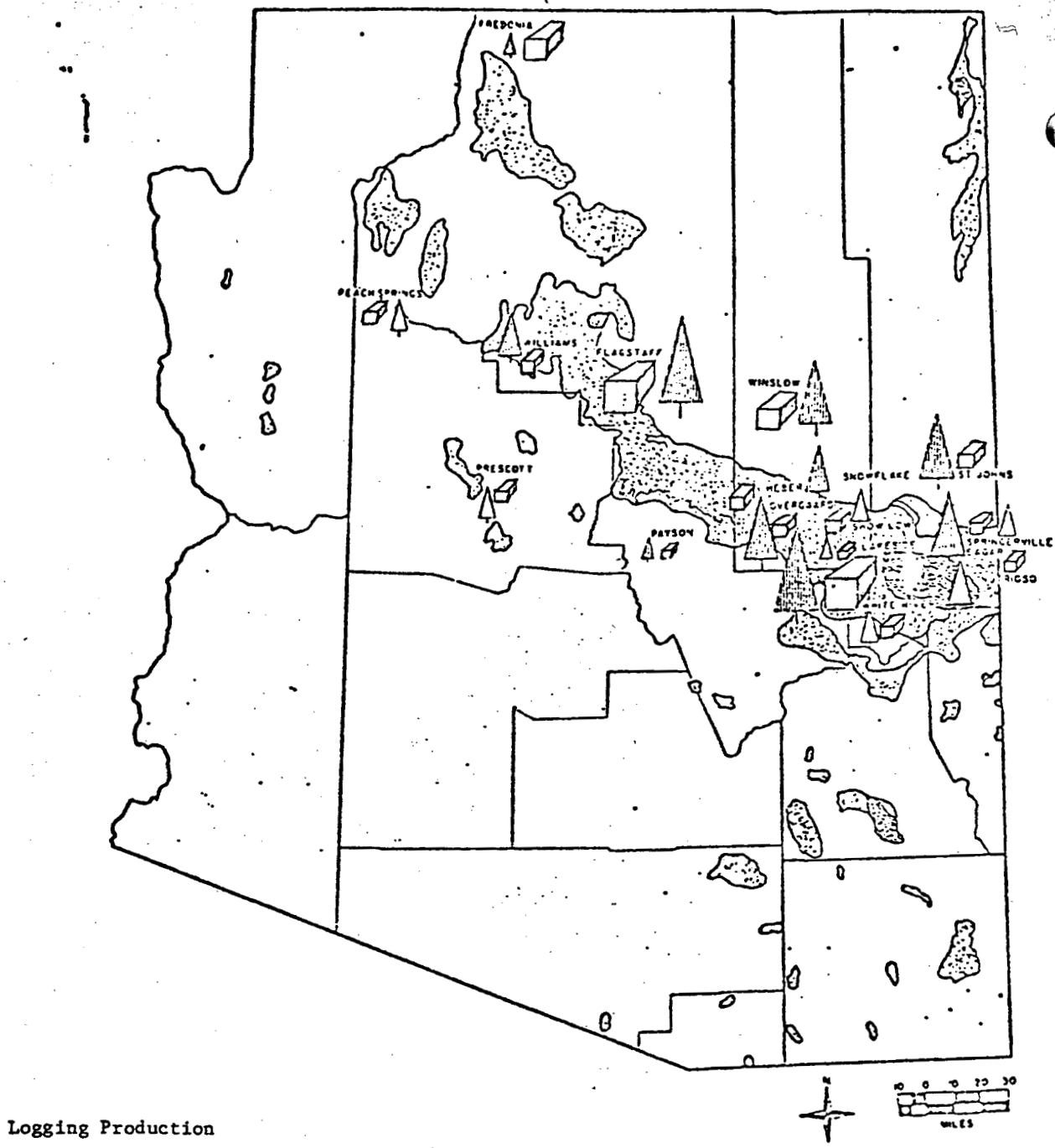


FIGURE 15: POPULATION DISTRIBUTION IN ARIZONA (*)

(*) 1970 Census



Logging Production

- Over 420 M/Day
- 150–200 M/Day
- 50–80 M/Day
- 25–40 M/Day
- Quantity unknown

Sawmill Production

- Over 375 M/Day
- 200–210 M/Day
- 50–85 M/Day
- 30–40 M/Day
- Quantity unknown

Ponderosa Pine

Spruce B Fir

Production Figures in Thousands of Board Feet Per Day

FIGURE 16: LOGGING AND SAWMILL OPERATIONS IN ARIZONA (*)

(*) Directory of Forest Products Industry, 1964

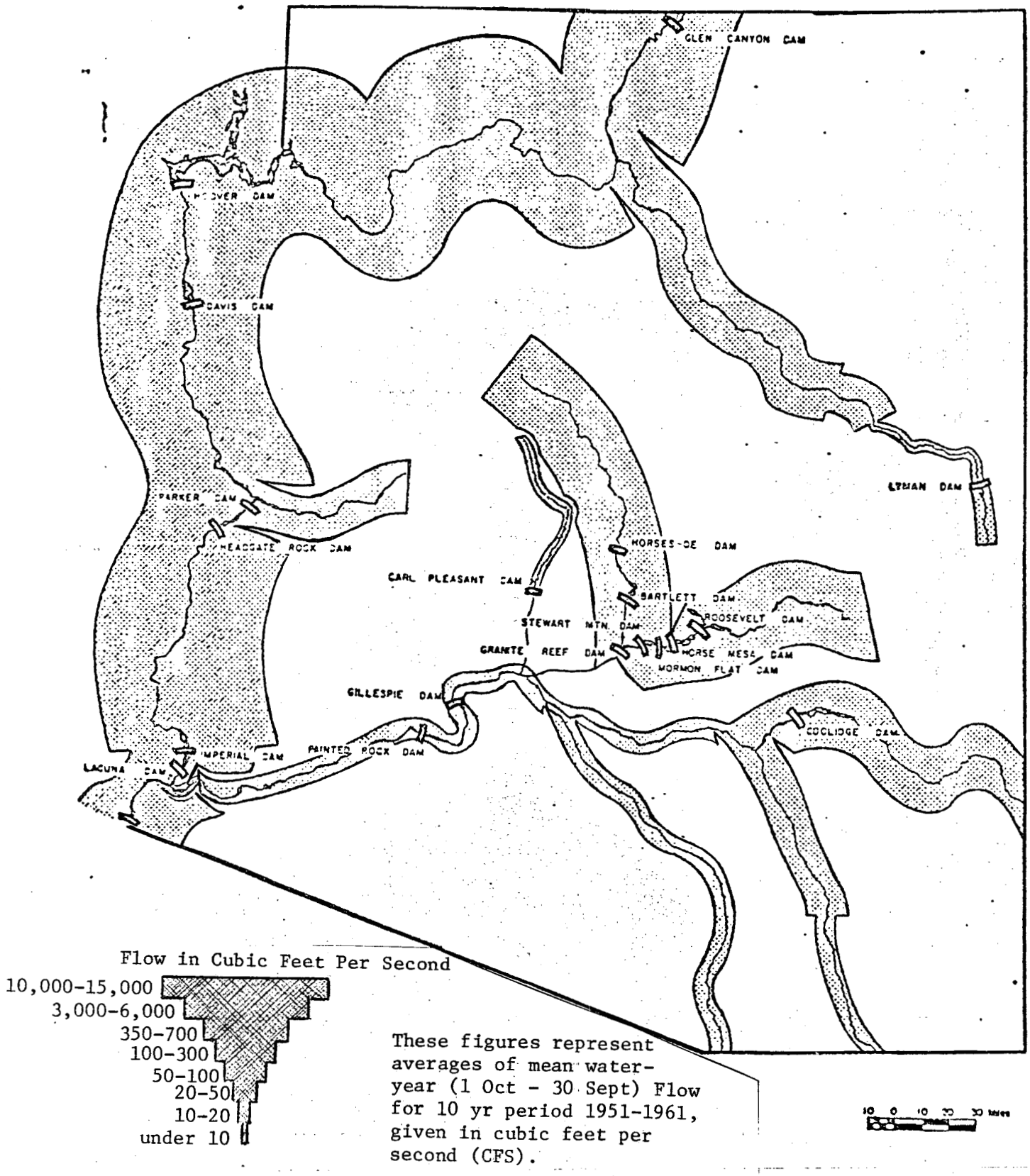


FIGURE 17: COLORADO RIVER DISCHARGE MEAN FLOW 1951-1960 (*)
(*) Geological Survey, Water Supply Paper 1733

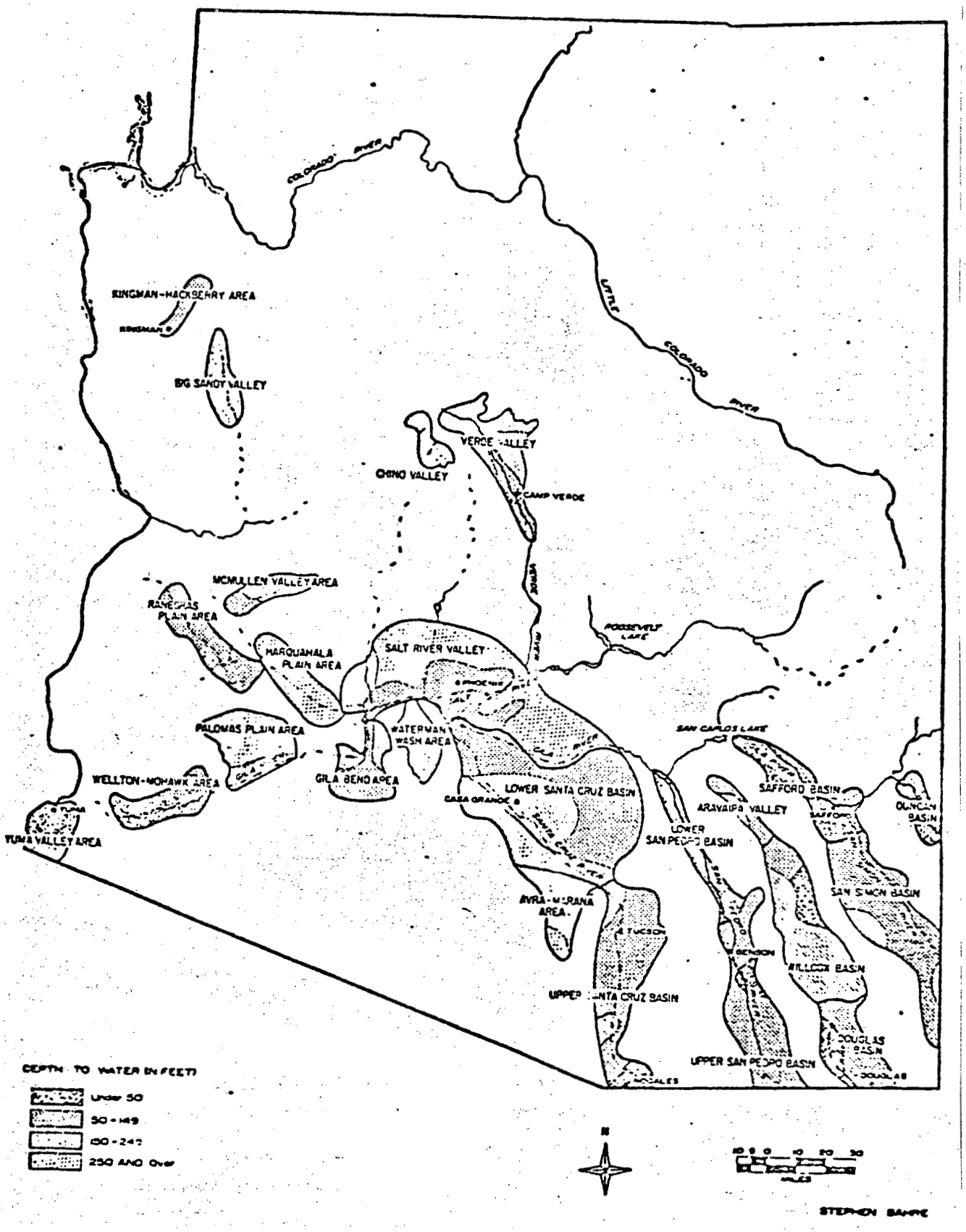


FIGURE 18: AVERAGE GROUND WATER LEVEL IN SELECTED BASINS AND AREAS(*)

(*) USGS Ground Water Report on Arizona

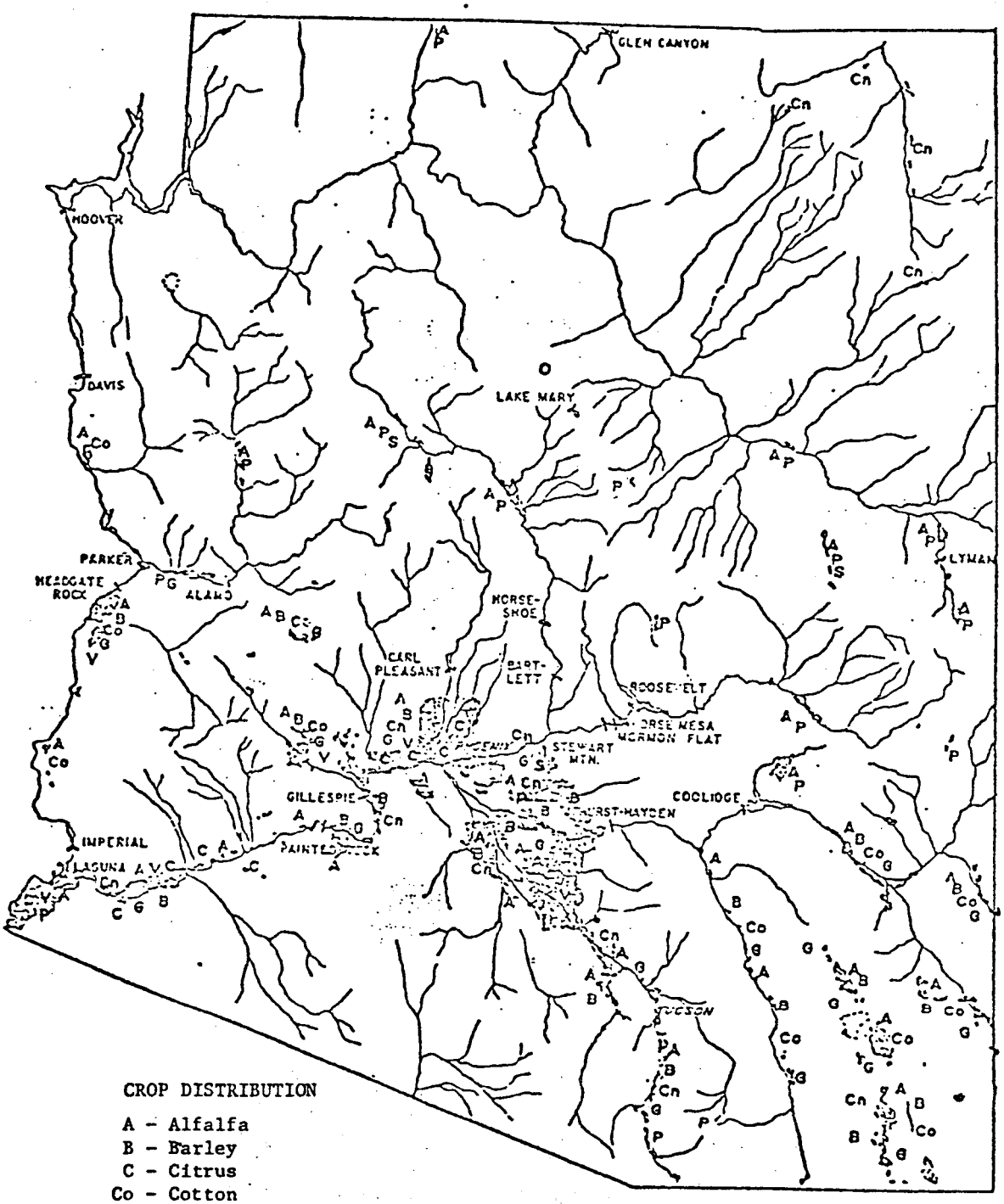


FIGURE 19: CROP DISTRIBUTION AND IRRGATED AREAS

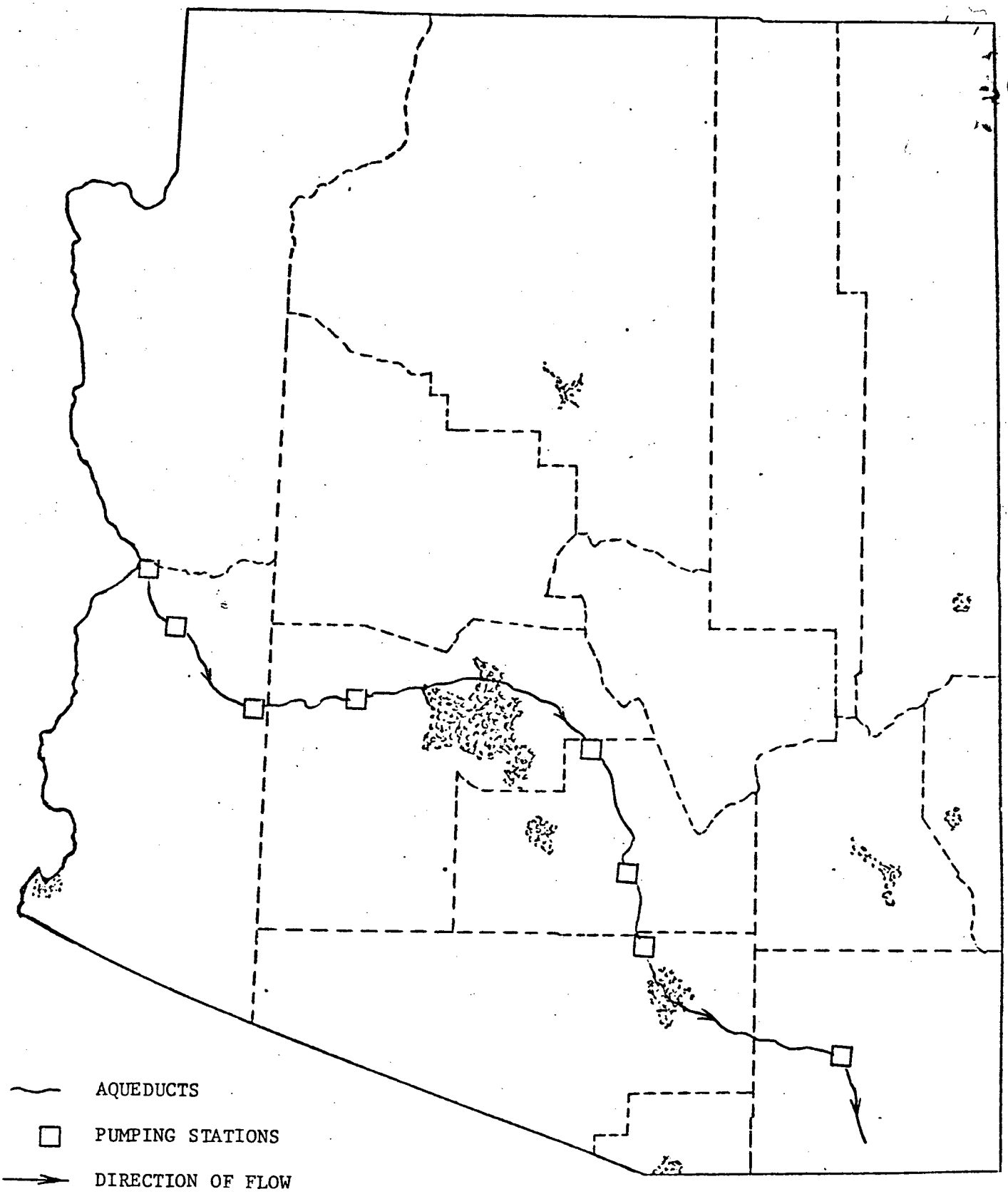


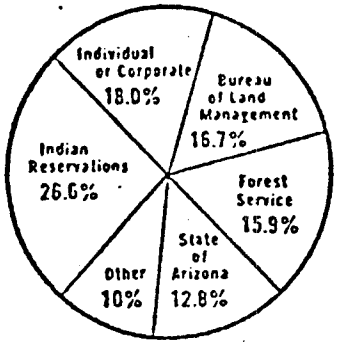
FIGURE 20: CENTRAL ARIZONA PROJECT

TABLE 8

ARIZONA

LAND

OWNERSHIP



ARIZONA LAND OWNERSHIP AND ADMINISTRATION BY COUNTY

(In Thousand Acres)

County	Forest Service	Bureau of Land Management	Indian Reservation	State of Arizona
Apache	480	130	4,447	705
Cochise	517	290	—	1,446
Coconino	3,319	646	4,401	1,042
Gila	1,717	59	1,143	28
Graham	395	779	1,000	494
Greenlee	780	172	—	145
Maricopa	730	1,848	268	583
Mohave	33	4,362	596	505
Navajo	488	97	4,214	327
Pima	385	373	2,488	957
Pinal	223	560	558	1,237
Santa Cruz	450	—	—	51
Yavapai	2,013	571	4	1,387
Yuma	—	2,255	230	427
TOTAL	11,531	12,142	19,349	9,334

County	Individual or Corporate	Other*	Total	% of Total
Apache	1,235	154	7,151	9.8%
Cochise	1,639	112	4,004	5.5
Coconino	1,617	862	11,887	16.4
Gila	92	1	3,040	4.2
Graham	282	—	2,950	4.1
Greenlee	102	—	1,199	1.7
Maricopa	1,585	891	5,905	8.1
Mohave	1,573	1,417	8,486	11.7
Navajo	1,194	23	6,343	8.7
Pima	813	897	5,914	8.1
Pinal	864	—	3,442	4.7
Santa Cruz	295	—	797	1.1
Yavapai	1,203	1	5,179	7.1
Yuma	543	2,936	6,391	8.8
TOTAL	13,038	7,294	72,688	100.0%

*Includes land administered by National Park Service, Department of Defense, Bureau of Sport Fisheries and Wildlife, Bureau of Reclamation and other miscellaneous public land (County, State and Federal).

Source: Arizona Crop & Livestock Reporting Service, "Arizona Agricultural Statistics, 1976."

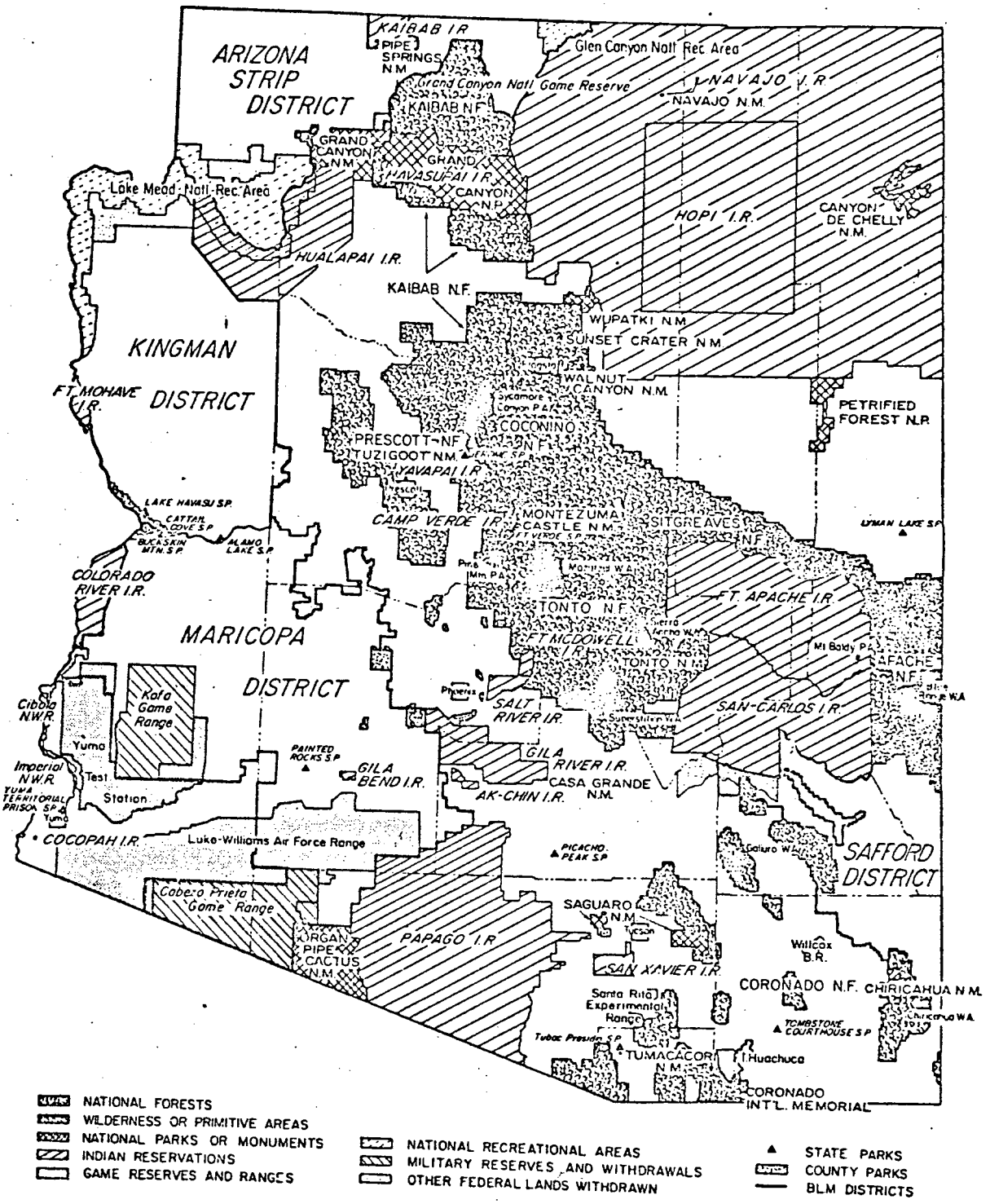
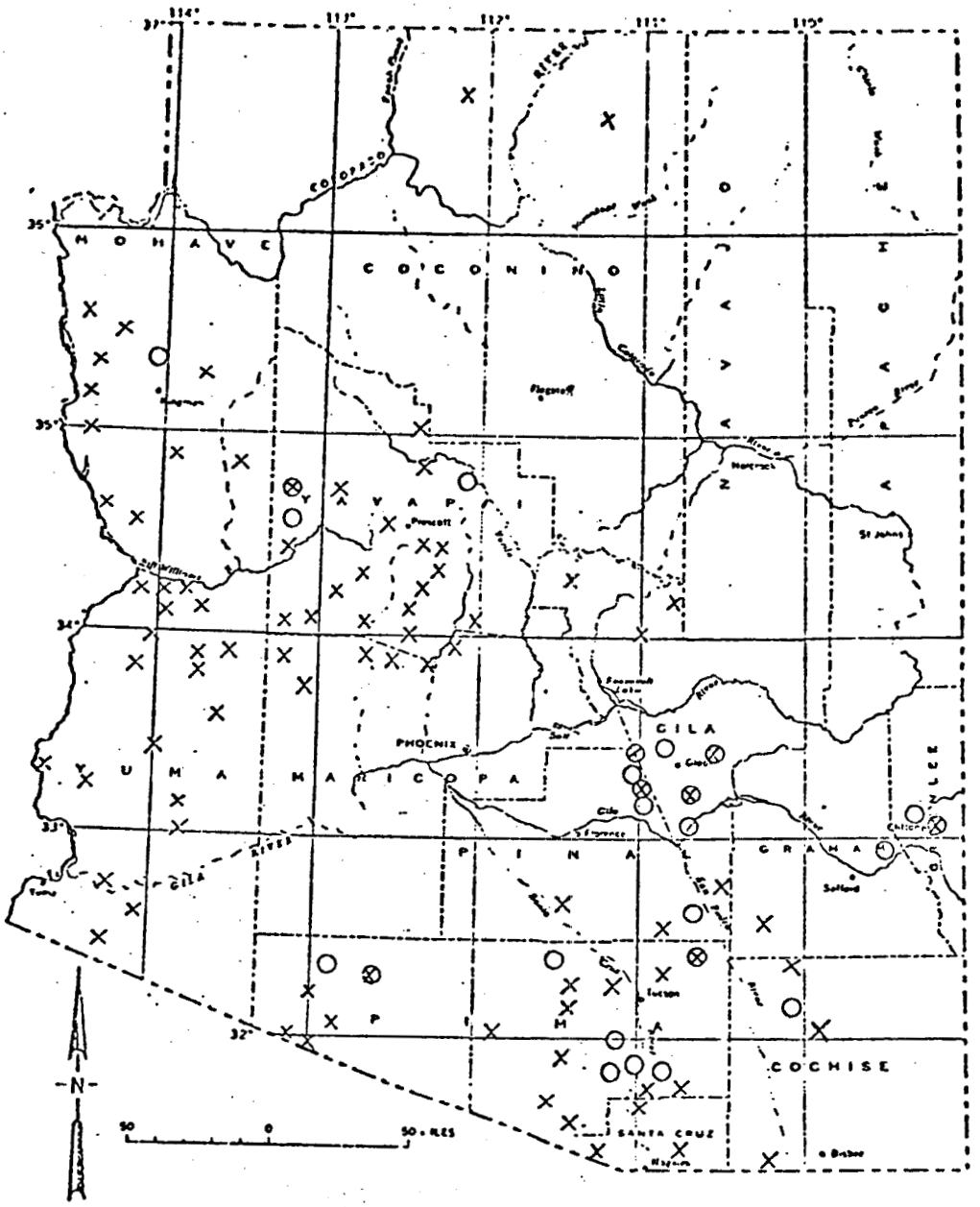


FIGURE 21: LAND OWNERSHIP BY LOCATION



⊗ *Large Sulfuric Acid Plants, recovering SO_2 from copper smelter stack gases*

TOTAL CAPACITY: 12,500 Tons per day

COPPER PRODUCTION

× *10 – 50,000 TONS*

○ *MORE THAN 50,000 TONS*

FIGURE 22: COPPER MINES AND SULFURIC ACID PLANTS IN ARIZONA

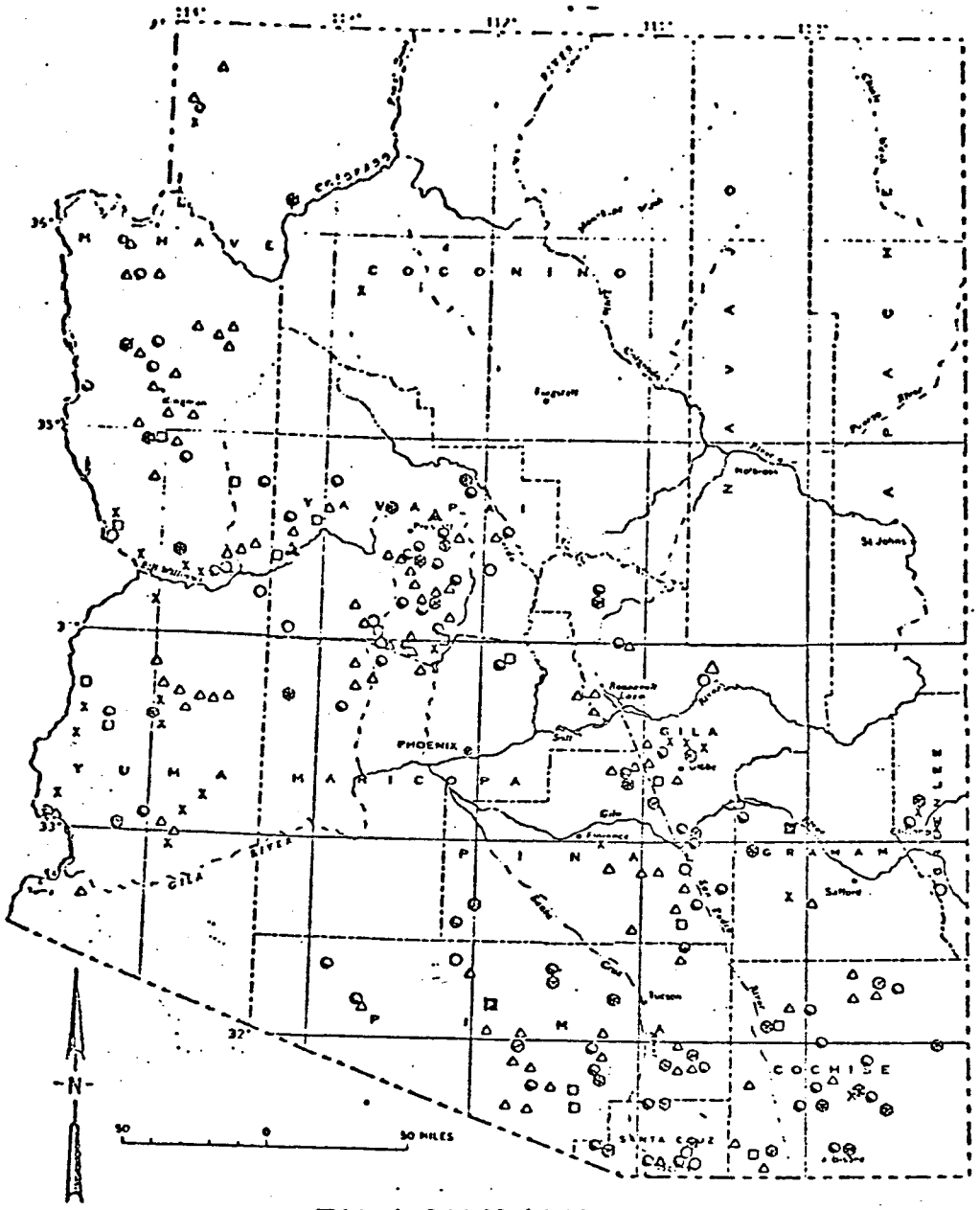
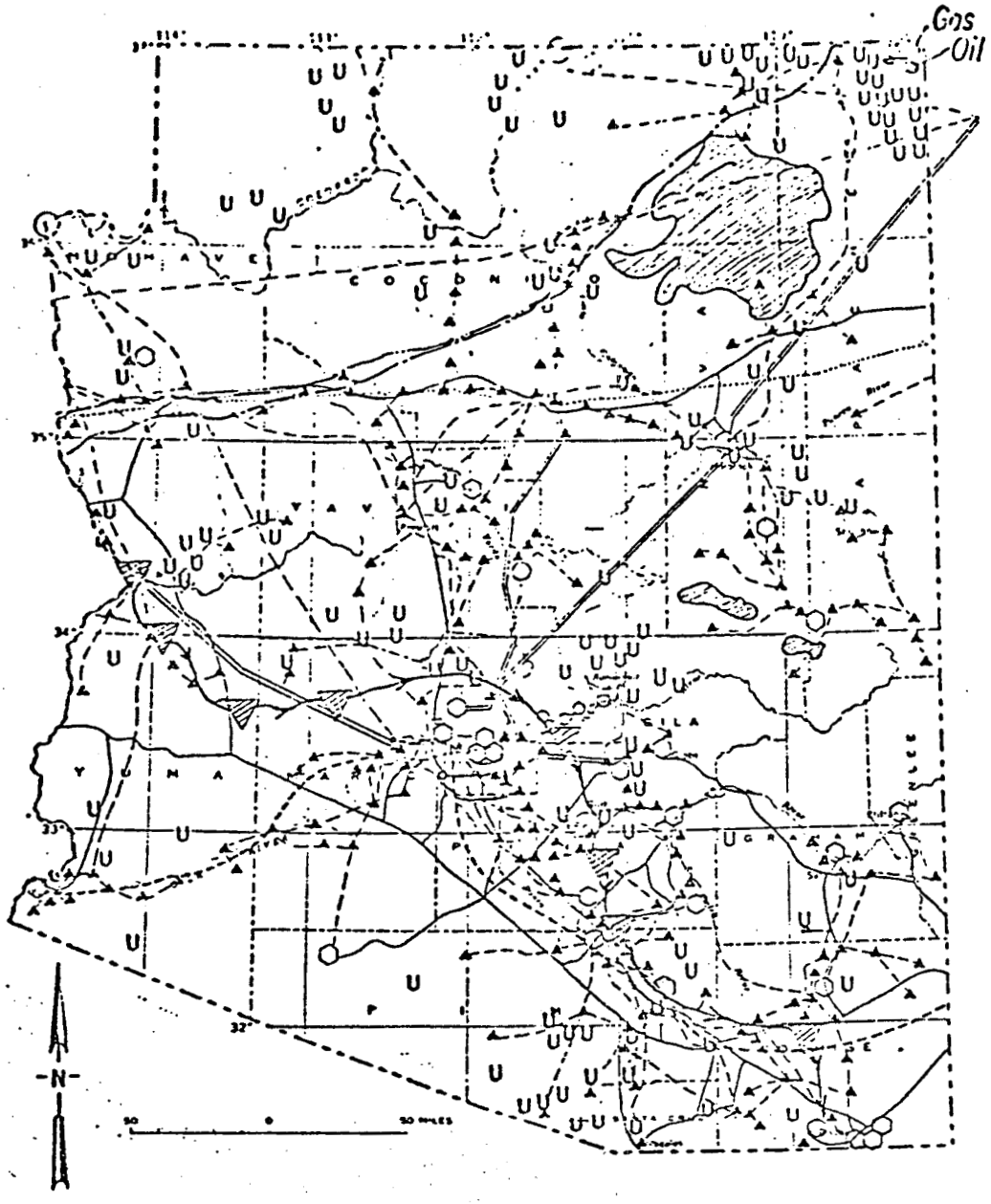


FIGURE 23: VARIOUS MINERAL DEPOSITS IN ARIZONA



PIPELINES

- El Paso Natural Gas
- Transwestern Natural Gas
- Southern Pacific Petroleum
- Coal Slurry
- Crude Oil

GENERATION PLANTS

Steam Hydro

- Natural Gas
- Crude Oil

TRANSMISSION LINES

- Over 80,000 volts
- Under 80,000 volts
- Substation
- Pumping Station

Aqueducts

Direction of flow

- Bituminous Coal
- U Uranium

FIGURE 24: POWER SOURCES IN ARIZONA

of Arizona's energy consumed is in the form of electricity, 34.1% for transportation and only 12.1% for industrial and 16.2% for residential uses. Arizona is growing very fast so energy consumption doubles every ten years.

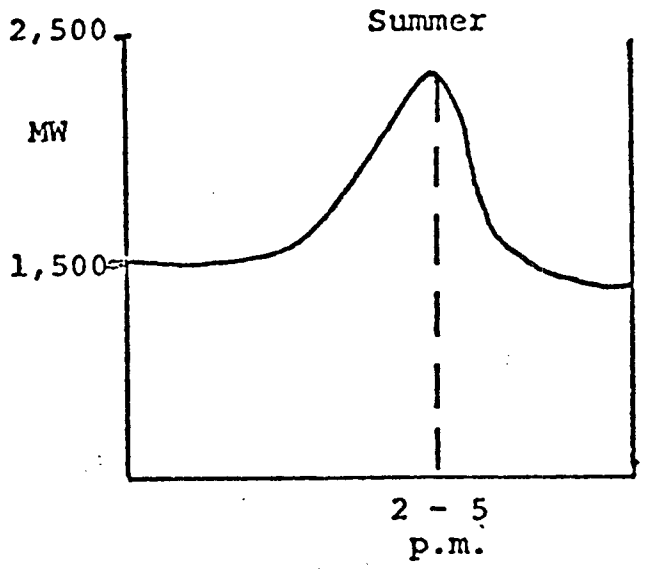
Electrical use is characterized by unusual daily and seasonal peak loads. The high cooling demand in the summer afternoons causes daily peak loadsto be different than in the winter (Fig 25) and also results in a seasonal peak during the hottest months, June - September (Fig 26). Also affecting this peak is the shutdown of a few industries (Motorola, Honeywell, etc), during weekends. Utilization of geothermal space-heating or cooling must be performed carefully, for the price of electricity may rise if the base power loads are removed from the present suppliers.

The total consumption of energy in Arizona increased from 250 trillion BTU in 1960 to 450 trillion BTU in 1970. Present consumption is near 700 trillion BTU per year. Tables 9-12 offer different perspectives of energy use by consumption type, energy source, and a chronological breakdown from 1960-1975. This data led to the prediction that consumption would double each decade.

C. ARIZONA'S WATER SITUATION

Most of Arizona has an arid to semiarid climate. The main surficial water discharge in Arizona is the Colorado River drainage system. Arizona has smaller ephemeral streams (i.e., that flow part of the year) resulting from the summer monsoon season of July and August. Tucson and Phoenix each receive an average annual precipitation of 12-15 inches. This meager recharge is but a small fraction of the water used each year. This recharge is less meaningful each year as water is used in ever increasing quantities for irrigation agriculture, the copper industry and the expanding population. The source of most water is pumped groundwater; consequently the water table is dropping at a significant rate in areas of heavy pumping. The volume of water that is extracted from the ground every year is 2,000,000 acre-feet. Hydrologists estimate problems recovering water in the future due to the higher energy required to pump deep ground water to the surface, as well as the possibility that one day some places will just dry up.

Salinity of groundwater like that in the Buckeye, Arizona area is in the brackish range. To obtain potable water they must desalinate the water using an electrodialysis method. Yuma has a reverse asmosis plant to upgrade the water that the United States must supply Mexico via the Colorado River under treaty agreement. So the water problem is realized in its lack of both availability and cleanliness. Development of a geothermal resource could help tackle both problems, depending upon the temperature of the reservoir, its size, depth and porosity. Under favorable conditions with respect to these parameters, geothermal energy would be highly beneficial to Arizona by reducing the cost of energy consumption.



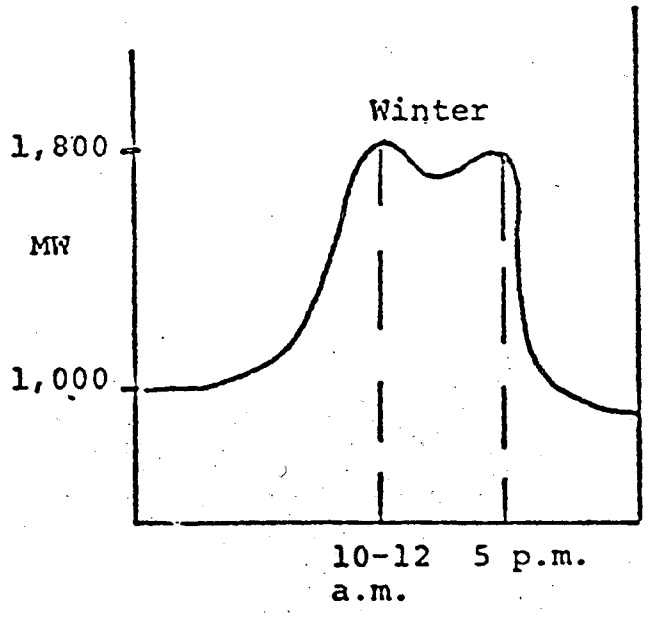


FIGURE 25: DAILY ELECTRIC PEAKS IN ARIZONA

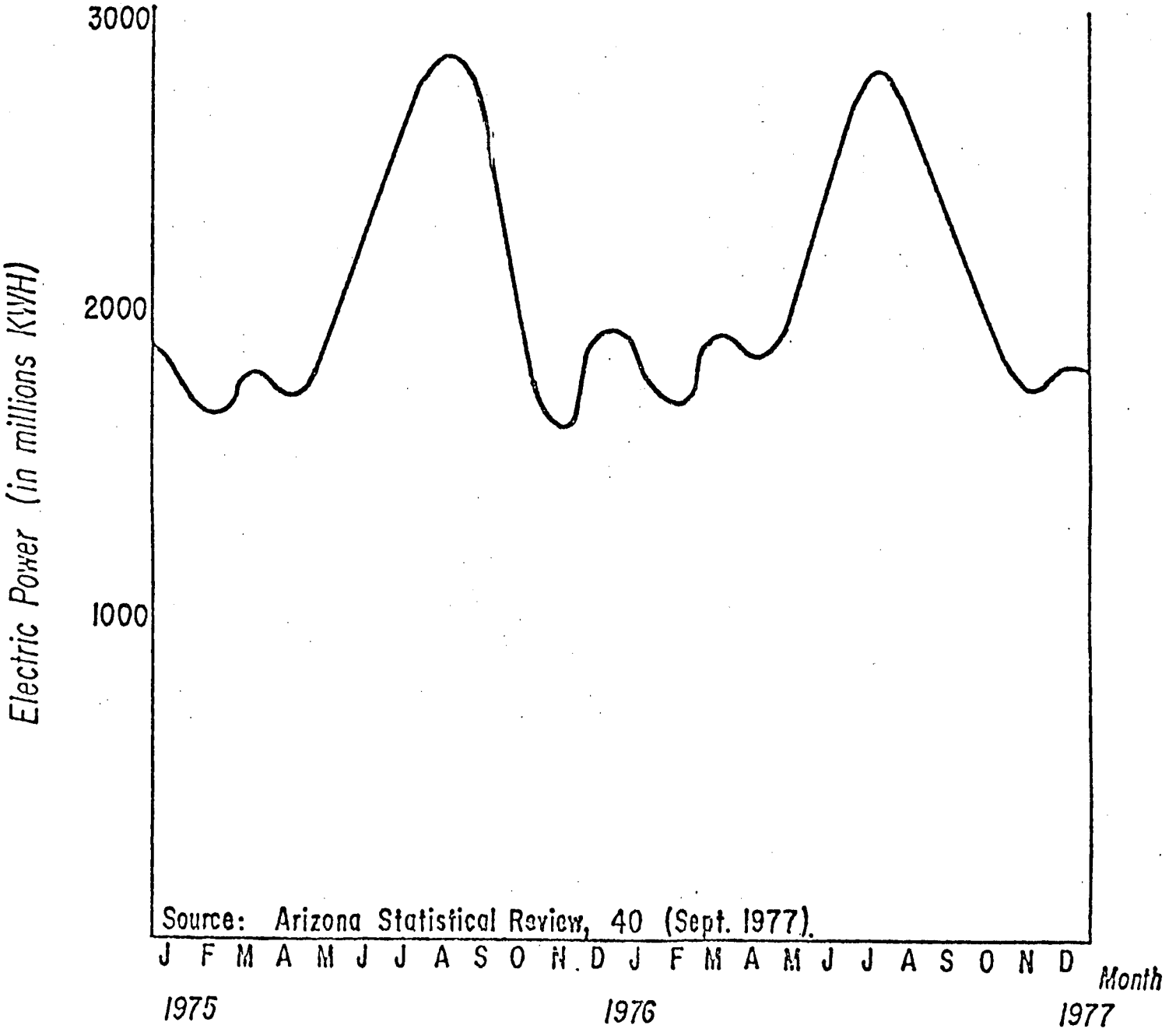


FIGURE 26: SEASONAL PEAK ELECTRIC LOADS IN ARIZONA

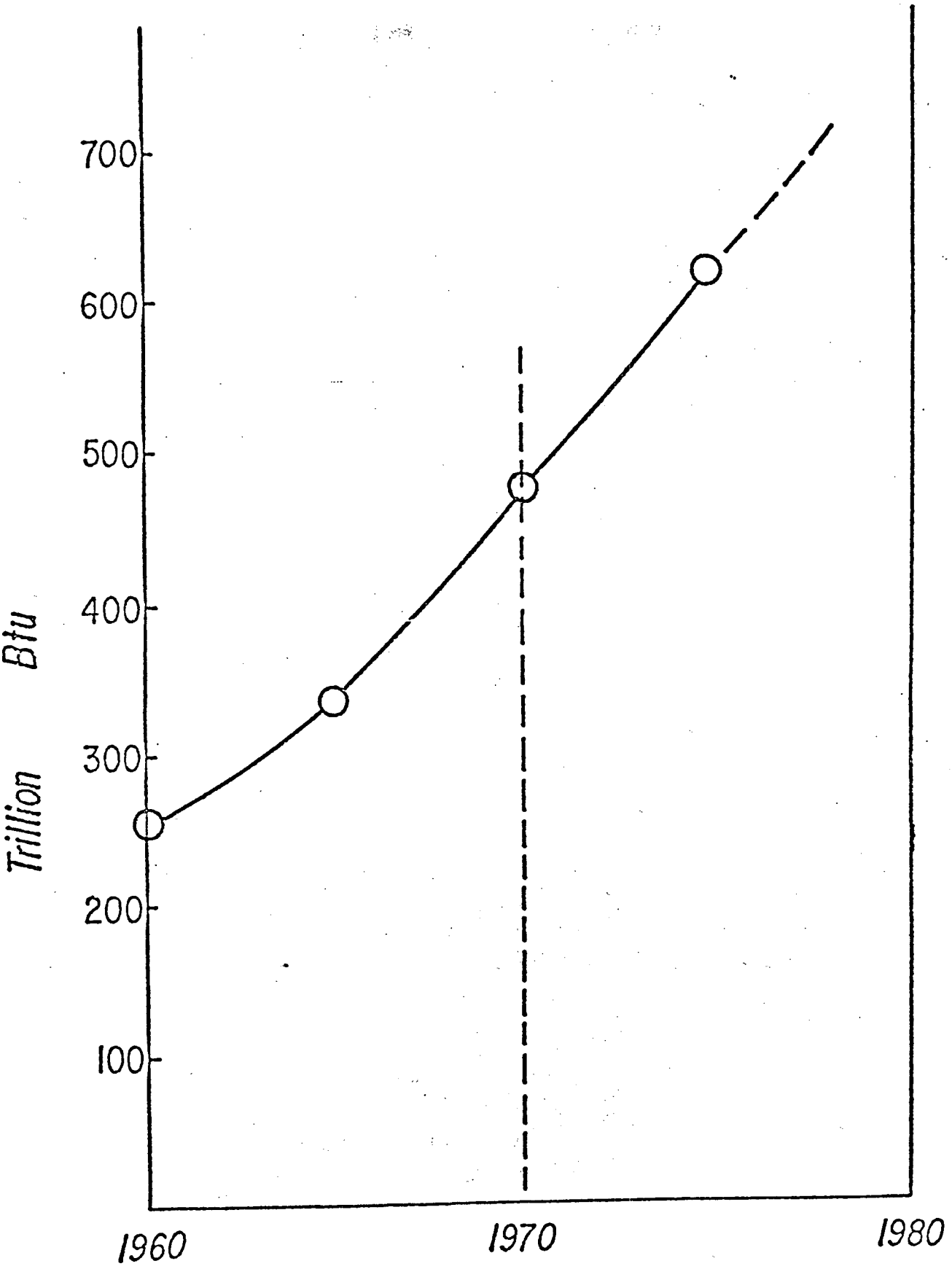


FIGURE 27: ARIZONA TOTAL ENERGY CONSUMPTION

TABLE 9

ARIZONA GROSS ENERGY INPUTS[a]
SUPPLY SOURCES BY USER CLASS, 1975*
ENERGY USED (IN TRILLION BTU'S)

	Coal	Natural Gas	Petroleum	Hydro-power	Total
Household/ Commerical	--	72.3	27.1	--	99.3
Industrial	2.4	52.5	19.5	--	74.4
Transportation	--	17.7	191.9	--	209.6
Electric	83.1[b]	18.3	49.6	77.8	228.8
Miscellaneous	--	--	2.3	--	2.3
Total	85.5	160.8	290.3	77.8	614.4

Percent of Energy Used

Household/ Commercial	--	45.0	9.4	--	16.2
Industrial	2.8	32.6	6.7	--	12.1
Transportation	--	11.0	66.1	--	34.1
Electric	97.2[b]	11.4	17.1	100.0	37.2
Miscellaneous	--	--	0.7	--	0.4
Total	100.0	100.0	100.0	100.0	100.0
Percent of Sources	13.9	26.2	47.2	12.7	100.0

[a]Includes BTU equivalent of total electricity sold from instate plants and net imports.

[b]Net imports attributed to coal.

*Preliminary

Source: Compiled by University of Arizona from official and private sources.

TABLE 10

SUMMARY

ARIZONA GROSS ENERGY CONSUMPTION

IN 1975

Energy Source	Percent	
Oil	47.2	Much transportation
Natural Gas	26.2	Much commercial/residential
Hydroelectric	12.7	— Electricity
Coal	13.9	

Consumption (Market)	Percent
Electricity	37.20
Transportation	34.10
Industrial	12.10
Residential/Commercial	16.20
Miscellaneous	0.40

TABLE 11

ARIZONA TOTAL ENERGY CONSUMPTION

1960-1975

Trillion BTU

Year	Residential	Commercial[a]	Industrial	Transportation	Total[b]
1960	46.7	31.8	78.7	104.2	261.5
1961	41.8	40.6	87.5	100.9	271.2
1962	40.7	43.9	86.2	104.4	275.6
1963	43.6	47.0	88.5	112.1	291.4
1964	50.8	53.2	94.5	119.3	317.9
1965	53.3	61.2	101.1	124.0	339.7
1966	55.6	68.7	105.2	134.4	364.1
1967	58.6	70.1	102.5	142.4	373.8
1968	62.1	73.5	113.6	158.2	407.5
1969	70.7	82.1	124.9	172.8	450.8
1970	77.8	93.0	131.9	182.7	486.0
1971	90.0	101.2	143.9	190.8	526.6
1972	101.2	117.3	154.9	212.0	587.2
1973	112.1	140.5	155.7	225.5	635.9
1974	111.2	143.2	156.7	212.3	626.3
1975	119.2	140.3	142.9	209.6	614.4

a) Includes government sector and nonprofit organizations.

b) Includes miscellaneous uses.

TABLE 12

ARIZONA ENERGY CONSUMPTION BY FUEL SOURCE

1960-1975

Trillion BTU

	Natural Gas		Petroleum Liquids			Electric Sales		
	R_a	C^{**}_a	R_a	C^{**}_a	I^{*}_a	R_b	C^{**}_b	I_b
1960	28.1	8.2	1.3	7.9	48.6	17.3	15.7	30.1
1961	25.9	10.9	1.8	8.7	54.2	14.1	21.0	33.3
1962	22.9	12.9	2.4	8.4	57.3	15.4	22.6	28.9
1963	24.2	13.7	2.4	10.1	61.0	17.0	23.2	27.5
1964	29.3	17.3	2.5	10.6	65.6	19.0	25.3	28.9
1965	26.0	19.8	2.4	10.1	65.8	24.9	31.3	35.3
1966	25.8	18.5	1.6	14.8	69.2	28.2	35.4	36.0
1967	26.2	15.6	2.5	15.0	64.6	29.9	39.5	37.9
1968	27.5	16.2	2.3	18.0	73.6	32.3	39.3	40.0
1969	29.3	17.2	2.6	21.3	78.4	38.8	43.6	46.5
1970	30.6	17.8	3.2	27.6	77.3	44.0	47.6	54.6
1971	33.6	22.1	3.1	23.4	82.5	53.3	55.7	61.4
1972	35.2	23.5	3.2	28.3	90.2	62.8	65.5	64.7
1973	37.5	32.9	3.0	33.4	90.2	71.6	74.2	65.5
1974	33.0	33.4	3.3	31.7	87.3	74.9	78.1	69.4
1975	38.8	33.4	2.3	24.8	74.4	78.1	82.1	68.5

*Industrial data is combination of Natural Gas & Petroleum Liquids i.e. nonelectric energy

**Includes government sector & nonprofit organizations

a) U.S. Bureau of Mines, IC8705, Historical Fuels and Energy Consumption Data, 1960-1972; IC8722 for 1973; 1974-75 compiled by University of Arizona

b) Edison Electric Institute, Statistical History 1961-70; Yearbooks 1960, 1971-75.

R = Residential

C = Commerical

I = Industrial

IV. GEOTHERMAL USE SCENARIOS

A. INTRODUCTION

The geothermal energy potential in Arizona appears large but is presently unproven. Geological studies indicate that geothermal sources exist in arizona of both the hot rock and hydration-field type. Temperatures in the range of 30-300°C can be expected. Due to the lack of significant geothermal well drilling most of the predictions are based on the knowledge of the geological conditions and water well temperature data. Minimum 500 ft depth of well is required to get reliable data on temperature gradients. Evidence of thermal activity is also available from oil and geothermal drillings. A map showing areas of geothermal potential is shown in Figure 7. Heat flow measurements in the basin range region where half of Arizona lies, average about 2.2 HFU, significantly higher than the crystal heat flow of 1.2 - 1.5 HFU*. Harnessing terrestrial heat flow depends on the existence of reservoirs of hot water in Arizona valleys and the economics of exploiting the resource as planned.

1. Preliminary Evaluation

Preliminary evaluation of some of these data has shown that many potential geothermal areas do exist in the State of Arizona. Should they be found, geothermal reservoirs may be suitable for various use applications and that many may be potential multi-use resources. In addition, evaluation has facilitated preliminary selection of several potentially favorable sites for the immediate development of practical planning diagrams, or site-specific scenarios.

Arizona has the fastest population growth of all states in the U.S.A. The growth of Arizona (as well as Florida and Nevada) during 1977 to 1985 is projected as 25% in population and 56% in earnings, compared with 7% and 35% for the U.S.A. Due to the heavy use of conventional mechanical refrigeration for air conditioning Arizona also has an excessive electrical load in the summer. These two factors cause many problems in planning for power expansions, but at the same time present an opportunity to plan a shift to alternative energy sources, such as geothermal energy. Many non-electrical uses have been identified to date, based in part on Arizona's industrial base in mining and electronics, its irrigated agriculture and the need for hot water for food processing, new industry and communities in the many desert regions of sparse population.

During the first year of participation in this Southwest Geothermal Project, the majority of funding and research was directed toward the identification of (a) potential geothermal resource areas in the State and

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* Norton, D. Gerlach, T., Decook, K.J. and Summer, J.S., "Geothermal water resources in Arizona - Feasibility Study", Technical report, Office of Water Research and Technology Project A-054 - Arizona, The University of Arizona, Aug. 1975

(b) typical cross-section of potential geothermal use scenarios. The responsibility of investigating these two main activities was given to the Arizona Bureau of Geology and Mineral Technology and the Department of Chemical Engineering respectively, both of the University of Arizona; the Arizona Solar Energy Commission accepted the responsibility of obtaining data on leasing activity and State-level institutional constraints, with the hope that most of these data can be obtained from on-going groups in the government and industry of the State.

Scenarios for the use of geothermal energy have been approached first (a) by examining the current and future needs for energy in Arizona, and from what possible sources the energy must come and (b) by reviewing the basic resources of the State, including people, water, industry, mining fossil fuels, agriculture, and current technological situations. Some 70 letters were sent to selected corporations of the State, attempting to reach a cross-section of energy consumers, state geological and water well data were reviewed, as well as international geothermal literature. Both daily and seasonal peak energy loads were identified, together with the type of energy needed. With these data in hand, a cross-section of potential geothermal use scenarios began to evolve, always keeping in mind the competitive picture of alternative sources of energy. Table 13 gives the geothermal energy potential uses in Arizona in summary form. While Table 14 presents the list of twenty-two scenarios discussed in this report.

2. Potential Constraints and Advantages

Economic feasibility of geothermal energy depends on the influence of many potential factors and advantages. Table 15 comprises a list of these parameters. This qualitative list will be continuously expanded, revised and refined throughout the remainder of the project.

a: Potential impediments

i. General Potential Impediments

Utilization of geothermal resources, in general, faces several impediments. Geothermal energy is considered a low-value energy due to the fact that it provides heat energy only, a fraction of which can be used efficiently. The extraction of this energy often involves many costly operations (e.g., drilling and pumping) which may not be offset by the value of the extracted energy (as occurs in petroleum exploration and production). Problems may be encountered such as the hot brine scaling equipment with silica, finding an appropriate means of brine disposal, and extensive lengthy governmental requirements for procedure. These inhibit production of geothermal energy and increase costs. However the use of geothermal energy by the private sector may lower the demand for electricity from utilities, causing an increase in the prices of electricity. This increased revenue may offset the costs associated with the impediments.

TABLE 13

GEOTHERMAL ENERGY POTENTIAL USES IN ARIZONA

I. POTENTIAL GEOTHERMAL ENERGY UTILIZATION IN ARIZONA

A. Agriculture

1. Irrigation Pumping
2. Brackish Water Utilization
3. Grain Drying
4. Hot Water for Dairies
5. Refrigeration for Lettuce Processing
6. Cotton Milling and Cottonseed Oil Extraction
7. Citrus Processing
8. Pecan Processing
9. Integrated Alfalfa Dehydration/Cattle Feedlots

B. Industrial

1. Mining
2. Copper Processing
3. Lumber Kiln Drying
4. Wood Pulp Processing
5. Other Industry that can use low temperatures in their processing (existing and potential)

C. Municipal

1. Conventional Electricity
2. Peak Electricity
3. Commercial Building Heating
4. Commercial Building Cooling

II. GEOTHERMAL ENERGY IN PERSPECTIVE WITH OTHER ENERGY SOURCES IN ARIZONA

A. Coal
B. Gas
C. Oil
D. Nuclear
E. Solar

TABLE 14

LIST OF SCENARIOS DISCUSSED IN THIS REPORT

SCENARIO #	TITLE
1	Space cooling for an industrial complex (Case Study: Electronics firm in Phoenix)
2	District heating and cooling (Case study: Retirement community outside Phoenix)
3	New communities
4	New industries
5	Energy storage for heat pump systems
6	Central Arizona Project/Peak Power
7	Wind energy/geothermal/energy storage
8	Hot igneous rock and power plant
9	Coal mining operations
10	Preheating/sulfur removal in coal field power plants
11	Solution mining
12	Hot Water for conventional mining
13	Hot mines
14	Salt production
15	Desalination
16	Biosalinity agriculture
17	Greenhouse/hydroponics
18	Irrigation pumping (Case Study: Hyder Valley area)
19	Crop drying
20	Kiln drying of lumber
21	Lettuce chilling
22	Sugar beet plant

TABLE 15

GENERALIZED IMPEDIMENTS AND ADVANTAGES
TO USE OF GEOTHERMAL ENERGY

I. POTENTIAL IMPEDIMENTS

A. General

1. High cost for low-value energy
2. Excessive governmental regulations
3. Generally causes an increase in cost of electric power
4. Corrosiveness and scaling
5. Disposal of brines
6. Distance from ocean (for disposal)
7. Competition from local fossil fuels

B. Specific for Arizona

1. Sparse geothermal data
2. Heterogenous land ownership
3. Must pump geothermal well water
4. Overall scarcity of potable water
5. Must compete with solar energy
6. Must compete with coal
7. Must compete with Alaskan oil

II. POTENTIAL ADVANTAGES

A. General

1. Hot water near surface economical
2. Dry steam and 50-year well economical
3. Dry hot rock/water injection attractive
4. Remoteness of Southwest from oil & gas production
5. Sheer size of Southwest states (among the largest)

B. Specific for Arizona

1. Good geothermal prospects based on geology
2. Steep temperature gradients based on water wells
3. Existence of hot springs
4. Rapid growth of State of Arizona
   a. Can we cope with changes in power demand
   b. Can we cope with general changes in energy
5. State of Arizona is still developing
   a. New communities can be planned
   b. New industries can be planned
6. State of Arizona rich in low-concentration minerals
7. State of Arizona has surplus sulfuric acid
8. Solar energy available for pond evaporation

ii. Potential Impediments in Arizona

Of the obstacles presently hindering the development of geothermal energy in Arizona, the most important is the need to discover a shallow geothermal reservoir near a population center. The conditions involving use of the resource are 1) legal consent to drill, 2) public approval of the chosen method of brine disposal, 3) type of land ownership overlying the geothermal resource and 4) overall economic projections of geothermal use as compared to projection of other energy sources, such as energy from Alaskan oil, coal and our sun.

The location of geothermal reservoirs in Arizona is being sought by various agencies, including the Geothermal Group of the Arizona Bureau of Geology. Once a reservoir is found, the effect of the aforementioned impediments on the intricate economics of competing energy sources must be evaluated.

b. Potential Advantages

i. General Potential Advantages

Production of geothermal energy may be profitable under conditions where high temperature water and proximity to the surface result in low cost to the entrepenuer, who may be forced into extra expenditures due to the potential impediments. The advantages of having a shallow hot water reservoir that lasts 50 years or more may outweigh the costly impediments. Technological advancements may render some of the impediments less significant.

Geological understanding will continue to improve in Arizona, where data on heat flow has been sparse. High geothermal gradients have been measured. Water flows hot from some springs. Consequently, most predictions depend on the geologist's educated guess. The rate of geological data input will increase sharply in the coming years, aiding exploration geologists in their quest for a hydrothermal reservoir. Should they be able to define a resource, geothermal energy development could proceed following the first successful drilling test. Geoscientists at the Geothermal Group of the Arizona Bureau of Geology have indicated that there is a good potential in Arizona for geothermal energy. Users of the resource would have to understand the scenarios and all steps involved. Potential users are listed in Table 16.

B. DETAILS ON THE SCENARIOS

For the more detailed study of the scenarios an extensive amount of data was needed; consequently the Arizona background was considered and relevant data was collected. A list is shown in Table 17. The key point in our thinking in the second iteration stage was to look for

TABLE 16

CATEGORIES OF POTENTIAL GEOTHERMAL USERS IN ARIZONA

UTILITY COMPANIES

MINING INDUSTRIES

SOLID STATE AND COMPUTER INDUSTRIES

OTHER MANUFACTURING INDUSTRIES

AGRICULTURAL INDUSTRIES

FOOD INDUSTRIES

INDIAN INDUSTRIES

INSTITUTIONAL FACILITIES

EXISTING COMMUNITIES

NEW INDUSTRIAL COMMUNITIES

NEW RETIREMENT COMMUNITIES

STATE WATER SUPPLY SYSTEMS

TABLE 17

COLLECTION OF ARIZONA BACKGROUND DATA

ANALYSIS OF EXISTING ENERGY SOURCES

ANALYSIS OF CURRENT ENERGY UTILIZATION

PROJECTION OF ENERGY SOURCES TO 2020

PROJECTION OF ENERGY UTILIZATION TO 2020

ARIZONA WATER SITUATION

POPULATION GROWTH CRISIS

TRENDS IN IRRIGATION AGRICULTURE

SOLUTION MINING POTENTIALS

BIO-SALINITY AGRICULTURE POTENTIALS

BIO-SALINITY FOOD POTENTIALS

NEW COMMUNITY PLANNING

integrated systems. Improved economics and reuse of water wherever possible are two important driving forces. For example, take the geothermal water, heat could be extracted and the waste water used for agriculture if possible.

A full detailed analysis of the scenarios was not possible this year and was proposed for next year's study. All of these scenarios are only theoretical and preliminary in nature with many simplifying assumptions; they should be treated as such. This is due to the lack of abundant geothermal field data in Arizona. A literature survey on the use of geothermal energy has been conducted and these scenarios were based on information accumulated from the literature survey. These are plans presented to illustrate how geothermal energy can be used in Arizona.

1. Geothermal Use Scenarios for Arizona

A number of the following scenarios tend to overlap in one form or another; but they are presented to show specifically the various uses of geothermal energy in Arizona.

Scenario #1: Space cooling for an industrial complex (Case Study: Electronics firm in Phoenix)

Location: Phoenix
Temp : 250°F
Depth : 1200 ft
Salinity: 2000 ppm
Land : Federal
Development: 1990

i. Introduction

The first scenario comprises a design for comfort cooling with a geothermal power source. An absorption cooling system would convert geothermal steam to refrigerated air, relieving the large summer electric load. Fig. 28 presents the steps of the site-specific scenario developments in flowchart form.

The hot summers of Phoenix normally have temperature ranges between 80°F and 115°F in each twenty-four hour period. The industrial plant in this case study has two large buildings with a combined total area of 170,000 square feet. The combined cooling load of the buildings is 3,230,000 KWH; the peak load is 1450 kilowatts.

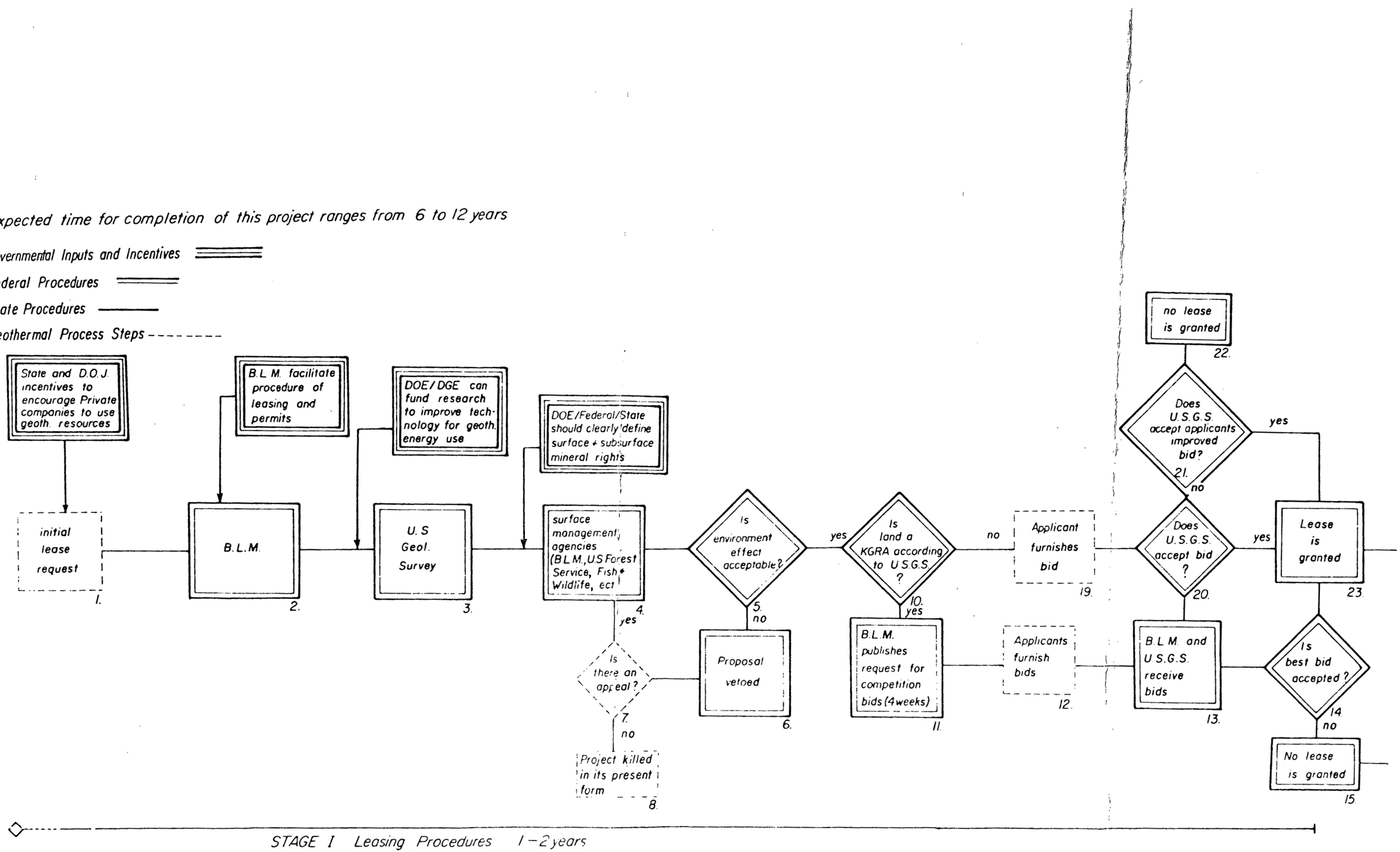
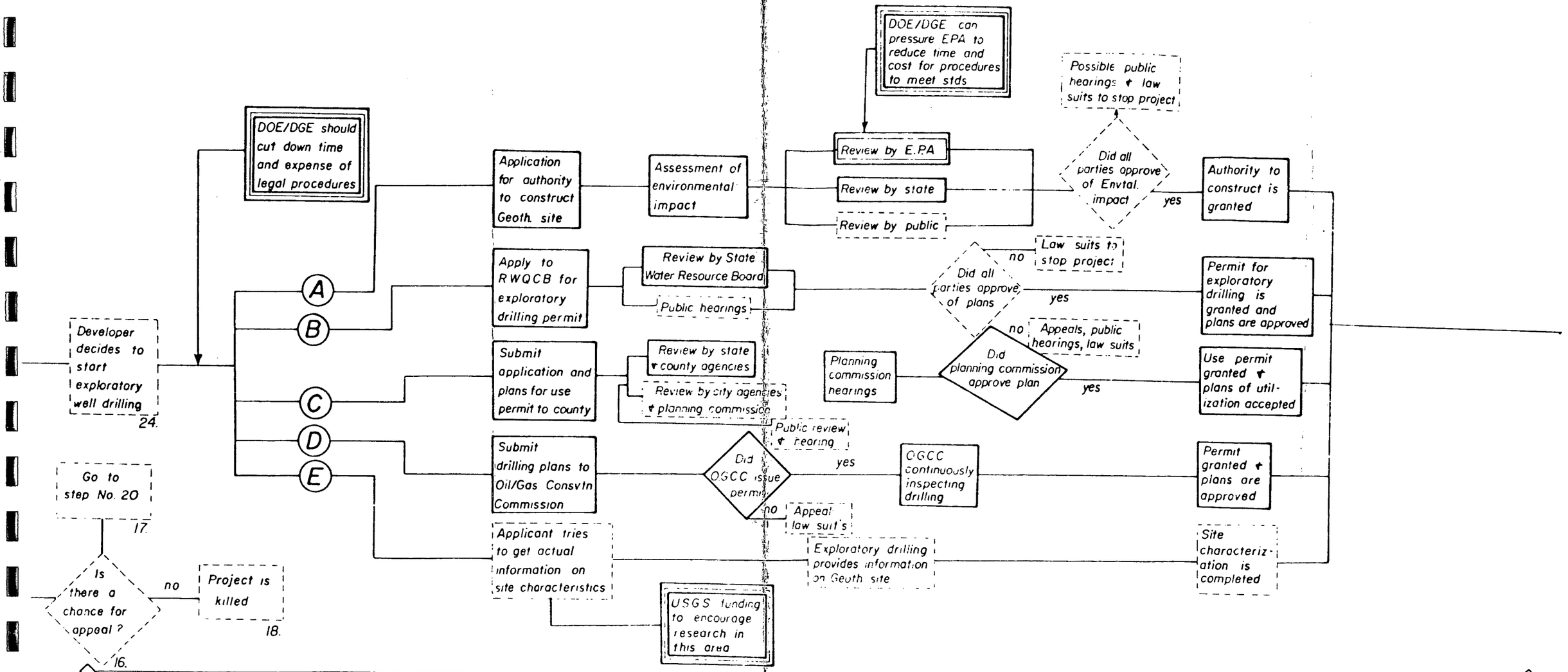
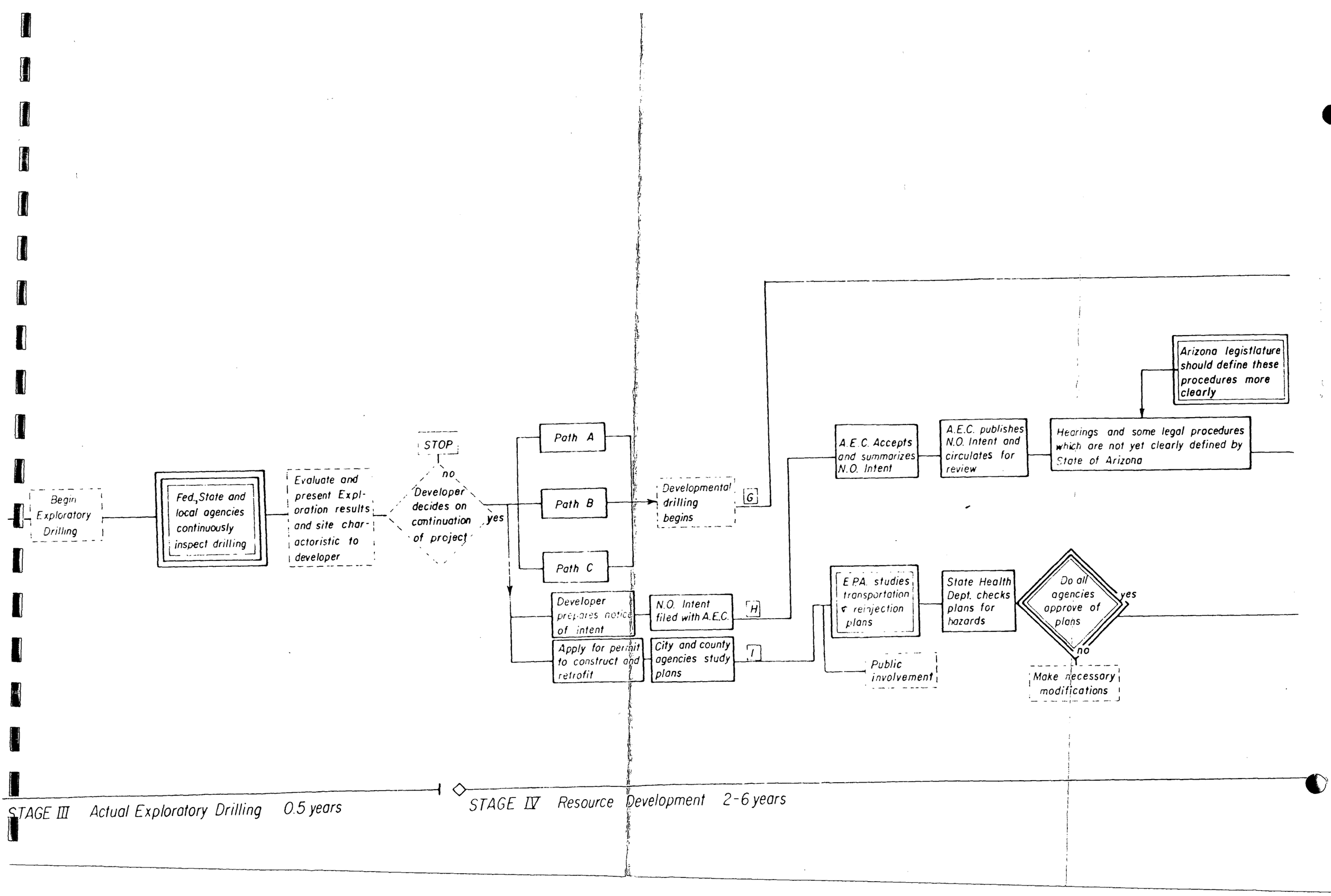
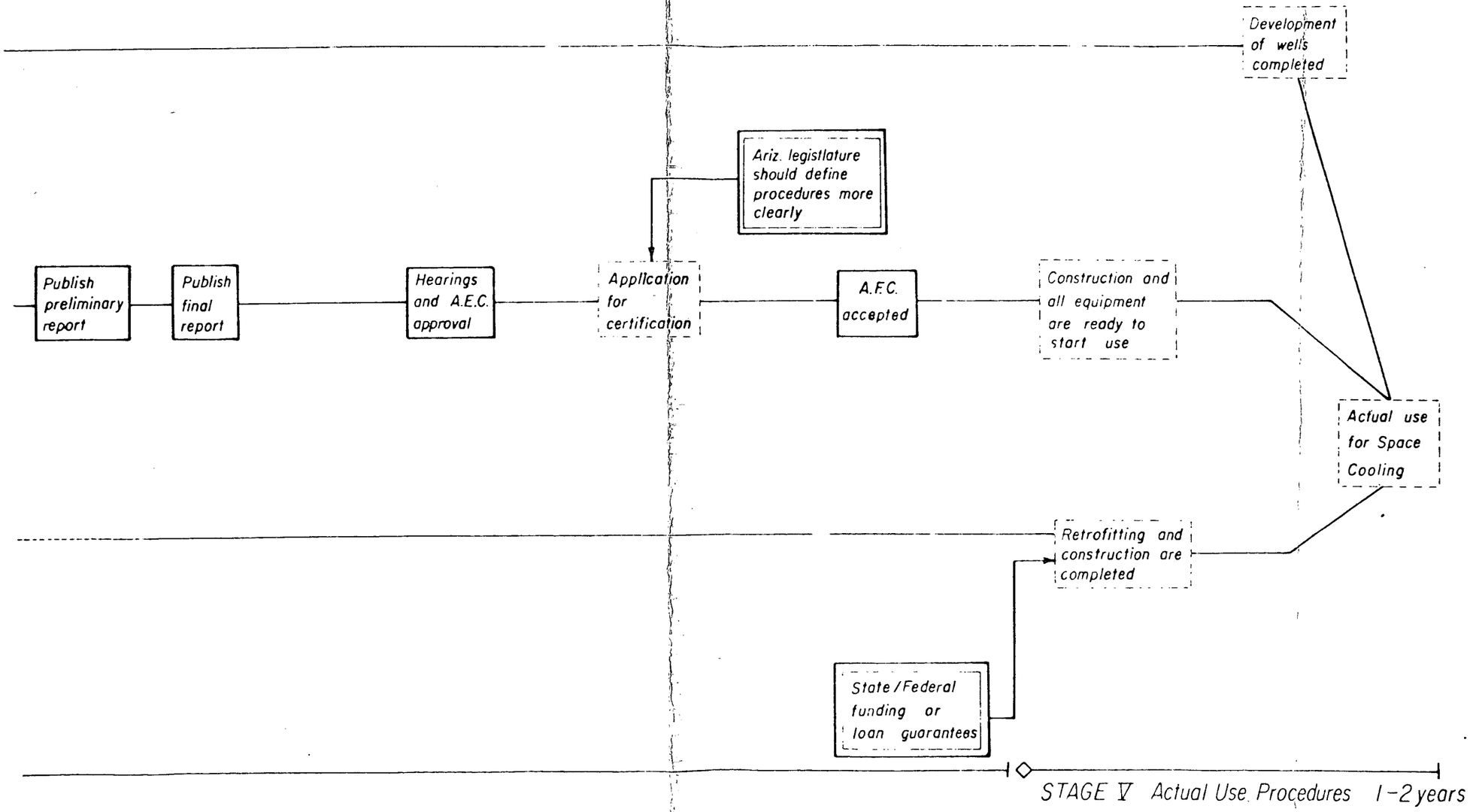


FIGURE 28: SPACE COOLING PROJECT - FEDERAL LANDS



STAGE II Exploratory Drilling Permit and other Preliminary Permits 2 – 6 years


Arizona legislature should define these procedures more clearly
Begin Exploratory Drilling
Fed., State and local agencies continuously inspect drilling
Evaluate and present Exploration results and site characteristic to developer
STOP
no
Developer decides on continuation of project
yes
Path A
Path B
Path C
Developmental drilling begins
G
Developer prepares notice of intent
N.O. Intent filed with A.E.C.
H
Apply for permit to construct and retrofit
City and county agencies study plans
I
A.E.C. Accepts and summarizes N.O. Intent
A.E.C. publishes N.O. Intent and circulates for review
Hearings and some legal procedures which are not yet clearly defined by State of Arizona
E.P.A. studies transportation & reinjection plans
Public involvement
State Health Dept. checks plans for hazards
Do all agencies approve of plans
yes
no
Make necessary modifications
STAGE III Actual Exploratory Drilling 0.5 years
STAGE IV Resource Development 2-6 years


Development of wells completed
Ariz. legislature should define procedures more clearly
Publish preliminary report
Publish final report
Hearings and A.E.C. approval
Application for certification
A.E.C. accepted
Construction and all equipment are ready to start use
Actual use for Space Cooling
Retrofitting and construction are completed
State/Federal funding or loan guarantees
STAGE V Actual Use Procedures 1-2 years

ii. Design Calculations for the Proposed System

To convert kilowatts to BTUs per hour, we multiply by 3413 BTU per hour/kilowatt. Thus, Q = peak load = 5.0 MM BTU/hr. Q is the amount of cooling required per hour. The design will be based on this value of Q. If Arkla absorption chillers with a capacity of 250 tons of refrigeration (1 ton refrigeration = 12000 BTU/hr) are used,

$$N = \text{no. of chillers required}$$
$$= 5.0 \text{ MM BTU/hr} \div (250 \text{ tons/chiller}) \times (12000 \text{ BTU/hr-ton})$$
$$= 1.7$$

Thus we need two 250 ton Arkla absorption chillers. The operating temperatures of the Arkla Chiller is 200°F for inlet temperature and 184°F for outlet temperature.

Using a closed cycle to prevent corrosion problems due to salinity of geothermal brine and using regular water at 75°F, the heat exchanger must heat this water to 200°F so it will meet the inlet temperature of the Arkla Chillers. The assumed geothermal resource has a well-head temperature of 250°F with a depth of 1200 ft and total dissolved solids of 2000 ppm. Thus, the inlet and outlet conditions for the heat exchanger are as in Fig. 29. Assuming 10°F temperature approach, the required flowrate from the well is

$$m = \frac{\text{required energy}}{(\text{heat capacity})(\text{temp change})}$$
$$= 5.0 \text{ mm BTU/hr} \div (1 \text{ BTU/lb.-}^{\circ}\text{F})(250^{\circ}-210^{\circ}\text{F})$$
$$= 125{,}000 \text{ lbs/hr.}$$

Assuming an overall heat transfer coefficient, u, with allowance for scaling factor,

$$u = 100 \text{ BTU/hr.-ft}^2\text{-}^{\circ}\text{F}$$

and using a 316 stainless steel tubing heat exchanger, we can compute the area required for the heat exchanger, A.

$\overline{\Delta T}_L$ = log mean temperature

$$= [(250^{\circ}-200^{\circ} - (210^{\circ}-75^{\circ})] \div \ln[(250^{\circ}-200^{\circ})/(210^{\circ}-75^{\circ})]$$
$$= 85.6^{\circ}\text{F}$$

T_m = corrected temperature

$$= \overline{\Delta T}_L \times 0.9$$
$$= 77^{\circ}\text{F}$$

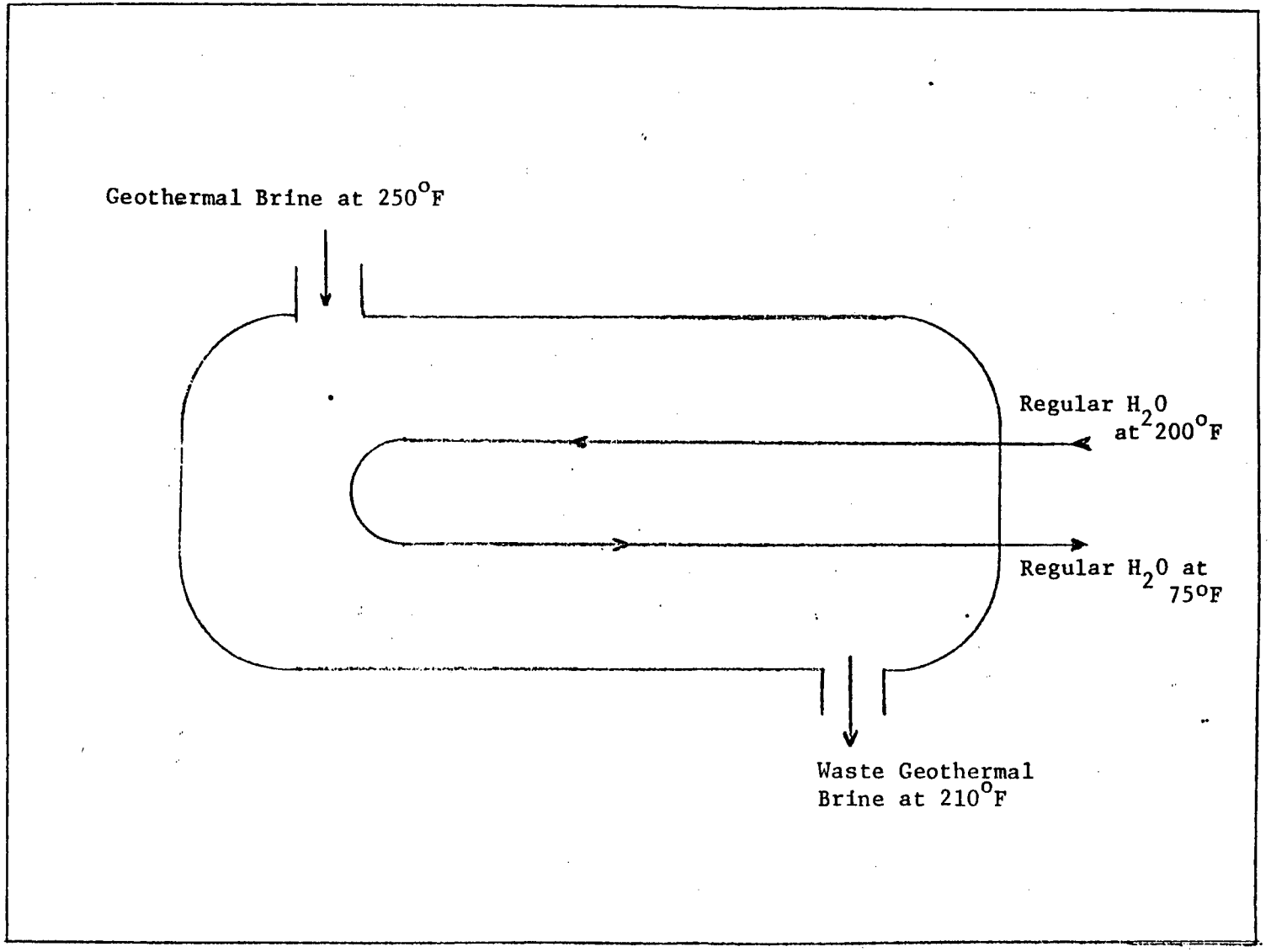


FIGURE 29: INLET AND OUTLET CONDITIONS FOR THE HEAT EXCHANGER

Since $A = Q \div [u \times T_m]$,

$A = 5.0$ MM BTU/hr $\div$ (100 BTU/hr.ft^2.$^\circ$F)(77°F)

$= 650$ ft^2

Thus the area to be used in the heat exchanger is 650 square feet.

iii. Cost Estimates

a. Cost of Well

One production well and one reinjection well are needed. The depth of the production well is assumed to be 1200 ft, at a cost of $50 per foot. The depth of the reinjection well is assumed to be 1000 ft, at a cost of $40 per foot. Total cost of well drilling
= (1200 ft)(50 dollars/ft) + (1000 ft)(40 dollars/ft)
= $100,000

b. Cost of Absorption Chillers

Each Arkla Absorption Chiller costs $120,000. Two units are required, totaling $240,000. This cost does not include installation.

c. Cost of Heat Exchanger

The cost of a 316 stainless steel tubing heat exchanger with an area of 650 ft is $15,000.

d. Estimated Capital Investment

Cost of items in parts a, b and c is:
$100,000 + $240,000 + $15,000 = $355,000.
This cost, other equipment, and installation costs are shown in Table 18.

e. Estimates of Simple Payout Period

Four cases have been studied. Each assumes a $732,000 capital investment, which is taken from Table 18 with $32,000 added to cover any miscellaneous well costs. Both 20-year and 5-year depreciation times are viewed as well as the same cases with tax incentives added. Calculations leading to the payout period length are tabulated below for each of the four cases.

TABLE 18

ESTIMATED COST OF PROJECT - SCENARIO #1

No.	Description	Cost
1	Items a, b and c	$355,000
2	Cost of pumps (for well, and 2 pumps for transmission of geothermal brine to building and from building to reinjection well)	$ 20,000
3	Cost of 4 in blacksteel insulated transmission pipe 1000 ft long buried in the ground	$ 15,000
4	Cost of 4 in blacksteel un-insulated reinjection pipe 1000 ft long buried	$ 10,000
5	Cost of installation of above equipment	$110,000
6	Cost of retrofitting the cooling system in the building	$ 90,000
7	Cost of Design	$ 40,000
8	Cost of permits and procedures for development of geothermal resource	$ 60,000
	ESTIMATED CAPITAL INVESTMENT	$700,000

Case 1: $732,000 Capital Investment
20 Year Depreciation

Gross Income* $\left[\frac{(\text{Load} \times \text{KWH/yr}) \times \text{cost/KWH}}{(3.23 \times 1{,}000{,}000) \times .036}\right]$		$116,280
*(Gross Income = Annual Utility Cooling Bill)		
Gross Expense		
Operating:	50,000	
Depreciation:	36,600	
	86,600	$86,600
Gross Profit		$29,680
Income Tax (50%)		$14,840
Net Profit		$14,840
Credit Depreciation		$36,600
Total Applicable to Simple Payout		$51,440

$$\text{Payout} = \frac{\$732{,}000}{\$\ 51{,}440} = 14.2 \text{ years}$$

Case 2: $732,000 Capital Investment
5 year Depreciation (Tax Incentive of Fast Amortization)

Gross Income*(same as Case 1)		$116,280
Gross Expense		
Operating:	50,000	
Depreciation:	146,400	
	196,400	$196,400
Gross Profit		-$80,120
Income tax credit (50%)		$40,060
Net Profit (Income Tax Credit)		$40,060
Credit Depreciation		$146,400
Total Applicable to Simple Payout		$186,340

$$\text{Payout} = \frac{\$732{,}000}{\$186{,}340} = 3.9 \text{ years}$$

Case 3: $732,000 Capital Investment
20 year Depreciation
DOE Pays 50% as part of PON System (DOE Incentive)

Gross Income*		$116,280/yr
Gross Expense		
Operating:	50,000	
Depreciation:	36,600	
	86,600	$ 86,600
Gross Profit		$ 29,680
Income Tax (50%)		$ 14,840
Net Profit		$ 14,840
Credit Depreciation		$ 36,600
Total Applicable to Simple Payout		$ 51,440

$$\text{Payout} = \frac{\$366,000}{\$\ 51,440} = 7.1 \text{ years}$$

Case 4: $732,000 Investment
5 year Depreciation (DOE Incentive & Tax Incentive)
DOE pays 50% as part of PON System

Gross Income*		$116,280
Gross Expense		
Operating:	50,000	
Depreciation:	146,400	
	196,400	$196,400
Gross Profit		-$80,120
Income tax credit (50%)		$ 40,060
Net Profit (Income tax credit)		$ 40,060
Credit Depreciation		$146,400
Total Applicable to Simple Payout		$186,340

$$\text{Payout} = \frac{\$366,000}{\$186,340} = 2.0 \text{ years}$$

Scenario # 2: District heating and cooling (Case study: Retirement community outside Phoenix)

Location: near Phoenix
Temp : 280°F
Depth : 3000 ft
Salinity: 2000 ppm
Land : Private
Development: 1990

i. Introduction

District heating and cooling draw heavily from energy resources, particularly the cooling load. This use design has two basic cases (scenario #2 and #3), one of which retrofits an existing community and the other designed for heating and cooling a new community. We begin by assuming that an existing community outside Phoenix can use geothermal well to provide the means of district heating and cooling. The case that develops geothermal usage in a new community will be discussed in scenario no. 3 which is similar to this scenario. A diagramatic representation of this scenario is given in Fig. 30.

ii. Description of Community

Let us choose a community of 10,000 houses near Phoenix. This area has a variable temperature range. Between the months of May and September the temperature is 65°F - 80°F at night; and 85 - 115°F during the day. Thus almost no heating is needed during this period, while a tremendous amount of cooling is required. However, during the months of November to April the temperature ranges from 30°F to 55°F at night; so a good amount of heating is needed. During the day the temperature is 50 - 85°F and either cooling or heating may be required.

iii. Wells' Characteristics

Flowrate of Brine: 2.5×10^5 lb/hr per well
Distance of wells from plant: 2 miles
Depth of injection well(s): 2000 ft

iv. System's Description and Energy Requirements

Assuming the area of each house is 2000 ft^2 and the energy required for heating and cooling (assuming that all houses have a forced air cycle for both heating and cooling) is 36,000 KWH/yr. Therefore total energy needed for all houses is 3.6×10^8 KWH/hr.

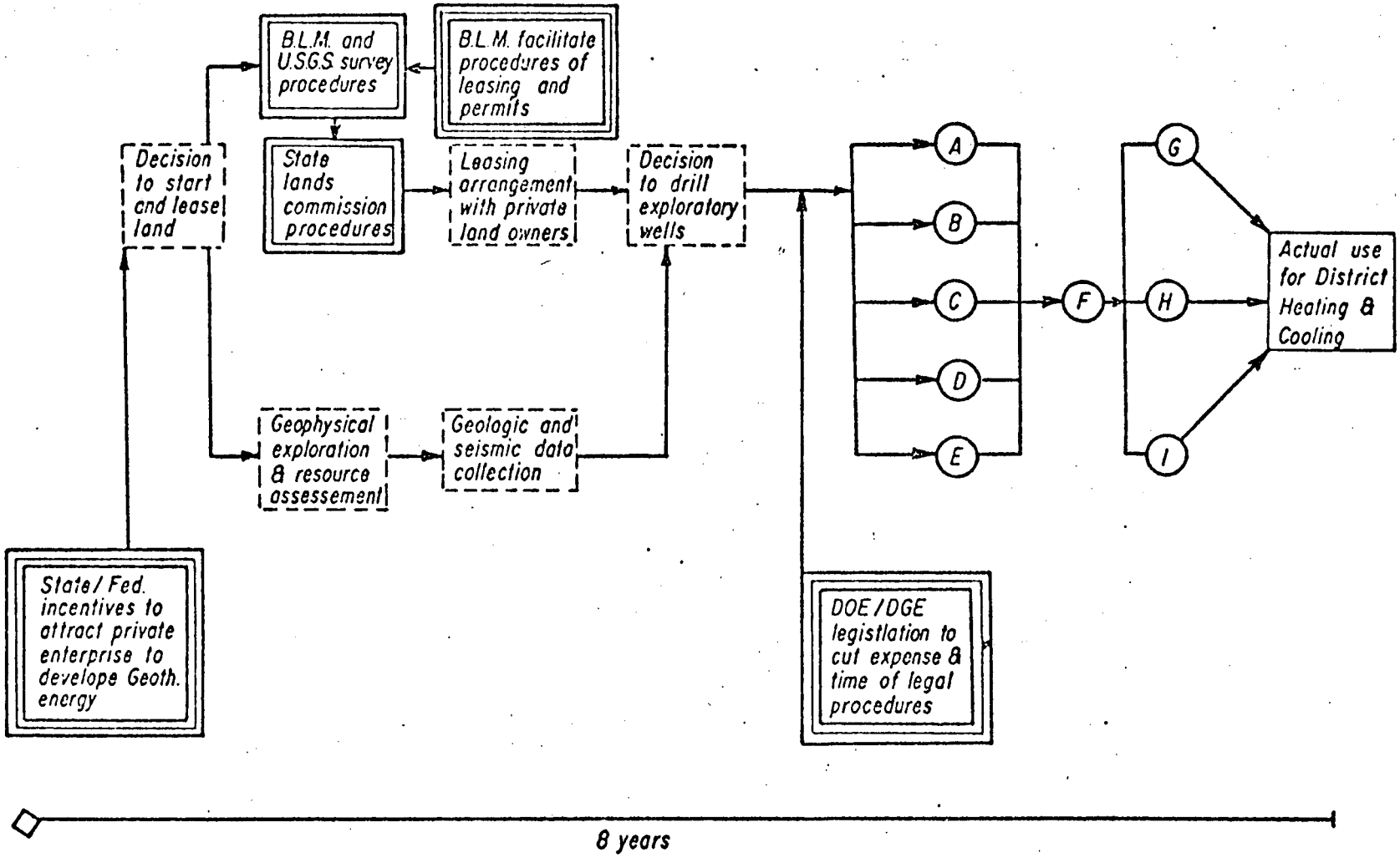


FIGURE 30: DISTRICT HEATING AND COOLING - PRIVATE LAND

The system that will be used is described as follows: a centralized plant with heat exchangers and absorption cooling system will be used. This system is depicted in Figure 31. The geothermal well provides brine at $280^{\circ}F$, which is used to heat regular water passed through a heat exchanger. Assume temperature of water is $70^{\circ}F$, assume that flowrate of brine in heat exchanger is equal to flowrate of regular water. Assume the fresh water in the heat exchanger is heated to $205^{\circ}F$, and is sent through insulated distribution pipelines to the houses, where they act as a source of heat for the fat in the force air cycle unit in the house. The thermostat of each unit in the house will be used to regulate the temperature in the rooms. The temperature of the hot water reaching the house is about $200^{\circ}F$. This fresh hot water could be used for household washing, etc. Assuming a $10^{\circ}F$ approach let us calculate required flowrate for heating in the winter season.

Q = energy required = (flowrate)(heat capacity)(temp. change)
$= mC_p\Delta T$
m = flowrate = $(3.6 \times 10^8$ KWH)(3413 BTU/KWH)$\div$($280^{\circ}-215^{\circ}F$)(3600 hr)
$= 5.2 \times 10^6$ lbs/hr

For cooling, $m = 1.3 \times 10^6$ lbs/hr
Assuming the flowrate for each well is 250,000 lbs/hr.
No. of wells = 5×10^6 lbs/hr $\div$ 2.5×10^5 lbs/well-hr
= 20 wells

Using heat exchangers with 316 stainless steel tubings, each has an area of 15,000 ft^2. Four heat exchangers are needed. Each costs $120,000. If we use Arkla Solaire absorption units, each with 2500 tons of refrigeration, we need about 5 Arkla units at $600,000 for each unit.

Let us now try to estimate the total cost of this project. (Most of the above calculations are approximations, based upon fallable assumptions)

v. Cost Estimates

Cost of production wells = no. of wells x depth x cost/ft
So cost of prod. wells = 20 x 3000 x 50 = $3,000,000
Assuming only 10 injection wells, 2000 ft. as depth of well and at a total cost of $40/ft, the cost of injection wells = 10 x 2000 x 40 = $800,000. Cost of heat exchangers without installation = 4 x 120,000 = $480,000. Cost of Absorption Chillers = 5 x 600,000 = $3,000,000 without installation.

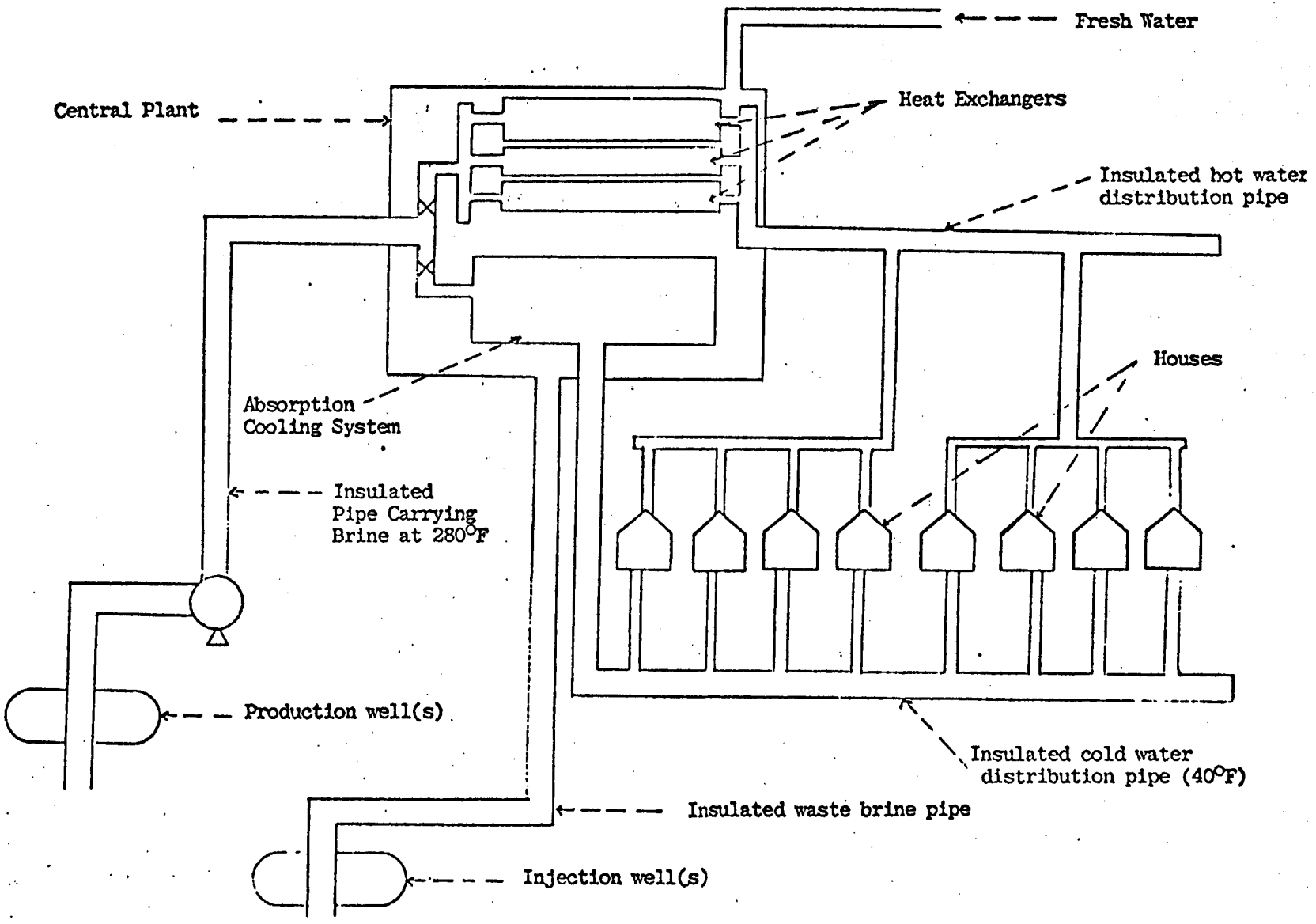


FIGURE 31: SCHEMATIC REPRESENTATION OF DISTRICT HEATING AND COOLING SYSTEM

A preliminary estimate of the total capital investment for this project is $25,000,000. The rate of return based on a simple payout with ten years amortization is calculated as follows:

G = Gross income - Annual utility bill for houses
= Load (KWH/yr) x cost ($/KWH)
= $3.6 \times 10^8 \times 0.036 = 13,000,000$ $/yr

Op = operating cost
= $200,000 per year (approximately)

$$Dp = \text{Depreciation} = \frac{\text{Total capital investment}}{\text{Years project is expected to last}}$$

= $25,000,000/10 years = 2,500,000 $/yr

Pg = gross profit = G -(Dp + Op)

= 13,000,000 -(2,500,000 + 200,000)

= $10,300,000 per year

Pn = net profit after 50% tax = 5,150,000 $/yr

$$\text{Simple payout} = \frac{25,000,000}{5,150,000 + 2,500,000} = 3.3 \text{ years}$$

Scenario #3: New Communities
Case Study: Pinacate area

Location	:	Unpopulated geothermal areas
Temperature	:	260°F
Depth	:	1 km
Salinity	:	2500 ppm
Land	:	private
Development	:	1995

i. Introduction

This scenario takes the area of Pinacate as a case study for using geothermal resources for space heating and cooling of residential homes. The geothermal heating and cooling system will be incorporated into the houses as they are constructed. As this new community expands the geothermal resources could be used along with conventional fuels in various areas of industry. At the present time we will consider the use of geothermal energy for comfort heating and cooling.

ii. Description of Community

Pinacate is a relatively remote area which as a good geothermal potential that could be used as a source of energy for a new residential community. Pinacate's hot dry climate points immediately to relative amounts of the energy required for cooling as compared with heating. This is because Arizona has a wide temperature range. The temperature range at Pinacate from May till August is 60 - 85°F at night and 85 - 115°F during the day. As predicted, a large amount of energy is needed for cooling, while from September till April the temperature ranges from 30 - 55°F at night; and 60 - 85°F during the day. Consequently, a moderate amount of energy is also required for heating.

Let us assume that a construction company is planning to build 200 housing units in Pinacate, and that the Department of Energy proposed to give this construction company a grant to encourage this company to build houses with individual geothermally based heating and cooling units.

iii. Well Characteristics

Flow rate of brine: 160,000 lb/hr
Distance of production and injection wells from houses: 1 mile

iv. System's Description and Energy Requirements

The system used in this scenario is described as follows; the geothermal well provides the hot brine that is transported to the houses by a 10 in. insulated pipe one mile long. This main pipe branches into smaller insulated pipes; (200 smaller pipes, 2" in diameter) one pipe for each house. We assume that the area of each house is 2000 ft^2; and all the houses have air conditioning units that use a forced air cycle. These air conditioning units can be used as coolers or heaters and the temperature inside the house is regulated by a thermostat. Each house has a heat exchanger unit and an absorption cooling unit. The hot brine will be sent into the heat exchanger to heat regular water at 70°F. This water comes out at a temperature of 200°F and is used in the air conditioning unit to produce hot air. On the other hand, the brine will be used in the absorption cooling unit to cool regular water from 70°F to 40°F. This cold water is used in the air conditioning unit to give cold air. For both cases of cooling and heating the brine does not circulate in the houses' plumbing pipes; it only circulates in the heat exchanger and absorption cooler, limiting problems of pipe corrosion and scaling. The waste water brine is sent through a small pipe which is connected to a main uninsulated pipe that flows into the injection well.

Let us calculate the required flowrate for all the houses; by calculating the flowrate required for each house. Assuming that each house requires 40,000 KWH/yr for heating and cooling and assuming that all this energy goes to heating,

m = required flowrate = $Q/C_p\Delta T$

= (40,000 KWH)(3413 BTU/KWH)÷(260°-210°F)(3600 hrs)

= 760 lbs/hr

Total flowrate for all houses = $760 \times 200 = 1.52 \times 10^5$ lb/hr and

$$\text{no. of wells} = \frac{\text{total flowrate}}{\text{flowrate/well}} = \frac{1.52 \times 10^5}{1.6 \times 10^5} = 1 \text{ well}$$

Thus one production well with a flowrate about 160,000 lb/hr and one injection well are needed.

Each house will have its own heat exchanger which will cost about $2500, and an absorption cooling unit which will cost $2600 with a capacity of four tons of refrigeration. Assume cost of installation to be $2000 for both the heat exchanger and absorption cooler, including pipes and labor.

v. Cost Estimates

Assuming the total cost of drilling to be $60/ft, the production well will cost $120,000 and injection well $90,000. Assume cost of equipment for well to be $50,000 (including pump and other miscellaneous items). Assume cost of 10" main pipe and 2" diameter branching pipes all insulated and installed to be $100,000. Total cost of equipment in 200 houses including installation is $920,000; but this cost would have been encountered anyway without using geothermal. If the houses had gas-fired heaters and air conditioning units the total cost of these units for all houses would be close to $920,000, so this cost will not be included in the total cost of the project.

Thus total cost of project using geothermal energy is $400,000. If we estimate the average cost of heating and cooling per month in one house to be $30, then cost of heating and cooling per year for 200 houses is $72,000.

Based on a simple payout and five years amortization, with 50% tax credit to compensate for net loss due to fast amortization, the payout will be in five years.

Scenario #4: New industries

Location	:	To be determined
Temperature	:	variable; 80°C if possible
Depth	:	1-2 km
Salinity	:	2000 ppm
Land	:	private if possible
Development	:	1990

This scenario considers possible industries that could use low temperature energy sources. It may be possible to attract new industries to Arizona by demonstration of a low temperature resource. Some of the industries that are being considered are: the dairy industry, baking industry, poultry raising, orange juice concentrate plant, tomato puree, and heavy water production. The dairy industry is considered in this scenario. A dairy has already been successfully retrofitted to geothermal sources in Klamath Falls, Oregon. The idea is therefore well worth perusing for Arizona's dairies.

The dairy company under consideration now uses a 170°F heat source for approximately 21 seconds, in the pasturization process. The heating requirements need a temperature source of 80° - 340°F and uses 6×10^9 BTU/year of natural gas energy. The cooling process is presently done electrically and requires 2.5×10^6 KWH/year. After the products are cooled, they are kept in storage facilities @ 35°F. Geothermal energy could be used for this industry if a resource is near the dairy. The system in Oregon could be used as a model for plans in Arizona.

Scenario #5: Energy storage for heat pump systems

Location	:	Phoenix, Tucson
Temperature	:	60 - 120°C
Depth	:	0.5 - 2 km
Salinity	:	2000 ppm
Land	:	Federal, state
Development	:	1990

This scenario involves using a heat pump system for heating purposes, or possibly heating and cooling process combined. The success of this geo-utilization is dependent on the finding of a high porosity aquifer near the surface containing low-temperature water; the colder the better. If such an aquifer were found, it would be considered as a cooling source for large schools, hospitals, and other large units. If this operation was deemed successful individual home units could then be considered.

The heat pump with cold storage should be compared with an absorption cooling unit operated on hot geothermal waters. For places with heating loads in winter time, the same heat pump can be used.

Technically, we should compare the central cooling and distribution of chilled fluid through houses with individual heat pump use, in which the cool water is circulated from a central source. The same question applies for absorption cooling units, where either the chilled fluid is transferred through the houses or the hot geothermal waters are pumped. In any case, best efficiency can be expected if the flow to each individual unit is in parallel rather than in series thus preventing reduction of temperature from one unit to another.

Scenario #6: Central Arizona Project/Peak Power

Location	:	Tucson, Phoenix
Temperature	:	60-120°C
Depth	:	0.5-2 km
Salinity	:	2000 ppm
Land	:	Federal, state, Indian
Development	:	1990

This scenario is designed to use either geothermal sources or a binary cycle to run turbines for the direct pumping of steam. The turbines would be used to power the pumps at the pumping station. This scenario would also evaluate whether or not it would be cheaper to use the geo-source or to use coal from the Four Corners Area to generate the electricity and have the investment of the transmission lines to the stations. 1.2×10^{6} acre feet of water will be pumped 900 ft high and then distributed to Tucson and Phoenix. For this scenario to work, the economics for electric pumping should be analyzed in comparison with steam turbine pumping, both with regard to investment cost and operational cost.

Scenario #7: Wind energy/geothermal energy/energy storage

Location	:	White Mtns, Flagstaff
Temperature	:	60°C, 210°C (HDR)
Depth	:	1 km
Salinity	:	2500-3000 ppm
Land	:	Indian, State, Federal
Development	:	1990

This scenario is designed for the northern mountainous areas of the state. If it designed to use wind energy as a supplement to geothermal or solar energy. This energy would be used in the paper and lumber industries, as well as for recreational and other related uses. For example, lakes that tend to freeze over could have a small area that would be kept ice-free in winter. This would deter fish deaths due to lack of oxygen and freezing.

Scenario #8: Hot igneous rock and power plant

Location	: Springerville/St. Johns, Safford Chandler
Temperature	: 210°C
Depth	: 1 km
Salinity	: 2500 ppm
Land	: Federal, State, Indian
Development	: 1990

This scenario studies the injection of water into hot igneous rock strata to obtain steam for power production and industrial uses. Geologic information indicates that hot dry rock resources may exist near Springerville. If the temperature of the rock is very high the system could be quite economical. However, the technology to develop hot dry rock is still in the early stages.

Scenario #9: Coal mining operations

Location	: Four-Corners area
Temperature	: 60-200°C
Depth	: 1-2 km
Salinity	: 3500 ppm
Land	: Indian
Development	: 1990

This scenario is designed for the coal-fired power plants that service Arizona and Southern California. The geothermal waters would be used for coal washing, dust control, slurry transporation, and local vegetation replanting. The potential energy of the geo-water would also be integrated into the systems.

Scenario #10: Preheating/sulfur removal in coal field power plants

Location	: Willcox
Temperature	: 110°, 205° C HDR
Depth	: 1 km
Salinity	: 4000 ppm

Land : Federal, State, Indian
Development: 1990 :

Since warm water will dissolve sulfides in coal (primarily FeS_2) more quickly than cooler water, geothermal waters could be used for the planned coal-fired power plants scheduled in the Springerville and the Willcox areas of Arizona. EPA air quality standards often require the removal of some sulfur prior to the release of coal smoke into the air. An adaption comprising the fundamental technical ideas involved in Burbank, California's plans for geothermal energy use will be made. This scenario will also examine the use of Four Corners coal and will critically examine how much sulfur is removed and how much coal can be saved in a large plant, if geothermal energy were used.

Scenario #11: Solution mining

Location : Statewide (Kingman)
Temperature: 50-200°C
Depth : 1 - 2 km
Salinity : 2000-4000 ppm
Land : State, Federal, Public
Development: Completed by 1990

Solution mining is an important scenario for Arizona. It is designed for the use of geothermal waters for the leaching processes in solution mining. The major advantages of using geothermal water is that since the water is already hot, dissolution occurs more rapidly. Solution mining via geothermal waters seems to be technically feasible but there are several pitfalls. To be successful an expertize in solution mining is needed, especially on the geological engineering aspects. This expertize is needed to direct the study to ore bodies of an economically feasible size, but have the correct geological structure to make the solution mining applicable. The proper chelating agents must be used for the recovery of the metals also. The most promising metals for this type of system are copper, cobalt, nickel and uranium, but other metals should also be considered (e.g. chronium, tin, antimomy, and the other so-called "strategic" metals). This technique has already been successfully tested and is in use in several places. Solution mining can reach deeper ore reserves, making the mining less expensive.

In some instances the solution mining may leave caverns which could be used as huge storage facilities (e.g. petroleum supplies). These caverns are also being considered for

storing chemicals to be used later for energy production. These chemicals are produced and stored, for example in the summer time when using solar energy, and are used in the winter time to supplement the low grade solar energy.

At this initial stage of the project a literature search has been conducted on the methods and different techniques used in solution mining. It has been found that solution mining has been practiced for several years. It has been applied to extract various ore deposits such as uranium and copper (in Arizona), and to disintegrate coal with a basic aqueous solution in order to form a slurry which can be extracted. Solution mining techiques have been combined by C.H. Jacoby with geothermal fluid techniques to extract NaCl deposits.

Our impression now is that solution mining is a technically feasible operation which in some instances is much more advantageous than conventional mining techniques. Solution mining provides an opportunity for 1) cost reduction, 2) extracting deposits which cannot be mined by conventional methods, 3) meeting environmental standards by careful control of solution mining techniques.

The major advances in the understanding of the chemistry and mineralogy of the process, along with new developments in the technologies of explosive, nuclear, petroleum, salt and geothermal fluid industries, will enable research workers in this area to develop a commercially workable method of solution mining that employs geothermal waters for highest efficiency. Improvement of solution mining techniques is being studied.

Scenario #12: Hot water for conventional mining

Location	:	Tucson
Temperature	:	60 - 90°C
Depth	:	1-2 km
Salinity	:	2000 ppm
Land	:	State, Federal, Private
Development	:	Completed 1990

This is somewhat different than the solution mining scenario in that it deals with the process currently used in the copper industry. The present rate of copper leaching could be increased at least three-fold if the operating fluid is at 35°C, instead of the normal ambient temperature of 21°C. This demonstrates that the hotter the leaching fluid, the better the production results, so the use of

geothermal water would be extremely desirable. This would conserve energy used to heat the storage pond water and create a better production rate, as well as preventing the storage ponds from cooling down to 10°C in the winter months.

Scenario #13: Hot mines

Location	:	Underground Mining Areas (Clifton)
Temperature:		50-90°C
Depth	:	1-2 km
Salinity	:	2000 ppm
Land	:	State, Federal, Private
Development:		1990

This scenario is concerned with the correction of an existing problem. Some underground mines have hot waters in them, causing severe ventilation and temperature control problems. This scenario's purpose is to see if these hot geothermal waters can be used for an advantageous purpose, instead of the problems they now cause.

Scenario #14: Salt production

Location	:	Yuma, Hyder Valley
Temperature:		60-180°C
Depth	:	0.5 - 2 km
Salinity	:	2500 - 3500 ppm
Land	:	Federal, state, Indian
Development:		1990

Extensive beds of salt exist in Southern Arizona. This scenario considers the use of geothermal water to recover the salt from these beds. The effluent waters would be used to dissolve the concentrated salts for the production of the raw material; then the waste geo-water would be reinjected in the salt storage caverns thus created. Alternatively, the waste water could be left with the salt brines to be purified by solar pond evaporation with the caverns used to store petroleum products under the USA policy of having on hand a reserve supply of crude oil and/or other selected products.

Scenario #15: Desalination

Location	:	Yuma, Phoenix
Temperature:		150-180°C
Depth	:	1.0 - 2.0 km

Salinity	:	3500 ppm
Land	:	Federal, State and Indian
Development	:	1990

This scenario as shown in Figure 32 considers the utilization of hot steam or hot waters to convert brackish waters, including the geothermal waters, to potable water. A good example of this type of operation is the Geysers project and that of the East Mesa test site. An example of a calculating process is given in this scenario. This scenario is important because water is scarce in Arizona, e.g., in the Northern part of the state, or are brackish, e.g. in the Safford area. Geothermal water could be helpful in solving the water problem in several ways:

1. Desalinate brackish or sea water using geothermal heat.
2. Use the condensed steam obtained after condensation of flashed geothermal water.
3. Use geothermal water as is wherever it happens to be of potable quality.

Two desalination plants are now in operation in Arizona.

1. At Buckeye using the electrodialysis method.
2. At Yuma using the reverse osmosis method.

At Buckeye potable water for 3000 people is produced while in Yuma they desalinate 600 acre feet/day (approx. 800,000 m^3/day).

In Arizona the amount of water consumed exceeds the amount being replenished by 2,200,000 acre feet/year. So the water problem becomes progressively more acute. This water can be considered as a nonrenewable resource, some people saying that it is "being mined"*. 89% of the water in Arizona is used for agriculture 16% for industrial and municipal use and 1% for fish and wildlife.

The import of water through the Central Arizona project will be only 1,200,000 acre feet/year, barely half the above mentioned overdraft. Therefore it is of great importance to make plans for the desalination of sea or brackish water. Since the cost of energy is a very significant factor in the desalination process, geothermal production at reasonable cost could be a very important asset for the desalination process; it is a source of both the water and the energy. About 7,000,000 acre feet/year is used in

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* H.W. Peirce, Field Notes, 6 No. 2, June 1976

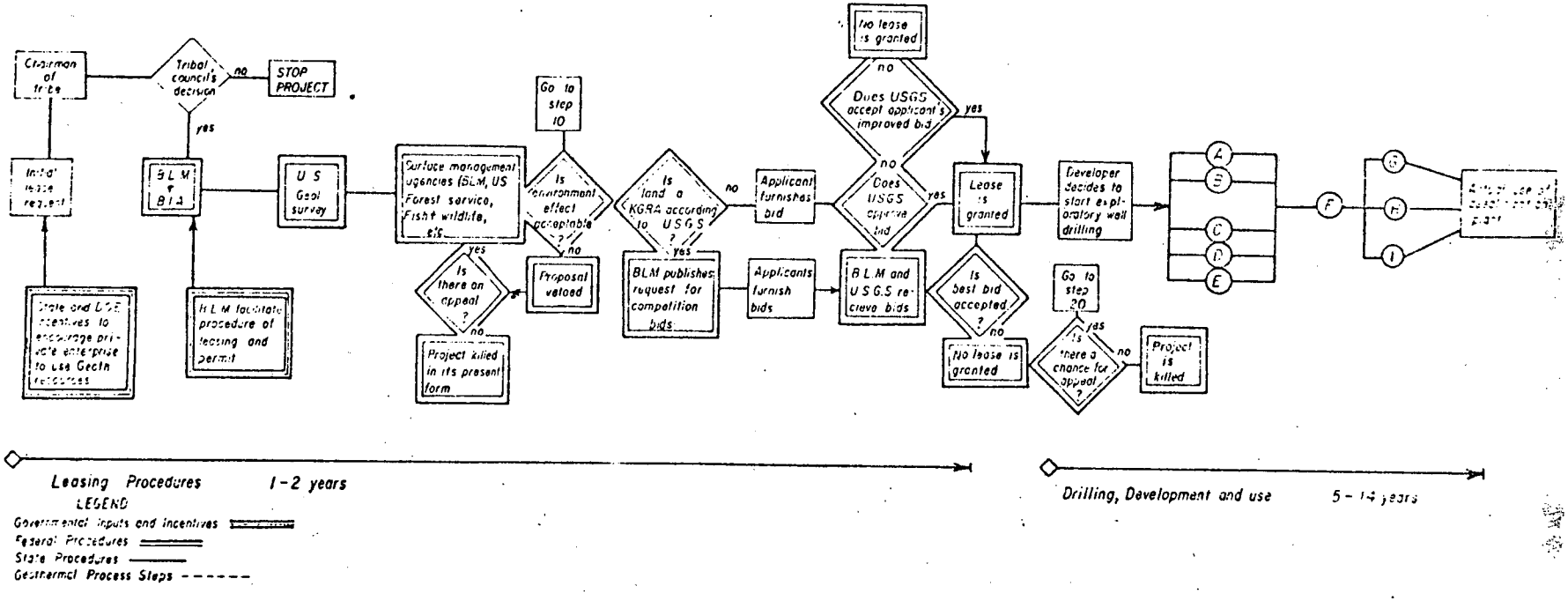


FIGURE 32: DESALINIZATION PROJECT - INDIAN LANDS

Arizona of which 5,000,000 is pumped from the ground (50% of it not being replenished) and 2,000,000 acre feet/year which comes from the Colorado river.

A Preliminary Calculation for Desalination

Objective: To calculate the amount of geothermal energy needed to produce 100 m^3/day of potable water from sea water. The temperature of the steam (geothermal) is 150, 200, 250°C.

The following calculations and assumptions will be based on the report:

Description of the equipment used - the solar collectors being replaced by a source of geothermal energy, other equipment the same. The actual operation given in the report by Hodges et al. is as follows:

a. Assume that the geothermal energy can be converted 100% into actual usable energy in the heating process.

b. Air water contact Equipment
Plane surface evaporators are used, which provides one enthalpy transfer unit operating at 1000 cfm air flow and 25 gpm water flow. A packed tower is used. The packing material is Dow's Maspac Fm-90, plastic tower packing.

c. Heat exchangers - conventional design consists of 6 shell and tube units. Area was over 1000 ft^2. Wire mesh was used to support film and promote turbulence.

Assuming steady-state conditions:
The total area of solar collectors -
#1: (150;)(9'8") = 1450 ft^2
#2: (98')(14') = 1372 ft^2
#3: (50')(3') = 150 ft^2
total area = 2972 ft^2

Taking the data at N_T = 5 (number of transfer units per component)

q_s = 2000 BTU/sq ft. day
γ = 5 lb/sq ft. hr (import of brine)
outside temp. = 70°F.

* Hodges, C.N. et al. Separate Component Multiple-effect Solar Distillation

The solar collectors have a glazing specific productivity:
0.10 gal/sq. ft-day
Brine input:

$$\frac{(5\ \text{lb})}{(\text{sq.ft hr})}(2972\ \text{ft}^2) = (14860\ \frac{\text{lb}}{\text{hr}})(\frac{24\ \text{hr}}{\text{day}}) = 356640\ \frac{\text{lb}}{\text{day}}$$

total energy/day:

$$\frac{(2000\ \text{BTU})}{\text{sq.ft day}}(2972\ \text{ft}^2) = 5.944 \times 10^6\ \frac{\text{BTU}}{\text{day}}$$

total output:

$$\frac{(0.10\ \text{gal})}{\text{sq.ft day}}(2972\ \text{ft}^2)\ \frac{(8.3121\ \text{lb})}{\text{gal}} = 2470.35\ \frac{\text{lb}}{\text{day}}\ \text{of fresh water}$$

Substituting geothermal energy for the solar energy input - calculate amount of steam at 150°F, 200°F, 250°F needed:

$Q = 5.944 \times 10^6$ BTU/day

At $T_s = 150^\circ$F, steam-sat'd vapor

$V_g = 97.20\ \text{ft}^3/\text{lb}$

$h_g = 1125.7$ BTU/lb

$Q = h_g$ (amount of steam needed)

$$5.944 \times 10^6\ \frac{\text{BTU}}{\text{day}} = 1125.7\ \frac{\text{BTU}}{\text{lb}}\ (\frac{X\ \text{lb}}{\text{day}})$$

$$X = 5280.3\ \text{lb}\ \frac{\text{steam}}{\text{day}}\ \text{at}\ 150^\circ\text{F}$$

which is

$$(5280.3\ \frac{\text{lb}}{\text{day}})(97.20\ \frac{\text{ft}^3}{\text{lb}}) = 5.1324 \times 10^5\ \frac{\text{ft}^3}{\text{day}}\ \text{of steam (150°F)}$$

produces $2470.35\ \frac{\text{lb}}{\text{day}}$ fresh water

+ the amount of water in steam

These calculations are based entirely on the process of solar distillation. Calculations differing from the solar distillation data can not be made since the data apply only to these processes.

If geothermal energy in form of 150°F water:

$$Q = \text{in } C_p \Delta T \qquad C_p = 1.0 \frac{\text{BTU}}{\text{lb°F}}$$

$$\text{in} = \frac{5.944 \times 10^6 \text{ BTU/day}}{\left(\frac{1 \text{ BTU}}{\text{lb°F}}\right)(150°-70°)} = 7.43 \times 10^4 \frac{\text{lb}}{\text{day}} \text{ producing } 2470.35 \text{ lb } H_2O$$

Steam at 200°F:

$$h_g = 1145.8 \frac{\text{BTU}}{\text{lb}} \qquad V_g = 33.67 \text{ ft}^3/\text{lb}$$

$$(5.944 \times 10^6 \frac{\text{BTU}}{\text{day}}) \; / \; 1145.8 \frac{\text{BTU}}{\text{lb}} = 5187.6 \frac{\text{lb}}{\text{day}} \text{ steam at } 200°F$$

$$(5187.6 \frac{\text{lb}}{\text{day}})(33.67 \frac{\text{ft}^3}{\text{lb}}) = 1.7466 \times 10^5 \frac{\text{ft}^3}{\text{day}} \text{ steam at } 200°F$$

producing 2470 lb/day H_2O

Water at 200°F

$$\frac{5.944 \times 10^6 \text{ BTU/day}}{(1 \frac{\text{BTU}}{\text{lb°F}})(200-70)} = 4.5723 \times 10^4 \frac{\text{lb}}{\text{day}} H_2O \text{ (l) at } 200°F$$

Steam at 250°F:

$$h_g = 1163.8 \frac{\text{BTU}}{\text{lb}} \qquad V_g = 12.84 \text{ ft}^3/\text{lb}$$

$$(5.944 \times 10^6)/1163.8) = 5107.4 \frac{\text{lb steam}}{\text{day}} \text{ at } 250°F$$

$$(5107.4 \frac{\text{lb steam}}{\text{day}})(13.84 \frac{\text{ft}^3}{\text{day}}) = 7.069 \times 10^4 \frac{\text{ft}^3}{\text{day}} \text{ steam}$$

Water at 250°F

$$\frac{5.944 \times 10^6 \text{ BTU/lb}}{(1 \text{ BTU})(250-70°F)} = 3.302 \times 10^4 \frac{\text{lb}}{\text{day}} \text{ water at } 250°F$$

Similar calculations can be made using different number of transfer units per component.

Scenario #16: Biosalinity agriculture

Location	:	Yuma area, Arizona
Temperature	:	150 - 180°C
Salinity	:	3500 ppm
Depth	:	1-2 km
Land	:	State, Federal, or Indian
Development	:	ready by 1990

This scenario uses the basic concepts of biochemical and related technologies for the growing of plants, micro-organisms, and the more primitive forms of plants and animals of the sea, so that these plants and animals can be integrated into a food chain system. This is especially promising for use in cattle and poultry feed supplements. The waste irrigation waters of the Yuma area could be combined with geothermal waste waters to consolidate potential irrigation resources. Yuma's proximity to the Pacific Ocean may also prove an influential factor. Other probable locations would be the Tucson and Phoenix areas.

Scenario #17: Greenhouse/hydroponics

Location	:	Tucson, statewide
Temperature	:	70 - 80°C
Depth	:	1 km
Salinity	:	2000 ppm
Land	:	State
Development	:	2000

Greenhouse production of winter vegetables could be aided via the use of geothermal H_2O. The University of Arizona has developed controlled-environment vegetable agriculture, and is recognized as the leader in the field, exemplified by the commercial operations now in existence in Abu Dhabi, Iran, Mexico and Arizona. The geothermal water would be used to heat the greenhouse, the waste water, then treated with nutrients and used for irrigation of the crop. The major problem is the salt content of the water; it causes the plants to wither faster. This can be easily overcome by rinsing the soil with PH balanced H_2O. This scenario appears unattractive for many parts of Arizona, but it still is worth consideration for the future.

Scenario #18: Irrigation pumping (Case Study: Hyder Valley area)

Estimates of Resource Characteristics

Subsurface Fluid Temp (^{o}C):		Range 55-210°C Best Estimate - 200°C
Total Dissolved Solids	:	2500 - 4000 ppm
Overlying Rock Depth	:	0.5-2 km
Land Status		
BLM Administered	:	22.55×10^5 acres
State land	:	4.27×10^5 acres
Indian Res.	:	2.3×10^5 acres
Individual & Corp.	:	5.43×10^5 acres
Misc. Public Land	:	29.36×10^5 acres
Development Status	:	Working Approx in 1990

The purpose of this study is to find an alternate fluid other than steam to produce peak power for a plant. The power could be used for irrigation pumping when the peak power is not demanded. This scenario was located in an irrigation area, with an orange juice concentrate plant in the vicinity. The irrigation pumping would be used to expand the citrus groves in Hyder Valley. (Yuma County's harvested crops total 322,360 acres, oranges 13,460 acres). Details on Institutional procedures for this scenario are given in Figure 33.

The major problem of using a geothermal fluid for the pumping as well as irrigation, is the total dissolved solid content (i.e. salinity). The water must have a low salinity 0-500 ppm in order for the fluid to be feasible. If the salinity is above this range a desalination process must be included in the scenario set-up. This is an added cost that must be considered in the economic evaluation.

The irrigation pumping in Arizona is about 1,250,000 acre feet of water but much more pumping of water is going on in Arizona and will extend even more with the Central Arizona project which will pump some 1,200,000 acre feet/year to an elevation of 900 ft. and afterward distribute it in the state mainly to Tucson and Phoenix. Therefore the great amount of pumping needed could be made at times when there is no peak demand of electricity and thus make the consumption of electricity more even during the day or season of the year. To be successful, it will be necessary to line up the loads for this particular scenario system so that it is also operating at nearly 100% of capacity. Since Arizona uses of electricl energy are much larger in the summer, as well as more irrigation pumping in the summer, it will be necessary to find a base load for non-peak uses for the geothermal system

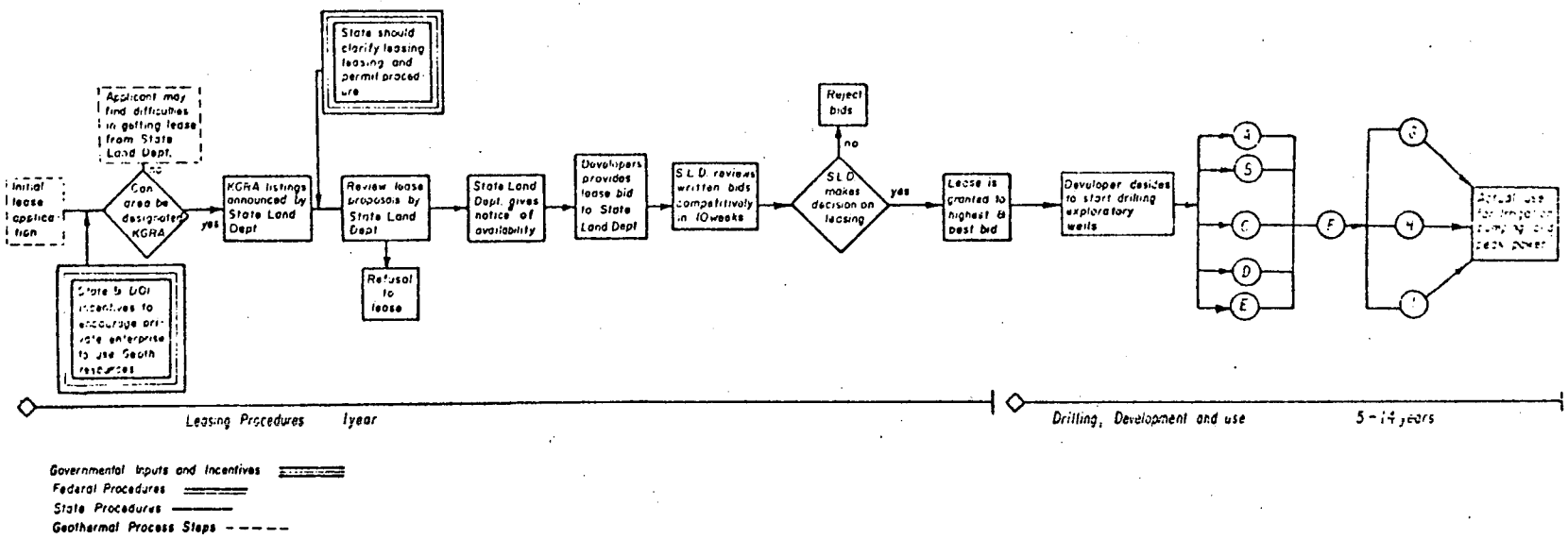


FIGURE 33: IRRIGATION PUMPING/PEAK POWER - STATE LAND

such that it can run at a higher capacity in the winter than in the summer. Also, it will be necessary for this off-peak use to be interruptable so that the irrigation pumping and the peak power generation can be accommodated. There is no obvious first choice for the off-peak use of such power or direct steam or direct hot water, but one agricultural candidate for such interruptable processing operation is the manufacturing of frozen orange juice in the Yuma area. Possibly some other interruptable agricultural or food processing operation not now in existance, but which could be moved from California to Arizona, could use geothermal power. The combination of an industrial plant with the irrigation pumping would also make the use of power more uniform thus using the industrial plant only in the off peak power period.

The use of solar energy for irrigation pumping in Arizona has been considered many times and therefore geothermal energy would be even more appropriate having more advantages than the solar energy system because geothermal water is at a constant temperature all the time (day and night) and in some cases by adding water to the area, if the water is suitable for use.

Binary system or steam turbines could be used. In the G.E. Report by J.H. Eskesen a total of ten compounds were selected as possible working fluids for the geothermal binary cycle:

Propane, Propylene, Isobutane, N-Butane, Isopentane, N-Pentane, $CHClF_2$, CH_2F_2, Ca Cl F_5 and Ammonia.

Comparison of steam turbine and binary cycles:

"If the noncondensible gas content in the brine is low, a dual flash steam turbine cycle will produce more power per unit or brine flow than a dual flash/binary cycle, but less power than the Brine/Binary Cycle" *

The best candidate for the Binary Cycle at the specific resource in question is N-Butane. The N-Butane cycle operating on the 500°F resource is investigated in detail.

Scenario #19: Crop drying

Location	:	Yuma, Casa Grande, Tucson
Temperature	:	60 - 120°C
Depth	:	1-2 km
Salinity	:	2000-3500 ppm
Land	:	State, Private, Federal, Indian
Development	:	Completed 1990

*JH Eskesen, Geothermal Energy report.

This scenario is designed to replace the steam used in the drying and pelleting of grain processes with a geothermal source. The steam used is in the 80 - 100°C range and it must be wet steam for the grain drying. For the pelleting process it must be dry steam. The products obtained are used primarily in cattle feed lots. The major set back to using geo-energy for this type of process is the high salinity content. The geo-water would have to be partially desalinable to use in the dehydration process.

Scenario #20: Kiln drying of lumber

Location :	Springerville/St Johns
Temperature:	55°C, HDR 210°C
Depth :	1 km
Salinity :	250 ppm
Land :	Federal and State
Development:	1990

This scenario would involve the use of geothermal energy for the conventional approach of kiln drying. It would also consider new approaches to drying systems that would take advantage of the low humidity in Arizona. The geothermal energy could also supply some off-peak power to the lumber mills, as well as be used for heating the buildings in the winter. Other probable locations would be Fredona and White Mountains areas.

Scenario #21: Lettuce chilling

Location :	Willcox
Temperature:	HDTF 50-80°C
	HDR 150-200°C
Depth :	0.8 km
Salinity :	3000 ppm
Land :	Federal, State
Development:	Completed 1990

The lettuce grown in the Willcox area during the winter months is shipped throughout the U.S.A. after it is harvested, it must be rapidly chilled to 4.4°C for storage. This is presently done by use of mechanical refrigeration systems. This scenario is an appraisal of the integration of this energy load into a larger geothermal absorption cooling system. It should be determined if the load could then use "off-peak" energy, so that the peak electrical energy use could be backed out.

Scenario #22: Sugar beet plant

Location	:	Chandler
Temperature:		HDTF 50 - 80°C
		HDR 150-200°C
Depth	:	1.4 km
Salinity	:	3000 ppm
Land	:	Federal, State
Development:		1990

This scenario as shown in Figure 34 is designed to retrofit part of the sugar production process to use geothermal brine integrated with conventional fuels to help alleviate Arizona's peak load. The present sugar refining process requires relatively large quantities of low pressure steam. Thus, it provides a good potential for geothermal use.

i. General Description of the Sugar-beet refining process

This process can be presented in a simplified form as follows: Sugar beets are washed, then sliced into cossettes; the cossettes are put into hot water where the sugar is leached out by diffusion. This makes a raw juice which is heated further and purified. The purified juice is filtered then the water content is reduced by evaporation to give a thick juice, this juice is now filtered and crystals are allowed to form. The crystals and juice are then certrifuged, after which the sugar crystals are dried and packaged. At the same time we have a by-product, the pulp of the beets, after the sugar is leached from beets by diffusion. The pulp is dried and sold as a by-product.

Geothermally generated steam at 25 - 28 psig and 270°F can be used in the evaporation stage and thus geothermal brine can provide approximately 25% of steam used in the process.

ii. Description of the Stages where Geothermal Brine Could be used

a. Evaporation stage - The geothermal brine at 300°F will pass through a heat exchanger to produce steam at 270°F from potable water. This design is chosen to avoid corrosion problems in the machinery and installations of the process. The exhaust brine is injected in an injection well. Using the Holly Sugar Plant in Brawey, California as an example for energy calculations, we can say that the total process steam requirement, for a sugar-beet plant that processes 270 tons of beats per hour, is 460,000 lbs of steam per hour. Geothermal wells can provide 25% of that steam requirement, i.e. 115,000 lbs/hr of steam at 270°F and

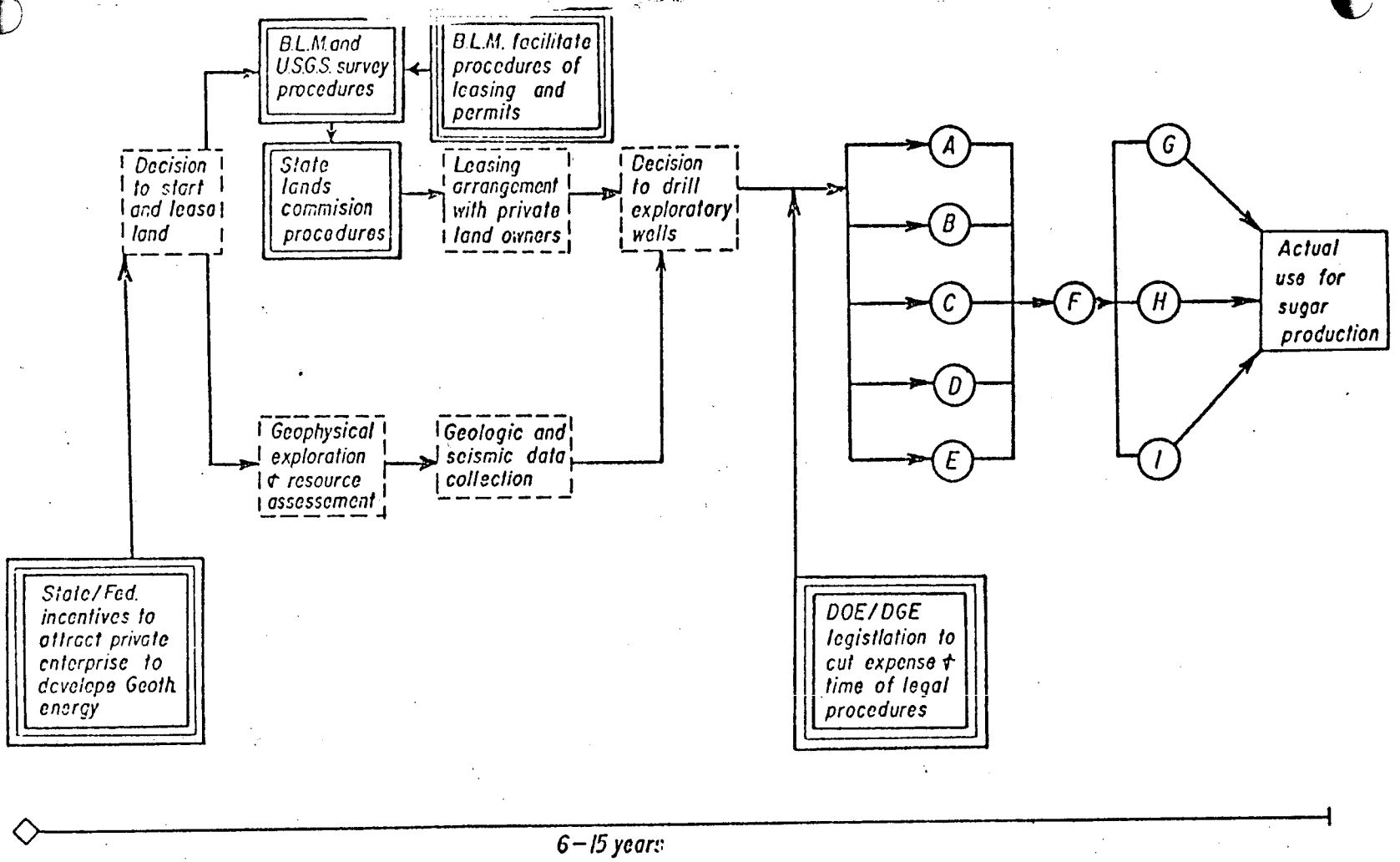


FIGURE 34: SUGAR PLANT OUTSIDE PHOENIX -PRIVATE LAND

26 psig in energy units we get, (115,000 $\frac{lbs}{hr}$ x 1180 $\frac{BTU}{lb}$ = 1.36 x 10^8 BTU/hr), 1.36 x 10^8 $\frac{BTU}{hr}$. Assuming that 1 $\frac{ft^3}{hr}$ of natural gas gives 10^3 BTU/hr, we can calculate the amount of gas savings by using geothermal energy; natural gas savings/hr = $\frac{1.36 \times 10^8 \text{ BTU}}{1000 \text{ BTU}}$ = 1.36 x 10^5 ft^3/hr. Thus using geothermal resource provides a savings in natural gas use of 136,000 ft^3 per hour:

b. Pulp Drying stage - Pulp drying uses about 40% of the energy required for the overall process. This stage is separated from the other operations of sugar refining and can be retrofitted very easily to use geothermally heated dryers. Again using the Brawley sugar plant example, the energy required for pulp dryers is approximately 270 MM BTU/hr. So the savings in natural gas per hour by using geothermally heated dryers is a significant 0.27 MCF/hr.

c. Refrigeration demand - A sugar-beet plant with the same capacity as the Brawley Sugar Plant requires 100 tons of refrigeration for the processes of crystallization and bulk sugar cooling. Geothermal brine at about 240°F could be used in an absorption cooling unit to provide 100 tons of refrigeration.

iii. Geothermal Wells' Characteristics

Temperature of hydrothermal fluid	:	300°F
Depth of Well(s)	:	3000 ft
Salinity of Brine	:	2000 ppm
Land status of site	:	Federal land
Assumed flowrate from each production well	:	500,000 lb/hr
No. of production wells	:	5
Total Flowrate from all wells	:	2.5 x 10^6 lb/hr
Depth of each injection well	:	3000 ft

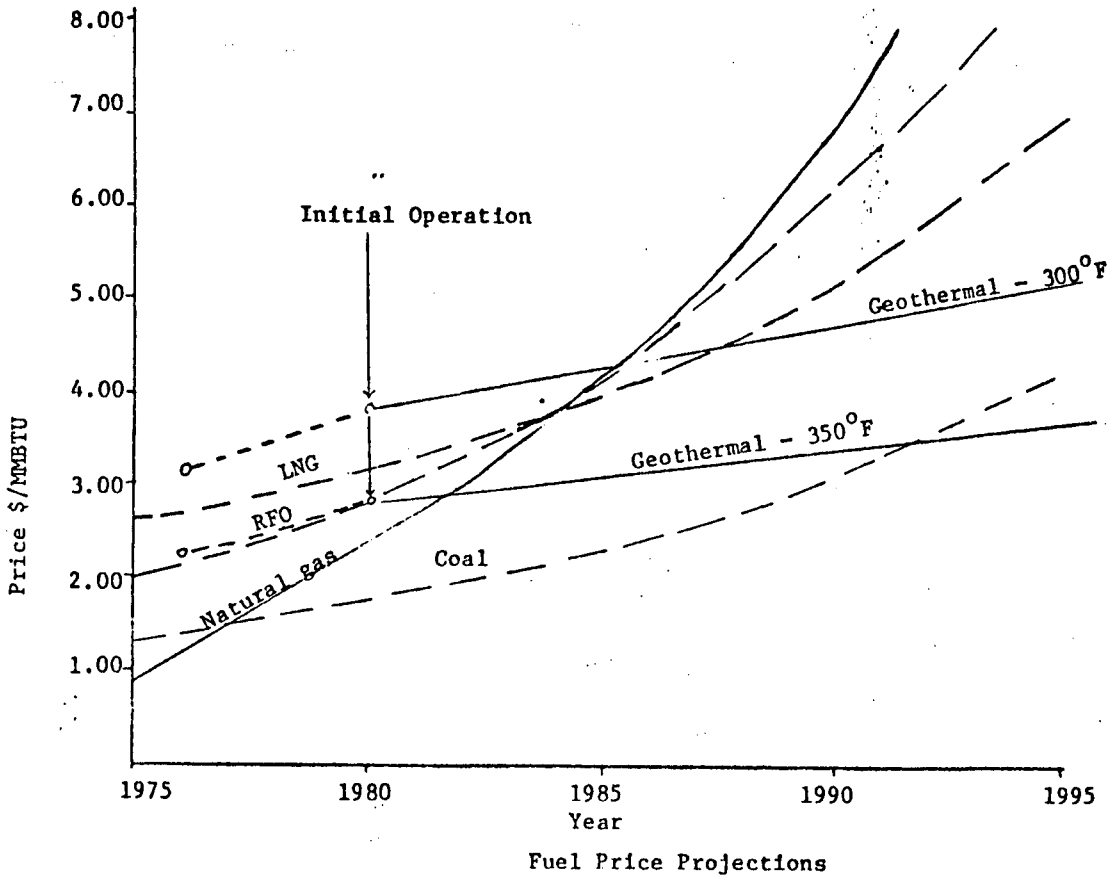
iv. Economic Comparison

This cost comparison will not consider actual cost of equipment needed for retrofitting; we will calculate an estimate of the cost of production and injection pipes. Then we will consider the savings in conventional fuels which will be encountered if geothermal energy is used in the above mentioned stages of the process.

Total cost of well = depth x cost/ft = 3000 x 50
total cost of well = $150,000/well
total cost for 5 production wells and 5 injection wells including pumps and other equipment is $1,500,000.

If geothermal site is 2000 ft away from sugar plant, the cost of insulated pipes is $100,000. While cost of reinjection pipes (uninsulated) is $80,000. Therefore; total cost of wells and pipes is $1,680,000.

Assuming that the campaign period is 174 days, savings in energy (if we retrofit parts of evaporation stage to use geothermal energy) are 1.36×10^4 ft^3 x 24 x 174 = 56.7 MCF/campaign. Savings during pulp drying is 1127.52 MCF/campaign. Savings in fuel for refrigeration is 2840 BBLOIL/campaign. Therefore, total savings per campaign are 1184 MCF of natural gas and 2840 BBLOIL. Thus, we can see the savings in energy and cost of operation if we consider the possibility of the increase in the prices of conventional fuel. Figure 35 shows fuel price comparisons given for sugar-plant in Brawley.



Legend

Natural Gas - Consumer (industrial) prices for gas in Calif - Economics of Oil and Gas for Use in Calif., S.H. Clark

LNG - Synthetic fuels commercialization Program, Vol. III. and S.H. Clark

Residual Fuel Oil (RFO) - Low Sulfur fuel oil Electric Utilities Study TRW Systems and Energy

Coal - 1976 U&I Costs escalated @ 6%/year

Geothermal - Cascaded from Boiler to Dryer geothermal Sugar Refining only (5½ mos.)

FIGURE 35: FUEL PRICE PROJECTION COMPARISONS OF CASCADED 300°F AND 350°F GEOTHERMAL SYSTEMS TO FOSSIL FUELS

V. ANALYSIS OF GEOTHERMAL POTENTIAL

A. SURVEY OF CURRENT NON-ELECTRIC APPLICATIONS OF GEOTHERMAL ENERGY

Non-electric applications of geothermal energy are of great importance in the development of our geothermal resources. Most of these applications are at a temperature below 250°C; and the fact that geothermal wells with a brine temperature below 250°C are abundant around the world and occur at moderate depths makes us realize the importance of using these geothermal resources as an alternate source of energy for non-electrical usage. *,**

Many different industries use temperatures of 250°C or below in certain stages of their industrial processes. Table 19 gives a list of such industries and the temperature range in some stages of the process and the amount of energy used in that temperature range.*** As shown in Table 19 a total of 5.823 Quads of energy are used in industry at below 250°C. However, non-industrial and commercial uses of energy require a temperature much lower than 250°C. For example, residential heating uses a temperature range of 50-74°C in most cases. So to show the potential for non-electric geothermal applications, Fig. 36 gives the temperature range and the amount of energy used in that range for all non-electric applications. From Fig. 36 we see that space heating in the United States requires 12.080×10^{12} BTU. Moreover, the bulk of the energy used is at temperatures up to 200°C. In addition, if we extend the above applications to approximate the realizable potential for non-electrical geothermal applications in the U.S., it is estimated that geothermal energy could provide 20 to 40% of the total potential indicated in Figure 36 or 10 to 20% of U.S. energy consumption.

It is a well known technical fact that the recovery of geothermal energy in non-electrical applications has a greater efficiency than the recovery for electrical applications. This, together with the realization that temperatures used in non-electrical applications are low to moderate, have made the use of geothermal resources economically competitive with conventional fuels used in non-electric applications. Geothermal resources are extensively used in several locations around the world like in Reykjavik and Lake Myvatin in Iceland, and Kaveran in New Zealand. The use of geothermal resources world wide encompasses a great variety of non-electrical applications such as space heating, agricultural uses and in industry.

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* Stanford Research Institute, 1972, Patterns of energy consumption in the United States; Stanford, California

** Lindal, B., 1973, Industrial and other applications of geothermal energy, in geothermal energy; Review of research and development: Paris, UNESCO (L (No. 72-97138, p. 135 - 148).

*** Reistad, G.M., 197, Analysis of potential non-electrical applications of geothermal energy and their place in the national economy: Livermore, California, Lawrence Livermore Lab., UCRL 51747.

TABLE 19

ESTIMATED USES OF PROCESS STEAM AT VARIOUS TEMPERATURES IN INDUSTRIAL SECTORS

Industry	Temperature Range (°C)	Total Steam use (% of sector)	Energy use 10^{12} BTU)
Primary Metals	≥250	~100	350.0
Chemical and Allied	≥250	5.0	54.7
Products	225-249	15% { 7.5	82.0
	200-224	15% { 7.5	82.0
	175-199	25	273.5
	150-174	25	273.5
	125-149	30	328.2
Total		100	1093.9
Petroleum	225-249	20% { 7	67.2
	200-224	20% { 7	67.2
	175-199	6	57.6
	150-174	40	384.0
	125-149	40	384.0
Total		100	960.0
Food and Kindred	150-174	10	90.0
Products	125-149	45	405.0
	100-124	45	405.0
		100	900.0
Total		100	900.0
Paper and Allied	175-199	70	703.5
Products	150-174	30	301.5
		100	1005.0
Other Industries*	≥250	7	407.6
	225-249	2	116.5
	200-224	2	116.5
	175-199	19	1106.4
	150-174	19	1106.4
	125-149	21	1222.8
	100-124	7	407.6
	75-99	2	116.5
	50-74	21	1222.8
Total		100	5823.1

* Divided according to steam use in other categories, except for space heating component since all space heating appears in this category. Space heating is classified as heating in the 50 to 74°C temperature range.

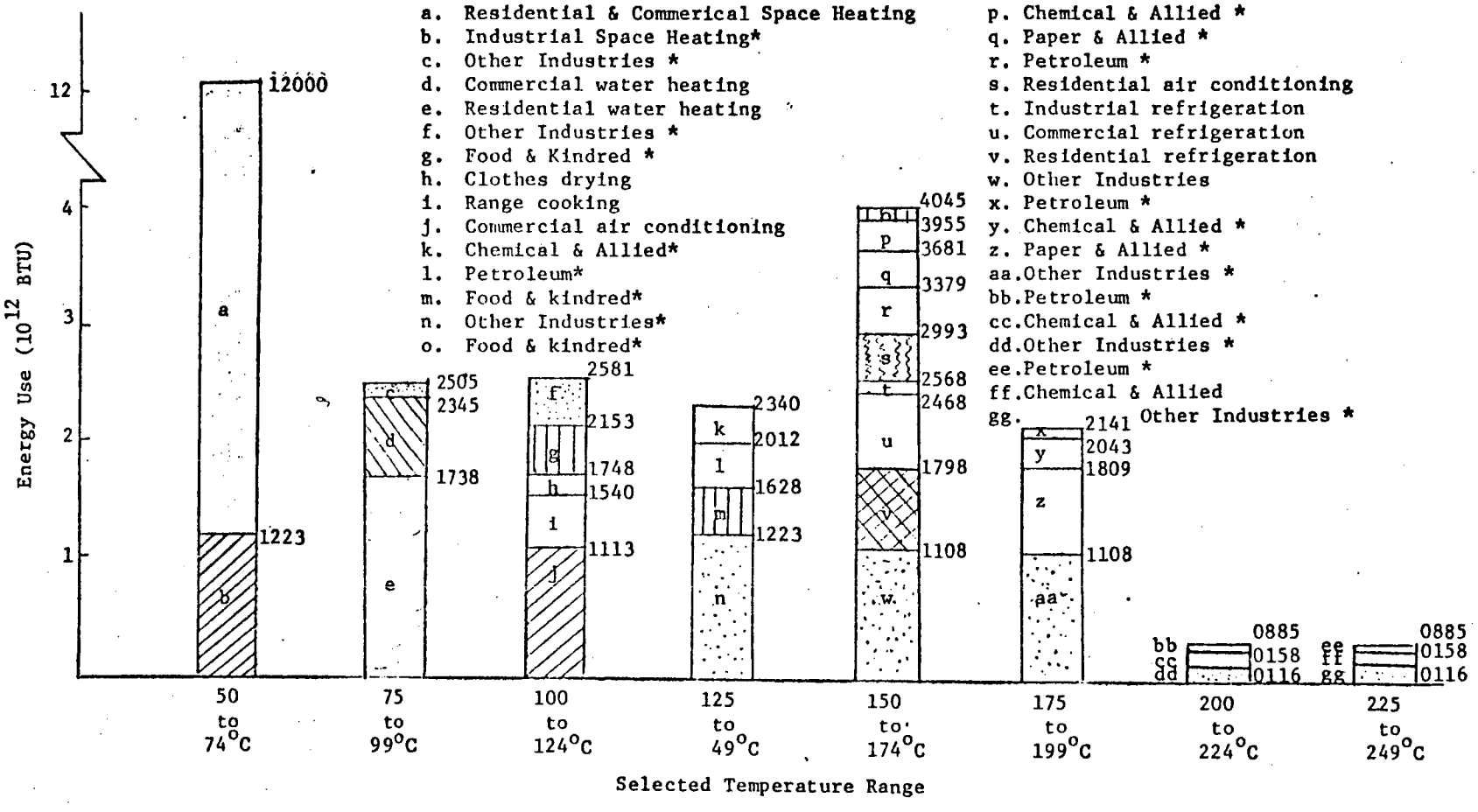


FIGURE 36: ESTIMATED HEATING ENERGY USE IN SELECTED 25°C TEMPERATURE RANGES
(*) INDICATES PROCESS STEAM USE IN SECTOR

B. ECONOMIC ASPECTS

1. Pricing of Geothermal Energy in Arizona

Pricing the energy obtained from a geothermal reservoir is an important yet complex problem. Predicting the price of an energy unit prior to geothermal development requires an insight into the future of the energy market. Various approaches to the problem have been studied and are outlined below.

i) Geothermal Steam Value for Electricity at a Given Location

Steam for the production of electricity is priced according to the value of the kilowatt-hour. The amount of steam from geothermal sources needed to supply one kilowatt hour is worth the going price of that unit of energy. Appraisal of geothermal energy's value is therefore based on the output of electricity it can produce per unit of steam.

ii) Delivered Alternative Fuel Value for Thermal Energy at Given Location

Consider the alternative fuel values compared to geothermal energy values at different locations. We want to know the value of fuel being replaced at a particular place. This value equals the value of geothermal energy which replaces it. The number of BTUs supplied is very important this causes a problem when low-grade heat is considered since BTUs at low-level temperatures are less valuable than at high-level temperatures.

iii) Capital Investment to Recover Low-Temperature Geothermal Energy

Problems with salt content of brine and other pollutants often occur. Knowing temperature and depth of the resource prior to making the capital investment allows a better estimate of necessary capital expenditures early in the project. The time to recover a capital investment is therefore an important assessment to make. Costs for using heat exchangers and pumping also hinge on the depth, salinity, and temperature of the thermal water in the reservoir. For example, the geothermal gradient influences the optimum surface area to be used on heat exchangers.

iv) Quality of Geothermal Energy based on Carnot Efficiency

Where geothermal steam is suitable for power production, the Carnot cycle could be seen as giving one good appraisement of the "quality of energy." Carnot efficiency depends on the temperature difference between the geothermal brine and the wastewater.

v) The cost of Geothermal Energy

The cost of geothermal energy must be commensurated with alternative energy systems, be they solar energy or any other type of energy used in Arizona. Geothermal energy must compete with all alternative sources

of energy. Table 20 outlines an approach to analyzing Arizona's energy alternatives. Arizona has neither oil nor natural gas, but Alaskan oil may be transported across Arizona in existing pipelines in the near future. Coal is abundant in Arizona and electrical power generation from coal at several power plants helps meet the State's power requirement as well as portion of Southern California's demand. The first nuclear power plant is currently under construction and its expansion is already being planned. Future use of coal gasification and/or liquefaction depends upon current DOE, R & D results. New absorption refrigeration technology, if developed, would be good for the geothermal as well as for solar energy. If developed, heat pump technology could also lower geothermal energy costs. Each storage technology is also important especially for solar energy. It is also important for helping on daily peak power loads. For example, if all homes in Arizona were to install a rock bed energy storage system, then two-stage evaporative cooling systems could be used during all peak power periods during the summer, instead of electricity.

2. The Economics of Geothermal Energy Compared to that of Fossil Fuels

Currently, geothermal energy use appears to be generally uneconomical compared to the conventional sources of energy like natural gas, fuel oil and coal. Exceptions occur in areas with high pressure steam, like in the Geyser geothermal areas. Nevertheless, any large geothermal reservoir could become an economical alternative source of energy in the future, especially when the conventional energy sources start to run short and as the prices of these conventional fuels constantly continue to increase. Moreover, the cost of using geothermal energy could be reduced as the technology of drilling is improved.

Let us first discuss the cost of geothermal energy versus the cost of the other fuels. Figure 37 shows the price projections for conventional fuels to the year 1995. It is predicted that these prices will increase several fold thus making the cost of geothermal energy quite competitive. Figure 37 shows that the cost of coal will be more than triple while natural gas will increase almost by an order of magnitude before the next century begins.

Figure 38 shows cost projections for conventional fuels versus geothermal where geothermal costs will be competitive with the costs of other fuels in about the year 1990 for the lowest cost alternative and in the year 1982 for the highest cost alternative.

The case study of the Holly Sugar Plant of Brawly, California * provides a good example where geothermal energy used in the sugar processing industry is practically as economical as the other fuels used and will be more economical than all these fuels in the year 1993, according to the price projections in Figure 35. Consequently, the constant decrease in the conventional fuel reserves and the increase in the prices of these

* Russel O.P., Use of Geothermal Heat for Sugar Refining. Final report Oct. 1, 1976 - May 31, 1977. TRW System and Energy, Redonda Beach, Calif.

TABLE 20

ANALYSIS OF ENERGY ALTERNATIVES

OIL IN ARIZONA

NATURAL GAS IN ARIZONA

ALASKAN OIL ACROSS ARIZONA

COAL IN ARIZONA

ELECTRIC POWER GENERATION IN ARIZONA

COAL GASIFICATION IN ARIZONA

COAL LIQUEFACTION IN ARIZONA

NUCLEAR POWER PLANTS IN ARIZONA

NUCLEAR POWER EXPORT

COAL POWER EXPORT

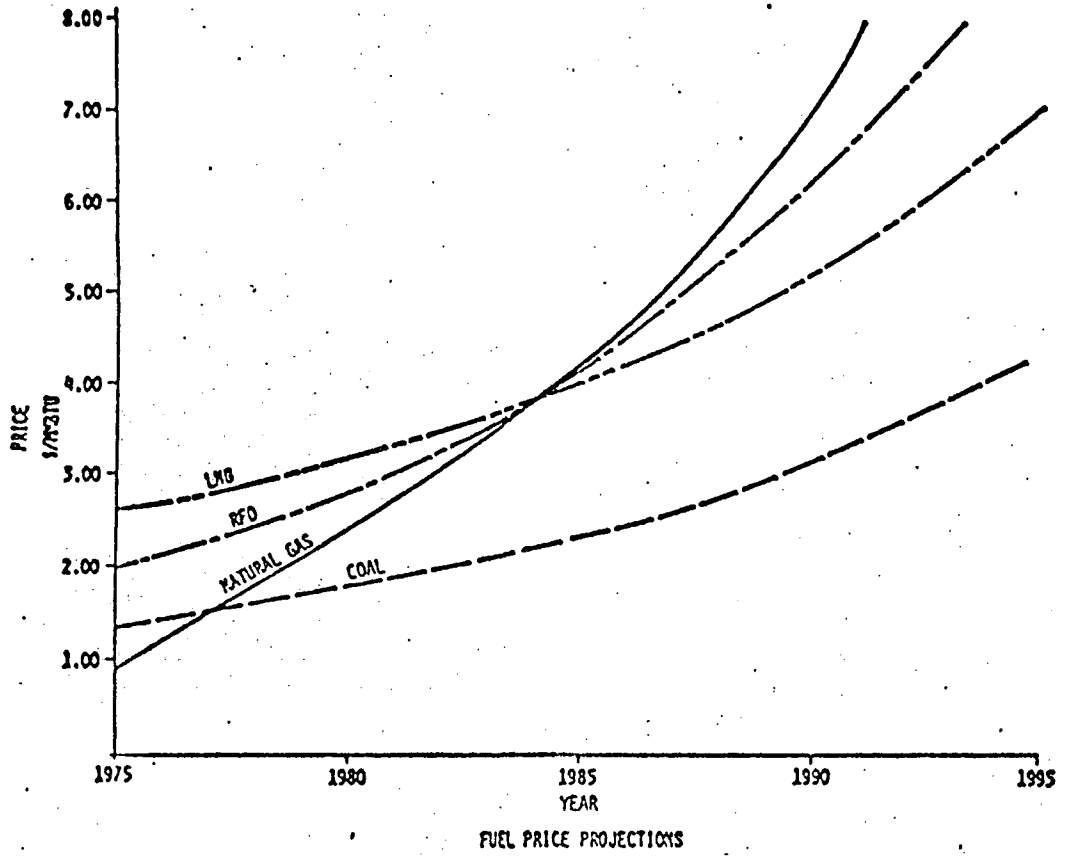
ENERGY CONSERVATION IN ARIZONA

MODIFIED ARCHITECTURE FOR ARIZONA

NEW ABSORPTION REFRIGERATION TECHNOLOGY

HEAT PUMP TECHNOLOGY

ENERGY STORAGE TECHNOLOGY



FUEL PRICE PROJECTIONS

LEGEND

Natural Gas - Consumer (industrial) prices for gas in California - Economics of Oil and Gas for use in Calif. S.H. Clark

LNG - Synthetic fuels Commercialization Program, VDY III and S.H. Clark

Residual Fuel Oil (RFO) - Low Sulfur Fuel Oil Electric Utilities Study. TRW Systems and Energy

Coal - 1976 U&1 costs escalated @ 6%/year

FIGURE 37: FOSSIL FUEL PRICE PROJECTIONS

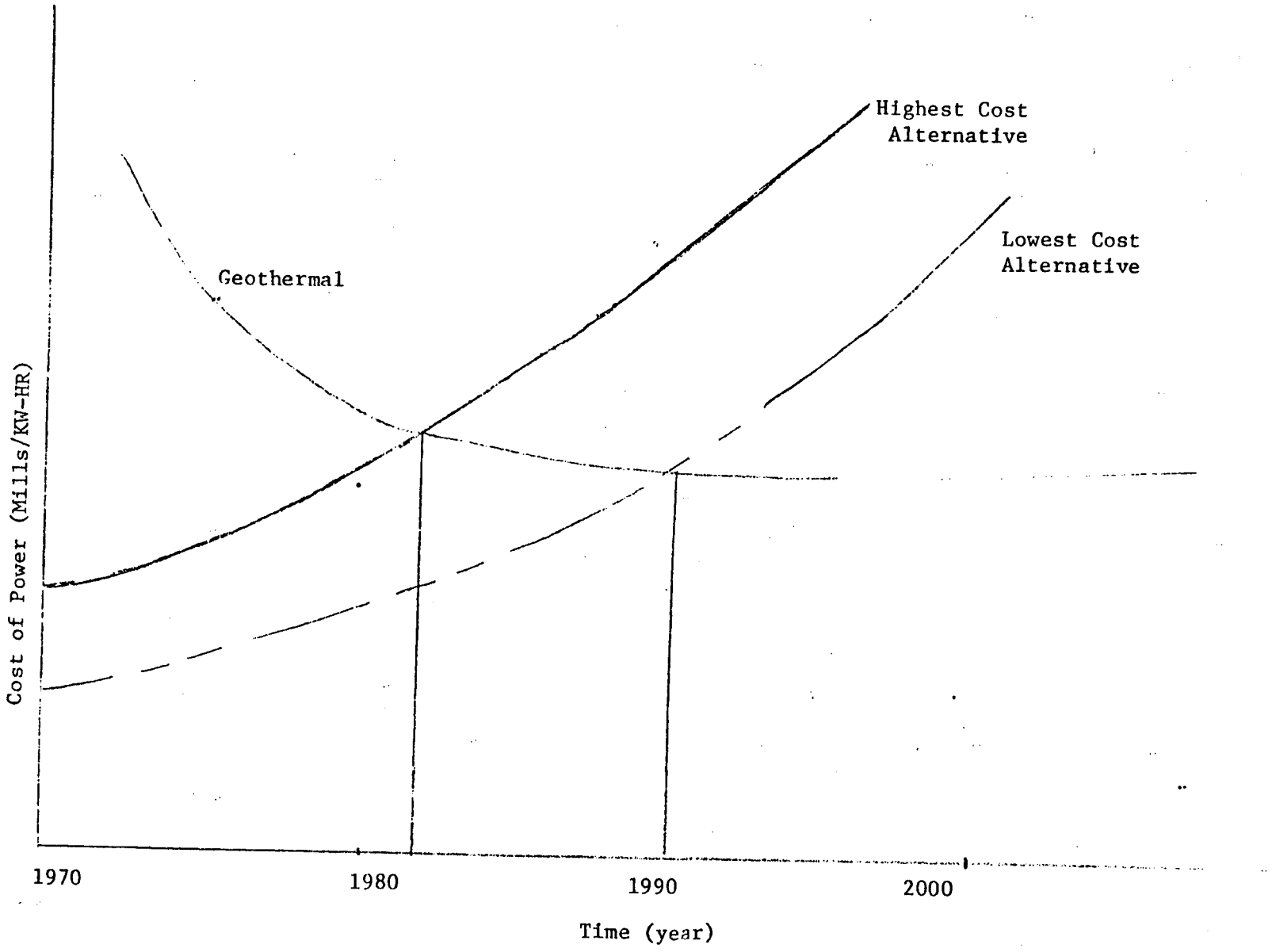


FIGURE 38: PROJECTIONS OF COST OF POWER PRODUCTION

fuels will enhance the attractiveness of geothermal resources. Table 21 gives a comparison of cost $/MMBTU for fuel versus geothermal water. Table 22 gives the amount of energy recoverable from geothermal resources.

Drilling cost is a major factor in the economics of this energy source. Drilling for geothermal brine costs more than drilling for oil. There are several factors that cause this increase.

i. Geothermal drilling usually takes place in harder rock formations than oil drilling, thus the drilling rate decreases and the bit life is reduced, causing delay in time to replace the bit. In order to illustrate this point, Figure 39 gives the average US Petroleum well costs. An oil well 10,000 ft feep costs $230,000 for drilling which is $23/ft. The cost of a geothermal well 10,000 ft deep is $870,900, i.e. $87.09/ft according to the report No. Sand 76-0228 published by Sandia Laboratories in June 1976. But if a new type of bit is used such as the Terra-Bit proposed by Sandia Laboratories the cost/ft is reduced by 54%; i.e. new cost/ft is $40.33.

An equation that computes the cost/ft is

$$F_c = \frac{C\,L + V\,(D + \frac{t}{2}) + B}{RL} \qquad (1)$$

where F_c = Cost in $/ft
R = Penetration rate (ft/hr)
D = Depth per bit system (ft)
L = Bit life (hours)
C = Rig rate ($/hr)
B = Cost per bit ($)
t = Interval to be drilled (ft)
V = Average trip rate hr/1000 ft)

Another report by Mitre published in December 1977 gives more conservative estimates for cost/ft as a function of hardness of rock and depth of well. These estimates are given in Table 23 where we see that cost/ft increases largely if the rock is abnormally hard or if the reservoir occurs at a level below 5000 ft.

ii. Geothermal drilling progresses in rock formations having higher temperatures than are encountered in oil or gas drilling. Higher drilling costs also result because improved high temperature downhole motors must be used to apply enough power to the rock face for both directional and straight hole drilling. High-temperature drilling fluids should be developed which can reduce drilling time and minimize fluid related problems. Finally, better bits with higher preformance in high temperature rock formations should be developed. This improved equipment will cost more than the conventional equipment used for oil drilling, but they may increase the efficiency of geothermal drilling in the future. Factors which determine penetration rates are outlined in Table 24.

TABLE 21 FOSSIL FUEL AND GEOTHERMAL PRICE PROJECTIONS

($/MMBTU)

YEAR	FUEL TYPE							
	NATURAL GAS	RESIDUAL FUEL OIL	COAL	LIQUEFIED NATURAL GAS	GEOTHERMAL CASCADED - 300°F	GEOTHERMAL CASCADED- 350°F	GEOTHERMAL CASCADED/OFF SEASON 300°F	GEOTHERMAL CASCADED/OFF SEASON 350°F
1976	1.42	2.10	1.38	2.70	3.10	2.22	1.73	1.27
1980	2.44	2.89	1.74	3.20	3.91	2.80	2.18	1.60
1985	4.25	4.21	2.33	4.00	4.32	3.09	2.41	1.77
1990	7.05	6.19	3.12	5.25	4.77	3.42	2.66	1.95
1995	11.82	9.09	4.17	7.00	5.26	3.77	2.94	2.16

TABLE 22 (*)

POTENTIAL RECOVERABLE ENERGY FROM GEOTHERMAL RESOURCES IN THE U.S.

HYDROTHERMAL:	TEMPERATURE	POTENTIAL RECOVERABLE (1)
	High 150°C +	14 to 154 quads
	Mid 90°-150°	110 quads
	Low 15°-90°	81.8 quads
	TOTAL HYDRO	205.8 to 345.8 quads
GEOPRESSURED:	TEMPERATURE	POTENTIAL RECOVERABLE (2)
	High 150°C +	81 to 315 quads
	Mid 90°-150°	270 to 1050 quads
	Low 15°-90°	178 to 693 quads
	TOTAL GEOP.	529 to 2058 quads
TOTAL COMBINED:	TEMPERATURE	POTENTIAL RECOVERABLE
	High 150°C +	95 to 469 quads
	Mid 90°-150°	380 to 1160 quads
	Low 15°-90°	260 to 775 quads

This represents, at a minimum, roughly 10 times our present annual consumption or at a maximum, about 35 times our present use levels.

(*) Elmer, D.B., An Open Letter on Geothermal Energy and Energy Consumption, Geothermal Energy Magazine, page 40, Vol. 5 No. 5, 1977.

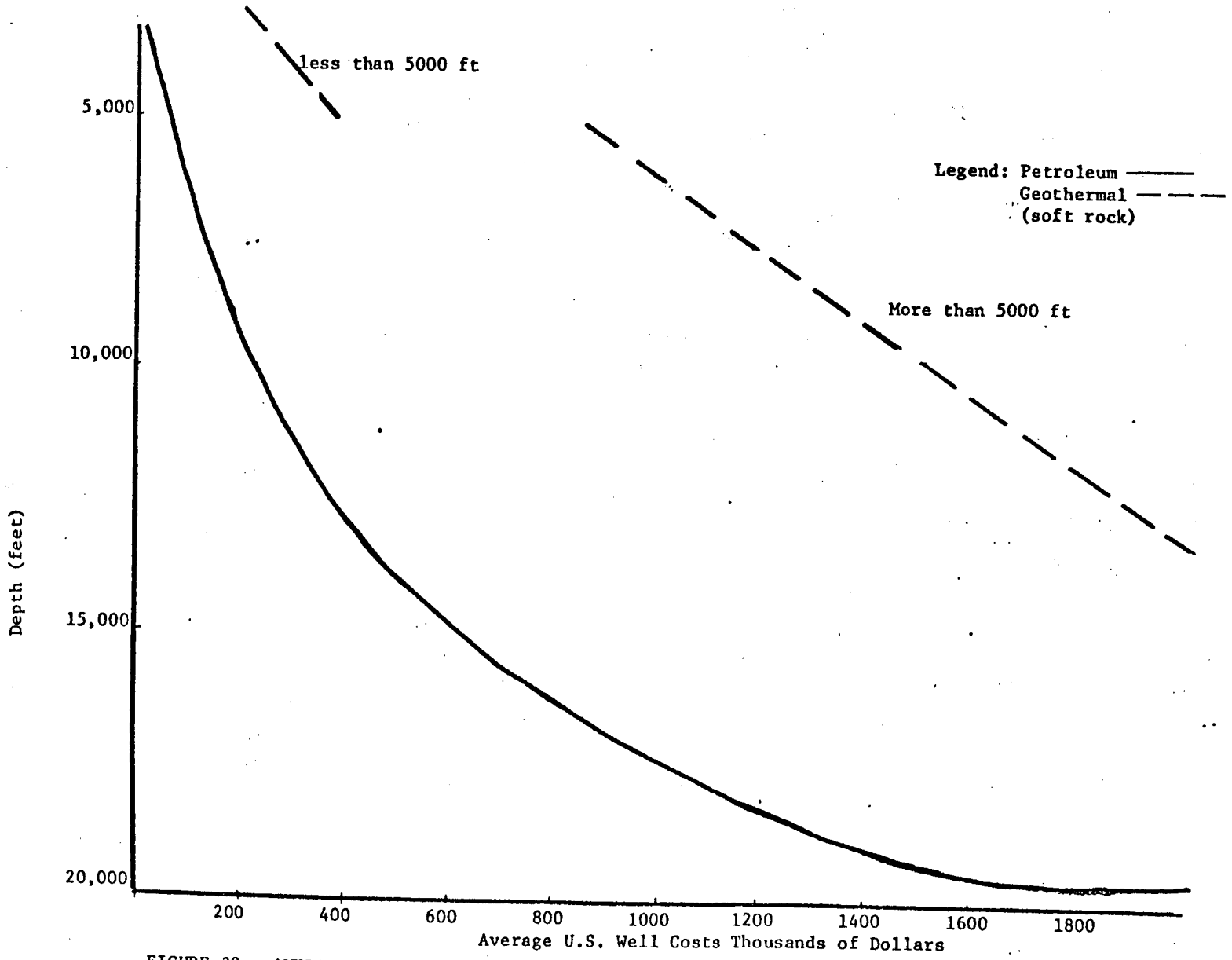


FIGURE 39: AVERAGE U.S. PETROLEUM AND GEOTHERMAL WELL COSTS

TABLE 23 (*)

FOOTAGE COSTS FOR GEOTHERMAL DRILLING
AS A
FUNCTION OF ROCK TYPE AND WELL DEPTH

ROCK HARDNESS	COST/FOOT (1977 DOLLARS)	
	<5000 FEET	>5000 FEET
Soft	80	160
Medium	100	120
Medium-Hard	125	250
Hard	200	400

(*) Friedman, E.J., et al, Prospects

TABLE 24 (*)

FACTORS WHICH DETERMINE PENETRATION RATE

1. Personnel efficiency
   a. Competence
      (1) experience
      (2) special training
   b. Psychological factors
      (1) company-employee relations
      (2) pride in job
      (3) chance for advancement

2. Rig efficiency
   a. State of repair, preventive maintenance
   b. Proper size
   c. Ease of operation, degree of automaticity, and power equipment

3. Formation characteristics
   a. Compressive strength
   b. Hardness and/or abrasiveness
   c. State of underground stress (overburden pressure, etc)
   d. Elasticity - brittle or plastic
   e. Stickiness or balling tendency
   f. Permeability
   g. Fluid content and interstitial pressure
   h. Porosity
   i. Temperature

4. Mechanical factors
   a. Weight on bit
   b. Rotating speed
   c. Bit type

5. Mud properties
   a. Density
   b. Solid content
   c. Flow properties
   d. Fluid loss
   e. Surface tension-wettability

6. Hydraulic factors-essential bottom hole cleaning

(*) Friedman, E.J., et al., Prosp.

iii. Corrosion of pipes also increases the cost of drilling. Considerable attention to metals specification and design techniques is required to keep corrosion at an acceptable level. Research into prevention of geothermal brine corrosion is currently being conducted.

These are some of the factors that cause an increase in the cost of geothermal drilling. To sum up the complete picture of the economics of geothermal energy use, we should emphasize the fact that the initial capital investment required for exploratory drilling, development and completion of geothermal well is large and presently discourages the exploration for geothermal resources. This may continue until the cost of developing this energy becomes competitive with the cost of using energy from conventional fuels. The cost breakdown of a completed steam well is given in Table 25, where a well 7000 ft deep costs $1,000,000 i.e. $143.3/ft. Thus, if we wish to develop and use the reserves of geothermal energy available at the present time, more incentives should be provided such as loans for exploration and development companies, tax credits, cutting the time and expense of "red tape" for leasing and permits procedures, and improving the drilling technology.

TABLE 25(*)

DRILLING AND COMPLETION COSTS AT THE GEYSERS

Cost of Completed Steam Well (7000 ft)

Build road, location and cellar	$ 50,000
Move rig in and out	65,000
Rig operating for 70 days	315,000
Air compressor rental	40,000
Fuel for rig and air compressors	34,000
Excessive drill pipe wear	25,000
Hardbanding drill pipe	3,000
Drill pipe and drill colar inspection	6,000
Water	15,000
Waste Disposal	20,000
20" Conductor pipe	4,500
13-3/8" casing	52,500
9-5/8" casing	67,500
Cement and Services	50,000
Rent 20" Hydril and Rotating Head	10,000
Rent shock sub and stabilizer	10,000
Rent monel drill collar and directional instruments	10,000
Drilling mud	30,000
Well head and muffler and flow line	20,000
Miscellaneous transportation	10,000
Logging	8,000
Mud well logging	25,000
Bits (27)	55,000
Miscellaneous	50,000
Direct supervision and overhead	28,000
	$1,003,500

(*) Friedman, E.J. et al. Prospects for Improvement in Geothermal well Technology and their Expected Benefits, Dec. 1977, MITRE

VI. INTERACTION WITH STATE GROUPS

A. EXPLORATION OF INDUSTRIAL POTENTIAL USERS IN ARIZONA FOR GEOTHERMAL ENERGY

In order to assess the value of the proposed scenarios and appraise potential users of geothermal energy in Arizona, we sent letters to over seventy companies and institutions asking for details concerning their energy usage. We principally wondered how geothermal energy could be useful to them. A list of companies and institutions that were approached is given in Table 26. Many replied by letter or phone, emphasizing their use of very high grade energy for which geothermal is not applicable. Others offered specific answers and suggestions for geothermal use. Some just said they could not participate in the study, supplying data without elaboration on the reasons.

Companies using very high temperature (>2000°C) cannot benefit from geothermal application. However, low grade temperatures are used for heating in a pulp and paper plant. This being a small fraction of their energy consumption, they could not guess how useful geothermal could be in their case, although they are willing to cooperate in later studies. One particular company expressed great interest in solar or geothermal energy and willingness to discuss the matter further. They operate three plants and in 1976/77 for heating purposes they used:

a) 201096 therms. in Plant No. 1 (1 therm = 100,000 BTU)
b) 60000 therms. in Plant No. 2
c) 24000 therms in Plant No. 3

and 10,000 gallons of oil was used at the plant No. 1 when gas was not available. Temperature needs were between 80°F and 338°F. For cooling purposes they used electrical power as follows:

a) 6,000,000 Kwh in plant no. 1
b) 2,500,000 Kwh in plant no. 2
c) 1,335,000 Kwh in plant no. 3

The cooling temperatures are from 170°F to 32°F for milk products and to -20°F for ice-cream storage.

A company which is operating several facilities thinks that a part of their energy use is amenable to alternative energy sources like geothermal and solar. It is worth mentioning that at least in one case they have already included solar energy. They expressed great interest in our project and are willing to work with us. One of their buildings requires 3 MW power which could be one geothermal power unit. They suggested that for economic evaluation the cost of 0.03 $/kwh and $0.17/therm of gas should be used.

A firm that uses hot water responded very favorably to our inquiry, they already have a program underway exploring the possibility of using solar energy and boiler waste heat. They produce their hot water by adding

TABLE 26

LIST OF COMPANIES WHICH WERE ASKED ABOUT ENERGY USE AND POTENTIAL GEOTHERMAL ENERGY APPLICATION

Phelps Dodge Corporation
Ajo, Arizona 85321

Phelps Dodge Corporation
Douglas, Arizona 85607

Industrial Asphalt
Phoenix, Arizona 85034

Inspiration Consolidated Copper Company
Inspiration, Arizona 85537

Mallin Brothers Iron and Metal Company
Phoenix, Arizona 85041

Cudahy Food Company
Phoenix, Arizona 85001

Can-Am Corporation
Douglas, Arizona 85607

Armour Food Company
241 West Jackson
Phoenix, Arizona 85030

Honeywell Information Systems
Phoenix, Arizona 85029

Honeywell Process Control Division/Phoenix
Phoenix, Arizona 85029

Phoenix Cement Company
Phoenix, Arizona 85012

Ray Mines Division
Hayden, Arizona 85235

Sahuaro Petroleum and Asphalt Company
Phoenix, Arizona 85005

The Tanner Companies
Parker, Arizona 85344

R.E. Darling Company, Inc.
Tucson, Arizona 85705

Motorola Government Electronics Division
Scottsdale, Arizona 85252

Motorola Inc. Semiconductor Products Division
Phoenix, Arizona 85008

Hexcel Corporation
Casa Grande, Arizona 85222

Burr-Borwn Research Corporation
Tucson, Arizona 85706

Apache Powder Company
Benson, Arizona 85602

West-Cap Arizona
Tucson, Arizona 85706

Tektron
Goodyear, Arizona 85338

Unidynamics/Phoenix, Inc.
Goodyear, Arizona 85338

Talley Industries of Arizona, Inc.
Mesa, Arizona 85201

Airesearch Manufacturing Company of Arizona
Phoenix, Arizona 85034

Sperry Flight Systems
Douglas, Arizona 85936

Western Electric Company, Inc.
Phoenix, Arizona 85002

Willcox Packing House
Willcox, Arizona 85643

Hamilton Aircraft Company, Inc.
Tucson, Arizona 85706

Goettl Bros. Metal Products, Inc.
Phoenix, Arizona 85016

Hughes Aircraft Company-Tucson Manf. Div.
Tucson, Arizona 85734

Anaheim Citrus Products
Yuma, Arizona 85364

Asarco Hayden Plant
Hayden, Arizona 85235

Arizona Portland Cement Company
Phoenix, Arizona 85013

Arizona Castings, Inc.
Tempe, Arizona 85281

Pioneer Paint and Varnish Company
Tucson, Arizona 85711

Southwest Forest Industries/Snowflake Paper and Pulp Division
Snowflake, AZ 85937

Southwest Forest Inds.
Phoenix, Arizona 85011

Kaibab Industries
Phoenix, AZ 85036

Deer-O Paints & Chem's Ltd.
Phoenix, AZ 85008

Southwest Feed & Seed Company
Phoenix, AZ 85035

Rainbo Baking Company of Phoenix
Phoenix, AZ 85007

Holsum Bakery, Inc.
Phoenix, AZ 85005

Capitol Castings Div.
Tempe, Arizona 85282

Paul Lime Plant Inc.
Douglas, Arizona 85607

Astro-Lite Battery Co.
Tucson, Arizona 85719

Chevron Asphalt Co.
Phoenix, Arizona 85005

Chemical Dist. DBA AZ Agrochemical Co.
Phoenix, AZ 85034

TABLE 26 CONTINUED

Arizona Refining Company
Phoenix, Arizona 85001

Tucson Coca-Cola Bottling Company
Tucson, Arizona 85705

Seven-Up Bottling of Phoenix, Inc.
Phoenix, Arizona 85007

Producers Cotton Oil Co.
Phoenix, Arizona 85001

Pepsi Cola Metropolitan Bottling Company, Inc.
Phoenix, Arizona 85040

Kalil Bottling Company
Tucson, Arizona 85719

Casa Grande Oil Mills
Casa Grande, Arizona 85222

Anderson, Clayton & Company
Phoenix, Arizona 85062

Hayden Flour Mills
Tempe, Arizona 85281

Arizona Feeds
Casa Grande, Arizona 85222

Arnold Pickle and Olive Co..
Phoenix, Arizona 85006

Spreckels Sugar Division
Chandler, Arizona 85224

Shamrock Foods Company
Phoenix, Arizona 85009

Safeway Stores, Inc., Milk Department
Tempe, Arizona 85282

Foremost Foods Company
Phoenix, Arizona 85021

Carnation Company
Phoenix, Arizona 85012

Borden, Inc.
Phoenix, Arizona 85030

Swift Fresh Meats Company
Tolleson, Arizona 85353

Associated Milk Producers, Inc.
Gilbert, Arizona 85234

steam to cold water, and would definitely consider geothermal or any other alternative energy. They operate several similar plants and they would be willing to use one as a demonstration plant.

Arizona's total energy use is estimated to be 2,280,870 MMBTUs/year or about 34,196 gallons of fuel per year. Potential savings are estimated to be forty times as much for the nation. The range of temperatures used in the estimations are 110°F, 140°F and 180°F. One of the big space users in Tucson uses its energy in the range of 72-78°F all year around. The amount of Natural gas used per year is in the range of 1,500,000 ft^3 of gas totaling some $2500/year. Electrical use amounts to 5,000,000 Kwh totaling some $220,000/year.

Another big company uses energy for heating and cooling as follows:

a) Production and building heating or cooling 29.2 million Kwh/hr.
b) Power heating 700,000 therms annually in terms of natural gas.

The ranges of temperatures are for cooling 40-44°F and for heating 212°F (10%) and 330°F (90%). They congratulated this project and expressed interest in receiving information about new development of other energy sources. A mining company is using some 500,000 ft^3/day of natural gas for drying ore samples at 250°F and some 130 tons of refrigeration by electric power costing 3/Kwh. Most of the smelter operations use natural gas for elevated temperatures (above 400°F). They are also interested in the results of this study and are willing to supply more data if necessary.

An interesting use was suggested for geothermal energy by one of the companies. They maintain 800,000 gallons of water at 120°F where the surface area is 132,000 ft^2 and ambient temperature is 73°F. Humidity and wind conditions were not specified. Geothermal use in this case should be very economical.

One plant used natural gas and has switched now to oil for the furnaces, used to keep tanks of asphalt hot. This operation is continuous: 24 hours a day and 7 days/week. All together, the burners are supplying 4.5 million BTU. This does not include space heating and cooling. They suggest coming to the plant and getting additional information needed for the planning of geothermal energy development and use.

Another company which appreciated very much our study supplied comprehensive data on their energy uses, which we won't reprint in detail for the sake of the confidentiality. Total electric consumption for year 1977 was around 35,000,000 KWh and some 250,000 therm of natural gas. 60% of one company's energy is used in the range of 400-140°F.

The rest is either lower grade heating in the range of 70-140°F or cooling between 0° and 70°F using electricity. Their annual energy cost is around $40,000 including space heating and air conditioning.

Another company which gave very detailed information used in 1976, 1,128,300 MCF of gas, 940,500 gallons of oil and 9,000,000 Kwh of electrical power.

Several companies have found interest in the study but did not have readily available information and promised to send it at a later stage. On the whole the replies were good and cooperative. We hope to extend the communication with these industries in the next year's study by mutual visits and discussions.

Late in the project we found that James V. Davey* has conducted a similar comprehensive study on the geothermal-heat utilization. In this study Davey made 75 contacts with people from industries such as food processing and machinery, chemicals, pulp and paper, horticulature and dairies. These industries are all heat intensive and suitable for using geothermal energy. The replies he received, like ours, ranged from no interest to great enthusiasm.

It is initially obvious that geothermal energy is not yet well recognized and a basic educational and promotional program is needed as well as local and federal encouragement and incentives.

B. PROPOSED ARIZONA WORKSHOP - AUGUST 1978

We have proposed that a geothermal workshop be arranged in Arizona where we will discuss problems with the various agencies and potential users involved. We include people from the State agencies handling State oil and gas conservation, Arizona solar, legal aspects, state, a preliminary outline of the program is given in Table 27. The problems of water, power geology, and related problems will be discussed. Representatives of potential users of geothermal energy should also be invited.

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* Davey, J.V. "Survey report - Study of Information/Education, Discussions with remote industries and public institutions on the Direct-heat utilization of geothermal energy", Energy and Environmental Division, Lawrence Berkeley Lab, University of California, Berkeley, CA., March 1977.

TABLE 27

TENTATIVE ARIZONA WORKSHOP PROGRAM - AUGUST 1978

WORKSHOP
GEOTHERMAL ENERGY PLANNING AND EVALUATION
FOR THE STATE OF ARIZONA

Sponsored by: Arizona Solar Energy Research Commission and Bureau of Geology and Mineral Technology

Overview

Geothermal Resources
Leasing and Drilling Activity
Governmental Regulations
Arizona's Energy Pattern
Potential Geothermal Uses

Workshop Topics

1. Summer Peak Power Alleviation
2. Irrigation Pumping
3. Daily Peak Power Assistance
4. The Water Situation
5. General Utilization of 100-400°F Energy
6. Population Growth and Community Planning
7. Recovery of Low-Grade Processing
8. Agricultural and Food Processing
9. State Regulations, Hindrances and Incentives
10. Federal Regulations, Hindrances and Incentives
11. Potential Geothermal Research Advances

VII. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

A. SUMMARY

Geological features of the state of Arizona have shown that there is good potential for geothermal energy; however, few exploratory wells have been drilled. Resource data were compiled on the basis of temperature gradients in water wells (and a few oil wells), hot springs, geochemistry of ground waters and the absolute age of rocks. For example, the San Francisco Mountain area has been identified not only as a source of hot dry rock and/or hot water but also as potential magma tap. The compilation of resource data in this first year of study was only partially completed, due to budget limitations, but there is sufficient data to conduct scenario planning, assuming the resources do exist in the state.

From a geothermal energy use standpoint, the energy needs for Arizona have been reviewed. The major potential moderate temperature uses (up to 250°C) in the U.S.A. and worldwide were collected for possible application to Arizona. Two iterations of the twenty-two "use scenarios" (given in Table 14) were made. There is a major need for electrical power systems and/or cooling absorption systems to help alleviate the larger air conditioning peak loads of hot summers of Arizona. Also, many interesting non-electrical potential uses were identified, based on the unique desert features, mining, irrigated agriculture, potential food processing, and planning for both industrial and personal needs, of the fastest growing state in the U.S.A.

The information currently available is too limited to enable presentation of exact and detailed scenarios for Arizona geothermal use. Therefore, the scenarios suggested at this stage were based mainly on local energy and economic conditions in Arizona with the application of current energy technology. As more data becomes available we shall be able to evaluate more exact uses of geothermal energy. However, from the work so far it is clear that additional research as well as economic studies are needed before geothermal energy gains widespread use.

We propose to continue the assembly and evaluation of all basic resource data. We need to generate definite use scenarios for geothermal energy utilization in the State of Arizona. Where gaps exist in the data base, information should be gathered to fill these voids. In general, the work should continue to expand the broad-spectrum, statewide data base necessary to identify and evaluate geothermal resources planning use scenarios and starting in-depth evaluation of site specific scenarios will be necessary to demonstrate geothermal potential. Increased emphasis should be placed upon planning, scenario flow charts, and identification of the actions necessary to realize geothermal energy use economically.

B. CONCLUSIONS

1. There has been very little drilling and exploration for geothermal energy in Arizona, yet we have evidence that resources may be there.

Geothermal energy will eventually be a factor in Arizona, but it will require industry awareness and additional funding for exploration work before this occurs.

2. At an early stage it was determined that Arizona has a heavy electrical peak load in the summer, due to air conditioning. It would be beneficial if integrated systems involving geothermal energy could be used to reduce this load.

3. There is a shortage of water in most of Arizona. It appears that the potential uses of biosalinity agriculture, integrated with geothermal energy resources might help alleviate this situation.

4. The possibility of integrating geothermal energy with certain specific solution mining projects is interesting in Arizona.

5. The population growth rate of Arizona is the highest in the nation, and therefore should allow reasonable lead time for the proper planning of geothermal exploration and development.

6. The cooperation of many groups may make it possible to establish new communities in Arizona that could be environmentally attractive through the use of geothermal energy.

C. RECOMMENDATIONS

1. Second Year on Current Project

For future work on this project we propose the specific tasks as outlined below. It proposes to reduce effort upon data collection, and increase effort upon planning and scenario development, assisted where necessary by a reasonable amount of effort upon special planning and scenario identification studies.

a. Data and Information Collection

Since certain data were collected during the first year, the main emphasis should be to obtain only that data and information necessary to develop scenarios. Resource assessment data are necessary to prescribe the energy/power base of the scenarios. Fewer institutional impediments and action recommendations should be emphasized, to assist planning the acceleration of much needed exploration drilling in Arizona. Also, any significant geothermal technology developments, additional potential geothermal resource areas, leasing and drilling activity and regulatory actions should be reported.

b. Scenario Development

Another iteration of the 22 site-specific scenarios should be conducted, especially those which show promise. These should then be

aggregated on a state level into (a) three broad belts of the state and (b) into some 10 to 12 specific geothermal resource areas. The development of these scenarios should be coordinated with state institutional groups and the key state groups dealing with power, mining, industry and agriculture, for example via an in-state workshop. Such a workshop, its structure and the agencies involved were proposed earlier in this report.

c. Planning Activities

The main planning activity should involve defining the events required to achieve the site-specific and state-aggregated scenarios reported during the first year of study. For this to be comprehensive and realistic, it is proposed to call upon the combined expertise within the Arizona Oil and Gas Conservation Commission, the Arizona Solar Energy Research Commission and the Division of Economic and Business Research, University of Arizona. This effort should be assisted by (a) more frequent and extensive interactions with those interested in geothermal energy, utilities, State government groups and potential users, (b) the identification of problems associated with geothermal implementation, (c) an assessment of the fast development of the area, and (d) understanding which groups could be helpful in the development of geothermal energy. Finally, a reconsideration may point out other ways to accelerate the rate of geothermal development in Arizona by say, 50 percent.

d. Special Studies to Achieve State Goals

Some of the scenarios proposed during the first year of study are only partially identified. These include several areas of great importance to Arizona involving water problems, mining and the excessive summer cooling load. A special effort should be made in the future to more clearly identify the plans related to these important problems. This should involve certain technology evaluations and preliminary feasibility studies. A more detailed and defined pattern of pursuit is warranted at this stage and is proposed below.

2. Exploratory Drilling in Arizona

As indicated in many sections of this report there is a high potential for geothermal resources in the State of Arizona. Many water wells have been drilled but only four geothermal exploratory wells have been drilled. Therefore, it is imperative that more geothermal exploratory wells be drilled in the state as soon as possible. This may transpire through industry awareness and/or certain incentives being extended by the Department of Energy. The Arizona Bureau of Geology is also continuing its research into geothermal energy potential in Arizona and may drill some heat flow holes next year.

3. Interactions with Local Groups

The first year's work showed many possibilities for geothermal energy use in Arizona. Increased interactions with local groups in the

state, consisting of potential suppliers of geothermal energy, potential users and the various agencies that must be involved would be beneficial. It should augment the objectives of the Department of Energy in the current project. The project progressed this past year in this respect by contacting some 70 companies in Arizona, visiting a number of places, and making preliminary plans for geothermal workshop for August 1978.

4. Department of Energy Assistance

The Department of Energy, with its base of research in energy, should make it convenient for teams researching aspects of geothermal energy to gain access to the energy data currently being generated. This should include, but not be limited to the following:

a. Status of advanced cooling systems.
b. Status of advanced power turbines.
c. Status of binary power units.
d. Status of drilling techniques and costs.
e. List of location and addresses of expertise in all areas of energy utilization.
f. List of pilot and demonstration plants.
g. Detailed report of low temperature energy application uses in industry.
h. Incentives for profit, for the few places where practical.
i. Predict future costs and prices of energy.
j. Publicize the potential of geothermal energy.
k. Organize workshops.
l. Compilation of the laws and regulations for geothermal energy exploration and application.

VIII. APPENDIX 1 - PARTIAL LITERATURE SURVEY

This partial literature review is based on 78 articles on geothermal energy. It places all geothermal literature into nine general categories. Each is composed of a brief description and a list of articles which constitute that category. The articles are referenced by number to the bibliography.

GENERAL

This category is for articles that give general overviews of geothermal usage, (20,27,28,45,46). One article contains approximate values of energy consumption and temperatures needed for certain applications (24). Some of the articles are concerned mainly with regional developments; Alaska (14), Japan (43(2)), Idaho (26), New Zealand (44(4)). Another article: Geothermal Wastes (60).

AGRICULTURE

In agriculture, geothermal resources are mainly used for greenhouse heating, hydroponics, and irrigation. Hydroponics is the practice of growing plants without soil. An excellent example of this is the Hobo Wells Project in Wendel, Calif., (where 99°C geothermal water is used at a flowrate of 12001 unit (gallons)/min). (1) A general view of the heat required, the equipment needed and other basic requirements is presented (7). In greenhouses, geothermal energy is mainly used for heating the building (2,47(1),64). Another facet of geothermal energy in agriculture is in the field of animal husbandry (8,45(2)). Other pertinent articles: 21,25.

INDUSTRIAL (FOOD PROCESSING)

Geothermal energy is now being used in industrial processes, some of which include the lumber industry (44(2)), dairy processing (e.g. milk pasturization) (3,44(3)), dehydration and sugar beet processing (5). A more detailed analysis of some of these processes is given by B. Lindal (2). Geothermal energy is also used in the process of making filters from diatomaceous earth (65).

HEATING AND COOLING

The major use of geothermal energy today is in the process of space heating and cooling. Cooling research has not progressed as far as the research for space heating, but some research has been done (18,19). Space heating, the process of using the natural heat of the geothermal fluids to heat buildings, has been widely researched. There have been several different schemes developed for space heating (32,38). A study of existing

installations is given by S. Einarsson (33). There have been many other articles written dealing with space heating and its future worldwide (3,13,29,34,35,36,37,40,42(1,2),43(1),34(1),47(2)).

DESALINATION

Most geothermal fluids contain a considerable salt quantity. If the salt is not removed from these geo-brines, undesirable scale will build up in the equipment used in most any process (16). Two ways to prevent this are: use of a multi-flash unit or a vertical tube exchanger (12). Geothermal steam is also used in the desalination of sea water (22,56); some of these salts can be saved after extraction (63). Other articles: 57.

MISCELLANEOUS

This category describes some limited uses of geothermal resources. One such usage is for health treatments (9). The production of heavy water may also use geothermal water (61). Some processes have even been described as linear programs (23). A specific example of geothermal usage is that of the East Mesa Test Site in Imperial Valley, Calif., (59).

TECHNICAL CONSIDERATIONS (PROCESSES AND EQUIPMENT)

This category deals with techniques of construction, functions of wells, etc., and the processes and equipment needed for the process (4). Information obtained from drilling must be considered an important factor (11,42(4)), because well data determines the temperature, size and capacity of the reservoir to be suitable for the proposed use (for heat systems, 30, 48). Another process considered is the use of a gravimetric loop (where circulation is based on the density difference of the fluids in a closed column (62)). The equipment used in the processes must also be considered. One of the best apparatuses for heat transfer with geothermal fluids is the heat pump (6,77). A heat exchanger is often needed in the process, too (72,73,74), down hole exchangers: (43(3),44(1)). Some general data and calculation methods of heat measurements have also been developed (2,17,25,39). Other articles: (13,15,39,42(3),78).

ENVIRONMENTAL AND WASTE DISPOSAL

The major environmental concern with respect to geothermal energy is the composition of the wastewater (49,51). The major component in the discharge that environmentalists are concerned with is hydrogen sulfide (H_2S). In an attempt to stop H_2S emissions, there have been H_2S abatement schemes developed (50,55). The high mineral content of geo-fluids also commonly results in deposits of scale (41,43(4)). This pertains especially to fluids containing silica and arsenic (52,53). Some geo-fluids contain rare elements that can be extracted and used (54).

ECONOMICS AND EVALUATIONS

One of the fundamentals of geothermal energy usage is its relationship with other energy sources (i.e. fossil fuels, solar energy, and nuclear power) (66,68). To compare the various sources the economic feasibility of using geothermal energy must be understood (71,75). R.A. Walter describes a computer program that simulates all major facets of a geothermal system and calculates the cost of energy production with respect to certain cost conditions (i.e. sunk costs, life of the plant, revenues, etc)(76). Other articles (67,69,70, economics of space heating 31).

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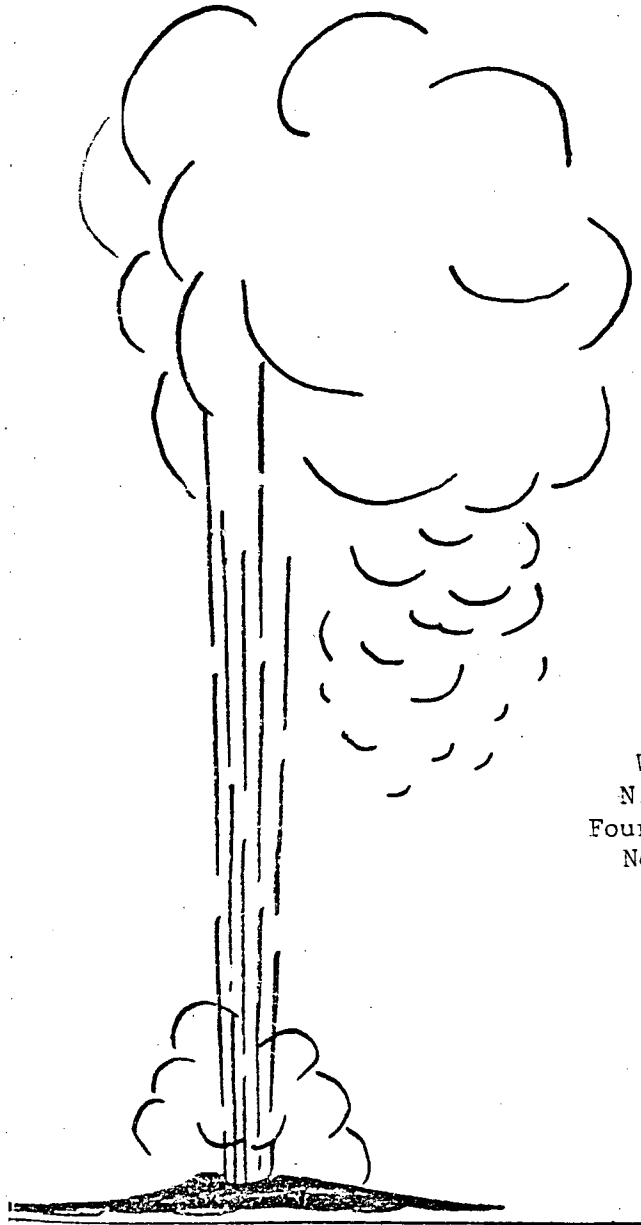
GEOTHERMAL ENERGY DEVELOPMENT IN COLORADO

Appendix 7 of

REGIONAL OPERATIONS RESEARCH PROGRAM
FOR DEVELOPMENT OF GEOTHERMAL ENERGY
IN THE SOUTHWEST UNITED STATES



Final Technical Report
June 1977 to August 1978

Colorado Geological Survey
Richard A. Pearl
Barbara Coe

January 1979

Work Performed under DOE Contract No. EG-77-S043992
N.M.Energy and Minerals Department Project No. 76-262
Four Corners Regional Commission Contract No. 672-066-C
New Mexico State University Sub-Contract No. 3104-X5

New Mexico Energy Institute at
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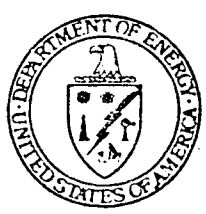
Las Cruces, New Mexico 88003



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Geothermal Energy

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TABLE OF CONTENTS

TITLE	PAGE
ABSTRACT	1
INTRODUCTION	2
METHODOLOGY	7
Resource Assessment	7
Development Status and Procedures	10
Energy Demand Assessment	11
Scenario Preparation	15
STATUS OF GEOTHERMAL DEVELOPMENT IN COLORADO	18
Leasing	21
Exploration	21
Technical Studies	26
OBTAINING LEASES AND PERMITS	27
Leasing	27
Private Lands and Minerals	27
State-Owned Lands or Minerals	27
Federal Lands or Minerals	28
Permits	29
State Permits	29
Federal Permits	31
Local Permits	32
DEVELOPMENT POTENTIAL	33
CONSTRAINTS TO GEOTHERMAL DEVELOPMENT	43
SUMMARY AND CONCLUSIONS	45
APPENDIX A - STATUS OF GEOTHERMAL WELLS IN PAGOSA SPRINGS	

TABLES

NO.		PAGE
1	RESOURCE ASSESSMENT	8
2	GEOTHERMAL RESOURCE DEVELOPMENT SCENARIO CATEGORIES	12
3	CURRENT USES OF GEOTHERMAL RESOURCES IN COLORADO	19
4	STEPS FOR GEOTHERMAL RESOURCE DEVELOPMENT	22
5	FEDERAL COMPETITIVE GEOTHERMAL LEASES	23
6	FEDERAL ACTIVE NON-COMPETITIVE GEOTHERMAL LEASES	24
7	COLORADO STATE ACTIVE GEOTHERMAL LEASES	25
8	CATEGORY IIB, AREAS OF KNOWN ACTIVITY	35
9	CATEGORY IIIA, NO KNOWN ACTIVITY BUT HIGH POTENTIAL	36
10	CATEGORY IIIB, AREAS OF MODERATE POTENTIAL	37
11	SOME POTENTIAL USES FOR GEOTHERMAL RESOURCES IN COLORADO	42
12	REQUIRED FEDERAL AGENCY ACTIVITIES FOR LOW TEMPERATURE GEOTHERMAL RESOURCE DEVELOPMENT IN COLORADO	47

FIGURES

1	LOCATION OF THERMAL SPRINGS AND WELLS IN COLORADO	3
2	POTENTIAL GEOTHERMAL RESOURCE USE AREAS IN COLORADO BASED ON 1° LOSS PER MILE	14
3	POTENTIAL GEOTHERMAL RESOURCE USE AREAS IN COLORADO BASED ON 30 MILE RADIUS	16
4	POTENTIAL GEOTHERMAL RESOURCE USE AREAS IN COLORADO BASED ON NEAREST COMMUNITIES	17
5	POSSIBLE GEOTHERMAL ENERGY DEVELOPMENT SCHEDULE FOR COLORADO ELECTRICAL POWER	34
6	POTENTIAL GEOTHERMAL RESOURCE USE AREAS IN COLORADO FOR SCENARIOS SCENARIOS	40
7	POSSIBLE GEOTHERMAL ENERGY DEVELOPMENT SCHEDULE FOR COLORADO LOW TEMPERATURE	41

ABSTRACT

The term "geothermal energy" is a term that means different things to different people. To an increasing number, it means a practical, environmentally compatible energy resource that can, right now, help to relieve an overdependency upon fossil fuels.

The potential for use of geothermal energy in Colorado seems to be substantial. As described by Barrett and Pearl (1978), at least 56 separate areas have surface manifestations of hydrothermal (hot water) resources. These areas are estimated to contain 5.914 quads (5.914×10^{15} Btu) of energy, with extractable energy of 1.48 quads.

Geothermal resources already contribute to Colorado's energy supply. In fact, since the early 1900's, practical uses of geothermal resources have been common in Pagosa Springs, in Southwest Colorado. Residents there have used hot-water wells to heat numerous buildings, including the County Court House, schools, churches, the newspaper office, a liquor store, 2 hotels, 2 service stations, a drugstore, and a bank, as well as for the swimming pool and spa. Where resources are in use in other parts of the State, most are used for swimming pools or baths. A few wells or springs serve other purposes, however, among them space heating and agriculture, including greenhouses, a fish farm and algae-growing.

At least 30 communities seem to be candidates for obtaining all or part of their space- and water-heating needs from geothermal energy. Twenty-three of these are within 10 miles of the resource area. Sixteen are virtually on-site. Based on the analysis, more than 16,000 homes, plus commercial, industrial, and public buildings could be supplied with heat and hot water. Along with this, heat could be supplied for such process uses as dehydrating vegetables and fruits, malting barley, warming hog pens and drying timber. Furthermore, 5 electrical generating units of 50 MWe each could be operating. The technology is readily available for all of these uses.

Seemingly, interest in and awareness of the resources is growing. If leases and permits are made available, along with some economic incentives, some or all of the three potential power-generation sites may be developed by private industry. Perhaps with the assistance of federal programs, initially, lower temperature resources, too, will be developed by private industry. While government can provide opportunities, the outcome depends upon the decisions of numerous individuals throughout the system. Colorado does have geothermal resources that can contribute to the energy supply. It remains to be seen whether these resources will fulfill their promise.

INTRODUCTION

The potential for use of geothermal energy in Colorado seems to be substantial. As described by Barrett and Pearl (1978), at least 56 separate areas have surface manifestations of hydrothermal (hot water) resources. In all, some 120 thermal springs and wells with temperatures over 20°C have been located. These have surface temperatures ranging from 20°C in several areas to a high of 83°C at Hortense Hot Spring southwest of Buena Vista. Using the technique of geochemical modeling, subsurface temperatures estimated for all the 56 areas are between 20°C and slightly over 200°C. The discharge rate is from 1 gallon per minute (gpm) at a number of springs to 2,263 gpm at Glenwood Springs. Contrary to popular opinion, some waters are quite pure, with the total dissolved solids ranging from 84 mg/l at Eldorado Springs southwest of Boulder to a high of 21,500 mg/l at Glenwood Springs (Barrett and Pearl, 1976). Figure 1 shows the resource areas.

The term "geothermal energy" is a term that means different things to different people. To some, it means an exotic resource that might at some point in the distant future, after an enormous technological breakthrough, contribute to the energy supply. To others it is a fluid in which to swim or bathe, either simply for pleasure or for improvement of one's health and well-being. To an increasing number it means a practical, environmentally compatible energy resource that can, right now, help to relieve an overdependency upon fossil fuels.

Expressed most concisely, geothermal energy is "the natural heat, steam, and hot waters of the earth's interior." (Pearl, 1972). It is, in fact, a practical energy resource which is readily usable with existing technology. Although techniques for using heat that is not contained in fluid, known as hot dry rock, are in the developmental stage, geothermal steam and hot water have been used for many years. Lardarello, Italy, has generated electricity with geothermal resources since 1904. Wairakei, New Zealand, and the Geysers in California have more recently begun generating electricity. In 1975 worldwide geothermal generating capacity was estimated to be 1100 MWe (The Futures Group, 1975). Reykjavik, in southern Iceland, uses natural hot water to heat 11,000 houses, plus some greenhouses and swim pools (Zoega, 1974). In Hungary geothermal energy is used to heat homes, greenhouses, cattle stalls, pigsties, chicken houses, hospitals, garages, machine shops, municipal buildings, factories, as well as for hot water supplies and for cooling and drying of agricultural products (Boldizsar, 1974). Other areas using geothermal energy are Japan and Russia, and, in the United States, Boise, Idaho, Klamath Falls, Oregon, and Pagosa Springs, Colorado. Facilities in these areas demonstrate that the technology and know-how are readily available for using geothermal resources.

In the United States, geothermal energy is considered to have significant potential, both for the generation of electricity and for use as direct heat, although estimates of the specific amounts vary widely. As a result, recent Federal policies have been initiated to encourage geothermal development. In 1970 the U.S. Congress passed the Geothermal Leasing Act to allow for issuance of geothermal leases on Federal lands (PL 91-581). In 1974 the Federal Energy Research Development and Demonstration Act was adopted, providing the mandate for geothermal programs that include resource assessment, planning and system development (PL 93-410). Among the planning programs is the Southwest Regional Geothermal Development Operations Research Project, of which this study is a part.

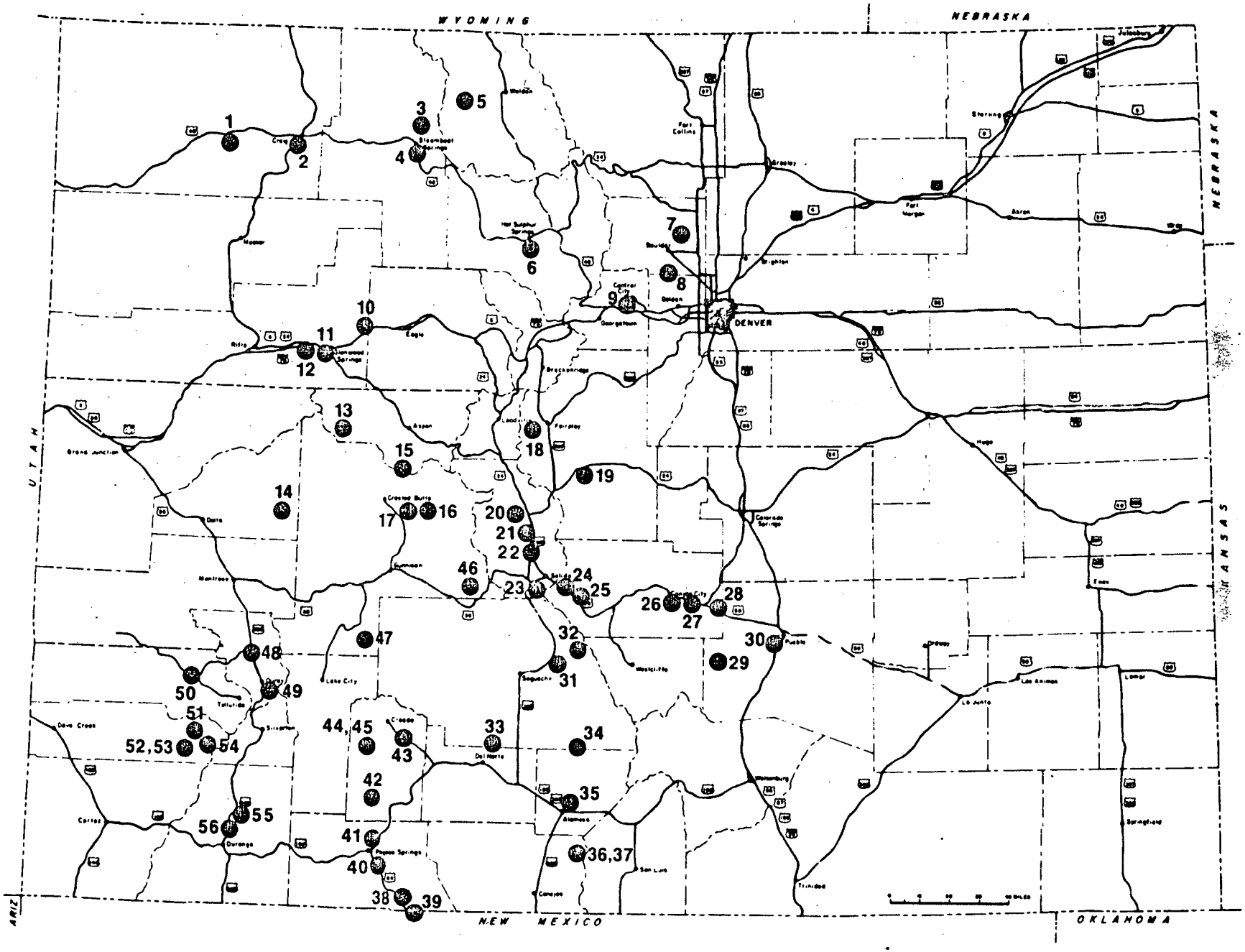

FIGURE 1. GEOTHERMAL RESOURCE LOCATIONS (THERMAL SPRINGS AND WELLS) IN COLORADO.

This project was initiated by the U.S. Department of Energy, Division of Geothermal Energy (DOE/DGE), to identify the potential for development of geothermal energy in the five-state region of Arizona, Colorado, New Mexico, Nevada and Utah. Once that potential was identified, a second objective was the identification of those actions that will be required in order to accomplish that development. Funding was provided to the prime contractor, the New Mexico Energy Institute, by the DOE/DGE, assisted by the Four Corners Regional Commission and the New Mexico Energy Resources Board. Each state arranged for a subcontractor. In Colorado the subcontractor is the Colorado Geological Survey, with staff members Richard H. Pearl, Chief, Groundwater Investigations Section, and Barbara A. Coe, Researcher, comprising the State Team.

This report summarizes the findings of the Colorado Team during the first project year. It is organized into seven sections--the Introduction, Methodology, Status of Geothermal Development, Obtaining Leases and Permits, Development Potential, Constraints to Development, and the Summary and Recommendations. The Methodology section describes the assumptions and the kinds of data used, as well as the methodology for scenario preparation. The next two sections summarize the information that was obtained about geothermal resources in Colorado, including existing uses, leasing, exploration and technical studies, and the leasing and permit requirements. Section V, Development Potential, discusses the estimated potential for the identified hydrothermal (hot water) resources in Colorado. Section VI describes some of the constraints to geothermal development in Colorado. The last section, Section VII, consists of the conclusions and the actions believed to be required in order to accelerate, or even initiate, geothermal development in Colorado.

Numerous individuals provided information and assistance for this study. Their help is greatly appreciated. Among them were the Colorado Team Leader, Mr. Richard H. Pearl, who provided not only direction but also a wealth of information about geothermal resource characteristics. Two of his staff members, Michael Galloway and Jay Dick, also were most helpful in providing valuable and necessary information.

Special mention should be made of the Members of the Colorado Geothermal Resources Development Advisory Committee, who assisted in numerous ways. They are:

Kenneth C. Bull, United States Geological Survey

Senator Martin E. Hatcher, Colorado State Senator

Dr. T. L. Grose, Colorado School of Mines

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Malcolm Mossman, Occidental Geothermal, Inc.

Irvin Nielson, Marine Minerals

Abner Hahn, Superintendent of Schools, Pagosa Springs, and other members of the Pagosa Springs Geothermal Resources Development Committee

George Parkins, Colorado Public Utilities Commission

Charles Underwood, General Geothermal

David Ford, Colorado Energy Conservation Office

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METHODOLOGY

To assess the potential for geothermal development in Colorado, several kinds of data were first obtained. These included information regarding procedures for geothermal development, estimates of the amount of geothermal energy available, the market areas, energy demand, and uses for the energy. Scenarios were then prepared that described possible geothermal energy development. In preparing them, the objective was to base them, to the extent possible, upon actual conditions while postulating that an aggressive development program was in place. To make the best use of available time, existing data were obtained whenever possible, from other agencies and officials, as well as from representatives of private industry. Furthermore, a strong effort was made to assure that the data collection was limited to only that information necessary for preparation of reasonably realistic scenarios.

Resource Assessment

To provide the starting point for the geothermal resource data base, the Colorado Team had available an inventory of hot springs and wells that included a brief description of each resource area, surface temperatures and estimated subsurface temperatures (Barrett and Pearl, in press). To aid in the evaluation of the energy content of these resource areas, an estimate was made of the areal extent and thickness of each. Using these estimates, the energy content of each reservoir was estimated, using the method employed in U.S.G.S. Circular 726 (Renner, White, and Williams, 1975), with two minor changes. One change was the assumption of an ambient air temperature of 20°C, rather than 15°C. The other was to use the midpoint of the range of subsurface temperatures estimated by Barrett and Pearl (in press). Table 1 lists the thermal areas, their areal extent and the amount of energy estimated to be contained in each system. The map, Figure 1, shows the location of the areas, and the resource identification numbers. As shown, the amount of geothermal energy contained in all these systems was estimated to total 5,914 quads (1 quad = 10^{15} Btu).

Estimates were then made of the usable energy contained in each thermal system. As indicated in Circular 726 (Renner, White, and Williams, 1975), 25 percent of the stored energy was assumed to be recoverable at the surface, and the efficiency of utilization was assumed to be 24 percent. From these calculations, the total usable energy in the 56 systems was estimated to be 0.35 quads (Table 1). To determine how much of the energy would be available annually, the total usable energy was then divided by 30 years, a commonly-used gauge of economic life for utility facilities. The total energy usable per year from all these areas was estimated to be 0.01 quads.

The reader is cautioned that this is, at best, a rough gauge of the usable energy available. Because of the lack of data, it was not possible to consider variations in permeability, flow rates, or efficiency of specific uses. This estimate is, however, considered to be extremely conservative. Because some systems will be renewable, the actual energy obtained will probably be much greater.

TABLE 1

Resource Assessment

of

Hydrothermal Resources in Colorado

by Jay D. Dick and Richard H. Pearl

February, 1978 (unpublished)

Thermal Spring Areas	Areal Extent (mi^2)	Thickness (ft.)	Temp. (°C) (midpoint of estimate)	Estimated Total Btu (10^{15})	Estimated Useable Btu (10^{15})
Juniper 1	1.01	200(S)	63	.0163	.0009
Craig 2	1.3	500(N)	55	.0428	.0026
Routt 3	0.5	1000(F)	138	.1110	.0067
Steamboat 4	.52	250(S)	70	.0122	.0007
Brand's Ranch 5	0.36	200(S)	49	.0039	.0002
Hot Sulphur 6	1.35	599(N)	75	.0698	.0042
Haystack Butte 7	1.54	300(S)	40	.0174	.0010
Eldorado 8	0.35	1000(S)	35	.0099	.0006
Idaho 9	1.12	1000(F)	80	.1260	.0076
Dotsero 10	0.84	250(S)	39	.0075	.0005
Glenwood 11	1.32	250(S)	65	.0279	.0017
South Canyon 12	0.1	1000(S)	75	.0103	.0006
Penny (Avalanche) 13	1.61	1000(F)	75	.1670	.0100
Colonel Chinn 14	1.55	200(S)	51	.0181	.0011
Conundrum 15	0.45	500(N)	45	.0106	.0006
Cement Creek 16	1.1	150(S)	45	.0078	.0005
Ranger 17	1.11	150(S)	45	.0078	.0005
Rhodes 18	1.53	1000(F)	35	.0432	.0026
Hartsel 19	0.87	500(N)	70	.0409	.0025
Cottonwood Creek 20	1.38	1000(F)	170	.3894	.0234
Mt. Princeton 21	3.14	1000(F)	200	1.0632	.0638
Browns Canyon 22	3.23	1500(S&F)	100	.7291	.0438
Poncha 23	2.19	1000(F)	145	.5150	.0309
Wellsville/Swissvale 24/25	0.94	240(S)	40	.0085	.0005
Canon City 26	0.52	100(S)	50	.0029	.0002
Freemont Natatorium 27	1.0	220(S)	43	.0095	.0006

TABLE 1 (Cont.)

Thermal Areas	Areal Extent (mi^2)	Thickness (st.)	Temp. (°C) (midpoint)	Total Btu (10^{15})	Useable Btu (10^{15})
Florence 28	1.0	200(S)	42	.0083	.0005
Don K. Ranch 29	1.5	500(N)	45	.0353	.0021
Clark Well 30	1.1	200(S)	40	.0083	.0005
Mineral 31	10.1	1000(S)	70	.9406	.0564
Valley View 32	1.05	1000(F)	50	.0593	.0036
Shaw's 33	0.63	500(N)	45	.0148	.0009
Sand Dunes 34	1.5	500(N)	75	.0776	.0047
Splashland 35	1.5	500(N)	75	.0776	.0047
Dexter/McIntyre 36/37	1.2	1000(F)	35	.0339	.0020
Dutch Crowley/Stinking 38/39	1.52	200(S)	65	.0257	.0015
Eoff Well 40	1.5	200(S)	50	.0169	.0010
Pagosa 41	2.15	200(S)	80	.0485	.0029
Rainbow 42	0.99	1000(F)	45	.0466	.0028
Wagonwheel Gap 43	4.24	500(N)	115	.3789	.0227
Antelope/Birdsie 44/45	2.38	500(N)	44	.0537	.0032
Waunita 46	1.4	200(S)	135	.0606	.0036
Cebolla 47	1.86	500(N)	60	.0700	.0040
Orvis 48	0.55	500(S)	75	.0285	.0017
Ouray 49	2.07	1000(F)	80	.2336	.0140
Lemon 50	0.81	425(S&F)	43	.0149	.0009
Dunton/Geyser/Paradise 51/52/53	1.16	400(S)	50	.0262	.0016
Rico 54	1.74	1000(F)	63	.1407	.0084
Pinkerton/Mound 55	0.98	180(S)	50	.0100	.0006
Tripp/Trimble 56	1.0	500(N)	58	.0357	.0021
				5.9142	.3549

(S) Stratigraphic reservoir
(F) Fracture reservoir
(N) unknown

Development Status and Procedures

Another task of the study was to explore the current status of geothermal development activity in Colorado. To obtain this information, records of geothermal leases on public lands were obtained from state and federal agencies. Subsequently, discussions were held with lease holders to learn about the current status and future plans. Additional information and ideas for future development plans were gleaned through various publications and conversations with community groups and potential users.

The investigation of procedures for development, both technical and institutional, was another important aspect of the study. Published documents were reviewed and copies of laws and regulations were obtained from state, federal, and local agencies. From discussions held with numerous officials in both the public and private sector, information was obtained about the actual practices and procedures of geothermal development and regulation, including the length of time generally required for various activities.

To judge what types of leases would be necessary to develop a given site, land ownership was also investigated. The Bureau of Land Management map series provided this information. The probable need for federal leases was based on the assumption that for direct use, they would be necessary only after commercial geothermal development was well established. Therefore, federal leases are assumed to be unnecessary in the early stages of development where private ownership seems adequate to accommodate the development.

Using this information, the resource areas were then organized into categories in order to simplify the scenario preparation. The categories are as follows:

Category I areas with significant commercial activity. No resources areas in Colorado currently seemed precisely to fit Category I.

Category II includes those resource areas where some activity toward exploration or development is known to be occurring. Areas where the activity is directed toward development of power generation are designated IIA. Those areas with activity toward nonelectric uses are shown in Category IIB.

Category III areas where no interest has been shown nor any activity has occurred, is divided into 3 subcategories, based upon: a) lease availability, b) the quality of the resource and the apparent use potential, judging from the proximity of the resource to communities, c) the potential for process use, and d) the competition from other resources. The 3 subcategories are A, High Potential, B, Moderate Potential, and C, Low Potential. Where the resource use area overlaps with another and could be combined into one economic unit, regional use areas are defined. It should be stressed that all these categories and subcategories are somewhat subjectively derived and applicable only to the extent that, and for as long as, the currently available data are accurate. When better information is obtained or if conditions should change, this category placement could be totally inapplicable.

Subcategory A includes areas which are near potential users, have high enough temperatures and have some private land surrounding them. Those areas in IIIB have slightly less ideal conditions.

The resource areas in subcategory IIIC have constraints to their development that seem at this time to virtually preclude their development. In each case, one of the following applies:

1. Leases are not obtainable, because the area is in a designated wilderness area or an area of Federal land that has been withdrawn for wildlife protection.

2. No community is within the range of possible transport of the resource, nor does any process use seem probable within the area.

3. The estimated subsurface temperature of the resource is inadequate for potential uses that seem reasonable for the area.

Complete scenarios were not written for these latter areas. Scenarios in both narrative and chart form were prepared for all the other areas listed. The amount of detail provided was greatest for the highest category, decreasing with the lower category levels.

Table 2 shows the categories to which each of the resource areas was assigned.

Energy Demand Assessment

Several kinds of cultural data were considered to be necessary for devising scenarios that would reasonably reflect characteristics specific to each geothermal resource site. These include population, energy demand, economic conditions, and the potential use areas for the geothermal resources.

Population - Population estimates for 1975 from the report Population Estimates and Projections (U.S. Dept. of Comm., 1976), were used for each of the incorporated municipalities within geothermal resource use areas. Projections for counties in Colorado to the year 2000 were obtained from Colorado Population Trends (State Division of Planning, 1976). Using the "high" projections to allow for some unincorporated places and rural areas, percentages were calculated for each of the communities from the percentage of the total 1975 county population which each represented. Population for the year 2020 was then extrapolated based on the rate of growth between 1975 and the year 2000. A dwelling-unit occupancy rate of 3.0 was assumed in order to determine the probable number of dwelling units.

Energy demand - The energy demand that could be satisfied by direct use of geothermal resources is based upon the current consumption of natural gas in Colorado. According to the Energy Conservation and Policy Office, an average of 151 Mcf of natural gas per year is consumed by residential customers of the Public Service Company of Colorado, who represent 70-percent of statewide natural gas customers. Using a 70 percent efficiency rate to derive beneficial energy and 840 Btu/cu ft results in an average 88,788,000 Btu per dwelling unit per year. Although this somewhat overestimates the need for geothermal resources because it includes a small amount of cooking, this was not considered to be significant. A 50-50 split between residential uses and all others is used in the scenarios to provide a rough estimate of the total energy demand.

Economic Conditions - Some knowledge of the economic conditions around each of the resource areas was necessary in order to determine what energy uses would be most reasonable. This was largely empirical, derived from travel throughout the State, complemented by discussions with staff at the State Division of Commerce and Development (Jack Olson,1978, pers. comm.).

TABLE 2

GEOTHERMAL RESOURCE DEVELOPMENT SCENARIO CATEGORIES
Revised April, 1978

I. SIGNIFICANT COMMERCIAL ACTIVITY - NONE

II. ACTIVITY - LEASES OR DEVELOPMENT EFFORT

A. POWER GENERATION SITES

MT. PRINCETON, COTTONWOOD CREEK, HORTENSE
PONCHA SPRINGS/BROWNS CANYON
CEBOLLA

B. NON-ELECTRIC SITES

GLENWOOD HOT SPRINGS
HARTSEL
PAGOSA SPRINGS
WAUNITA

SAN LUIS VALLEY
SHAWS
SAND DUNES
SPLASHLAND
MINERAL/VALLEY VIEW

III. NO INTEREST OR ACTIVITY

A. HIGH POTENTIAL

ROUTT/STEAMBOAT SPRINGS
HOT SULPHUR SPRINGS
OURAY

DUNTON/GEYSER/PARADISE
HAYSTACK BUTTE
ELDORADO SPRINGS
IDAHO SPRINGS

B. MODERATE POTENTIAL

JUNIPER/CRAIG
BRAND'S RANCH
SOUTH CANYON
PENNY
CEMENT CREEK/RANGER
WELLSVILLE/SWISSVALE

CANON CITY/FREMONT
DON K RANCH/FLORENCE
CLARK
WAGON WHEEL GAP
ORVIS
RICO
PINKERTON/MOUND
TRIPP/TRIMBLE

C. LOW POTENTIAL

DOTSERO
RHODES
DEXTER/MC INTYRE
STINKING SPRINGS/DUTCH CROWLEY
LEMON

RAINBOW
ANTELOPE/BIRDSIE
CONUNDRUM

Although process uses offer opportunities that may be more financially lucrative, space and water heating were emphasized in the scenarios for several reasons. First, the State is very dependent upon natural gas, which constitutes 41 percent of the total energy consumed. About 30 percent of the supply of natural gas was interruptible in 1974. Seventy-eight percent of the natural gas is used for industrial, commercial, and residential sectors, 71 percent of the residential use being for space heating. Further, the state imports about 60 percent of the natural gas consumed in the State (CERI, 1976). Reducing the demand for natural gas could reduce the dependency upon outside suppliers, as well as conserving the availability of natural gas for areas where alternative supplies are not available.

Furthermore, the encouragement of process uses of energy may be inappropriate in some areas. In most of the geothermal resource locations, existing industry is minimal. An analysis of the probable environmental and socioeconomic impacts is believed to be needed before suggesting the introduction of new industry to specific areas.

In addition, new process uses of energy would increase the net energy consumption. This would not contribute to the goal of energy independence, which is the primary reason for programs to accelerate development of alternative energy resources.

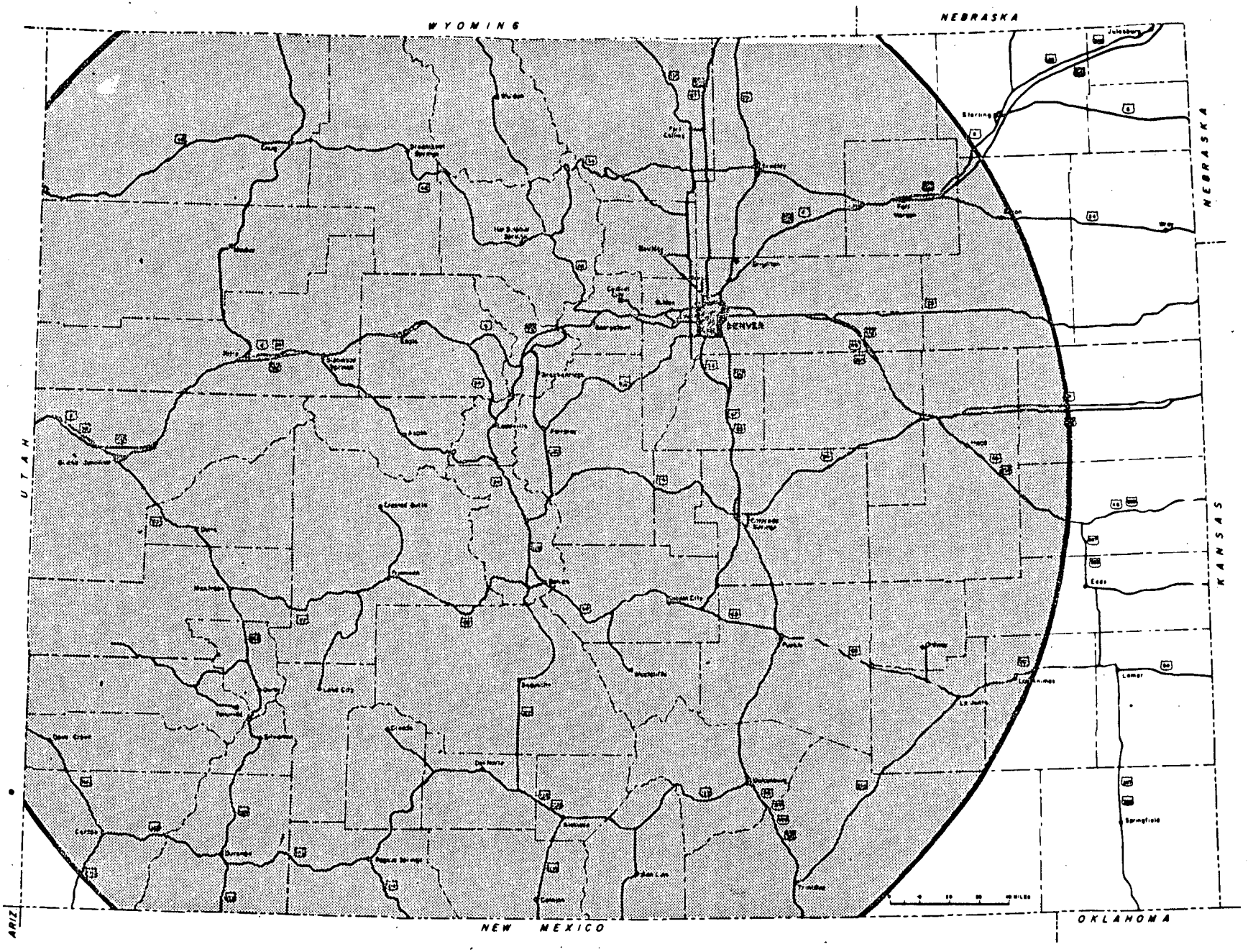
Enormous benefits can be derived, on the other hand, from promotion of new process uses where the adopted policy is to encourage economic growth. Because energy availability is an increasingly important facet of industrial location decisions, economically depressed areas can benefit if their geothermal resources are made available for industrial use.

To develop scenarios envisioning any sort of use for geothermal resources, it was necessary to assume the existence of a market demand. In most instances, that means either a lack of sufficient natural gas to satisfy the demand, or an increase in natural gas prices. In addition, it was necessary to assume comparable project costs at the different sites.

Use Areas - Several analyses ultimately resulted in the final "use areas" used in the scenarios. For the initial analyses, several assumptions were made. One assumption was that the highest of the range of estimated subsurface temperatures in each resource area would be available at the surface. Secondly, 40°C was assumed to be the lowest temperature that would be beneficial for use. This temperature was considered sufficiently high for space heating, since such temperatures are currently used. A further assumption was that 1°C is lost per mile in transporting the resource. The resource is then assumed to be transportable for as many miles as will lower the temperature to 40°C. Using the existing spring or well as the center of the reservoir, a circle was drawn to indicate the potential use area of each resource area.

The map, Figure 2, shows that when an outline is drawn to include all of the area contained in each of the circles, most of Colorado and parts of Utah, New Mexico and Wyoming could use Colorado's geothermal resources, given these assumptions.

Obviously, costs for pipe and rights-of-way would be higher the greater the transport distance, but might be warranted if a large enough market existed. Colorado Springs is about 68 air miles from the Mt. Princeton resource area; Denver is about 100 miles. The water supply for the Denver suburb of Aurora is currently piped from the same valley that contains the



POTENTIAL GEOTHERMAL RESOURCE USE AREA IN COLORADO BASED ON $1^{o}C$ TEMPERATURE LOSS PER 1 MILE.

Mt. Princeton resource area. A geothermal resource use area that would include the cities of Denver and Colorado Springs might also be feasible, depending upon the future value and supply of the various energy resources.

For a second analysis, circles were drawn around the hot springs locations on a map of the state. The equivalent of 30 miles was used to indicate the maximum distance that geothermal fluid may be transported. Again the hot spring or well is used as a center. As Figure 3 shows, approximately half the state theoretically could use geothermal resources.

To be more commensurate with current economic assumptions, more conservative use areas were assumed. If the initial analysis of the potential use area showed it to be less than 30 miles in radius, the smaller radius was used. Where analysis showed the use area to be 30 miles or more, a 30-mile radius was used. The municipalities within that radius were then identified. When communities fell within more than one resource area, they were assigned to the nearest area. This analysis resulted in much smaller use areas, as shown on Figure 4. Then, the use areas were altered so that the estimated geothermal energy supply in each compared with the estimated natural gas demand. The resulting use areas were smaller still than previously in some cases. Since estimates of the resource potential were very conservative, often one small community was estimated to consume all of the energy estimated to be available. To further refine the use areas, topography was cursorily examined, resulting in elimination from the scenarios of long-distance pipelines over extremely rugged terrain. These use areas are shown in the section entitled Resource Potential.

Scenario Preparation

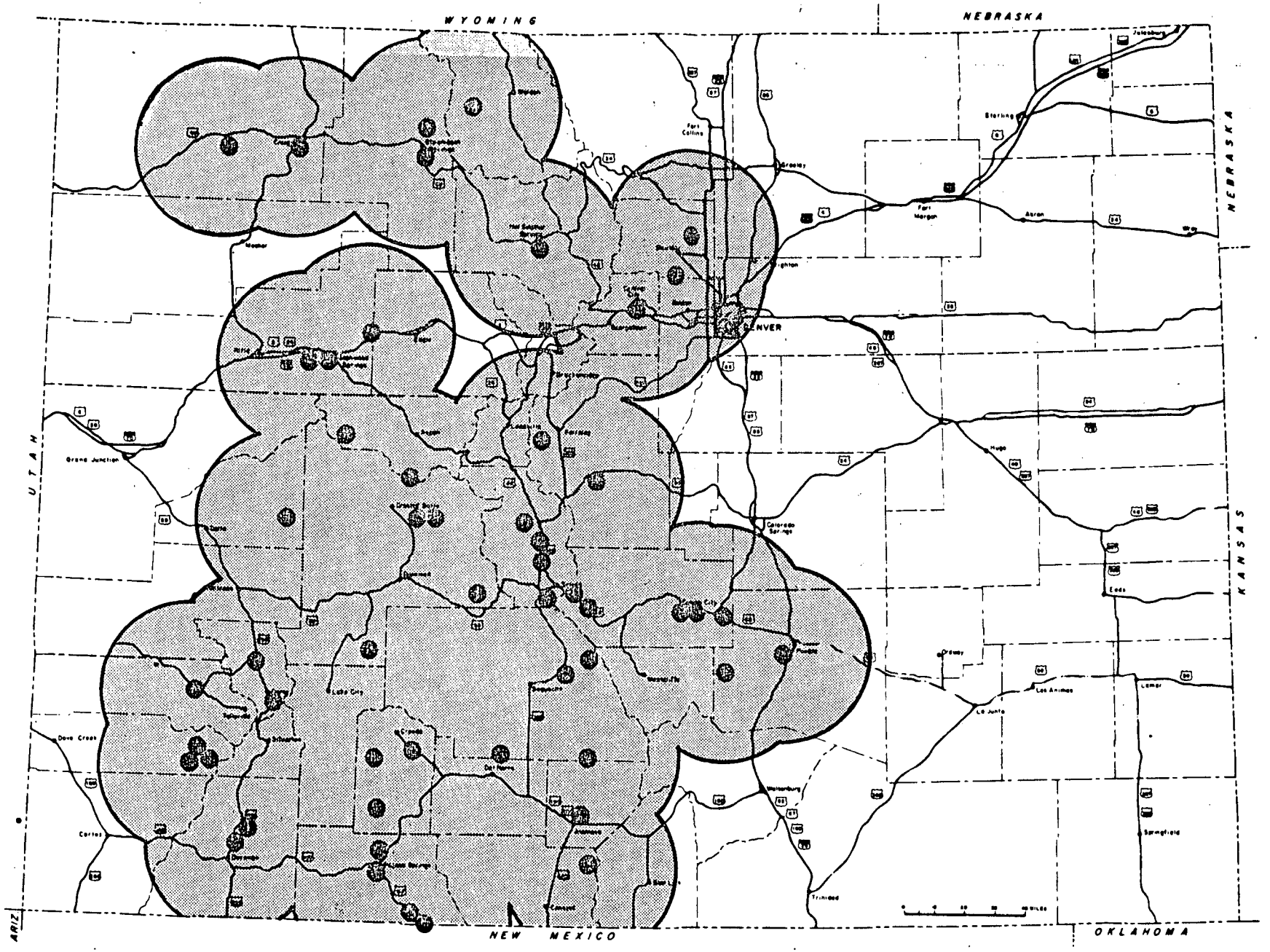
Scenarios were then prepared for both power generation and low-temperature sites. For power generation, only geothermal resources that are considered to have subsurface temperatures of at least 200°C are considered feasible.

In those areas where the lessees considered the temperatures to be suitable, as well as indicating that some work was planned, power generation potential was assumed. The areas are: Mt. Princeton and Poncha Springs in Chaffee County and Cebolla in Gunnison County (Amax Exploration, Chevron Resources, Inc., Occidental Geothermal and Phillips Petroleum Company representatives, 1977, 1978, pers. comm.).

The plans for these areas as well as the problems constraining development were discussed at some length with the lessees. Then, following scenario preparation, the draft scenarios were submitted to the lessees for their review and refinement.

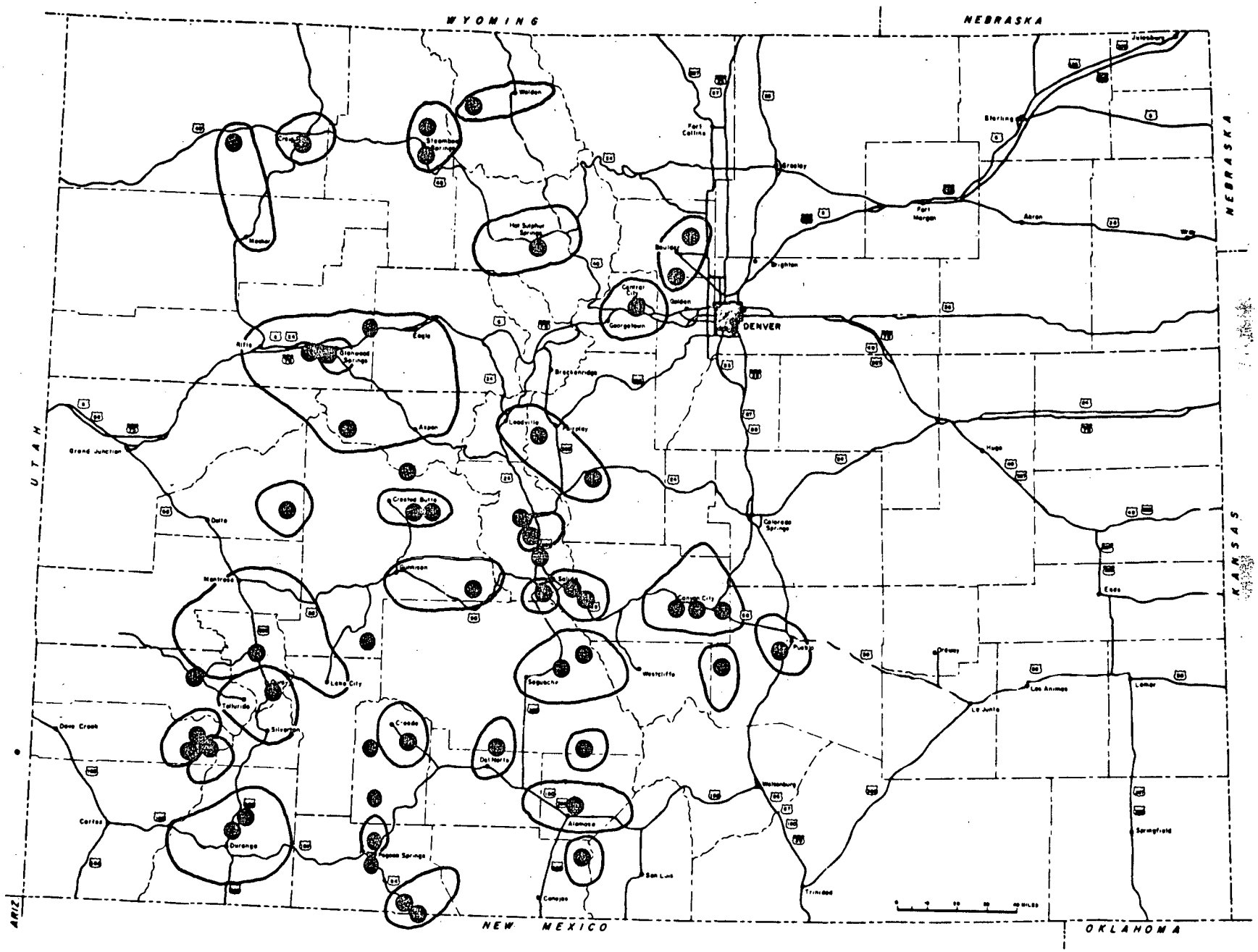
For the low-temperature sites, scenarios were derived in one of two ways. For those sites where potential developers expressed interest in specific uses, those uses were indicated. Otherwise, the scenarios were somewhat hypothetical, although they incorporated existing industries and population.

The scenarios, which were prepared in both narrative and chart form, describe the types of uses, the activities necessary for resource development, and a possible schedule for accomplishing those activities. In some of the use areas, more than one resource area was included. Some of the resource areas with similar characteristics were combined into one scenario in order to simplify scenario preparation. The results of the scenario compilation are described in the Resource Potential section.



POTENTIAL GEOTHERMAL RESOURCE USE AREAS IN COLORADO BASED ON 30 MILE RADIUS FROM SURFACE EXPRESSIONS.

FIGURE 4



POTENTIAL GEOTHERMAL RESOURCE USE AREAS IN COLORADO BASED ON NEAREST COMMUNITIES.

STATUS OF GEOTHERMAL DEVELOPMENT IN COLORADO

Geothermal resources already contribute to Colorado's energy supply. In fact, since the early 1900's, practical uses of geothermal resources have been common in Pagosa Springs, in Southwest Colorado. Residents there have used hot-water wells to heat numerous buildings, including the County Court House, schools, churches, the newspaper office, a liquor store, 2 hotels, 2 service stations, a drugstore, and a bank, as well as for the swimming pool and spa. Although the corrosion of heating system equipment, along with the low price and availability of natural gas induced the conversion of some geothermal systems to natural gas, 12 wells are still in use. (Dick and Galloway, unpublished report, 1978). A list of the known wells is found in the Appendix.

Where resources are in use in other parts of the State, most are used for swimming pools or baths. A few wells or springs serve other purposes, however, among them space heating and agriculture, including greenhouses, a fish farm and algae-growing. Table 3 shows the known users and uses in geothermal resource areas throughout the state.

Interest in developing the geothermal resources in Colorado has grown since the beginning of the 1970's. Because of the problem of transporting the energy to the user, most of the recent interest has been in geothermal power generation. Toward this end, some leasing and exploration activity have occurred. It is commonly believed, however, that Colorado's resources offer high enough temperatures for power generation in only a few areas, given today's economic criteria. Efforts toward the development of low-temperature uses such as space or water heating of industrial or agricultural process use so far seem minimal. However, several planning and preliminary engineering studies emphasizing these uses are either completed or underway. Judging from conversations with potential developers throughout the state, interest is growing. If a planned development of a district heating system in the town of Pagosa Springs is funded by the Department of Energy, this may well be the first step toward significant development of the low-temperature geothermal resources throughout Colorado.

TABLE 3
CURRENT USES OF GEOTHERMAL RESOURCES
IN COLORADO
1978

Type of Use	Name of Area
Swimming Pools	Juniper Hot Springs
	Steamboat Hot Springs
	Hot Sulphur Springs
	Eldorado Warm Springs
	Idaho Hot Springs
	Glenwood Hot Springs
	Cement Creek Hot Springs
	Cottonwood Creek Hot Springs
	Mt. Princeton Hot Springs
	Hortense Hot Springs
	Poncha Hot Springs
	Shaws Warm Spring
	Splashland Hot Water Well
	Pagosa Hot Springs
	Wagon Wheel Gap Hot Springs
	Upper Waunita Hot Springs
	Ouray Hot Springs
	Pinkerton Hot Springs
	Valley View Hot Springs
Baths	Juniper Hot Springs
	Hot Sulphur Springs
	Idaho Hot Springs
	Glenwood Hot Springs
	South Canyon Hot Springs
	Mineral Hot Springs
	Valley View Hot Springs
	Cebolla Hot Springs
	Orvis Hot Springs
	Ouray Hot Springs
	Dunton Hot Springs
	Paradise Hot Springs

TABLE 3 (Cont.)

Space Heating	Cottonwood Creek/Jump Steady Hot Springs - Mt. Princeton - cabins/House, resort
	Wright Hot Water Wells - 2 houses
	Poncha Hot Springs - 1 house
	Sand Dunes Swimming Pool Well - 1 house
	Ouray - 2 motels
	Pagosa Springs - approx. 10 buildings
	Upper Waunita Hot Springs - headquarters building
Other	
Laundry	Hot Sulphur Springs
Greenhouses	Penny Hot Springs
	Wright Hot Water Wells
	Tripp Hot Springs
Algae Growing	Wellsville
Irrigation	Dutch Crowley
Bottled Water	Clark Artesian Well
	El Dorado Warm Spring
Fish Farming	Sand Dunes Hot Water Well

SOURCES: Barrett and Pearl, 1978 and unpublished data from Dick and Galloway, 1978.

The development of a geothermal resource for either power generation or direct uses, such as space heating, involves several steps, namely leasing, exploration and development. A program may begin with preliminary exploration followed by acquisition of leases in areas that seem to offer potential. Or it may begin with identification of desired uses, followed by feasibility studies and finally location of a suitable resource.

Table 4 shows the tasks that are usually required for development of a geothermal resource system and the minimum amount of time that will probably be required for each. Some of the tasks may, of course, be accomplished simultaneously. The following sections describe the status of the various activities.

Leasing

Although records of the geothermal leases with private parties in Colorado are not readily available, listings of leases on public lands were obtained from the State and Federal agencies. As Table 5 shows, federal geothermal leases are active in Known Geothermal Resource Areas (KGRA) on a total of 5,035 acres.

Noncompetitive geothermal leases on federal lands were issued on 28,487.5 acres as shown on Table 6. On state lands, geothermal leases are in effect on a total of 83,192 acres, as shown on Table 7. Applications for other leases, which were submitted as early as 1974, are still pending. These applications are primarily for leases on national forest lands.

No new leases on public lands have been issued since August, 1977. In fact, in late 1977, federal leases on about 8,021 acres and state leases on about 31,487 acres were dropped by the lessees. Since most of the lessees are interested primarily in resources suitable for power generation, while most of Colorado's resources are considered to be lower temperature, the lack of vigorous leasing is not surprising.

The areas in which leasing of federal and state acreage has occurred are:

Mt. Princeton Hot Springs No. 21A
Poncha Springs No. 23
Mineral Hot Springs/Valley View No.31/32
Sand Dunes Swimming Pool Hot Water Well No. 34
Splashland Hot Water Well No. 35
Waunita Hot Springs No. 46
Cebolla Hot Springs No. 47

Exploration

Exploratory work in the geothermal areas may be grouped into three categories: 1) preliminary exploration, especially geophysics and geochemistry; 2) thermal gradient holes; 3) test wells. The main activities in each category are described below.

1) Preliminary Exploration - Although the information concerning geophysics and geochemical analyses performed by private companies is scant, undoubtedly both types of exploration have been done in a number of areas. And in one area, Pagosa Springs, the Colorado Geological Survey (CGS) had geophysical work performed in the fall of 1978. CGS also performed geochemical tests for the 56 identified thermal areas (Barrett and Pearl, 1978).

TABLE 4

STEPS FOR GEOTHERMAL RESOURCE DEVELOPMENT

APPROXIMATE MINIMUM TIME	ACTIVITY
2 mo.	PRELIMINARY EVALUATION OF AREAS
	OBTAIN LEASES
2 mo.	BLM
3 mo.	USFS
7-8 mo.	State
?	Fee
	PERMITS FOR GRADIENT HOLES
2 mo.	State
3 mo.	USGS
1 mo.	USFS
2 mo.	CONTRACT FOR DRILLING
1/2	DRILL GRADIENT HOLES & EVALUATE
3 mo.	FEASIBILITY AND ENGINEERING STUDIES
	OBTAIN FINANCING FOR EXPLORATORY WELLS
1 mo.	Loan
6 mo.	Bond Issue
6 mo.	Government
	PERMITS FOR EXPLORATORY WELLS
2 mo.	State - O&GCC, Engineer, WQCC, APCC
3 mo.	USGS
1 mo.	USFS
2 mo.	City or County
2 mo.	HIRE DRILLING CONTRACTOR
1 mo.	DRILL EXPLORATORY WELL
1 mo.	EVALUATE POTENTIAL OF RESOURCE
1 mo.	OBTAIN WATER RIGHTS IF NECESSARY
1 mo.	SECURE MARKET OR ESTABLISH HEATING/COOLING DISTRICT
	OBTAIN FINANCING FOR DEVELOPMENT
1 mo.	Loan
6 mo.	Bond Issue
6 mo.	Government
2 mo.	PERMITS FOR DEVELOPMENT
3 mo.	R.O.W. FOR PIPELINES
2 mo.	CONTRACT FOR CONSTRUCTION OF FACILITIES
6 mo.	INSTALL SYSTEM
1 mo.	OBTAIN FINANCING FOR PRODUCTION WELLS
1 mo.	Loan
6 mo.	Bond Issue
6 mo.	Government
	PERMITS FOR PRODUCTION, DISPOSAL, ETC.
2 mo.	State
15 mo.	USGS
1 - 18 mo.	USFS
6 mo.	County or City
2 mo.	HIRE DRILLING CONTRACTOR
1 mo.	DRILL ONE WELL

TABLE 5

FEDERAL ACTIVE COMPETITIVE GEOTHERMAL LEASES

(KGRA'S)*
IN COLORADO
December, 1977

LESSEE	ACRES	TOWNSHIP & RANGE	DATE ISSUED
The Anschutz Corporation	915	49 N, 8 E	1975
Phillips Petroleum Company	2484	45 N, 8 E	1975
Phillips Petroleum Company	1636	45 N, 9 E	1975
	5035		

*Designated Known Geothermal Resources Areas by Federal Government

SOURCE: Bureau of Land Management, Denver, Colorado

TABLE 6

FEDERAL ACTIVE NON-COMPETITIVE GEOTHERMAL LEASES
IN COLORADO
December, 1977

LESSEE	ACRES	TOWNSHIP & RANGE	DATE ISSUED
Buttes Resources Company	781.32	46 N, 2 W	1977
	2,226.88	46 N, 1 & 2 W	1977
	1,804.57	46 N, 1 ! W	1977
	1,040.04	46 & 47 N, 2 W	1977
	1,970.30	46 & 47 N, 2 W	1977
Chevron Oil Company	1,867.94	46 & 47 N, 2 & 3 W	1977
	2,127.56	46 & 47 N, 3 W	1977
	645.74	47 N, 3 W	1977
	160.00	45 N, 9 & 10 E	1975
Earth Power Corporation	1,000.00	46 N, 10 E	1976
Geothermal Kinetics, Inc.	1,000.00	37 N, 12 E & 38 N, 13 E	1975
	1,106.00	29 W, 73 W	1975
	827.31	38 N, 13 E & 29 S, 73 W	1975
	1,042.47	29 S, 73 W	1975
Ladd Petroleum Corp.	883.65	45 N, 11 E	1975
	280.00	46 N, 10 E	1975
Occidental Petroleum	80.00	49 N, 8 E	1975
	1,280.00	49 N, 3 E	1975
	2,113.30	49 N, 7 & 8 E	1975
	1,549.66	49 N, 9 E	1975
	1,286.17	51 N, 8 E	1975
Phillips Petroleum Co.	320.00	46 N, 10 E	1975
	1,120.00	45 N, 10 E	1975
	1,644.50	46 N, 10 E	1975
	329.50	46 N, 11 E	1975
	28,487.51		

SOURCE: Bureau of Land Management, Denver, Colorado

TABLE 7

COLORADO STATE ACTIVE GEOTHERMAL LEASES

December, 1977

LESSEE	ACRES	TOWNSHIP & RANGE	COUNTY
General Geothermal, Inc.	9,639.90	41 N, 6 E 45 N, 9 E 46 N, 10 E	Saguache
	8,183.33	39 N, 11 E 40 N, 12 E	Alamosa
	360.00	49 N, 8 E	Chaffee
	640.00	35 N, 2 W	Archuleta
	640.00	12 S, 75 W	Park
	480.00	11, 12 S, 75, 76 W	
	560.00	35 N, 1 W	Archuleta
Geothermal Products, Inc.	2,004.85	14 S, 78 W	Chaffee
	3,692.00	15 S, 78 W	
	1,280.00	15 S, 78 W 14 S, 78 W	
Mapco, Inc.	640.00	40 N, 11 E	Alamosa
	1,625.00	41 N, 11, 12 E	Saguache
	17,895.00	41 N, 10, 11, 12 E	
	9,611.88	39, 40 N, 11, 12 E	
	3,920.00	37, 38 N, 11, 12 E	Alamosa
	2,532.24	42, 43, 44, 45 N, 10 E	Saguache
Marine Minerals	640.00	40 N, 12 E	Alamosa
Occidental Oil Co.	640.00	49 N, 4 E	Gunnison
Petro-Lewis	2,004.85	14 S, 78 W	Chaffee
	3,692.31	15 S, 78 W	
	1,280.00	15 S, 78 W 14 S, 79 W	
	3,226.61	50 N, 8 E	
	1,560.00	49 N, 7 E, 9 E 50 N, 8 E	
	40.00	14 S, 78 W	
Phillips Petroleum	1,764.40	48, 49 N, 4, 5 E	Gunnison & Saguache
Underwood, C. A.	3,520.00	14 S, 78 W	Chaffee
		45, 46 N, 8, 9, 10 E	Conejos, & Saguache
	1,120.00	33 N, 8 E	Conejos
TOTAL	83,192.37		

2) Gradient Holes - Gradient holes are known to have been drilled in only two thermal areas in Colorado. At the first, Mt. Princeton Hot Springs, one 2,000-ft hole was drilled in the fall of 1978 by Amax Exploration, Inc. At Pagosa Springs, the second site, the Colorado Geological Survey drilled 5 holes in the fall of 1977. Chevron has a permit from U.S.G.S. to drill five shallow thermal gradient holes in the Cebolla area. Presumably, that drilling will be done in the summer of 1978.

3) Test Wells - One exploratory geothermal well has been drilled in Colorado. Mapco in 1974 drilled a 9,480-ft well on the eastern side of the San Luis Valley near the Great Sand Dunes area to determine temperature gradient and hydrologic properties of the aquifer, as well as oil and gas potential. The test was inconclusive, although high bottom hole temperatures were encountered, and water flowed to the surface in 21 minutes from depths of 5,304 to 5,491 ft. (Completion Report, Colorado Oil and Gas Conservation Commission).

One exploratory well is now being drilled by the Colorado Geological Survey at Pagosa Springs. This 2,000 ft deep well is funded by the U.S. Department of Energy (DOE). If a usable resource is found, the town of Pagosa Springs will assume ownership of the well and put the resource to beneficial use. A similar exploration program will be conducted in the Glenwood Springs area sometime in 1979.

In the Mt. Princeton, Cebolla, and Poncha Springs areas, the companies who hold leases in those areas plan to drill test wells if and when the additional leases they have requested are obtained and if preliminary exploration findings are satisfactory.

Technical Studies

Other efforts directed toward geothermal development include planning, engineering and feasibility studies, as well as preliminary investigations. Among these planning studies is one being conducted by the National Council of State Legislatures to define state legislation needed to encourage geothermal development and this operations research project.

Engineering and feasibility studies that have been conducted include the evaluation of reconversion to geothermal heat of the heating systems in the Pagosa Springs schools (I.A. Engen, 1977), residential space heating in Glenwood Springs (Nannen, Kreith, and West, 1975), and barley malting and sugar-beet processing in the San Luis Valley (Coury and Associates, in preparation). A current study is investigating the use of geothermal resources for residential space heating and other uses in the San Luis Valley (Coury and Associates, in preparation).

Preliminary investigations for other geothermal development have been indicated, some through requests for information from the CGS. Among these are heating for hogpens, greenhouses, homes and resorts in various areas. These may represent only a small percentage of the preliminary investigations actually underway. Since any new project must begin with some sort of preliminary investigation, this may mean the start of numerous future geothermal resource development projects.

OBTAINING LEASES AND PERMITS

Before any new geothermal development can occur in Colorado, certain legal requirements must be met. In this section, the two primary requirements, obtaining leases and permits, are discussed. As indicated, the requirements vary depending upon whether the ownership of the land and/or mineral rights is federal, state or private.

Leasing

Developers generally have obtained geothermal leases on wide areas, usually several thousand acres, in an area in which they are interested. This assures that they will have adequate control of any discovery that might be made. In the case of federal land, control in advance of a discovery is especially vital. If a discovery is made, the area may be designated a Known Geothermal Resource Area (KGRA). In KGRA's, leasing is competitive, with no allowance for preferential leasing rights to the company making the discovery. For this reason, a company must have control of the area before they can justify spending large sums of money on exploration. In Colorado, the KGRA provision usually makes the acquisition of a combination of federal, state and private leases necessary. Especially where much of the land ownership is "checkerboarded" or split among various types of jurisdictions, obtaining several types of leases may be the only way to control sufficient amounts of acreage. The steps necessary for obtaining leases vary depending upon what entity owns the land and the minerals.

Private Lands and Minerals

Where ownership is private, leases are obtained simply through negotiation and contractual agreement with the owner. The transaction is then usually reported by the lessee to the county clerk of the county or counties in which leases are located.

State-Owned Lands or Minerals

Leasing of state-owned land and minerals is under the jurisdiction of the Board of Land Commissioners, whose mandated objective is to maximize the income from state lands. Under the Board are four sections, Minerals, Rights-of-Way, Surface and Accounting. The Minerals Director is responsible for administration of geothermal leases, and the accounting department is responsible for collection of the rental and royalty payments for these leases (T. E. Bretz, 1978, pers. comm.).

To obtain a state geothermal lease, an application is filed with the Minerals Section. The request is then posted on the bulletin board, and a questionnaire is circulated for comment among state, local and federal agencies, as well as county commissioners' and county planners' offices in the respective county or counties. The feasibility and impacts of the proposal are evaluated, taking into consideration the comments returned from other agencies and individuals. After reviewing all the information, the Board decides whether or not to issue the lease. The entire process usually requires about six months. Leases may also be auctioned, but have been noncompetitive thus far because of limited interest in geothermal leasing.

Prior to any exploration or development, the Board must be notified. The applicant must also post bond to guarantee compliance with the Board's requirements for restoration of the surface and settlement of damages to the surface

property. The lessees must agree to conduct his operations in a manner satisfactory to federal and state agencies concerned with air and water pollution. Further, he is required to submit reports following drilling, and to pay an annual rental, a minimum royalty and, where there is production, a production royalty. The amounts are established by the Board.

Although various types of leases have been issued by the Land Board since adoption of the Colorado Constitution, geothermal leases have been issued only since 1973, when the Geothermal Resources Act was adopted (CRS 36, Art. 1, Sec. 113).

Federal Lands or Minerals

Geothermal leases on federal land or mineral ownership are issued by the Bureau of Land Management (BLM) of the U.S. Department of the Interior (USDI), as mandated by the Regulations on the Leasing of Geothermal Resources (43 CFR 3210.2). The procedures for leasing vary depending upon whether or not the area has been designated a Known Geothermal Resources Area (KGRA).

If the area is not a KGRA, an application for leases is filed with the BLM. The surface management agency, which may be the BLM, the U.S. Forest Service (USFS) or the Bureau of Indian Affairs (BIA), in consultation with the United States Geological Survey (USGS), assesses the probable environmental impacts and determines the necessary mitigation procedures, which are added to the lease application. The Menlo Park, California, USGS office reviews the lease stipulations for adequacy and for compatibility with development of the lease. The USGS investigates to ensure that the area has not been classified as a KGRA following submittal of the application. The lease is then sent to the applicant who may accept or refuse the lease with its stipulations.

Lease applications may also be rejected by the BLM in the event the environmental analysis indicates that critical environmental considerations and mitigation measures cannot be implemented (43 CRF 3210.4).

The Geothermal Steam Act defines "Known Geothermal Resources Area" as "an area in which the geology, nearby discoveries, competitive interests, or other indicia would, in the opinion of the Secretary, engender a belief in men who are experienced in the subject matter that the prospects for extraction of geothermal steam or associated geothermal resources are good enough to warrant expenditures of money for that purpose" (P.L. 91-581).

Based upon this definition, all wells within a five mile area of a discovery well are classified as part of the KGRA if the extent of the geologic structure is unknown, unless the USGS determines that the geothermal resource is in a different geologic structure. If the geologic structure is known, all land in the structural area is considered to be part of the KGRA. In addition, if during the same filing period, two or more applications have an overlap of 50 percent or more, the entire area is classified as an administrative KGRA (Kenneth Bull, 1978, pers. comm).

In a KGRA, lands are leased competitively to the bidder offering the highest bonus bid, if it is above the minimum acceptable bid. Before offering such lands for lease, the impacts on the environment must be assessed, the comments of appropriate federal agencies, business and industry and private organizations must be solicited, and public hearings may be held. If issuance of leases may significantly affect the environment, an environmental impact statement may be required (Kenneth Bull, 1978 pers. comm).

The first term of any lease is for 10 years. The law requires diligent exploration, determined by a review of the USGS Area Geothermal Supervisor. After the fifth year, annual exploration expenditures must be at least twice the year's rental payment. However, expenditures during the first five years as well as excess expenditures during subsequent years may be credited to help fill the expenditure requirements. The lease may continue for up to 40 years as long as geothermal steam is produced or utilized in commercial quantities, with preferential right to renewal for a second 40-year term (43 CFR 3203.1).

In some cases the land is privately owned, while the mineral rights are owned by the federal government. After a long appraisal, the courts in 1978 determined that the geothermal resources belong with the mineral rights. This means that both mineral and surface rights must be obtained from their respective owners in order to conduct any geothermal operations on such properties.

Permits

The permit requirements for geothermal operations also vary depending upon the ownership, except that prior to drilling any geothermal well in Colorado, a permit must be obtained from the Colorado Oil and Gas Conservation Commission. Other state permits may be required, depending upon the particular activities. In some cases, the county or municipality in which the well will be drilled may also require a permit. If the well will be drilled on federal or state land, the approval of the respective government agency is required.

State Permits

To obtain a permit to drill (or deepen) a geothermal well, an application must be filed with the Director of the Oil and Gas Conservation Commission, along with a filing and service fee of $75.00. If the permit is requested for an exploratory well, the application must include a "written statement based on competent geological opinion or data derived from similarly situated geothermal resource areas containing whatever information the Commission requires to carry out the purposes as described in Section 34-70-102 of the Act." (State of Colorado, Oil and Gas Conservation Commission, 1975). If the permit requested is for a development well, information is required from the drilling of the discovery well, competent geological opinion or data from a "similarly situated geothermal resource area" as follows:

1) Names and addresses of the owner, operator and their designated agents
2) Location of the wells and their proposed depth
3) Description of the base
4) Amount and extent of anticipated surface development
5) Mitigation measures for land subsidence, water and air pollution and noise pollution
6) Proposed methods of by-product disposal and recovery
7) Mineral and chemical composition of brine and gases of the geothermal resource
8) Proposed casing program
9) Other information required by the Commission

Permission must also be obtained to recomplete or abandon a well or to change the specific manner in which any of the operations is carried out. Drilling and completion rules limit or specify ways some of the operations are to be conducted. Following any operation, a report must be filed with the Commission describing in detail the work done and the manner in which it was done,

the daily production and other pertinent information. A monthly production report is required, as well. Confidentiality is protected by the provision that logs so marked shall be kept confidential for six months following their filing.

The applicant for a drilling permit must also submit evidence of public liability insurance. Except where a bond has been required for federal or Indian leases, a bond of at least $10,000 is required to assure that when the well is abandoned, it will be plugged in the manner in which the rules require.

The staff of the Oil and Gas Conservation Commission is authorized to issue the permits and to maintain the records of activity. The 5-member commission conducts hearings to resolve questions relating to the administration of the Geothermal Act, such as spacing of wells, correlative rights, unitization, pollution, and any other problems or conflicts that may arise.

An application for a geothermal well must also be referred by the Commission to the State Engineer for his determination whether the well will have any adverse effect upon existing water rights. Either he must, within 60 days, find no adverse effect, or he must recommend denial of the permit (Frank Piro, 1977, 1978, pers. comm).

Permit for Fluid Discharge - In the case of geothermal exploration, field development or power plant operation, a developer may wish to discharge geothermal fluid into a stream or injection well. If so, he must obtain a permit from the Colo. Dept. of Health, Water Quality Control Division, since a 1973 amendment to the Colorado Water Quality Control Act gave the Division control of the issuance of permits for the discharge of pollutants into surface and subsurface waters in the state. Either heat or dissolved solids could pollute the water in excess of the water quality standards.

The Water Quality Control Division regulations state that a developer must submit an application at least 180 days prior to the date upon which he wants to begin discharging material into the stream. Prior to issuance of a permit, a public hearing and a 30-day public review period may be required.

The U.S. Environmental Protection Agency, the federal agency that provides a large part of the operating funds for the Division, may prevent issuance of permits not considered to be in conformance with the federal regulations (Water Quality Control Commission, 1977, and Bud Flynn, 1978, pers. comm.).

Air Pollution Permit - The Colorado Department of Health Air Pollution Control Commission and its staff are responsible for controlling point-source emissions and ambient air quality as established by the Federal Clean Air Act and the Colorado Air Pollution Control Act of 1970 (Air Pollution Control Commission, 1977). A potential developer is advised to contact the agency even when not anticipating the release of any material into the air. If the Commission officially exempts a project, the developer will be protected in case of any unexpected release of pollutants. Furthermore, the developer will wish to be informed about all the regulations that are applicable.

Geothermal System Development Permits - Permits are required in order to construct a power plant or utility system except where a municipally-owned public utility will provide service within its boundaries.

The Colorado Public Utilities Commission (PUC) issues permits and regulates activities of common carriers, pipelines, electrical facilities, telephone systems, telegraph systems, or water systems for public use. The staff, which is divided into the Transportation and the Fixed Utilities Sections, provides technical and administrative assistance to the Commission as well as testifying at hearings when necessary.

Proposed development of geothermal utility facilities would be reviewed by the Fixed Utilities staff prior to consideration by the Commission. The utility construction permit process usually requires from three to four months (George Parkins, 1978, pers. comm.).

Federal Permits

Geothermal operations on federal lands or minerals are under the jurisdiction of the USGS, subject to the authority of the Secretary of the Interior and the Director of USGS (30 CFR, 270.10.). Some preliminary exploration and "casual" uses that do not disturb the land, improvements or resources may be done without obtaining leases (43 CFR 3209.0).

If leases are held, approval may be obtained from the surface management agency of a "Notice of Intent and Permit to Conduct Exploration Operations," in order to conduct such activities as geochemical and geophysical surveying and drilling of shallow gradient holes (43 CFR 3209.0).

Prior to drilling thermal gradient holes, lessees have been required to obtain approval of a plan of operations, a lengthy process. Recent regulation revision, however, requires submittal by the lessee of a description of development and its approval by the U.S.G.S. With this change, a lessee or non-lessee may now obtain approval in most cases in less than 30 days (Kenneth Bull, 1978, pers. comm.).

Any drilling other than thermal gradient holes may be done only by the lessee or his agent on his own leases. Prior to conducting activities, a plan of operations must be approved by the USGS. Such plans of operations may cover one or a combination of activities, as follows: exploration, collection of baseline data, development, injection, production, and utilization. All require an environmental analysis, which is reviewed by numerous organizations and individuals (60 in Colorado, at this time) (Kenneth Bull, 1978, pers. comm).

The plan of operations must include, in addition to a description of the primary activities, a description of the measures to be taken for protecting the environment, for disposal and reclamation, and for monitoring. If the plan of operations is for production, disposal or utilization plans, baseline data are required, including air and water quality, noise, seismic and land subsidence and ecological systems covering a period of one year. The baseline data may be obtained from other sources if available. After the environmental analysis is conducted by the USGS, it is reviewed by the surface management agency and must be jointly approved by the two agencies. Interested parties, including state and local governments, are invited to comment. The entire process usually requires a minimum of from three to six months (30 CFR 270.35).

Plans of operation are reviewed by a geothermal advisory panel. If the area is a newly identified geologic area or if the operation is unusual, the panel may hold a public hearing, extending the review process to about

nine months' time. A full environmental impact statement (E.I.S.) may be required for any plan if considered to be necessary by Washington offices of the responsible agencies. An EIS usually adds about two years to the process (Kenneth Bull, 1978, pers. comm.).

A geothermal operator on federal leases must file reports periodically, including:

1. Report of significant effect on the environment or industrial accident.
2. Log and well history.
3. Monthly report of operations.
4. Monthly report of sales and royalties.
5. Annual report of compliance with environmental protection requirements.
6. Annual report of expenditures for diligent exploration operators.

Production royalties are determined by the area supervisor of the U.S.G.S. (30 CFR 270.02).

Local Permits

Both counties and municipalities are permitted by legislation to regulate numerous activities, including geothermal development, within their boundaries. But such authority must be specifically implemented by adopting regulations. Not all local governments in the state have felt it necessary or wise to expand their regulations to include geothermal resource development. In those instances where regulations for geothermal development have been adopted, they are often made a part of the subdivision regulations.

Following is a description of the procedures required by one county where geothermal resources are regulated. Since the procedures would probably be similar in other areas, this should provide an indication of the kinds of requirements to be expected.

Alamosa County - Alamosa County has included in their subdivision regulations mineral regulations that specifically refer to geothermal resources. To obtain county approval to develop a geothermal resource, the developer first meets with the planning commission or staff informally about the specific requirements. He then prepares and submits a proposal that is circulated to various agencies, including the Colorado Geological Survey, for review and comment. After those comments have been received, the application goes through final review by the planning commission, which recommends denial or approval. Then the proposal is submitted to the Board of County Commissioners, which holds a public hearing to allow interested parties to comment. The Commissioners then decide whether or not to allow the activity.

It is expected that the time required to obtain permission for exploration activity would be at least two months. For development activity six months would probably be required (Alamosa Planning Office, 1977).

DEVELOPMENT POTENTIAL

Geothermal energy undoubtedly can make a significant contribution to the total energy supply in Colorado. Although the geothermal energy in the community of Pagosa Springs has been barely tapped, its importance there may be observed. The other 55 identified resource areas, plus those not yet discovered, are virtually untapped. Although data are lacking for an accurate assessment, the potential of the 56 identified hydrothermal systems has been estimated. As Table 1 showed, those areas are estimated to contain 5.914 quads (5.914×10^{15}Btu) of energy, with extractable energy of 1.48 quads. The total usable energy after extraction of 0.35 quads was converted to annual usable energy, resulting in an estimated 0.01 quads. Although this equals only about three percent of the total natural gas consumption for the state in 1972 (CERI, 1976), it is theoretically sufficient to supply more than 112,000 dwelling units.

While this amount of geothermal energy would make a significant contribution to the total energy supply, it is believed to be extremely conservative. The estimates of available energy are necessarily conservative because of the lack of sufficient exploration data to assure that any of the geothermal systems are renewable. Moreover, sequential use of the resources from process use to space heating can increase the efficiency of use of the resources enormously.

At least three areas seem at this point as though they might have high enough subsurface temperatures for economical generation of electricity. These areas are: Mt. Princeton and Poncha Springs in the Upper Arkansas Valley and Cebolla or Powderhorn in southern Gunnison County. Discussions with industry officials resulted in an estimated potential of 100 MWe for Mt. Princeton, 200 MWe for Poncha Springs and 200 MWe for Cebolla (Amax Exploration, Occidental Geothermal, Inc., and Chevron Resources Company, 1978, pers. comm.). Figure 5 shows a composite of the scenarios for the power generation sites. Before development can proceed even to the stage of drilling of test wells, however, additional leases will be required. In the first two areas, Mt. Princeton and Poncha Springs, federal lease applications are pending. In the Cebolla area, leases on private land are needed.

To envision potential low temperature uses, communities were matched with resource areas, based on their proximity and the amount of energy estimated to be available. This allowed the demand/supply congruity to be estimated. It also supplied data that may be used for subsequent feasibility testing of the direct use of the resource for the predominant existing demand sector, space and water heating. Tables 8, 9, and 10 show the estimated energy demand and supply for the developable low temperature geothermal resource areas.

Figure 5.
POSSIBLE GEOTHERMAL ENERGY DEVELOPMENT SCHEDULE
FOR COLORADO

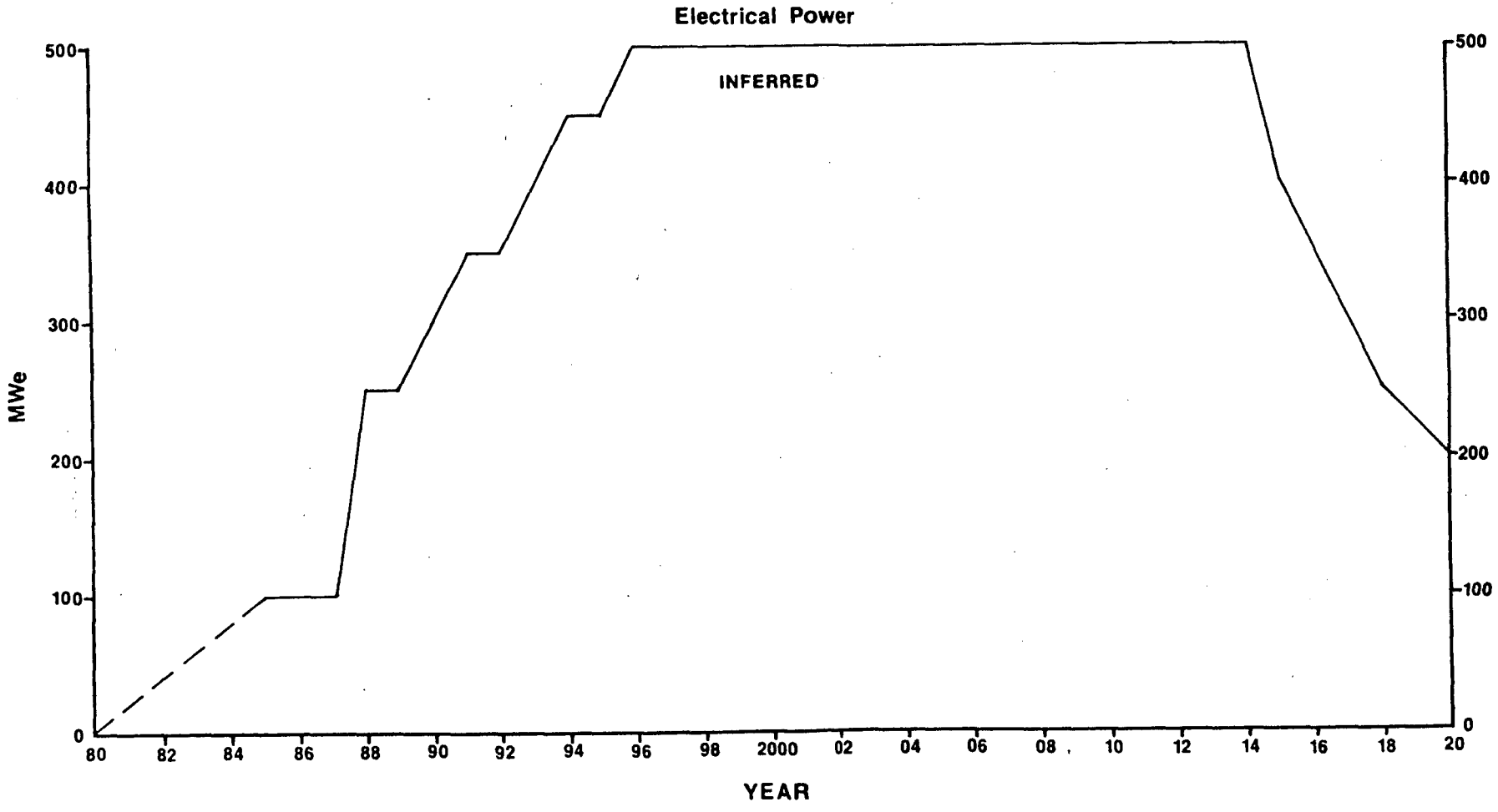


TABLE 8
CATEGORY II B
AREAS OF KNOWN ACTIVITY

Area Name	Number	Use	Distance	1975 Estimated Dwelling Units	1975 Estimated Natural Gas Demand (10^{12}Btu's)	2020 Estimated Dwelling Units	2020 Estimated Natural Gas Demand (10^{12}Btu's)	Estimated Usable Energy Available (10^{12}Btu's)	Estimated Usable Energy Available Per Year for 30 Years (10^{12}Btu's)
Glenwood	11	space heat Glenwood Springs	0	1,784	.32	3,796	.68	1.7	.06
Hartsel	19	space heat Fairplay	16	215	.04	271	.04	2.5	.08
Splashland	35	Alamosa	2	2,807	.50	8,083	1.44	4.7	.16
Sand Dunes	34	Baca Grande	14	225	.02	10,000	1.78	4.7	.16
Shaws	33	greenhouse	0	NA*	.02	NA	NA	.9	.03
Mineral/Valley View	31/32	space heat Saguache	12	226	.04	380	.06	60.0	2.00
		timber kiln			.04				
		barley melting			.22				
		potato flakes			.86				
Pagosa Springs	41	space heat Pagosa Springs	0	524	.09	1,481	.26	2.9	.10
Waunita	46	space heat Gunnison	22	1,880	.33	4,326	.77	3.6	.12
		timber drying							

*Not applicable

TABLE 9
CATEGORY III A
NO KNOWN ACTIVITY BUT HIGH POTENTIAL

Area Name	Number	Use	Distance	1975 Estimated Dwelling Units	1975 Estimated Natural Gas Demand (10^{12} Btu's)	2020 Estimated Owelling Units	2020 Estimated Natural Gas Demand (10^{12} Btu's)	Estimated Usable Energy Available (10^{12} Btu's)	Estimated Usable Energy Available Per Year For 30 Years (10^{12} Btu's)
Routt/Steamboat	3/4	space heat Steamboat	0	1,004	.18	1,832	.33	7.4	.25
Hot Sulphur Springs	6	space heat Granby Kremmling Hot Sulphur Spgs.	 14 14 0	820	.14	NA	NA	4.2	.14
Haystack Butte	7	space heat new subdivision	0	337	.03	NA	NA	1.0	.03
Eldorado Springs	8	space heat resort	0	112	.02	NA	NA	.6	.02
Idaho Springs	9	space heat Idaho Spgs.	0	707	.13	2,985	.53	7.6	.25
Ouray	49	space heat Ouray	0	281	.05	832	.15	14.0	.47
Dunton/Geyser/ Paradise	51,52,53	Dunton	0	10	.002	NA	NA	1.6	.05

TABLE 10
CATEGORY III B
AREAS OF MODERATE POTENTIAL

Area Name	Number	Use	Distance	1975 Estimated Dwelling Units	1975 Estimated Natural Gas Demand (10^{12}Btu's)	2020 Estimated Dwelling Units	2020 Estimated Natural Gas Demand (10^{12}Btu's)	Estimated Usable Energy Available (10^{12}Btu's)	Estimated Usable Energy Available Per Year For 30 Years (10^{12}Btu's)
Juniper/Craig	1/2	space heat Craig	24/.7	1,809	.32	2,241	.40	3.5	.12
Brand's Ranch	5	space heat Walden	16	325	.03	NA	NA	.2	.007
South Canyon	12	space heat New Castle	8	247	.05	NA	NA	.6	.02
Penny	13	space heat Carbondale Basalt	12 13	549	.10	1,050	.19	10.0	.33
Col. Chinn	14	space heat Paonia	3	444	.08	NA	NA	1.1	.04
Cement Creek/ Ranger	16/17	space heat Crested Butte	7	289	.05	NA	NA	1.0	.03
Wellsville/ Swissvale	24/25	space heat Salida	4	1,729	.31	NA	NA	.5	.02
Canon City/ Fremont	26/27	space heat Canon City	0	4,264	.76	NA	NA	.8	.03
Don K Ranch/ Florence	28/29	space heat Florence	18/4	1,051	.19	NA	NA	2.1	.09
Clark	30	space heat new subdivision at Pueblo	0	225	.02	NA	NA	.5	.02

CATEGORY III B
AREAS OF MODERATE POTENTIAL

Area Name	Number	Use	Distance	1975 Estimated Dwelling Units	1975 Estimated Natural Gas Demand (10^{12}Btu's)	2020 Estimated Dwelling Units	2020 Estimated Natural Gas Demand (10^{12}Btu's)	Estimated Usable Energy Available (10^{12}Btu's)	Estimated Usable Energy Available Per Year For 30 Years (10^{12}Btu's)
Wagon Wheel Gap	43	space heat Creede	10	208	.04	422	.07	22.7	.76
Orvis	48	space heat Ridgeway Montrose	4 28	2,665	.47	NA	NA	1.7	.06
Rico	54	space heat Rico Stoner Ski Lodge	0 17	99	.02	119	.02	8.4	.28
Pinkerton/Mound	55	space heat Animas Valley	0-10	NA	.02	NA	NA	2.7	.02
Tripp/Trimble	56	space heat Animas Valley	0-10	NA	.07	NA	NA	2.1	.07

Scenarios were then compiled for the identified use areas. Thirty-nine areas were combined into 27 scenarios for low-temperature applications. The scenarios showed that, at the very least, ample energy seemed to be available to supply a substantial portion of the space and water heating for 27 incorporated municipalities, plus several subdivisions and settlements. Twenty-three of these are within 10 miles of the resource area. Sixteen are virtually on site. In 14 areas, federal leases seemed to be required, if not at the outset, then later in order to expand systems. Ten of those were national forest leases. Thirteen areas seemed to require only fee leases. Figure 6 shows the use areas.

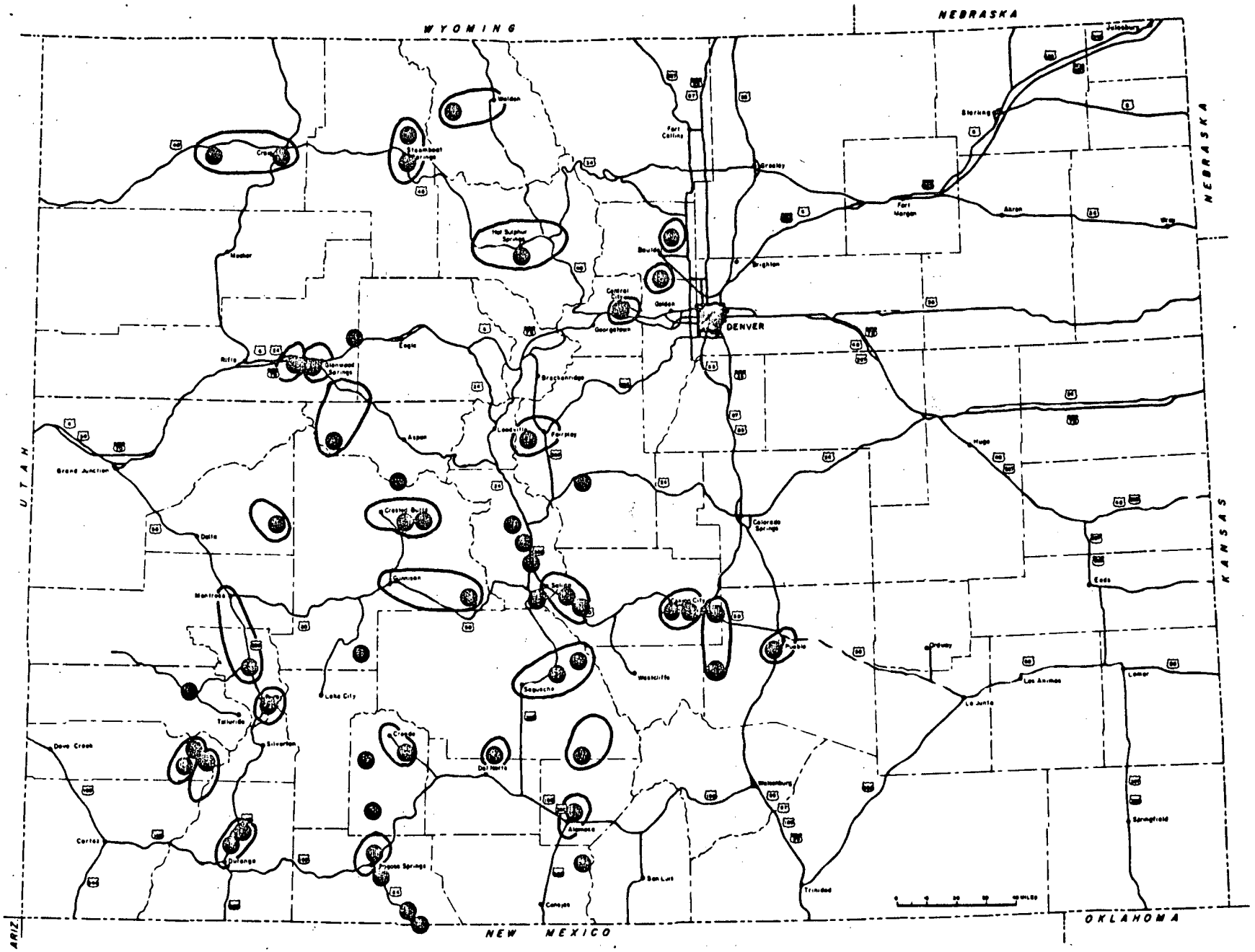
In those 27 areas enough energy for more than 16,000 homes, plus an equivalent amount for existing industrial, commercial, and public buildings seemed to be available. Also indicated in the scenarios were two timber kilns, one feed lot, one hog pen, three greenhouses, one barley malting plant, and one food dehydrating plant. The composite of the low temperature scenarios, Figure 7, shows a total of 0.003 quads on line by 1991.

The opportunity for realizing this magnitude of geothermal development is limited by the economics of converting structures from natural gas to geothermal. Retrofitting to use geothermal heat is generally not competitive with the existing price of natural gas. However, in those areas where new structures of sufficient number and size are being built, and especially where electricity, propane, or solar is the only available heat source other than geothermal, the economies of geothermal use are greatly enhanced. Moreover, it may be the case that retrofitting is economically justified over the long run. If geothermal systems were developed now, the energy would be available for new buildings when they were built. Over a period of time, economies of scale could then be effected.

In these scenarios the emphasis was on space and water heating. For the most part too little information was available to judge specifically where agricultural and industrial process uses should be suggested. Enormous benefits can be derived, however, from promotion of new process uses where economic growth is appropriate. Because energy availability is an increasingly important facet of industrial location decisions, economically depressed areas can benefit if their geothermal resources are made available for industrial use. Especially in those areas where a surplus of geothermal energy is discovered, process uses could be encouraged. The following table lists some of the uses that seem promising for Colorado.

As shown, a wide variety of uses of geothermal resources is possible. As shown previously, the resource estimates indicated a substantial amount of available energy. Yet, little development has occurred. Whether the use of the resources does begin to meet its potential will probably depend largely upon the removal of existing barriers and the provision of new opportunities. Some of these possibilities are described in the next two sections.

FIGURE 6



POTENTIAL GEOTHERMAL RESOURCE USE AREAS IN COLORADO FOR SCENARIOS, JUNE, 1978.

Figure 7.

POSSIBLE GEOTHERMAL ENERGY DEVELOPMENT SCHEDULE
FOR COLORADO

Low Temperature

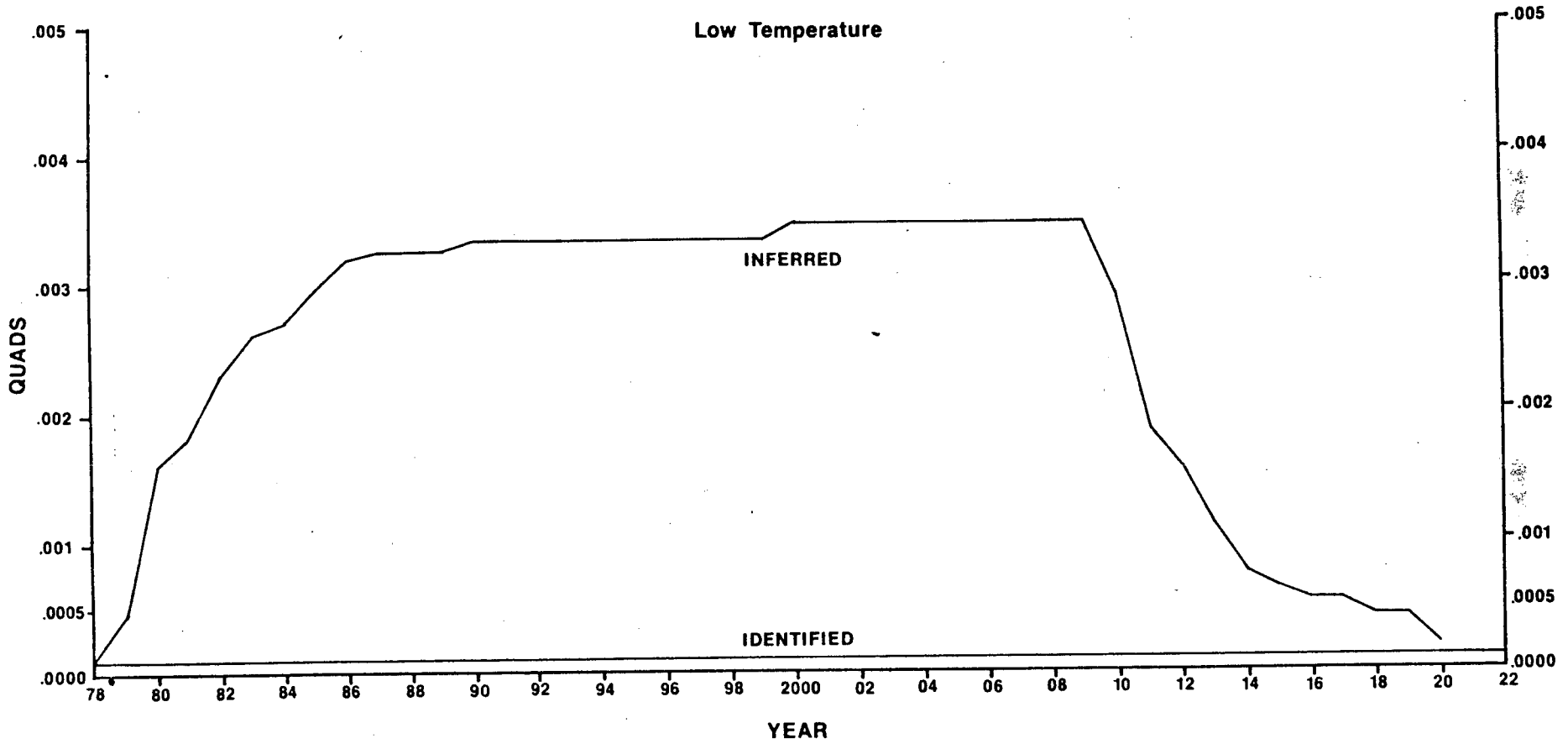


TABLE 11
SOME POTENTIAL USES FOR

GEOTHERMAL RESOURCES

IN COLORADO

POWER GENERATION

SPACE HEATING OF SCHOOLS, OFFICES, STORES, HOMES, WAREHOUSES, ETC.

WATER HEATING

SPACE COOLING

REFRIGERATION OF FOOD PRODUCTS SUCH AS FRUIT, LETTUCE, SPINACH

BIOMASS PROCESSING FOR FUEL, FERTILIZER

FEEDLOT WARMING

LIVESTOCK PEN WARMING FOR POULTRY, HOGS

CROP DRYING SUCH AS ALFALFA

DIATOMACEOUS EARTH DRYING

APPLE, PEACH, PEAR, PRUNE, APRICOT DEHYDRATION AND FREEZE-DRYING

POTATO, ONION, CARROTS, TOMATO, BELL PEPPER, CHILI DEHYDRATION

WOOD CHEMICALS

MANUFACTURE OF PLYWOOD, VENEER, PARTICLE BOARD, LUMBER CURING

PAPER AND PULP

DAIRY FARMING INCLUDING MILK CHILLING AND PASTEURIZATION

MUSHROOM GROWING

FREEZE DRYING

SODIUM CHLORIDE PRODUCTION

SOIL STERILIZATION

SEED DRYING

NAHCOLITE DAWSONITE PROCESSING

ALUNITE PROCESSING

WOOL DRYING

SWIM POOLS, BATHS

TROPICAL GARDENS

CONSTRAINTS TO GEOTHERMAL DEVELOPMENT

Several conditions have constrained geothermal development in Colorado. Among the most prominent are federal regulations and procedures for leasing and permit approval and the lack of financial incentives. Other conditions may limit development in the future. Among these are state water policy and laws. Probably the most restrictive constraint, though, is the lack of a system for delivery of geothermal energy for direct use. The following describes these constraints in some detail.

Leases and permits - One severe constraint is the inability of developers to obtain the necessary leases. Even if all other conditions are favorable, without leases to protect the company's investment, no development can proceed. In Colorado, leases on national forest lands are needed in the Mt. Princeton and Poncha Springs areas, and fee leases are needed in the Cebolla area. Applications for leases on national forest lands have been pending since 1974. In light of the failure of the Forest Service to aid in the issuance of leases, it seems probable that their goals conflict with the goal of acceleration of geothermal development. The problem may well be one of conflicting legislative mandates, which can only be resolved legislatively.

Obtaining permits for geothermal operations on federal lands is sometimes a long and tedious process. Such delays can cause investment funds to be diverted to other investments. Only when investors can expect a return on their investment in a reasonable or at least predictable time are they willing to commit to that investment. Furthermore, such delays can simply frustrate potential developers such that they abandon the effort.

Economics - Natural gas prices are not yet high enough to generate widespread conversion of direct use systems such as space heating from natural gas to geothermal resources. Even though many types of projects are economically feasible, drilling test wells to locate the resources is costly and risky. The current tax structure provides no incentives for the encouragement of geothermal exploration.

Financing of geothermal projects can be a serious problem, even though numerous uses are economically feasible, barring retrofitting. Small communities or small businesses often lack funds to cover substantial front-end expenditures. Lenders may be reluctant to risk funds on innovative or untested projects. Bond issues are frequently defeated because of the reluctance or inability of taxpayers to become more heavily obligated. Indeed, many communities in Colorado with limited paid staffs may be severely limited in their ability even to prepare applications for federal grants.

System Development - Although industry is undertaking high-temperature geothermal development, currently no formalized system for low-temperature geothermal development exists in Colorado. Technicians in numerous fields are evaluating resources, potential uses and constraints, and potential users are exploring geothermal applications in various industrial and agricultural processes. Communities are planning establishment of district heating systems. But for a commercial geothermal energy industry to develop, in this as in any other commercial venture, able and determined enterpreneurs must see and then seize the opportunity to make a profit. Few people are aware of the potential of the resource, know how to use it, and have the necessary funds to develop it.

Technology - There are no apparent major constraints to geothermal development arising from technology deficiencies. What could be a problem, however, is that sufficient amounts of the necessary equipment and services might not be available. This includes drill rigs, pipe and other hardware, plus the skilled workers to build and operate the equipment. Furthermore, an increased demand could in the future increase geothermal development costs such that geothermal energy is still not competitive.

Environment Reports - Environmental assessments will be necessary prior to many new geothermal developments. The manpower requirements for assessments, and when necessary, for environmental impact statements, could be enormous were an accelerated development program to be initiated.

Water - The availability of water will be a major consideration in Colorado as in other western states in geothermal development plans. Most projects will need to avoid excessive consumptive use of water. Heat exchangers can be of help where practicable, as can reinjection of the fluid.

The limitation of water rights may also indirectly affect the development. For example, new water rights may be unavailable in the San Luis Valley, one of the prime areas for low-temperature geothermal development. Since Colorado must meet its treaty obligations to provide water from the Rio Grande River, concern has been expressed that existing water rights might be endangered in the future. If so, the lack of water could limit future agricultural production in the Valley and thereby curtail operation of processing plants for agricultural products.

Some of these conditions are now limiting geothermal development. Others are possibilities that may or may not come to pass in the future. There will undoubtedly be others that are as yet unidentified. These conditions are controlled by various sectors, some are by the federal government, some by the energy industry, by potential users and potential enterpreneurs, others by the physical attributes of the sites. The U.S. Department of Energy, Geothermal Resources Division, is making a concentrated effort to find ways to relieve constraints to geothermal development. If the State of Colorado should also choose to encourage the use of geothermal resources, undoubtedly appropriate legislation and policy could be enacted that would aid that goal.

SUMMARY AND CONCLUSIONS

This 10-month study has attempted to estimate the potential for geothermal resource development in Colorado. It has also attempted to identify those conditions that seem to impede that development. As a third objective, it has attempted to identify at least preliminarily those actions that seem necessary to advance the development of geothermal resources.

The results show that geothermal resources in Colorado do have significant potential. Geothermal energy in the amount of 5.914 quads was estimated to be in the 56 hydrothermal (hot water) systems identified in Colorado. This is theoretically sufficient for heating more than 112,000 homes for a 30-year period.

However, geothermal energy use is limited by the distance it can be transported. For that reason, industry has been interested primarily in high-temperature resources for power generation. Since most of Colorado's resources seem more suitable for such near-site uses as space heating, a site-specific assessment was necessary for these. That analysis illustrated that most resource areas are close enough to population concentrations to be useful. There is, however, a lack of congruency between the magnitudes of the energy demand and supply in many areas. Even so, at least 30 communities seem to be candidates for obtaining all or part of their space- and water-heating needs from geothermal energy.

Based on the analysis, more than 16,000 homes, plus commercial, industrial, and public buildings could be supplied with heat and hot water. Along with this, heat could be supplied for such process uses as dehydrating vegetables and fruits, malting barley, warming hog pens and drying timber. Furthermore, 5 electrical generating units of 50 MWe each could be operating. The technology is readily available for all of these uses.

The system for developing geothermal resources in Colorado seems, so far, to be reasonably straightforward. Geothermal leasing on public land is permitted by law and regulation. Experts are available to provide the necessary services. The state regulatory system seems reasonable. In light of this, the question then is, "why are the geothermal resources not being developed?"

Several impediments seem to be conspicuous. The most important one seems to be a lack of market demand for geothermal resources. Until recently natural gas was plentiful and cheap in most areas in Colorado. Even now, natural gas costs may not be sufficiently high to stimulate competition from geothermal where the expense of conversion of heating systems must be borne. If natural gas prices increase substantially, through deregulation or additional taxes, all alternatives will become more attractive. Federal incentives, such as depletion allowances and tax credits, would probably stimulate geothermal development even more. Other forms, such as a direct subsidy of part of the cost of drilling test wells, may be appropriate.

Secondly, policies and actions of public agencies and other institutions profoundly influence development of energy resources. The existing leasing laws and procedures make obtaining federal leases in advance of major exploration necessary. Those same laws and procedures make it virtually impossible to obtain geothermal leases, at least on national forest lands. Leasing problems must be reconciled in some manner if significant development of

geothermal resources is to to occur. Although these problems might be resolved through the development of more efficient procedures, they may require action as strong as new legislation. To make investing in geothermal resource development a sound venture, criteria for designation of a known geothermal resource area might need to be revised and leasing might need to include provisions to protect and motivate the developer.

A third constraint is that geothermal development is expensive, initially, and includes a certain amount of risk. Few communities or interested entrepreneurs at this stage have the financial means to support the front-end costs of an entire geothermal development process. For low-temperature development, federal loan and grant programs will be of the utmost benefit for initiating geothermal resource uses that can then serve to stimulate ideas and action in other areas. At this stage, too, technical assistance for planning and feasibility studies will probably be a key ingredient in accelerating or even initiating geothermal development in Colorado.

A fourth hindrance may be illustrated by the following excerpt from the report Future Energy Alternatives for Colorado: "Geothermal energy is estimated to be minimal" [because of the] "lack of knowledge about Colorado's geothermal resources and the economics of geothermal development" (CERI, 1976, p. 51). Enlightenment of both lay persons and professionals in the energy field is essential if geothermal development is to be realized. Demonstration programs and information dissemination programs can be of enormous benefit in making known the opportunities geothermal resources offer.

The accomplishment of geothermal development, at least the low-temperature resources, appears at this time to be largely dependent upon federal government assistance. An attempt was made, therefore, to list and quantify the actions by the various federal agencies that seem necessary in order to realize the development envisioned in the scenarios. Although this is only one of many possible views, it may at least provide a starting place for further discussion of ways to stimulate development of this idle resource.

As shown in Table 12, federally guaranteed loans or grants will probably be needed for up to 13 geothermal utility systems. Federal funding for as many as 11 test wells may be needed. Another small sum is indicated for an Outreach Program to disseminate information and provide technical assistance. About 13 federal leases, most on national forest land, might need to be issued by the BLM in order to accomplish the geothermal development. To develop these leases, at least 10 environmental reports would have to be prepared by the U.S. Forest Service and about 30 permits would have to be issued by the U.S. Geological Survey. After this investment of federal funds, it is conjectured that private industry will be firmly established and will continue the development using private monies.

These are substantial commitments of monetary resources and staff time, for which economic analyses have not yet been done. Such analyses will indicate what monetary value may result from what level of investment. Undoubtedly, the direct costs and the direct benefits of both programs and individual projects will be calculated. Individual projects will probably be weighed in two different ways, both as government investments and as potential business investments. But such commitments must also be weighed in the context of the long-range potential and the long-range opportunity.

TABLE 12
REQUIRED FEDERAL AGENCY ACTIVITIES
FOR LOW TEMPERATURE GEOTHERMAL RESOURCE DEVELOPMENT IN COLORADO
INDICATED BY SECOND ITERATION SCENARIOS

NUMBER OF ACTIVITIES AND DOLLARS

Agency and Activity	YEAR 1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
DOE - GUARANTEED LOAN OR GRANT -														
SYSTEM DEV.*	3 $2,000,000	5 $2,000,000	5 $4,500,000											
TEST WELL *	4 $ 600,000	7 $1,000,000												
OUTREACH PROGRAM*	Consultant, part-time $ 10,000	$ 20,000												
BLM - ISSUE LEASES-														
BLM LAND	2													
FS LAND		1	6	3								1		
R.O.W.-BLM LAND		1				1								
USFS - EAR'S/EIS'S	1	6	3								1			
R.O.W.			1			4								
USGS - PERMITS -														
TEST WELLS - BLM LAND		1				3								
USFS LAND			1	2	3									
FIELD DEV - BLM LAND		2		4		4								
USFS LAND		2		3	1	1		2						1
SYSTEM DEV. -														

As an example, retrofitting of structures now might effect economies of scale in the long run, although conversion from natural gas to geothermal heating is generally not considered to be economically feasible currently.

A community may have insufficient new construction to support a geothermal well, yet new structures that are being built may be forced to use electric heat. Developing geothermal resources now could assure that the energy would be available as needed and effect economies of scale over a longer period.

Also, because of moratoriums on gas taps in many parts of the State, electricity is becoming more and more popular for space heating. Not only is such use thermodynamically inefficient, but increased electricity demand must ultimately require more power-plant capacity. Use of thermodynamically efficient geothermal resources for space heating can keep the demand for electricity from increasing unnecessarily (Elmer, 1977).

Also, development of geothermal resources may spur the development of new industry. New jobs could be created in the geothermal industry itself if private business takes up the task of geothermal development for both high- and low-temperature resources. Secondary employment would then be generated by the need for supplies and services. Further, the availability of geothermal energy can attract new energy-using industries. This could significantly improve the economy of many areas of the state.

Other considerations are nonquantifiable. The resource temperatures are appropriate to the direct uses, enhancing energy efficiency. Many of the geothermal systems will probably be renewable. One use for which the resources are ideally suited, namely space heating, is an essential energy need, not a frivolous one. These attributes may outweigh other more concrete ones in decisions by individuals, industry, and government to invest both money and time in geothermal development.

None of Colorado's resource areas are currently in the development phase. Some leases have been issued, and some preliminary exploration has occurred. Planning and preliminary studies that are both completed and underway may lead to development in the near future. Seemingly, interest in and awareness of the resources is growing. If leases and permits are made available, along with some economic incentives, some or all of the three potential power-generation sites may be developed by private industry. Perhaps with the assistance of Federal programs initially, lower temperature resources, too, will be developed by private industry. While government can provide opportunities, the outcome depends upon the decisions of numerous individuals throughout the system. Colorado does have geothermal resources that can contribute to the energy supply. It remains to be seen whether these resources will fulfill their promise.

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APPENDIX A

STATUS OF

GEOTHERMAL WELLS IN PAGOSA SPRINGS

AS OF OCTOBER, 1977

	WELL DESCRIPTION AND NUMBER	TEMPERATURE	DEPTH	DATES	STATUS	WELL NAME
1.	Spa Motel, by Pool	46°C	400'(+)		in use	Giordano #1
2.	(Spring Inn) by Spa Motel		385'(+)		not used	Spring Inn
3.	N. parking lot by river				abandoned	
4.	Courthouse well		85'(±)	~1930 (d)	in use	Courthouse
5.	Plugged courthouse well	56°C	85'(±)	~1920 (d)	abandoned	Abandoned courthouse
6.	Courthouse- SW	~44°C (?)	85'	~1935 (d)	not used	Martinez
7.	Texaco Well- E	57°C	85'		in use	Texaco #1
8.	Texaco Well- W					Texaco #2
9.	County garage					County garage
10.	New Football Field				abandoned	Football field
11.	Harvey Catchpoles Well					Catchpole
12.	Perkins' Well					Perkins
13.	Standard Station	59°C	~300-400'		in use	Amoco
14.	Brown Well (Wilsey)				in use	Brown-Wilsey
15.	Montroy Well				to be used	Montroy
16.	Rexall Drugstore			1964 (a)	abandoned	Drugstore
17.						
18.						
19.						
20.	Rumbaugh Well	~58°C (?)		late 1920's (d)	in use	Rumbaugh
21.	Well behind Adobe Inn				not used	Bank
22.	W.of Adobe Inn by Lewis St.	67°C (?)		early 1900's(d)	in use	Adobe Inn
23.	Methodist Church	56°C	400'	1969 (d)	in use	Methodist Church
24.	O.B.Sanders	34°C	468'	1960 (d)	in use	Sanders
25.	Spa Motel well near Spring Inn Well	52°C	400'(+)		in use	Giordano #2
26.	Spa Motel N of bathouse	43°C		1954 (d)	in use	Giordano #3
27.	Sinter Cone well N.of river	54°C				Sinter Cone
28.						

(d) drilled
(a) abandoned

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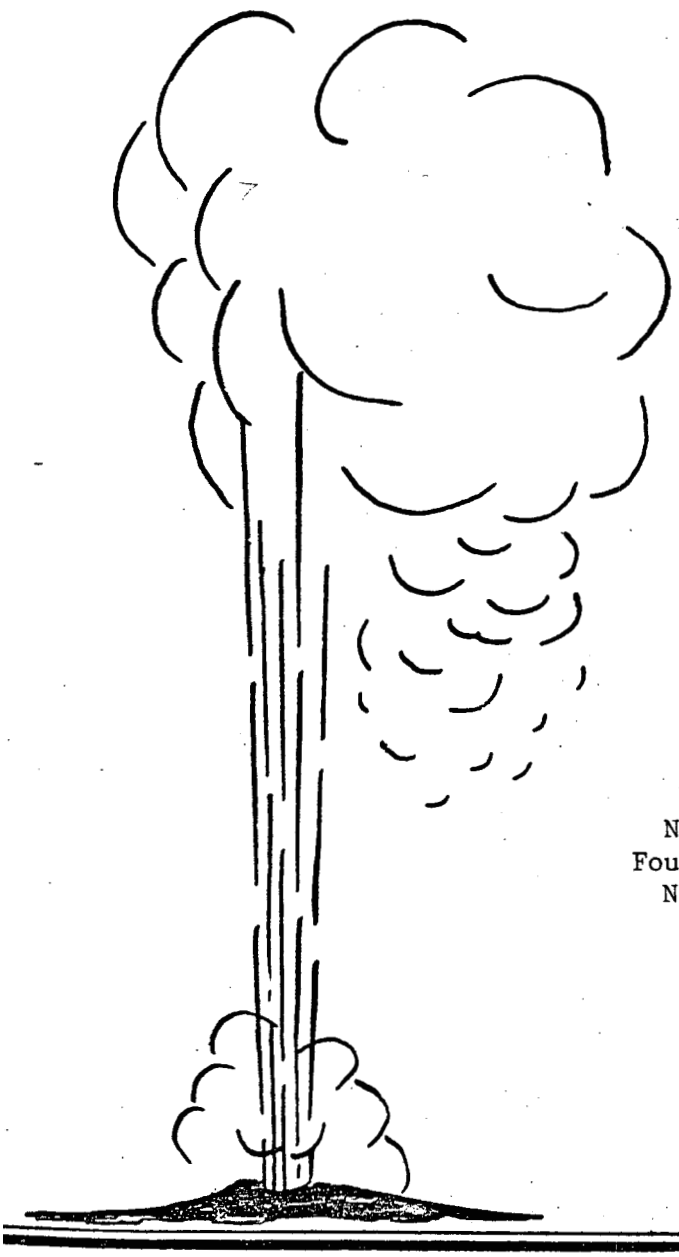

NEVADA SOUTHWEST REGIONAL GEOTHERMAL DEVELOPMENT OPERATIONS RESEARCH PROJECT

Appendix 8 of

REGIONAL OPERATIONS RESEARCH PROGRAM
FOR DEVELOPMENT OF GEOTHERMAL ENERGY
IN THE SOUTHWEST UNITED STATES

Final Technical Report
June 1977 to August 1978

Nevada Department of Energy
Noel A. Clark
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January 1979

Work Performed under DOE Contract No. EG-77-S043992
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New Mexico Energy Institute at
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Las Cruces, New Mexico 88003

U. S. DEPARTMENT OF ENERGY
Geothermal Energy

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Final Report

NEVADA

SOUTHWEST REGIONAL GEOTHERMAL

DEVELOPMENT OPERATIONS RESEARCH PROJECT

First Year

Prepared by

Nevada State Team
G. Martin Booth III
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Barbara K. Helseth

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New Mexico Energy Institute
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Las Cruces, New Mexico

July 7, 1978

TABLE OF CONTENTS

		Page
List of Tables		v
List of Figures		vi
1.0	Area Scenarios, Nevada - Second Iteration	1
1.1	Introduction	1
1.2	Area Scenarios and Postulated Site Development Schedule for First Electric and/or Direct Thermal Use Plant	1
1.3	Scenario Summary and Conclusions	3
1.4	Area and Site Evaluation Technique	5
1.4.1	Nevada Geothermal Areas	6
1.4.2	Circular 726	6
2.0	Recommendations for Stimulating the Lethargic Development of Geothermal Energy in the State of Nevada	9
3.0	Leasing Activity	11
3.1	Federal Land	11
3.1.1	KGRAs	11
3.1.2	Non-KGRAs	11
3.2	State Land	11
3.3	Private Land	12
4.0	Nevada Drilling Activity	13
4.1	Production Wells	13
4.2	Injection Wells	13
4.3	Temperature Gradient Holes	14
4.4	Exploration	14

TABLE OF CONTENTS (Continued)

		Page
5.0	Environmental Assessment Record (EAR)	15
	5.1 EAR's Relationship to Project	15
	5.2 Progress to Date	16
	5.3 Criteria Used to Evaluate Data from EAR's for Delineation and Compilation - Phase IV	16
6.0	Special Research Project: Study of Nevada State Geothermal Rules and Regulations	21
7.0	U. S. Geological Survey - Menlo Park	22
8.0	Regional Planning Workshop/April 26, 1978	23
9.0	Regional Planning Workshop/June 28, 1978	24
10.0	Geothermal Streamlining Task Force Workshop/ June 28 and 29, 1978	24
11.0	Geothermal Reservoir Case Study Northern Basin and Range	26
12.0	Geothermal Loan Guaranty Program - Brady's Hot Springs	29

APPENDICES

A	Nevada State Team Organization	A-1
B	Nevada State Team Advisory Committee	B-1
C	Humboldt House Data Sheet	C-1
D	Exploratory Geothermal Drilling in Nevada	D-1
E	Notice of Intent	E-1
F	Temperature Gradient Holes	F-1
G	EAR's from BLM	G-1
H	BLM Map of Nevada State Office District Boundaries	H-1
I	Land Use Planning and Management Units	I-1
J	Nevada Map of Resource Area, Planning Unit, and District Boundaries	J-1

TABLE OF CONTENTS (Continued)

		Page
APPENDICES (Continued)		
K	Components of the Environments for EAR Stipulations	K-1
L	Explanation of Land Categories	L-1
M	Summary of Nevada State Team Presentation at Regional Planning Workshop, April 26, 1978	M-1

LIST OF TABLES

		Page
1	List of Resource Areas for which there are Postulated Site Development Schedules for Each of Nevada's Geothermal Areas	2
2	Identified Nevada Hot-Water Convection Systems with Indicated Subsurface Temperatures above 150°C (from USGS Circular 726)	6
3	Identified Nevada Hot-Water Convection Systems with Indicated Subsurface Temperatures 90° to 150°C (from USGS Circular 726)	7

LIST OF FIGURES

		Page
1.	Physiographic Units Map of the Western United States	27
2.	Index Map of Battle Mountain Heat Flow High, Northern Basin and Range Province	28

1.0 AREA SCENARIOS, NEVADA - SECOND ITERATION

1.1 Introduction

By the end of the first year of the Southwest Regional Geothermal Project, the Nevada State Team has defined over 300 geothermal sites. Because of the multitude of sites and data, scenarios for this first project-year have been completed for the twenty-six Nevada Geothermal Areas, which include all the specific sites. It is not improbable that fully one-third of the sites will eventually prove to be of high to intermediate temperature (i.e. > 150°C and 90° - 150°C) resources. Low temperature sites are also prominent, not only in number, but also in their distribution - each of Nevada's 17 counties has several such sites.

1.2 Area Scenarios and Postulated Site Development Schedule for First Electric and/or Direct Thermal Use Plants

Area scenarios have been developed for each of the twenty-six State Geothermal Areas. For each Area a Postulated Site Development Schedule has been constructed for the first electrical generating plant and/or the first direct thermal use plant (Table 1) to come on line. A total of 31 postulated Site Development Scenarios have been constructed (See Appendix 5 of DOE Report - ALO/3992-1).

Each Area scenario also includes a Composite Postulated Site Development Schedule, which includes a listing of site (Resource Area) names. Those Sites, which presently appear to have a reasonable chance for commercial development by the year 2020, have been given a postulated

TABLE 1. List of Resource Areas for which there are Postulated Site Development Schedules for Each of Nevada's Geothermal Areas.

Resource Area Name	Utilization	State Geothermal Area
The Needles Rocks	Electric	1
Dyke Hot Springs	Electric	2
Cordero Mercury Mine	Electric	3
Hot Sulphur Springs	Electric	4
Humboldt Wells	Electric	5
San Emidio Desert	Electric	6
MacFairlane's	Electric	7
Rye Patch	Electric	8
Golconda	Direct Thermal	9
Leach Hot Springs	Electric	10
Battle Mountain	District Thermal	11
Beowawe Geysers	Electric	12
Darrough's Hot Springs	Electric	13
Elko Hot Springs	Direct Thermal	13
Sulphur Hot Springs	Electric	14
Steamboat Spring-Huffaker	Electric	15
	Direct Thermal	15
Desert Peak	Electric	16
Brady's Hot Springs	Direct Thermal	16
Carson Sink-Alkali Flat, West Side	Electric	17
Soda Lake-Upsal Hogback	Electric	18
	Direct Thermal	18
Dixie Hot Springs	Electric	19
Wabuska Hot Springs	Electric	20
	Direct Thermal	20
Dead Horse Wells-Wedell Springs	Electric	21
Sodaville Springs	Direct Thermal	22
Fish Lake Valley	Electric	23
Warm Springs	Electric	24
Caliente Hot Springs	Direct Thermal	25
Sarcobatus Falt-Beatty	Direct Thermal	26

development schedule.[1] The schedules are given in megawatts where

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BEFORE PROCEEDING FURTHER

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utilization would be for electrical power generation, and in quads, where the heat resource would be used directly.

The postulated energy on line for each Site (and Area) is shown for a 30 year resource life to the year 2020: (1) in cumulative form for electrical generation, and (2) in useable reservoir energy for direct use evenly divided over reservoir life. The remaining Sites listed are largely unknown quantities at this time.

The power or energy postulated to be on line is based very largely on subjective judgements, since pertinent factual data is at best sketchy, and normally entirely lacking.

1.3 Scenario Summary and Conclusions

The Postulated Development Schedule for Nevada Geothermal Areas for Electric Power Generation (in MWe) and Direct Thermal Utilization (in Quads) is given in Appendix 5 of the DOE Report - ALO/3992-1. The prognosis for development to the year 2020 assumes development of the resource in each

---

[1] Although this report gives numerical energy capacities to sites with specific names, it must be strongly emphasized that the technical criteria for competent estimations is almost entirely lacking. It is fully expected that many electric sites will be incapable of providing a single megawatt, while some, not yet recognized, will provide substantial power. The estimates are largely subjective judgements which are more credible in aggregate for the State than for each specific site.

one of the twenty-six Areas. Thirty-one scenarios covering these Areas include twenty-one for electric power generation and ten for direct thermal utilization.

The first electric plant may be a 20 MWe installation of Phillips Petroleum Co. and Sierra Pacific Power Co. on private land. The scenario shows a Commitment to Development in 1979, with power-on-line in 1982. For the State as a whole power-on-line from 1985 to 2020 would be:

MWe	Year
195	1985
2,120	1990
5,030	1995
7,785	2000
10,120	2005
12,400	2010
14,095	2015
(14,240)	2020

The apparent slackening in energy use (or availability) as shown in Total MWe (from year 2116) and in Total Quads (from year 2005) is statistical in nature. For details, see Appendix 5 of DOE report - ALO/3992-1). Although the reservoirs are assumed to have a life of 30 years for these projections, in actuality they undoubtedly will be much longer. Further, newly developed reservoirs will provide additions not specifically taken into account here. Therefore, the highest best guess for electric, 14,240 MWE in year 2016 and for direct utilization, 0.618 Quads in year 2005, are somewhat conservative.

Direct Thermal utilization is presently grossly underdeveloped at all sites in Nevada. The ten scenarios are indicative of major expansions at presently used sites, plus initiation of direct thermal use in wholly new Resource Areas.

Geothermal Food Processors, Inc. received a DOE Guaranteed Loan in October 1977, and will be on line with their $3 million food dehydration operation in September 1978. The prognosis for quads available at sites which may show major development between 1985 and 2020 are:

Quads Available	Year
0.144	1985
0.333	1990
0.461	1995
0.571	2000
0.618	2005
(0.618)	2010
(0.618)	2015
(0.618)	2020

The energy (in quads) available for commercial use at each site, is unlikely to be wholly utilized; nor is it assumed to be developed in the optimum or most efficient manner within the prescribed time frame.

1.4 Area and Site Evaluation Technique

The State of Nevada is divided into twenty-six geothermal areas, each area having a number of geothermal sites. The individual sites are by definition those localities where there are thermal springs, thermal well water, and/or geothermal leasing activity.

1.4.1 NEVADA GEOTHERMAL AREAS

Consideration has been given to geothermal site distribution, density, and character; topography, and land status, in outlining each of the twenty-six Areas. To the east and south where prospective sites are fewer and usually of low temperature, AMS sheet boundaries may, in part, form the boundaries of some Areas.

1.4.2 CIRCULAR 726

The resource assessment of thirty-nine high and intermediate temperature geothermal sites in Nevada was presented by the U. S. Geological Survey in Circular 726 (1975) and are shown in Table 2 and 3.

TABLE 2. Identified Nevada Hot-Water convection systems with indicated subsurface temperatures above 150°C (from USGS Circular 726).

Beowawe Hot Spring
Kyle Hot Spring
Leach Hot Spring
Hot Springs Ranch
Jersey Valley Hot Spring
Stillwater Area
Soda Lake
Brady Hot Spring
Steamboat Springs
Wabaska Hot Spring
Lee Hot Spring
Smith Creek Valley

These sites each have surface and subsurface temperatures. The subsurface temperatures are either, (1) measured reservoir, (2) silica geothermometer, or (3) Na-K-Ca geothermometer.

Normally each of the other sites will have a spring or well water temperature, but no geothermometer temperature. In order to make judgements or submit certain assumptions for planning purposes, temperatures, reservoir characteristics, and energy potentials had to be grossly

quantified for a total of 102 sites. This data is shown on the Hot-Water Convections Systems sheet for each Area scenario (See Appendix 5 of DOE Report - ALO/3992-1).

Based upon these semi-quantitative data, along with information on the Non-Technical Components section for each site, Postulated Site Development

TABLE 3. Identified Nevada hot-water convection systems with indicated subsurface temperatures from 90° to 150°C (from USGS Circular 726).

Bog Hot Spring	
Howard Hot Spring	
Dyke Hot Spring	
Near Soldier Meadow (Soldier Meadows Hot Springs)	
Double Hot Spring	Double Hot Spring-Black Rock Hot Spring
Near Black Rock	
Fly Ranch Hot Spring	
Butte Spring (Trego)	
Mineral Hot Spring	
Hot Hole (Elko Hot Springs)	
Near Carlin (Carlin)	
Hot Sulphur Springs (Humboldt Wells)	
Hot Springs Point	
Walti Hot Springs	
Spencer Hot Spring	
Hot Pot	
Buffalo Valley Hot Spring	
Hot Springs (The Hot Springs)	
Golconda Hot Spring	
Sou or Gilberts Hot Springs	
Dixie Hot Spring	
The Needles (The Needles Rocks)	
Walleys Hot Spring	
Nevada Hot Spring (Hind's Hot Springs)	
Darrough Hot Spring	
Warm Springs	
Bartholomae Hot Spring (Klobe Hot Spring)	

Schedules were constructed for the first electric power plant and/or the first significant direct thermal project for each Area.

The planner should be aware that the site scheduels suggested are not much more than best guesses for most of the sites. Only when deep exploratory

drilling has penetrated the reservoir at a site, should the planner begin to have confidence in a site specific resource assessment.

Too much dependence must not be put on specific site scenarios to gauge progress of the geothermal industry. Much more is unknown than is understood. For example, four years ago the Desert Peak and Rye Patch (or Humboldt House) geothermal sites of Phillips Petroleum Co., areas without thermal springs - were essentially "blind" prospects. Today these areas are probably the most explored (drilled) geothermal resource areas in Nevada. Brady's Hot Springs, with numerous exploratory test wells was a prime electrical power site just a short time ago. But today there is under construction, a major food dehydration plant (on-line in September 1978) backed by a $3 million DOE Loan Guaranty.

2.0 RECOMMENDATIONS FOR STIMULATING THE LETHARGIC DEVELOPMENT OF GEOTHERMAL ENERGY IN THE STATE OF NEVADA

The foremost barrier to the development of geothermal resources in the State of Nevada is the fact that 86 percent of the lands are under Federal jurisdiction. There is an insignificant amount of State lands to lease; and diligent, workmanlike development on fee lands creates no problems with the private land owner who also holds the original geothermal rights.

Geothermal energy development needs stimulation in several areas simply because it is presently a poor investment in comparison to other energy sources such as oil, gas, coal, and uranium. In order to improve the present status of the geothermal energy industry, within this state, it will be necessary to pay more attention to factors which adversely affect the rate of return of those companies that are undertaking its development. Geothermal energy is in direct competition for investment dollars with the established, energy industries, yet the Federal government has not seen fit to create a fair and equitable environment for it to grow.

Development within the industry is really a long-term educational process of gaining an understanding of the geothermal reservoir, which has little or no similarities to oil or gas reservoirs, or a mineral deposit. The overall tendency of the Federal regulatory and taxing agencies, as well as Congress, is to assume that:

(1) The geothermal industry can be treated as one that is robust and mature; and a rather attractive investment for venture capital, and

(2) Everything that could possibly have a detrimental effect on the environment and indirectly, on the "consumer," will be done - - and led by the "big oil and coal companies."

The Institutional Barrier Panel to the Geothermal Advisory Council has reported on institutional and legal barriers to geothermal energy development,

along with many other committees, commissions, and boards for the past several years. Despite continued efforts from within DOE/DGE, industry, and other concerned and knowledgeable parties, who strive to make improvements, the policy and law makers in Washington, D.C. have not remedied the situation - - despite our Nation's growing concern for new energy supplies and conservation.

Positive advancement of geothermal energy development in Nevada can be achieved if provision is made for:

(1) Amendments to the Federal tax code for the, (a) expensing of intangible drilling costs, and (b) percentage depletion.

(2) Abolishment of KGRA's.

(3) Set time limits or timeframes (through administrative directive and/or regulations) for issuance of leases and permits.

(4) Improve uniformity and consistency of policies and procedures with respect to lease stipulations among the involved agencies. Provide for equal representation of the involved Federal agencies, the Western States, industry, and environmentalists on high-level boards which make policy for the stipulations.

(5) Improvement of the ponderous and time consuming methods of handling the "necessary" paperwork of BLM and USGS Conservation Division from the time lag of leasing through development.

(6) Initiation of a Federal investment tax credit for the developer.

(7) Increasing the total allowable Federal lease acreage a company or individual may hold in a single state - from 20,480 to 51,200 acres.

(8) The continuation of the DOE/DGE Case History Program - at a higher funding level.

(9) Continue the present DOE/DGE Loan Guaranty Program.

(10) Abolishment of taxation of non-productive leases by the State of Nevada.

3.0 LEASING ACTIVITY

Eighty-six (86) percent of the land in Nevada is Federally administered. Less than 2 per cent is State land. One-half of the remaining 12 percent is private land, of which is owned by the Southern Pacific Railroad.

3.1 Federal Land

Natural Resource or Public Domain land is administered by the Bureau of Land Management. It has leases totaling 881,971 acres (to February 1, 1978).

3.1.1 KGRAS

Of the total Federal acreage under lease, 152,662 acres were sold in 15 KGRA sales. to date, 23 of the 30 KGRAs in the state have been offered in public sales. A total of seventy-nine leases were sold for an average of 1,930 acres per lease.

3.1.2 NON-KGRAs

The 729,309 acres of Non-KGRA Federal leases (to February 1, 1978) is a poor gauge (i.e. low) as to geothermal potential and industry interest. The average application is approximately three (3) sections (1920 acres). There have been 1374 applications by over 150 different applicants since 1974, for an estimated 2,638,000 gross acres (to September 30, 1977). Included in this are several 100,000 acres of lease applications pending.

3.2 State Land

Less than 2 percent of Nevada is State owned land and therefore participation and interest has been low until very recently. The rapid change is due to the anticipated large scale commercial processing and electrical power generation which is nearing reality, just 60 miles from Reno at Brady's Hot Springs and Desert Peak.

3.3 Private Lands

An estimated 12 percent of the land in Nevada is privately owned. A large proportion of this land is leased and/or presently being evaluated. One half of the 12 percent private acreage is owned by the Southern Pacific Railroad, and being evaluated by an experienced operator, Phillips Petroleum Company, with offices in Reno. It is a reasonable estimate at this stage of the Southwest Regional Project, that 6 percent of the remaining private acreage which is held under lease by developers, is difficult to come by. Large percentages of this land is held by developers in the northern and western portions of Nevada, where the resource potential is very large.

4.0 NEVADA DRILLING ACTIVITY

Temperature gradient holes continue to be drilled on Private Lands, and such activities are not recorded with Federal and State Agencies.

Phillips Petroleum Company has submitted a Plan of Operation to drill six (6) geothermal test wells to a depth of 2438 meters (8,000 ft.) on Federal leases in the Rye Patch Reservoir area, Pershing County, Nevada. Included is a handout (Appendix C), data sheet on Phillips Petroleum Campbell E-1, geothermal well at Humboldt House (i.e., the Rye Patch site).

Exploratory drilling in Nevada to date amounts to 64 tests by private companies for the express purpose of developing the energy resource for electrical power generation. All of the drilling has been done on private lands. No deep tests have been on Federal lands, due to institutional barriers.

4.1 Production Wells

There are no wells now on production, but there are numerous wells which have the capability of providing sustained energy for electric power production, commercial processing, and other even lower temperature uses. These wells are included with the wells listed in the (Appendix D) Exploratory Geothermal Drilling in Nevada, a Publication of the Nevada Bureau of Mines and Geology.

There are many other thermal wells, not presently listed which are currently providing (or capable of providing) energy for commercial processing, space and recreational heating in many sections of the State.

4.2 Injection Wells

There is no present need for injection wells, but a number of the exploratory wells listed in Appendix D will undoubtedly be used for such purposes in the not too distant future.

4.3 Temperature Gradient Holes

As with the 64 Exploratory tests referred to above, most of the slim-hole temperature gradient holes have been drilled on private lands. Under these circumstances recordation of such activities is not made with federal or state agencies, and as such is not readily known. Even so, Bureau of Land Management has recorded 67 separate Notices of Intent to carry out temperature gradient surveys (Appendix E). Temperature gradient holes drilled on private lands are estimated to be in the thousands.

4.4 Exploration

Exploration in Nevada is at a high level considering the formidable institutional barriers holding up private development. Notices of Intent (Appendix E) show a serious effort on the part of industry in geophysical techniques as well as drilling. Further, the 1976-1977 Status Report for the Reno Geothermal District of the USGS shows a formidable amount of drilling for this recent period (Appendix F). The anticipated increase in deep tests is startling. At least 25 private, government and educational entities have filed such Notice.

"Casual" exploratory efforts such as geologic mapping and geochemical sampling of spring and well waters are not required to be recorded.

5.0 ENVIRONMENTAL ASSESSMENT RECORD (EAR)

Presently our research program is involved with the investigation of Environmental Assessment Records (EAR) for Nevada, as prepared by the Bureau of Land Management (BLM). These reports have been drafted in response to the National Environmental Policy Act of 1969. This Act addresses all Federal agencies to use a systematic, interdisciplinary approach in the decision-making which will affect man's environment. Both the natural and social sciences are integrated in these studies.

The EAR's are prepared in varying detail according to the anticipated impact of the decision on the environment. Therefore, we have found differences in the degree of analysis throughout the 20 (Appendix G) different EAR's received from BLM. Each EAR represents studies prepared for the separate Planning Units, Planning Areas and or Resource Areas which are found within the different BLM districts (Appendices H, I, and J).

5.1 EAR's Relationship to Project

The EAR has Several Purposes:

1. The major purpose is to make a recommendation, whether an Environmental Statement is necessary (ES).

2. As an aid in assuring consideration of environmental values at all Bureau levels of planning and decision-making.

3. And as a vehicle for recommending the most effective mitigating measures which can be used by the decision-maker to reduce adverse impacts.

It is the third purpose which is related to our current research into leasing patterns and trends.

Since most of the recommendations referring to leasable Federal Lands were defined in legal descriptions, we plotted the data on overlays for the 18 different AMS Quadrangles which cover the State of Nevada.

The compilation procedure is producing a graphic picture of the various environmental measures affecting the availability of Federal Lands for leasing.

No one has ever compiled this unique information in a graphic form using a State-wide or Regional format.

When these overlays are used in conjunction with our previously compiled leasing and drilling data, interesting patterns develop. Some areas of potential geothermal development show large blocks of land with various environmental stipulations. Another pattern in one of the most potential areas of Nevada, the Black Rock Desert, delineates sizeable areas which have been excluded from leasing, pending additional environmental studies, while a considerable number of geothermal lease applications are waiting for a final land use decision.

5.2 Progress To Date

The mitigating measures recommended in the EAR as to which lands are to be excluded from leasing, and which lands may be leaseable with particular stipulations, most certainly qualifies for inclusion, the Institutional factors which are being considered in the geothermal development programs. These recommendations can influence, as well as alter decisions, such as, leasing, exploration, development, financing, plant sites, power line corridors, and others.

This environmental data, along with the above mentioned leasing and drilling compilations, can be easily included in our Data Base System (RPPM) and is comparable with other retrievable information now in the data base storage.

5.3 Criteria Used to Evaluate Data from EAR's for Delineation and Compilation - Phase IV

The first step towards defining the criteria to be used, was to prepare a list of all the possible components described in the suggested or recommended stipulations for each EAR. Some of the various elements are: sage

grouse, bighorn sheep, Historic Places, archeological sites, withdrawn areas, and so on. Each component was given a number so delineated areas on the map could be identified. (Appendix K)

The second step was to establish an "intensity guide." This is the identification of KEY WORDS used to describe an area as to the recommended stipulations. Some of the KEY WORDS are:

critical

prime

detrimental

hazardous

multiple use

extremely

extinction

withdrawn

site-by-site

proposed

unique

endangered

excluded or exclusion from

Next, an explanation was developed so the two previous steps would have a framework in which they could be applied.

Two categories were defined:

I. Lands Excluded from Leasing

II. Leasing - with restrictions

Each of these categories was then sub-divided into two (2) groups each (Appendix L).

I. Lands Excluded from Leasing

a) No Leasing: (Solid lined areas colored red with either an encircled component number, or component number without a circle.)

This entire group is composed of selected areas where NO LEASING IS PERMITTED.

The determination as to whether the element number will be encircled or not is a judgement based on the intensity of the described lands AND the types of, and, number of elements for the described area. All of these areas will be described in EAR's as:

"Land Recommended to be Excluded from Leasing"

An Example:

Certain archaeological sites may be recommended for exclusion from leasing, but will not be described as intense areas of recommendation. So, these areas will appear as red areas, outlined with a solid line and have the element number, 21 within its boundary; or, an area designated as a Historical Place which has the qualification or has been proposed for the National Register of Historical Places will be identified with an encircled 23 and be colored red.

But, if the archaeological site is identified as an EXTREMELY VALUABLE site, then the number 21 will be encircled; likewise, if the historic Place is ALREADY on the National Register of Historic Places it will be shown or identified with the number 22 which will be encircled. It is almost certain that no future leasing will be allowed in these areas. (Virginia City is an example of both).

The point here is the application of the KEY WORDS and the text.

The Pine-Nut Walker EAR is a fine example of NO Leasing recommendations with KEY WORDS.

b) No Leasing-Pending: (Solid lined areas colored yellow with or without component numbers).

These areas have been identified as lands where there is PRESENTLY no leasing being permitted pending additional envirnmental studies. No land use decisions or project impacts upon the area can be or will be determined before these reports are completed.

It is possible these lands will be available for leasing in the near future, or perhaps, be permanently excluded from leasing.

The key for this group is:

"Pending additional environmental studies"

or

"Site-by-Site Study as leasing is proposed"

II. Leasing-With Restrictions

a) Non-Critical: (Dashed lined areas colored blue with associated component number).

This group includes lands subjected to the additional stipulations of restricted seasonal entry, as well as those stipulations already contained in the Geothermal Resource Lease, Sections 14, 18, and 19.

The key here is the ABSENCE of such key works as Critical.

b) Critical: (Dashed lined areas colored orange with a component number).

These lands are also subject to the regular stipulations found in the Geothermal lease, but have had ADDITIONAL stipulations placed upon the lessee.

All of these lands are defined as CRITICAL areas and will have special stipulations, such as:

- no surface entry
- no surface water use
- site-by-site consideration
- "prior to . . ."
- seasonal constraints (associated with critical habitat area)
- buffer zones
- siting improvements
- equipment limitations
- special reclamation techniques

The key to this group is the application of such words as "critical, endangered, natural areas," and so on.

Tonopah EAR is a fine example of the special stipulation.

Note: In each designated area, more than one element number may be applicable.

6.0 SPECIAL RESEARCH PROJECT: STUDY OF NEVADA STATE GEOTHERMAL RULES AND REGULATIONS

The professional services of Allan Buchanan were obtained to assist the Nevada State Team in a special research study into the State geothermal rules and regulations. Mr. Buchanan, who specializes in the energy field, holds a Public Intern position with the Nevada Department of Energy.

This on-going project details any and all rules and regulations on the State, county and municipality level which are of a direct concern to the development of geothermal energy. While conducting numerous personal interviews, in both the public and private sector, emphasis was directed at: possible legal and institutional constraints, case histories and experiences pertaining to direct thermal uses, and opportunities for development.

Numerous specific questions posed by the Core Team were also answered as a result of this study.

7.0 U. S. GEOLOGICAL SURVEY - MENLO PARK

A two day series of conferences with the U. S. Geological Survey at Menlo Park, California was initiated by members of the Nevada State Team in February 1978. This visist proved to be a very useful and productive one for the Team.

The meetings were held with personnel from the divisions of Conservation, Water Resources and Geology. Included in the discussions and data received, were the following:

(1) Geothermal Leasing Procedures

(2) KGRA classification and evaluations

(3) Geothermometry

(4) Low and High Temperature research work

(5) Water Resource data

(6) Circular 726

The USGS continues to be a valuable source of information and referral for the Nevada State Team.

8.0 REGIONAL PLANNING WORKSHOP/APRIL 26, 1978

The Southwest Regional Geothermal Development Operations Research Project, due to a organizational change in DOE/DGE, has recently come under the Rocky Mountain/Basin and Range Region.

The Nevada State OR Team was represented at the planning workshop in Salt Lake City, on April 26, conducted by personnel from DGE Headquarters, DOE Idaho Operations (ID), DGE Nevada operations, U. S. Geological Survey, EG&G Idaho, Inc. (the prime contractor to ID), and the Earth Science Laboratory of the University of Utah Research Institute.

Detailed short-and long-term planning activities included all aspects of stimulation of geothermal energy development from resource definition through utilization, encompassing presently existing programs as well as new programs.

Presentations by State Teams addressed the following topics (Summary of Nevada State Team presentation, Appendix M):

(1) Location and nature of known geothermal sites with emphasis on the best sites in terms of development of electrical generating capacity or direct heat uses.

(2) Potential for further resource discovery.

(3) OR data generated to date and its applications.

(4) Recommendations for future DGE programs and initiatives.

9.0 REGIONAL PLANNING WORKSHOP/JUNE 28, 1978

A second regional planning workshop was held in Salt Lake City on June 28 to review and comment on the DOE/DGE Draft Regional Hydrothermal Development Plan for the Rocky Mountain/Basin and Range Region. Representatives of industry also participated.

10.0 GEOTHERMAL STREAMLINING TASK FORCE WORKSHOP/JUNE 28 and 29, 1978

The Interagency Geothermal Streamlining Task Force held a meeting open to the public in Salt Lake City on June 28 and 29, in order to assist the Interagency Geothermal Coordinating Council (IGCC) in carrying out its mandate:

> "for assessing legal, environmental, regulatory, and other aspects of Federal, State, and Local government policy as they relate to geothermal energy and for developing recommendations for changes and improvements in related laws, policies and procedures, and for examination of other institutional aspects of geothermal energy, including non-governmental aspects."

Specifically, the Task Force is to develop recommendations to IGCC for appropriate action to implement the President's commitment to Congress that:

> "The Department of the Interior and Agriculture will streamline leasing and environmental review procedures to remove barriers to development to geothermal resources."

The commitment was prompted by the fact that although the Geothermal Steam Act was passed nearly seven and one-half years ago, there is still no commercial production of this resource on Federal lands.

It is widely known that the cumbersome Federal leasing and permitting program constitutes a major deterrent to timely development. As long as the inhibiting influence of the regulatory program clouds the rate of development on Federal lands, the effects of other impediments cannot be fully and accurately assessed.

The Geothermal Streamlining Task Force has undertaken a study which includes (1) a comprehensive analysis of the elements of the present program designed to identify the sources of delay and quantify delays which are actually occurring; and (2) to determine the potential effects upon program performance of a series of options for program modification. The effectiveness of alternative options will be assessed in terms of their relative ability to support the Department of Energy's projected geothermal power-on-line schedule while adequately protecting the public interest and the environment.

The study will also incorporate input provided by the public, industry, environmental groups, and state agency officials through a series of workshops held in the western states in June.

The Salt Lake City workshop was one such meeting which reviewed and commented on the series of options developed by the Task Force, for modifying the geothermal leasing and permitting program. In addition, discussion groups formally presented suggestions for additional alternatives.

11.0 GEOTHERMAL RESERVOIR CASE STUDY, NORTHERN BASIN AND RANGE PROVINCE

The Nevada Operations Office of DOE on March 31, 1978 solicited a proposal to provide data not now publicly available and from within the northern portion of the physiographic region known as the Basin and Range province (Figure 1.). More specifically, the area of interest is the high heat flow anomaly known as the Battle Mountain Heat Flow High, the approximate boundaries of which are depicted in Figure 2.

The great portion of the State of Nevada's most prospective geothermal sites are included in the subject of this RFP. The program will make available to the public this data which DOE acquires from successful proposers. The proposers may:

(1) Perform an investigation and offer new geological data, geothermal reservoir data, and/or reservoir engineering studies.

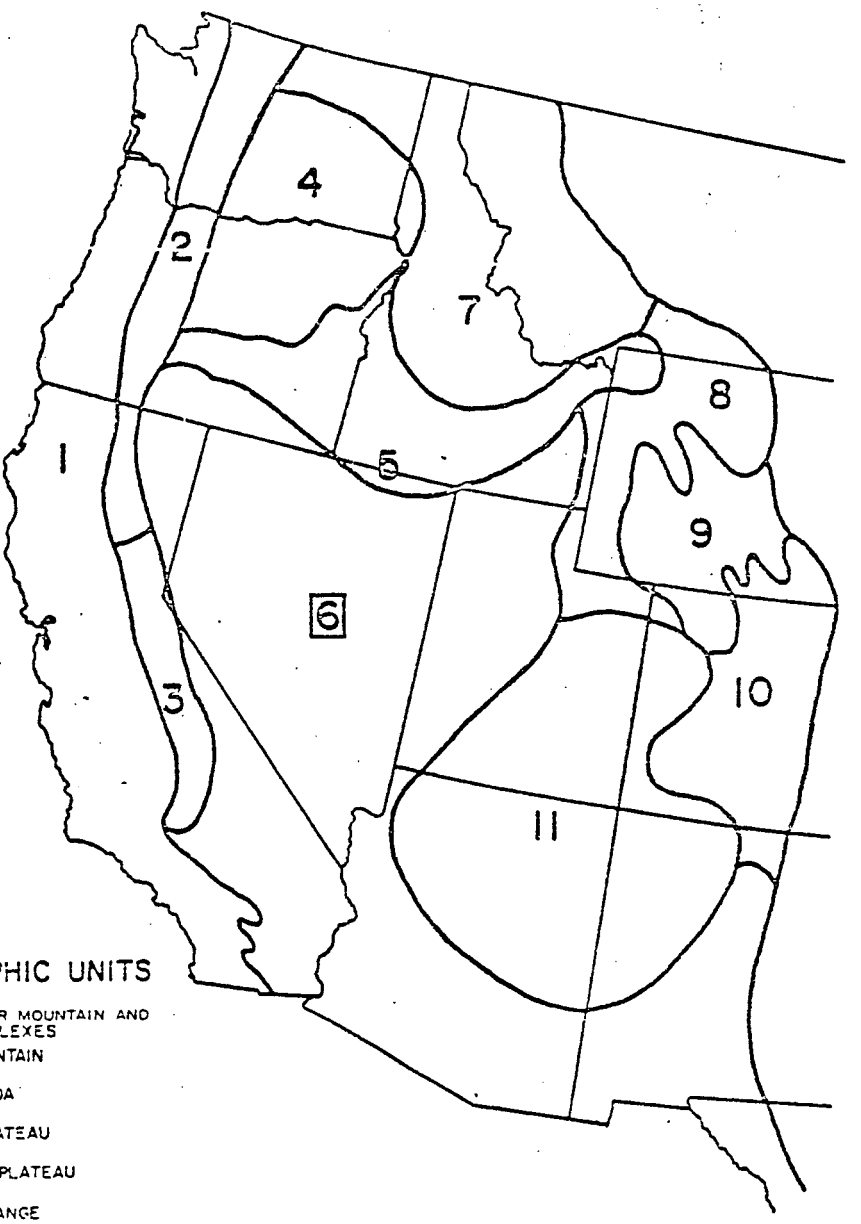
(2) Offer existing data of the above type obtained from prior investigations.

(3) Offer any combination of (1) and (2).

The objectives of this case study is to further the development of commercial geothermal energy by accumulating and publishing for use by industry and the public at large case history information on geothermal reservoirs in order to stimulate exploratory drilling as well as to reduce the risk and cost of exploration and reservoir assessment and the uncertainties of reservoir engineering.

In order to obtain a greater range of data applicable to the evaluation of a geothermal resource, it is anticipated that several of the proposals received will be selected for awards. DOE has allocated approximately $1,300,000 to be used for contracts resulting from this RFP during fiscal year 1978. Additional funding is anticipated to be approximately $8 million, and expected to be made available during FY 1979 subject to appropriation by Congress.

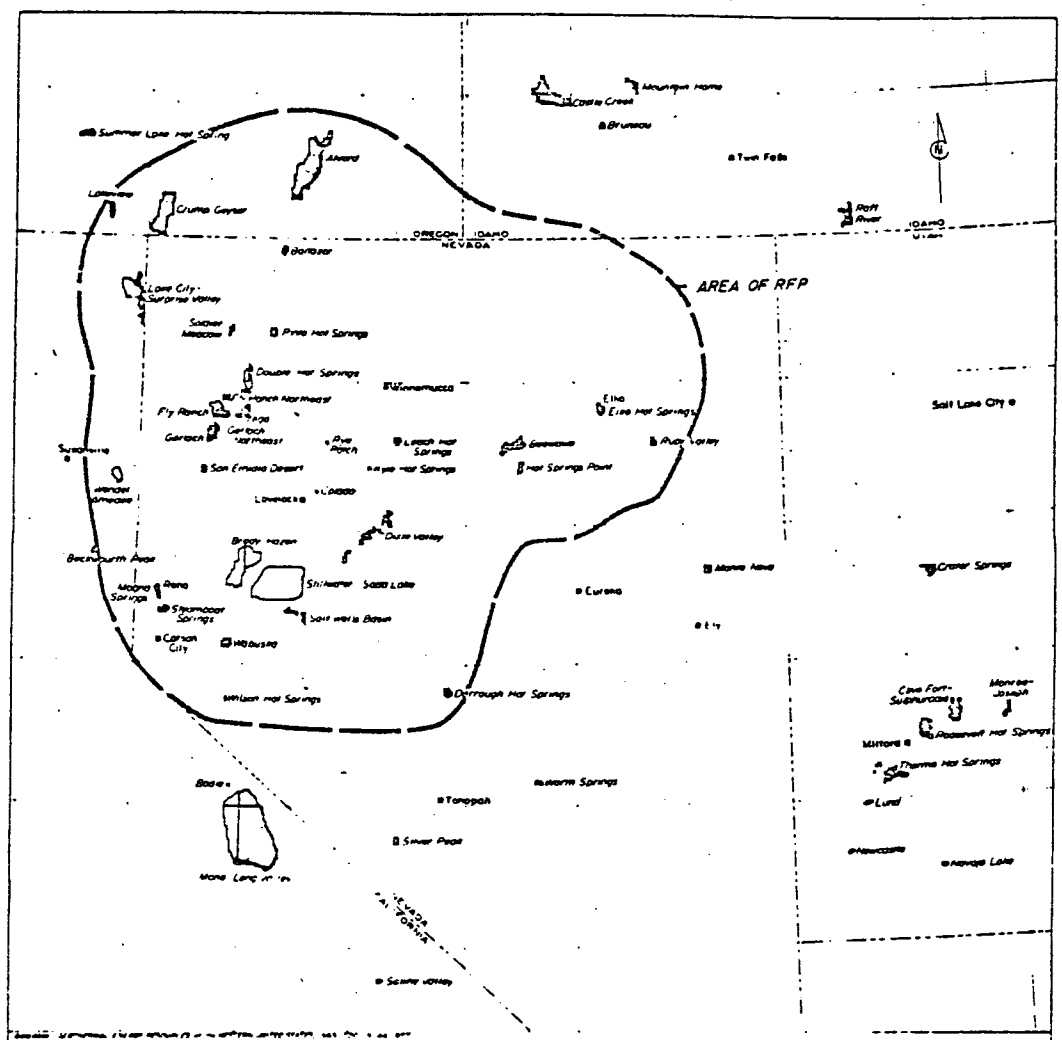
FIGURE 1.



PHYSIOGRAPHIC UNITS

1 PACIFIC BORDER MOUNTAIN AND VALLEY COMPLEXES
2 CASCADE MOUNTAIN
3 SIERRA NEVADA
4 COLUMBIA PLATEAU
5 SNAKE RIVER PLATEAU
6 BASIN AND RANGE
7 NORTHERN ROCKY MOUNTAIN
8 MIDDLE ROCKY MOUNTAIN
9 WYOMING BASIN
10 SOUTHERN ROCKY MOUNTAIN
11 COLORADO PLATEAU

FIGURE 2.


AREA OF RFP
OREGON
NEVADA
IDAHO
Summer Lake Hot Spring
Alvord
Crump Geyser
Lakeview
Borax Lake
Lake City - Surprise Valley
Soldier Meadows
Pyramid Lake
Pyramid Hot Springs
Double Hot Springs
Winnemucca
Fly Ranch
Garlock
Garlock Northeast
Pine Forest
Leach Hot Springs
Gerlach
San Emidio Desert
Hot Springs Point
Pine Valley
Lovelock
Warner Mountains
Black Rock Desert
Buena Vista Valley
Mopung Hot Springs
Pana
Shoshone Basin
Soda Lake
Stillwater
Salt Wells Basin
Carson City
Hazen
Wilson Hot Springs
Darrough Hot Springs
Basin
Mono Lake
Tonopah
Silver Peak
Warm Springs
Nevada Test Site
Scotty Valley
Eureka
Ely
Mineral Mountains
Cove Fort-Sulphurdale
Monroe-Joseph
Roosevelt Hot Springs
Thermo Hot Springs
Milford
Lund
Newcastle
Antelope Valley
Twin Falls
Mountain Home
Boise
Salt Lake City
Grand Junction
Provo
Price
Green River
Rock Springs
Evanston
Kemmerer
Afton
Jackson
Yellowstone National Park
Idaho Falls
Pocatello
Logan
Ogden
Brigham City
Tremonton
Wells
Elko
Battle Mountain
Austin
Fallon
Reno
Sparks
Virginia City
Winnemucca
Lovelock
Fernley
Fallon
Hawthorne
Tonopah
Goldfield
Beatty
Las Vegas
Boulder City
Henderson
Searchlight
Needles
Barstow
Victorville
San Bernardino
Riverside
Los Angeles
Long Beach
Anaheim
Santa Ana
Pasadena
Glendale
Burbank
Hollywood
Santa Monica
Malibu
Oxnard
Ventura
Santa Barbara
Lompoc
Santa Maria
San Luis Obispo
Paso Robles
Atascadero
Morro Bay
Cambria
San Simeon
Hearst Castle
Big Sur
Carmel
Monterey
Salinas
Gilroy
San Jose
Palo Alto
Redwood City
San Mateo
San Francisco
Oakland
Berkeley
Richmond
Vallejo
Napa
Santa Rosa
Petaluma
Sonoma
Healdsburg
Ukiah
Willits
Fort Bragg
Mendocino
Eureka
Arcata
Crescent City
Klamath Falls
Lakeview
Alturas
Susanville
Chester
Quincy
Portola
Truckee
Lake Tahoe
Carson City
Minden
Gardnerville
Yerington

Closing date for proposals was May 30. Final selection of winning proposals should be complete by Mid-July, with contract negotiated to be complete by the end of August to late September.

12.0 GEOTHERMAL LOAN GUARANTY PROGRAM-BRADY'S HOT SPRINGS

The Nevada Team contacted Mr. Allen Craigmiles, Vice President of Nevada National Bank, and one of the State Advisors, for information concerning the Geothermal Guaranty Loan Program. Nevada National Bank is the lender for the new direct-geothermal use food processing plant at Brady's Hot Springs.

APPENDIX A

NEVADA STATE TEAM ORGANIZATION

The Nevada State Team Leader, G. Martin Booth III, was selected by the Nevada Department of Energy in conjunction with the Nevada Bureau of Mines and Geology, University of Nevada-Reno, to head the Nevada State team.

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John H. Schilling, Director
Nevada Bureau of Mines & Geology
Mackay School of Mines
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Nevada State Team consists of:

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Team Leader
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Reno, Nevada 89509
(702) 747-3463

Doris Weber
Research Assistant
Providing research work,
compilation and drafting

Barbara Helseth
Research Assistant & Office Support
Providing research work, compilation,
secretarial and bookkeeping

The New Mexico Energy Institute at New Mexico State University proposed to perform regional operations research in the development of geothermal energy resources for the Division of Geothermal Energy, U. S. Energy Research and Development Administration, and the Four Corners Regional Commission.

An Agreement was entered into in October 1977, between the Nevada Department of Energy and Nevada Bureau of Mines and Geology, University of Nevada-Reno, the latter being contracted to perform the Geothermal research activities necessary under the Subject of the sub-contract which Nevada DOE had executed with the Regents of New Mexico State University; Sub-Contract 3104-X6.

APPENDIX B

NEVADA STATE TEAM ADVISORY COMMITTEE .

Noel Clark Chairman	Director Nevada Department of Energy
Robert Forest	Exploration Office Phillips Petroleum
John H. Schilling	Director Nevada Bureau of Mines & Geology
Leslie B. Gray	Lawyer Gray & Brooks Magma Power Company
John Arlidge	Nevada Power Company
Dick Richards	Sierra Pacific Power
Jack Cardinalli	Nevada Dept. of Conservation & Natural Resources Division of Water Resources
Ernie Gregory	Nevada Dept. of Conservation & Natural Resources Division of Environmental Protection
Allen Craigmiles	Vice President Nevada National Bank
Susan Orr	Consumer Representative Citizen Alert
Keith Ashworth	Senator Nevada Legislative Representative
Gil Flores	Delegate to the State FCRC Office of Economic Development

APPENDIX C

HUMBOLDT HOUSE DATA SHEET

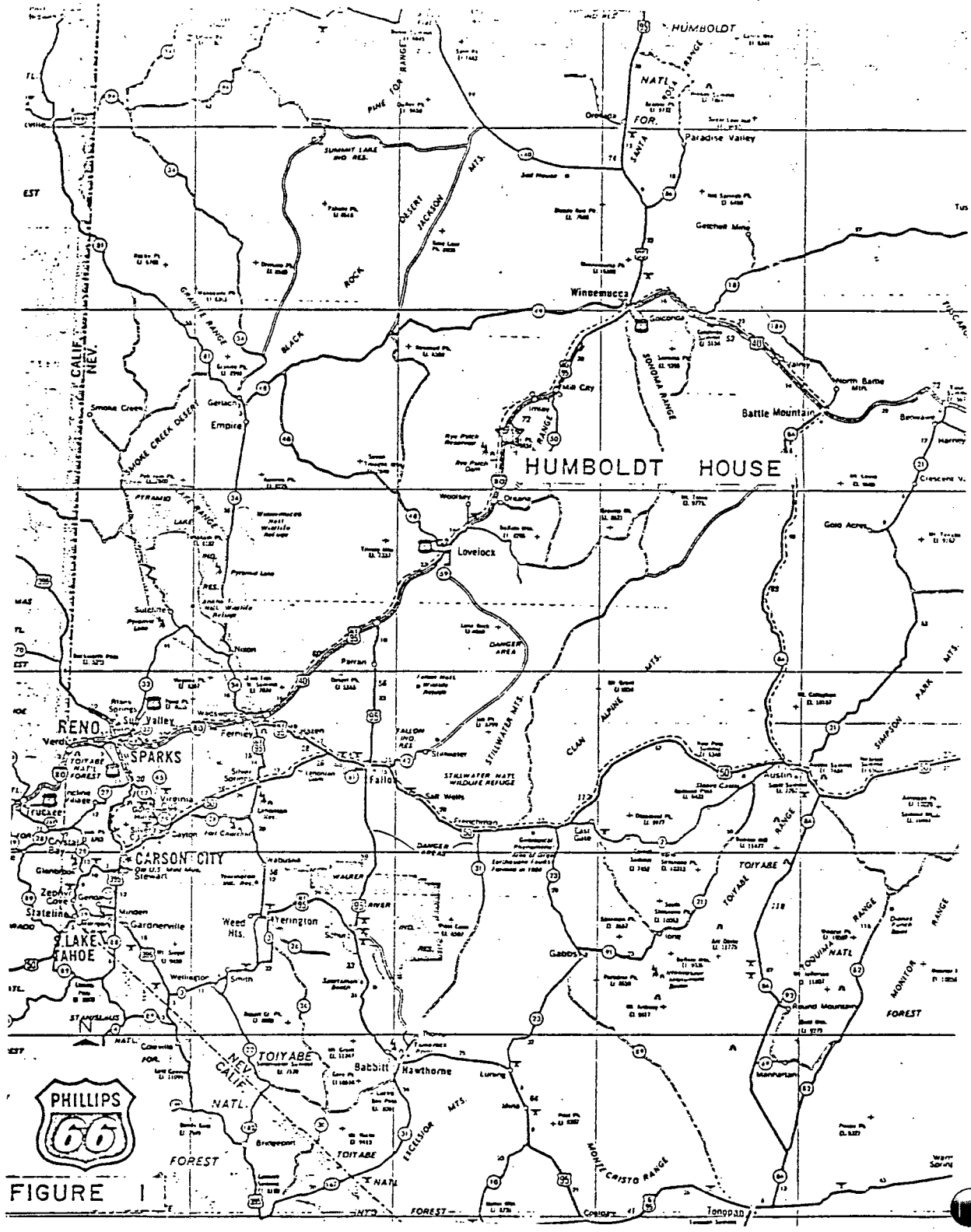

HUMBOLDT
Paradise Valley
Winnemucca
Battle Mountain
HUMBOLDT HOUSE
Lovelock
Empire
RENO
SPARKS
CARSON CITY
LAKE TAHOE
Fallon
Austin
Gabbs
Babbitt
Hawthorne
TOIYABE
PHILLIPS 66

FIGURE 1

HUMBOLDT HOUSE

The Humboldt House geothermal prospect is located in Pershing County, Nevada along highway I-80 about halfway between lovelock and Winnemucca (Figure 1). The geothermal prospect is mostly within the Humboldt River Valley graben which is situated between fault blocks of the Humboldt Range on the east, the Eugene Mountains on the north, the Antelope Range on the west and the Trinity Mountains on the southwest.

In December 1977, Phillips Petroleum Company completed the Campbell E-1 geothermal well. This well was completed at 1835 feet due to severe lost circulation problems in middle Triassic carbonate rocks. The relatively impermeable Tertiary valley fill appears to act as a caprock. It is possible that the finely clastic Grass Valley Formation could also act as a caprock. Geothermal fluids can only enter the Campbell E-1 well in the lowest 82 feet of borehole which is uncased.

These fluids reach the well head as hot water with total dissolved solids of 4500 ppm. This hot water flashes to steam which would be used to generate electricity. Initial tests indicate that the steam from this well is capable of producing about seven megawatts of electricity. If this test and future tests are encouraging, additional wells will be drilled. Power would then be generated by a utility company and presumably fed directly into the transmission line just east of the well head.

Seven megawatts of electricity is enough electricity to supply approximately 7,000 people with power. The total population of Winnemucca and Lovelock, the two largest towns in the Humboldt area, is approximately seven to ten thousand people.

HUMBOLDT HOUSE CHRONOLOGY

October 24, 1973	Entered into Exploration and Option Agreement with Southern Pacific Land Company covering Southern Pacific lands in Nevada, California and Utah.
January 14, 1975	Commenced drilling shallow temperature-gradient holes.
May 14, 1976	Commenced drilling 5 stratigraphic tests to 2000' for temperature and geologic information
March 8, 1977	Completed drilling stratigraphic tests.
November 3, 1977	Commenced drilling Campbell E-1.
December 9, 1977	Completed drilling Campbell E-1.

APPENDIX D

Exploratory Geothermal Drilling in Nevada

Updates and corrects Table 1 of Nevada Bureau of Mines and Geology Report 21

Geothermal Exploration and Development in Nevada through 1973.

(Updated January 24, 1978)

Operator	Name	API No.	Location	Depth	Compl. Date	Max. Temp. (°F)
Churchill County)						
Brady's Hot Springs						
Magma Power Co.	Brady No. 1	27-001-90000	NE/4,NE/4,SW/4,S12,T22N,R26E	700'?	1959?	
Magma Power Co.	Brady No. 2	27-001-90001	NE/4,NE/4,SW/4,S12,T22N,R26E	241'	1959?	330
Magma Power Co.	Brady No. 3	27-001-90002	SE/4,SE/4,NW/4,S12,T22N,R26E	610'	1961?	335
Magma Power Co.	Brady No. 4	27-001-90003	SE/4,SE/4,NW/4,S12,T22N,R26E	723'	1961?	
Magma Power Co.	Brady No. 5	27-001-90004	NW/4,SW/4,NE/4,S12,T22N,R26E	593'	1961?	
Magma Power Co.	Brady No. 6	27-001-90005	NW/4,SW/4,NE/4,S12,T22N,R26E	770'	?	
Magma Power Co.	Brady No. 7	27-001-90006	NW/4,SW/4,NE/4,S12,T22N,R26E	250'	?	
Earth Energy Inc.	R Brady EE No. 1	27-001-90007	S12?,T22N,R26E	5062'?	1964	414
Earth Energy Inc.	Brady Prcs. No. 1	27-001-90008	S12?,T22N,R26E	1758'?	1965?	355
Union Oil Co. of Calif	SP-Brady's No. 1	27-001-90010	NE/4,SW/4,SE/4,S1,T22N,R26E	7275'	1974	371
Magma Energy Inc.	SP-Brady No. 2	27-001-90013	NE/4,NW/4,SE/4,S1,T22N,R26E	4446'	1975	
Magma Energy Inc.	SP-Brady No. 8	27-001-90014	NE/4,SE/4,NW/4,S12,T22N,R26E	3469'	1975	
Desert Peak Area						
Phillips Petroleum Co.	Desert Peak No. 29-1	27-001-90011	SE/4,SE/4,S29,T22N,R27E	7662'	1974	
Phillips Petroleum Co.	Desert Peak B No. 21-1	27-001-90015	S/2,SE/4,S21,T22N,R27E	4150'	1976	
Phillips Petroleum Co.	Desert Peak B No. 21-2	27-001-90016	NE/4,NE/4,S21,T22N,R27E	3192'	1976	390
Stillwater						
O'Neill Geothermal Inc.	J.I. O'Neill, Jr. -Reynolds No. 1	27-001-90009	NE/4,SW/4,SW/4,S6,T19N,R31E	4237'	1964	265
Union Oil Co.	Weishaupt No. 1	27-001-90017	Lot 2, S6,T19N,R31E	4000'±	1976	
Union Oil Co.	Weishaupt No. 2	27-001-90018	Lot 4, S5,T19N,R31E	4000'±	1977	
Union Oil Co.	De Braga No. 1	27-001-90019	Lot 1, S1,T19N,R30E	4000'±	1977	
Soda Lake						
Chevron-Phillips	Soda Lake No. 1-29	27-001-90012	C,SE/4,SE/4,S29,T20N,R28E	4306'	1974	
Chevron Resources Co.	Silver Lake No. 44-5	27-001-90020	S5,T19N,R28E	4700'	1978	
Lee Hot Springs						
Oxy Geothermal Inc.	Federal No. 72-33(K)	27-001-90021	NW/4,NW/4,S34,T16N,R29E		1978	

Operator	Name	API No.	Location	Depth	Date	(°F)
(Douglas County)						
Wally's Hot Springs						
U.S. Steel Corp.	Wally's No. 1	27-005-90000	SE/4,NW/4,NW/4,S22,T13N,R19E	1268'	1962	181
U.S. Steel Corp.	Wally's No. 2	27-005-90001	SW/4,SW/4,NW/4,S22,T13N,R19E	499'	1962	
(Eureka County)						
Beowawe Geysers						
Magma Power Co.	Beowawe No. 1	27-011-90000	NE/4,SE/4?,NW/4,S17,T31N,R48E	1918'	1959?	
Magma Power Co.	Beowawe No. 2	27-011-90001	NW/4?,NW/4,S17,T31N,R48E	715'	1959?	
Vulcan Thermal Power Co.	Vulcan No. 1	27-011-90002	NW/4,SE/4,SW/4,NW/4,S17,T31N,R48E	638'	1961	414
Vulcan Thermal Power Co.	Vulcan No. 2	27-011-90003	NE/4,SE/4,SW/4,NW/4,S17,T31N,R48E	655'	1961	407
Vulcan Thermal Power Co.	Vulcan No. 3	27-011-90004	NW/4,SW/4,SE/4,NW/4,S17,T31N,R48E	796'	1961	407
Vulcan Thermal Power Co.	Vulcan No. 4	27-011-90005	NE/4,SW/4,SE/4,NW/4,S17,T31N,R48E	767'	1961	410
Vulcan Thermal Power Co.	Vulcan No. 5	27-011-90006	,S17,T31N,R48E	237'	1963?	
Vulcan Thermal Power Co.	Vulcan No. 6	27-011-90007	NW/4,SW/4,NE/4,S17,T31N,R48E	478'	1963	282
Sierra Pacific Power Co	Sierra No. 1	27-011-90008	C,NW/4,SE/4,SW/4,S17,T31N,R48E	927'	1964?	
Sierra Pacific Power Co.	Sierra No. 2	27-011-90009	C,NE/4,SW/4,S17,T31N,R48E	418'	1964	
Sierra Pacific Power Co.	Sierra No. 3	27-011-90010	NW/4,SE/4, SW/4,NW/4,S17,T31N,R48E	2052'	1965	
Sierra Pacific Power Co.	Sierra No. 4	27-011-90011	NW/4,NE/4,NW/4,S17,T31N,R48E	1005'	1964?	240
Magma Energy Inc.	Batz No. 1	27-011-90013	SW/4,NW/4,NE/4,S17,T31N,R48E	5447'	1975	
Springs Point (Cresent Valley)						
Magma Power Co.	(?) Hot Springs Point No. 1	27-011-90012	S1, 2, or 11,T29N,R48E	410'	1965	
Chevron Oil Co.	Hot Springs Point No. 1	27-011-90014	NW/4,SW/4,NW/4,S1,T29N,R48E	2335'	1975	

Operator	Name	API No.)	Location	Depth	Compl. Date	Max. Temp. (°F)
(Humboldt County)						
Hot Springs Ranch Magma Power Co.	Tipton No. 1	27-013-90000	SW/4,NW/4,SW/4,S4,T33N,R40E	3071'	1974	
(Lander County)						
Beowawe Geysers Chevron-American Thermal Resources Chevron U.S.A., Inc.	Ginn No. 1-13 Rossi No. 21-19 -Beowawe No. 1	27-015-90000	C,SE/4,SE/4,S13,T31N,R47E	9563'	1974	
		27-015-90001	SW/4,NW/4,NW/4,S19,T31N,R48E	5680'	1976	

Operator	Name	API No.	Location	Depth	Compl. Date	Max. Temp. (°F)
Lyon County)						
Wabuska Hot Springs						
Magma Power Co.	Wabuska No. 1	27-019-90000	S16?,T15N,R25E	488'	1959	
Magma Power Co.	Wabuska No. 2	27-019-90001	SE/4,NE/3,SW/4,S16,T15N,R25E	532'?	1959	
Magma Power Co.	Wabuska No. 3	27-019-90002	NE/4,SE/4,SE/4,S16,T15N,R25E	2223'	1959	227
Fernley (Hazen)						
Magma Power Co.	Hazen No. 1 (?)	27-019-90003	SW/4,S18?,T20N,R26E	750'	1962	275+
Magma Power Co.	Hazen No. 2 (?)	27-019-90004	S18?,T20N,R26E	300'?	1962	
Magma Power Co.	Hazen No. 3 (?)	27-019-90005	S18?,T20N,R26E	300'?	1962	
Magma Energy Inc.	Fernley No. 1	27-019-90009	SW/4,SW/4,SE/4,S24,T20N,R25E	3668'	1974	
Hind's Hot Springs						
U.S. Steel Corp.	Hind's No. 1 (?)	27-019-90006	SW/4,SE/4,S16,T12N,R23E	?	1962?	150
U.S. Steel Corp.	Hind's No. 2 (?)	27-019-90007	SW/4,SE/4,S16,T12N,R23E	?	1962?	
U.S. Steel Corp.	Hind's No. 3 (?)	27-019-90008	SW/4,SE/4,S16,T12N,R23E	?	1962?	
(Nye County)						
Darrough Hot Springs						
Magma Power Co.	Darrough No. 1 (?)	27-023-90000	S17?,T11N,R43E	812'	1962	265
(Pershing County)						
Humboldt (Rye Patch)						
Phillips Petroleum Co.	Campbell E No. 1	27-027-90000	SE/4,S21,T31N,R33E	1853'	1977	325

Operator	Name	API No.	Location	Depth	Compl. Date	Max. Temp. (°F)
(Washoe County)						
Steamboat Hot Springs						
Nevada Thermal Power Co.	Steamboat No. 1	27-031-90000	NW/4,NE/4,S28,T18N,R20E	1830'	1954	
Nevada Thermal Power Co.	Steamboat No. 2	27-031-90001	SE/4,SW/4,S28,T18N,R20E	964'	1959	
Nevada Thermal Power Co.	Steamboat No. 3	27-031-90002	NW/4,NE/4,S32,T18N,R20E	1263'	1960?	
Nevada Thermal Power Co.	Steamboat No. 4	27-031-90003	NE/4,NW/4,S32,T18N,R20E	520'?	1960	367
Nevada Thermal Power Co.	Steamboat No. 5	27-031-90004	NW/4,NW/4,S32,T18N,R20E	826'	1961	347
Nevada Thermal Power Co.	Steamboat No. 6	27-031-90005	NW/4,NW/4,S32,T18N,R20E	716'	1961	354
The Needles (Pyramid Lake)						
Western Geothermal Inc.	Needles No. 1	27-031-90006	NW/4,SW/4,SW/4,S6,T26N,R21E	5888'	1964	~240
Western Geothermal Inc.	Needles No. 2 (?)	27-031-90007	C,W/2,NE/4,S12,T26N,R20E	4000'±	1962	
Western Geothermal Inc.	Needles No. 3 (?)	27-031-90008	NW/4,SW/4,SW/4,S6,T26N,R21E	?	1964	
rd's Hot Springs (Fly Ranch)						
Western Geothermal Inc.	Fly Ranch No. 1 (?)	27-031-90009	SW/4,NE/4,SE/4,S2,T34N,R23E	1000'+	1964	
nite Ranch						
Western Geothermal Inc.	(?)Granite Creek Ranch 1	27-031-90010	S35?,T34N,R23E	800'	1965?	
San Emidio Desert						
Chevron Oil Co.	Cosmos No. 1-8	27-031-90011	SE/4,S8,T29N,R23E	4013'	1975	
hite Pine County)						
nte Neva Hot Springs						
Magma Power Co.	Monte Neva No. 1 (?)	27-033-90000	S24?,T21N,R63E	402'	1965	

Elko District - Nevada

	Company Name	NOI Period of Exploration	Notice of Completion	Location	Type of Work	D/O #
4/1/74	Chevron Oil	5/1/74-12/1/74		Whirlwind Valley W. end Crescent Valley	Resistivity Survey	25
6/20/74	U.S.Geol. Survey	7/1/74-9/1/74		Delcer Buttes, Lone Mtn. Crescent Valley E.&W.	Temperature grad.	35
8/3/74	U.S.Geol. Survey	8/1/74-8/1/76		White Mtns	Temperature grad.	38
7/24/74	Chevron Oil	8/1/74-12/15/74	4/23/75	Crescent Valley	10 Temp. gr. downhole	36
11/14/74	Union Oil	12/1/74-2/20/75		Ruby Valley	2 temp. grad.	G-1
1/31/75	U.S.Geol. Survey	3/1/75-12/1/75		Swalo Mtn	Temp. grad.	G-2
3/6/75	Chevron Oil Co.		10/6/75	Crescent Valley	Gravity	G-3
8/11/75	Phillips		9/4/75	Crescent Valley Pine Valley	11 temp. grad. hole	G-4
9/11/75	U.S.Geol. Survey	9/10/75		Elko KGRA	Electromag-Gravity Survey	G-5
11/17/75	So. Union Oil	12/1/75-10/31/76			Hot Sulphur Springs Hot Springs N. of Wells	G-6
11/26/75						
4/12/75	Chevron Oil		1/23/76	Rease River Sheep Creek Range	Resistivity Survey	27000-3
12/5/75	Chevron Oil	12/1/75	1/23/76	Crescent Valley	Surface Resistivity Survey	G-7
12/23/75	Phillips Petroleum	12/23/75	12/8/76	Sheep Creek Range	Temperature Grad.	G-8
3/30/76	Chevron Oil	3/30/76	9/23/76	Crescent Valley	Surface Resistivity Survey	G-9
4/22/76	Chevron Oil	4/22/76	9/23/76	Crescent Valley	Magneto-tellurie	G-10
6/17/76	U.S.Geol. Survey	6/17/76		Ruby Valley	Magneto-tellurie	T3-01
8/20/76	Chevron Oil	9/1/76-9/1/77	8/4/77	Battle Mtn.	Temperature Grad.	TO-02
8/26/76	Dow Chemical	9/1/75-9/1/77	1/12/77	Crescent Valley Whirlwind Valley	Resistivity Survey	TO-03
4/24/76	Union Oil	4/1/76-10/31/77		Ruby Valley	Temperature Grad.	
9/23/76	U.S.Geol. Survey	10/13/76		Whirlwind Rosewood Area	Temperature Grad.	
10/18/76	Chevron	10/13/76-10/1/77	8/4/77	Crescent Valley Fault & Vicinity	Temperature Grad.	C.N.V.010 77.-1
11/22/76	Chevron	11/22/76-11/1/77	2/4/77	Hot Springs Point	Temperature Grad.	77-02
12/6/77	Phillips	12/6/76-12/1/77		Rock Springs Antelope Creek	Temperature	77-03
4/4/77	U.S.Geol. Survey	6/1/77-6/1/78		Elko District	Cemperature Grad.	77-04

Winnemucca District - Nevada

	Company Name	NOI Period of Exploration	Notice of Completion	Location	Type of Work	D/O #
1	Phillips	2/15/74-7/15/74	11/22/74	T 41-45 N 30-32 C	Temp. Grad. Hole	N2-4-74
2	Phillips	4/1/ 74-3/30/74	10/3/74	Pinto Mountains	Temp. Grad. Hole	N2-5-74
3	Phillips	2/1/74-3/15/74	5/22/74	Gradys Hot Spring	Seismic Survey Temp. Grad. Hole	112-6-74
4	Phillips	3/1/74-7/1/74	7/24/74	San Emidio Desert	Temp. Grad. Hole	N2-7-74
5	Chevron	4/22/74-8/1/74	11/21/74	Northern Dixie Valley	Electric Resistivity Survey	N2-3-74
6	(AEC) ERDA	7/1/74-12/31/76		Buffalo Valley	Geophysical Survey	N2-14-74
7	(AEC) ERDA	4/15/74-12/31/76		Kyle Hot Springs	Geophysical Survey	N2-15-74
8	(AEC) ERDA	4/15/74-12/31/76		Leach Hot Springs	Geophysical Survey	N2-16-74
9	Chevron	6/1/74-12/1/74	11/21/74	(Gerlach Area) Alkali Flat	Electric Resistivity Survey	N2-18-74
10	Chevron	5/1/74-12/1/74	11/21/74	Leach Area	Electric Resistivity Survey	N2-19-74
11	Al-Aquitane	5/1/74-7/1/74	6/17/74	San Emidio Desert	Gravity & Survey	N2-20-74
12	U.S.Geol. Survey	8/1/74-8/1/76		Blue Wing Planning Unit	Temp. Grad. Hole	N2-22-74
13	Phillips	7/15/74-10/15/75	10/16/75	Rye Patch Northern Buena Vista Valley	Temp. Grad. Hole	N2-28-74
14	Chevron	9/1/74-2/15/75	4/14/75	San Emidio Desert	Temp. Grad. Hole	N2-29-74
15	Union	10/7/74-12/4/74	1/20/75	Rye Patch	Thermal Probe hole	N2-35-74
16	U.S.G.S.	7/3/74-7/8/76		T38N,R33E T39N,R38E	Temperature Monitoring well	SLUP N2-22-74
17	U.S.G.S.	3/15/74-3/15/75	7/3/74	Denio	Temperature Monitoring well	SLUP N2-1-74
18	U.S.G.S.	12/13/73-12/12/74		Mills Denio & Slumbering	Temperature Monitoring well	SLUP N2-27-75
19	Colo. School Mines	5/74-12/31/75	2/29/76	Gerlach Area	Geophysical Survey and Test Hole	N2-6-75
20	Sun Oil Co.	1/75-6/75	8/21/75	Northern Dixie Valley	Temp. Grad. Hole	N2-7-75
21	Sun Oil Co.	1/75-6/75	8/21/75	Northern Dixie Valley	Temp. Grad. Hole	N2-7-75
22	Phillips	3/7/75-11/1/75	10/6/75	Gerlach Area	Temp. Grad. Hole	N2-12-75
23	Chevron	4/1/75-12/31/75	5/27/75	Leach Hot Springs	Electric Resistivity Survey	N2-13-75
24	Sun Oil Co.	4/20/75-6/1/75	6/3/75	Northern Smoke Creek Desert	Electric Resistivity Gravity Survey	N2-15-75
25	Chevron	5/1/75-12/31/75	3/26/76	San Emidio Desert	Gravity Survey	N2-16-75
26	S. Union Prod.	5/15/75-7/15/76	12/9/76	Northern	Research Evaluation	N2-17-75
27	S. Union Prod.	5/15/75-7/15/75	12/9/76	Northern Black Peak Desert	Research Evaluation	N2-18-75
28	S. Union Prod.	5/17/75-5/17/77		Brady Area	Temp. Grad. Hole	N2-19-75
29	Chevron Oil	5/23/75-12/31/75	10/6/75	Gerlach-	Resistivity Survey	N2-22-75
30	Chevron Oil	7/1/75-12/31/85	3/26/76	Gerlach-	Gravity Survey	N2-23-75

Winnemucca District - Nevada (Continued)

	Company Name	NOI Period of Exploration	Notice of Completion	Location	Type of Work	D/O #
31	U.S.Geol. Survey	6/9/75-6/9/77		Leach Hot Springs	Shallow Test Holes	N2-24-75
32	Phillips	6/75-11/75	10/16/75	Pumpernickel Valley Hot Springs Ranch	Temp. Grad. Hole	N2-25-75
33	Hunt Oil	8/75-10/75	11/26/75	Black Peak Desert	Electric Resistivity Survey	N2-3-76
34	Union Oil (La)	9/15/75-10/31/75	11/75	Black Peak Desert	Thermal Probe Holes	N2-5-76
35	Sun Oil (Dallas)	9/1/75-1/1/76	2/9/76	Black Peak Desert	Electric Resistivity & Survey	N2-6-76
36	U.S.Geol. Survey	9/23/75-10/20/75	11/7/75	San Emidio Desert	Audio-magneto & Tellurie Survey	N2-10-76
37	S. Union Prod.	11/18/75-10/31/76	10/27/76	Pumpernicke, Jersey & Buffalo Valleys	Surveys	N2-13-76
38	S. Union Prod	-10/31/76	10/27/76	Desert Areas Gerlack - Black Rock	Surveys	N2-14-76
39	Phillips	3/1/76-3/1/77	3/11/77	Rye Patch	Cancelled	N2-17-76
40	Chevron	3/19/76-9/15/76	1/27/77	Leach Hot Springs	Temp. Grad. Hole	N2-18-76
41	Union Oil	7/19/76-9/30/76	11/22/76	Sulphur Area	Thermal Probe Hole	N2-20=76
42	Colorado Sch. Mines	3/30/76-12/31/76		Gerlach-Hualapai	Surface Survey & Mapping	N2-22-76
43	Chevron Oil Co.	6/1/76-9/30/76	6/76	SAn Emidio Desert	Electric Resistivity Survey	N2-24-76
44	Chevron Oil Co.	7/1/76-10/30/76	9/24/76	San Emidio Desert	Seismic Resistivity Survey	N2-27-76
45	U.S.Geol. Survey	6/27/76-7/31/76	11/11/76	Pinto KGRA	Audio Magneto Tellurie Survey	N2-28-76
46	U.S. Geo. Survey	6/27/76-7/31/76	11/11/76	Rye Patch KGRA	Audio Magneto Tellurie Survey	N2-28-76
47	Chevron	9/2/76-12/15/76		Kyle Hot Springs	Temp. Grad. Hole	N2-30-76
48	Hunt Energy			Sulpherania	Temp. Grad. Hole	N2-31-76
49	U.S.Geol. Survey	8/4/76/-8/8/76	11/11/76	Pinto KGRA	Gravity Survey	N2-32-76
50	Sunoco	9/17/76-5/17/77		Granite Creek Gerlach	Heat Flow	N2-34-76
51	Sunoco	11/15/76-1/31/77		Gerlach	Magneto Tellurie Soundings	N2-2-77
52	So. Union Prod. Co.	12/6/76-12/1/77		Leach & Kyle Hot Springs	Geophysical Surveys	N2-4-77
53	So. Union Prod. Co.	1/3/77-1/1/78		Jersey Dixie Valley	Geophysical Surveys	N2-6-77
54	So. Union Prod. Co.	1/3/77-1/1/78		Pumpernickel Buffalo Valley	Geophysical Surveys	N2-7-77
55	So. Union Prod. Co.	1/3/77-1/1/78		Gerlach Empire	Geophysical Surveys	N2-8-77
56	Phillips	3/20/77-3/20/78	1/10/77	San Emidio Desert	Temp. Grad. Hole	N2-15-77
57	Chevron	4/1/77-10/1/77		Kyle Hot Springs Area	Temp. Grad. Hole	N2-1-677
58	U.S.Geol. Survey	4/20/77-4/30/77		Bartazar Area	Surface Geophysical Survey	N2-17-77
59	Chevron	5/1/77-11/1/77	7/15/77	San Emidio Desert	Temp. Grad. Hole	N2-17-77
60	Chevron	7/1/77-4/28/78		Grass Valley (Packing Co.)	Temp. Grad. Hole	N2-19-77

Winnemucca District - Nevada (Continued)

	Company Name	NOI Period of Exploration	Notice of Completion	Location	Type of Work	D/O #
61	U.S.Geol. Survey	7/1/77-7/1/78		Thacher Pass, Brady H.Spring Brian Meadow,Battle Creek	Temp. Grad. Hole	N2-20-77
62	U.S.Geol. Survey Earthquake Studies	4/18/77		Black Rock Desert Dyke Hot Springs	One Seismic Hole	N2-21-77
63	Earth Power	4/13/77-9/3078		McDermit Area	Temp, Grad, Hole	N2-22-77
64	Earth Power	4/18/77-9/30/78		Eenio Area	Temp, Grad, Hole	N2-23-77
65	Hydro-Search	5/77-8/77		Brady H ot Springs	Temp, Grad, Hole	N2-24-77
66	Earth Power	4/18/77-9/30/77		McGee Mtn (Humbolt Co.)	Temp, Grad, Hole	N2-27-77
67	Chevron Geophys. Co.	7/1/77-11/30/77		San Emidio Area	High Resolution Seismic Survey	N2-30-77
68	U.S.Geol. Survey (Water Resources	7/1/77-7/1/78		Grasi Valley Pershing Co.	One 4' Diam. Hole	N2-31-77
69	Republic Geoth. Inc.	7/17/77		Jersey Valley	Temp, Grad, Hole	N2-34-77
70	U.S.Geol. Survey (Geothermal Studies)	7/15/77-7/17/78				
71	U.S.Geol. Survey (Water Resources)	7/24/77-7/24/78		Leach Hot Springs	Shallow Heat Hole	N2-36-77
72	Encco, Inc. Seismic Explo. Co.	8/77-9/77		Gerlach Area	Seismic Emission Study	N2-37-77
73	Electrocyne Survey Service	6/30/77-8/15/77		Northeast of Lovelock Area	Electric Resistivity Seismic Study	N2-39-77
74	Earth Power	8/2/77-2/1/78		McGee Mts,	Temp, Grad, Holes	N2-40-77
75	Earth Power	8/2/77-2/1/78		Pueblo Mt, Area	15 ea Temp, Grad, Holes	N2-41-77
76	Union Oil Geothermal Div.)	8/20/77-8/1/78		Rye Patch Area	Audio-Magneto Tellur & dipole-diple R,S,	e N2-42-77
78	U.S.Geo. Survey	8/16/77-9/2/77		Grass Valley Jungo Area	Heat Flow Study	N2-43-77
79	Phillips Petro.			Adobe Flat-Granite Springs Valley	7 ea, 300 temp, Grad, Holes	N2-45-77
80	United Geophysical			San Emidio Desert	Seismic Survey	N2-47-77

Carson City District - Nevada

	Company Name	NOI Period of Exploration	Notice of Completion	Location	Type of Work	D/O #
1	Phillips Petro.		7/1/74	T16N,P.30E	10 Temp. Grad. Holes	27-030-01
2	Chevron Oil		11/15/75	T19-20N,R.25-26E	Resistivity Survey	27-030-02
3.	Chevron Oil		8/8/74	T10-11N,R25-26E	Resistivity Survey	27-030-03
4	Al-Aquitane		6/28/74	T13N,R33,34E T12N,$34,35E	Gravity AMT	27-030-04
5	Al-Aquitane		6/28/74	T16N,R22#	Gravity AMT	27-030-05
6	Al-Aquitane		6/28/74	T21N,R33E	Gravity AMT	27-020-06
7	U.S.G.S. Thomas H. Moses			T23N, R18E	2 Temp. Grad. Holes	27-030-07
8	Sun Oil Col		6/30/75	T23-25N. R35-33#	15 Temp. Grad. Holes	27-030-08
9	Phillips Petro.		11/1/75	T16-25N, R27-33E	5 Temp. Grad. Holes	27-030-09
10	(USGS) Geotronics Corp		4/17/75	Stillwater Soda Lake	Magneto Tellurie Survey	27-030-09
11	Phillips Petrol.		11/1/75	T19N, R27-28E	2 Temp. Grad. Holes	27-030-12
12	Westinghouse (USGS)		5/15/75	(KGRA) Stillwater Soda Lake	Magneto Tellurie Survey	27-030-13
13	Union Oil Co.		6/11/75	T17-18N,R29-30E	10 Temp. Grad. Holes	27-030-14
14	Geonomics		6/15/75	T14-17N,R33-35E	Resistivity Survey	27-030-15
15	U.S.G.S., Denver			(KGRA) Steamboat-Wabuska	Gravity Survey	NV-030-16
16	Hydro Search, Inc.			Wabuska (KGRA)	Survey Gravity Resistivity	NV-030-17
17	Hydrosearch, Inc.		9/76	Steamboat (KGRA)	Gravity Resistivity Survey	NV-030-18
18	Chevron Oil		4/30/76	North Dixie Valley	5 Temp. Grad. Holes	NV-030-20
19	Hydrosearch, Inc.			Fallon Area	Gravity Resistivity Survey	NV-030-21
20	Hunt Oil		3/19/76	Salt Wells Area	Resistivity Survey	NV-030-22
21	USGS, Denver		2/5/76	Dixie Valley	Resistivity Survey	NV-030-23
22	Phillips Oetrol		7/22/76	Steamboat	2 Temp. Grad. Holes	NV-030-24
23	Chevron		5/31/76	Wilson Hot Springs	2 Temp. Grad. Holes	NV-030-25
24	Geonomics		6/15/76	Carson Sink	Resistivity Survey	NV-030-26
25	Republic Geothermal			Gabbs Valley	Temp. Grad. Hole	NV-030-27
26	(Hunt Energy Co.) Geothermal Services			T17-20N, R20-21E	17 Temp. Grad. Holes	NV-030-28
27	(Hunt Energy Co.) Geothermal Services			T22-24N, R31-33E	30 Temp. Grad. Holes	NV-030-29
28	Dow Chemical		12/20/76	T22-24N, R35-37E	14 Temp. Grad. Holes	NV-030-30
29	(Hunt Energy) Geothermal Services			T15-19N,R31-34E	43 Temp. Grad. Holes	NV-030-31
30	Sun Oil Co. Geothermal Services			Dixie Valley	2 Temp. Grad. Holes	NV-030-32

Carson City District - Nevada (Continued)

	Company Name	NOI Period of Exploration	Notice of Completion	Location	Type of Work	D/O #
31	Geonomics, Inc.		1/17/77	Wilson H ot Springs	22 Temp. Grad. Holes	NV-030-33
32	Dow Chemical			T22-23N, R35-36 E	Withdrawn	NV-030-34
33	Al-Aquitane Ltd.		3/23/77	Gabbs Valley	5 Temp. Grad. Holes	NV-030-35
34	(Sun Oil) Sunoco Energy Dev. Co			T24N, R36-37E) Dixie Valley	Magneto-telluric	NV-030-36
35	Photo Gravity			Wilson Hot Springs	Gravity Survey	NV-030-37
36	Anadarko Prod. Co.		3/6/77	Salt Wells Basin	Gravity Survey	NV-030-38
37	Anadarko Prod. Co.			Salt Wells Basin	Resistivity Survey	NV-030-39
38	Sunoco Energy Dev. Co		6/1/77	Dixie Valley	Passive Seixmic Emission Study	NV-030-41
39	Chevron, USA, Inc.		6/20/77	Wilson Hot Springs	6 Shallow Temp. Grad. Holes	NV-030-42
40	(USGS-Moses) Western Geophysical			Clan Alpine Mts.	1 Temp. Grad. Hole	NV-030-43
41	Chevron USA, Inc.			Soda Lakes	Seismic Survey	NV-030-44
42	Republic Geothermal			Dixie Valley	13 Temp. Grad Holes	NV-030-45
43	USGS (Hoover)		6/29/77	(KGRA) Salt Wells Basin	Gravity AMT Survey	NV-030-46
44	Al-Aquitane Explo Ltd			Gabbs Valley	16 Temp. Grad. Holes	NV-030-47
45	Al-Aquitane Explo.Ltd			Gabbs Valley	Gravity Magneto Magneto telluric Sur	NV-030-47
	Amax Exploration			Augusta Mts.	15-500 ft. shallow Temp. Grad. Holes	NV-030-51

Ely District - Nevada

	Company Name	NOI Period of Exploration	Notice of Completion	Location	Type of Work	D/O #
	(USGS-Moses) Western Geophysical	6/1/77-6/1/78		T14-15N, R67-68E T15,R54E T20N, R57E	Temp. Grad. Hole	

Las Vegas District - Nevada

	Company Name	NOI Period of Exploration	Notice of Completion	Location	Type of Work	D/O #
	U.S.Geol. Survey			Colorado Valley Gold Lutte - El Dor.	Regional Geophysical	

Battle Mountain District - Nevada

	Company Name	NOI Period of Exploration	Notice of Completion	Location	Type of Work	D/O #
1	Chevron Oil Co,	2/6/75		T31N, R47E		27-060-01
2	Chevron Oil	3/25/75		T33-34N, R45E		27-160-02
3	S. Union Prod. Co,	11/19/75		T32-34N, R 40-41E		N2-13-76
4	Phillips Petrol. Co.	12/17/75-12/17/76	12/6/75	T31N,R45E T32N, R54E		27-060-05
5	Union Oil	3/23/76-3/1/77	11/25/76	T16-17N,R39E T17N, R40E		NV-060-09
6	Chevron Oil	4/76-10/77		T33N, R45-46E		G-NV-010-
7	Chevron Oil	4/26/76-4/1/77	9/20/76	T29-31N, R47-48E		NV-060-11
8	Chevron Oil	5/12/76-5/1/77	9/20/76	T30-31N, R47-48E		NV-060-12
9	S. Union Prod.	8/23/75-8/1/77		T31N, R47#		NV-060-15
10	So. Union Prod.	8/23/76-8/1/77		T31N, R47E		NV-060-16
11	U.S.Geol. Survey	4/4/77-		T15,25N, R45E T19N, R49E T24N, R51E	Shallow Temp. Grad. Hole	NV-060-25
12	Lanton Survey Co.			Warm Springs		NV-060-77

APPENDIX F

TEMPERATURE GRADIENT HOLES

Per a 1976-1977 Status Report for the Reno Geothermal District of the Conservation Division of USGS, the following data summarizes the planned and completed activity in the Area during this period.

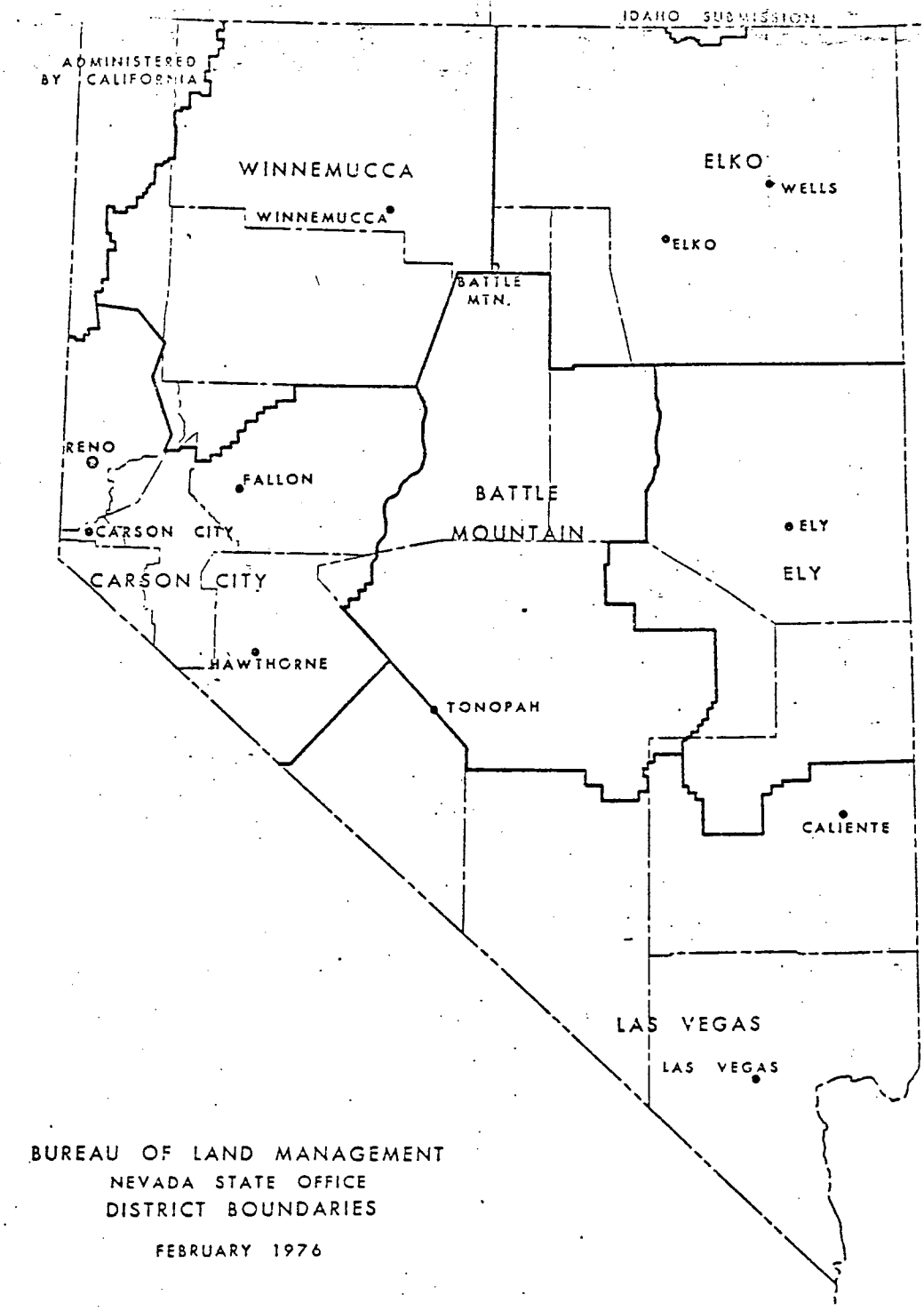
Depth of Wells	No. of Wells
100'	51
300'	3
490'	44
500'	37
1000'	3
1500'	2
2000'	2
3000'	7
5500'	7
8000'	6
9000'	5

APPENDIX G

EAR'S FROM BLM

1. BAKER
2. BUFFALO HILLS
3. CALIENTE-VIRGIN VALLEY PLANNING UNIT
4. CHERRY CREEK RESOURCE AREA
5. ELKO
6. ESMERALDA
7. EUREKA
8. FAIRVIEW
9. JAKES VALLEY-SUNNYSIDE
10. FORT CHURCHILL-CLAN ALPINE AREA
11. PINE-NUT WALKER AREA
12. PYRAMID AREA
13. STATELINE PLANNING AREA
14. TONOPAH RESOURCE AREA
15. WINNEMUCCA
16. BATTLE MOUNTAIN
17. SHOSHONE RESOURCE AREA
18. MINA AREA
19. LITTLE SMOKY VALLEY
20. SONOMA-GERLACH-BUFFALO HILLS PLANNING UNIT

APPENDIX H



BUREAU OF LAND MANAGEMENT
NEVADA STATE OFFICE
DISTRICT BOUNDARIES

FEBRUARY 1976

APPENDIX I

LAND USE PLANNING AND MANAGEMENT UNITS

01-ELKO DISTRICT

48-Elko Resource Area
- Tuscarora Planning Area
  - 0101-Tuscarora Planning Unit
  - 0102-North Fork PU
- Humboldt PA
  - 0105-Buckhorn PU

68-Wells Resource Area
- Wells PA
  - 0103-Contact PU
  - 0104-Currie PU

02-WINNEMUCCA DISTRICT

48-Paradise-Denio Resource Area
- Paradise PA
  - 0201-Paradise PU
- Denio PA
  - 0202-Denio PU

68-Sonoma-Gerlach Resource Area
- Sonoma-Gerlach PA
  - 0203-Buffalo Hills PU
  - 0204-Blue Wing PU
  - 0205-Sonoma PU

03-CARSON CITY DISTRICT

48-Lahontan Resource Area
- Clan Alpine-Ft. Churchill PA
  - 0301-Clan Alpine PU
  - 0302-Fort Churchill PU
- Pyramid-Long Valley PA
  - 0306-Pyramid PU
  - 0321-Long Valley PU*

58-Walker Resource Area
- Walker-Mina PA
  - 0303-Walker PU
  - 0304-Mina PU
- Pine Nut-Markleeville PA
  - 0305-Pine Nut PU
  - 0322-Markleeville PU*

04-ELY DISTRICT

48-Schell Resource Area
- Moriah PA
  - 0401-Moriah PU
- Pony Springs PA
  - 0410-White River PU
  - 0411-Lake Valley PU
  - 0412-Wilson Creek PU

58-Egan Resource Area
- Cherry Creek PA
  - 0404-Steptoe PU
  - 0405-Butte PU
  - 0406-Newark PU
- Currant PA
  - 0407-Duckwater PU
  - 0408-Preston Lund PU
  - 0409-Horse and Cattle Camp PU

05-LAS VEGAS DISTRICT

48-Caliente-Virgin Valley Resource Area
- Caliente PA
  - 0501-Caliente PU
- Virgin Valley PA
  - 0502-Virgin Valley PU

68-Stateline-Esmeralda Resource Area
- Esmeralda PA
  - 0503-Esmeralda PU
- Stateline PA
  - 0504-Stateline PU
- Defense & Test PA
  - 0505-Mustang Range PU
  - 0506-Withdrawal PU

06-BATTLE MOUNTAIN DISTRICT

48-Shoshone-Eureka Resource Area
- Shoshone PA
  - 0601-Cortez PU
  - 0602-Mount Airy PU
- Eureka PA
  - 0603-Pony Express PU
  - 0604-Devil's Gate PU

68-Tonopah Resource Area
- Tonopah PA
  - 0605-Manhattan PU
  - 0606-Tybo PU
  - 0607-Crater PU

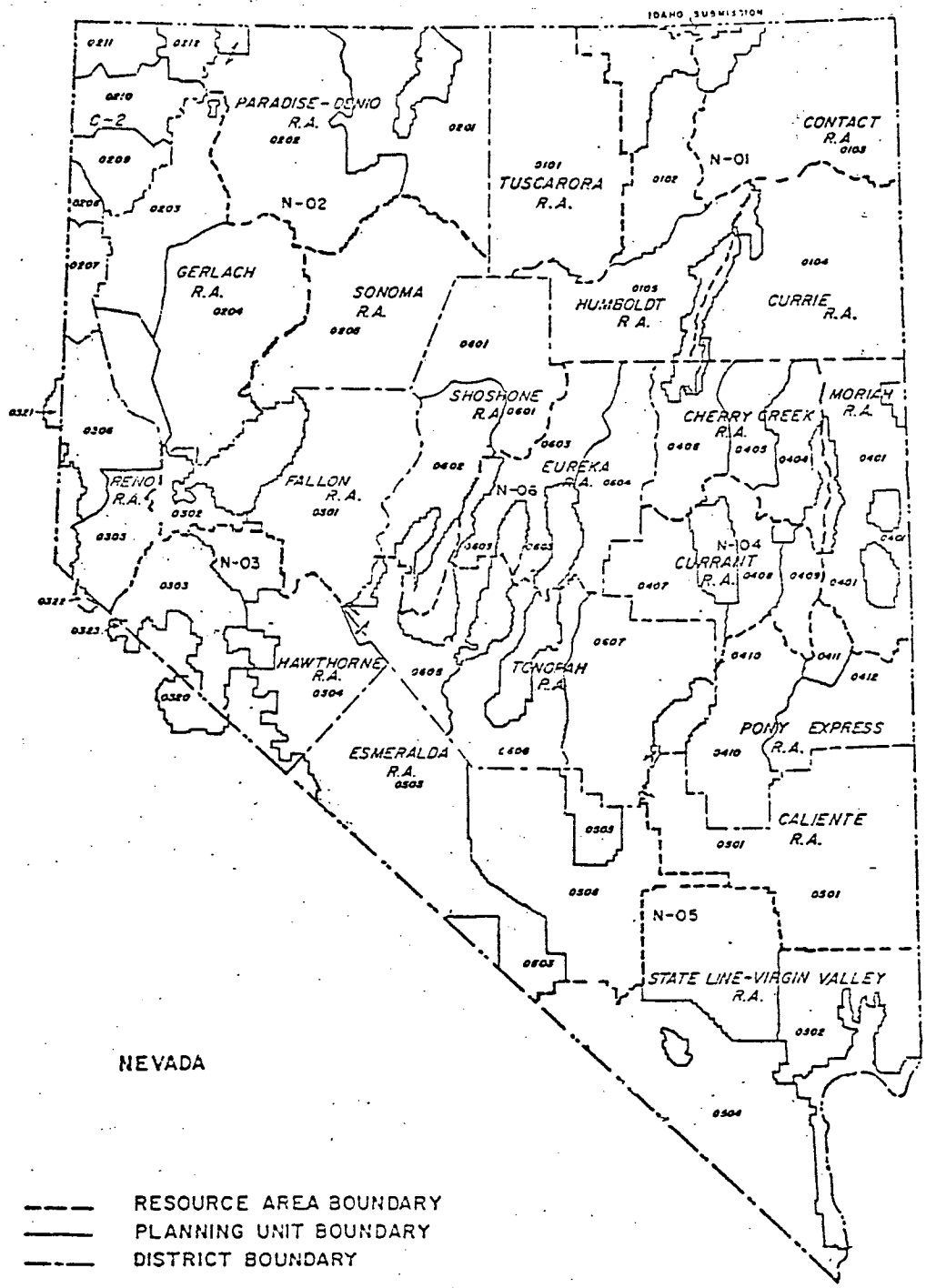
NEVADA BLM SUMMARY

District Offices	- 6
Resource Areas	- 12
Planning Areas	- 22
Planning Units	- 41

* Located in California
Preface digits are ADP identification codes

APPENDIX J

NEVADA MAP OF RESOURCE AREA, PLANNING UNIT, AND DISTRICT BOUNDARIES



Revised June 1977

APPENDIX K

COMPONENTS OF THE ENVIRONMENTS FOR EAR STIPULATIONS

GROUP I - Living Components

1. Wildlife Habitat

2. Sage Grouse-strutting, brooding and nesting sites.

   Blue Grouse-associated with White Fir areas.

3. Wildhorse and Burro Habitat

4. Bighorn Sheep Habitat

5. Deer Habitat

   Mule Deer

6. Elk Habitat

   Pronghorn

8. Wildlife Management Areas

   Alkali Lake

9. Birds of Prey

   Prairie Falcon
   Peregrine Falcon
   Bald Eagle
   Golden Eagle
   Raptors

10. Life Water

    Waterfowl Habitat
    Wildlife Conservation & protection of water (surface) for various wildlife uses.
    Water resources (for wildlife and fish)

11. Fish Habitat

    Pahrump Killifish
    Ash Meadows Pup Fish
    Desert Dace
    Cutthroat Trout (Lahontan)

12. Mourning Dove

GROUP II - Ecological and Cultural Components

21. Archaeological Sites

22. Historic Places

(Those places NOW LISTED with the National Register of Historic Places).

23. Historic Places

(Those places which are QUALIFIED FOR, PROPOSED or, NOMINATED to the National Register of Historic Places.

24. Natural Areas (Ecological)

Thermal Springs
Geologic Areas
Pinyon-Juniper Woodlands
Botanical Areas
- Joshua Tree Forest (Paiuite Valley)
- Swamp Cedar
- Bristlecone Pine
- Potosi Barrel Cactus
- Cottonwood Cholla

Desert View Environment Area
Ecological Values

25. Scenic Areas

26. Antiquities and Objects of H istoric Value

Cultural Resources
Historic Sites
Trails (Historic trade and Wagon Train Routes, Pony Express, Etc.)

27. Indian Pinyon-Nut Gathering Stipulation

GROUP III - Human Values

31. Recreation Areas

Hiking
Picnicking
ORV
Hunting
Water Sports
Administration Sites
Water Resources-for recreation

32. Wilderness Areas (Existing)

33. Wilderness Areas (Proposed)

34. Primative Areas (Proposed)

35. Roadless Areas (Proposed and Inventoried)

36. State Parks (Proposed)

37. Multiple Use Classification

38. National Forest

Watershed and Fire Rehabilitation
Research Areas
Recreation Areas
Lake Tahoe Basin

GROUP IV - Non-Living Components

41. Bureau of Reclamation Withdrawls

    Irrigation and Dam Projects

42.

43. Unstable/Erodable Soils (recommended by USFS and BLM)

    Ecology and terrain such as to be extremely sensitive to distrubance

44. Military

    Ordinance Areas

45. Rights-Of-Way Areas

46. Federally Controlled or Developed Water Projects

    (Other than those listed under the Bur. of Reclamation)

47. Snow Survey Transects

48. Critical Watershed Areas

    Municipal

APPENDIX L

EXPLANATION

LANDS EXCLUDED FROM LEASING

RED

No Leasing

YELLOW

No Leasing- Pending
(No leasing permitted until a final land use decision is made following additional environmental studies.)

LEASING - WITH RESTRICTIONS

BLUE

Non- Critical

ORANGE

Critical

The two divisions under this category are the Non-Critical and Critical. The non-critical areas are those upon which entry will be allowed after permission is obtained from the district offices. These areas are subject to the stipulations contained within the Geothermal Resource Lease (Sections 14 and 18) and additional restrictions.

Critical areas are those areas with stipulations of CRITICAL in their explanations, or NO SURFACE ENTRY, and others explained in the criteria used for the evaluation of EAR data. Areas with the stipulations of SITE-BY-SITE decisions may also be included. These additional stipulations are also attached to the Geothermal Resource Lease Stipulations (Sections 14 and 18).

APPENDIX M

Regional Planning Workshop
Salt Lake City, Utah
April 26, 1978

SUMMARY NEVADA OPERATIONS RESEARCH SOUTHWEST REGIONAL GEOTHERMAL PROJECT

G. Martin Booth III
Nevada Team Leader

By the end of the first year of the Southwest Regional Geothermal Project, the Nevada State Team will have defined over 300 potential geothermal sites. Because of the multitude of sites and data, scenarios for this fiscal year are being completed for 26 "areas" which will include all the specific sites. It is not improbable that fully one-third of the sites will prove to be of high to intermediate in temperature (i.e. >150°C and 90° - 150°C). Low temperature (<90°C) sites are also prominent, not only in number, but also in their distribution - each of our 17 counties has several such sites.

Fully 86 percent of the land in Nevada is Federally administered. Less than 2 percent is State land. The remaining 12 percent is private land, one-half of which is owned by the Southern Pacific Railroad.

Essentially all the leasing in the State is on Natural Resource Lands (Public Domain) which is under the jurisdiction of the BLM. Since leasing on Federal Lands was initiated in 1974, there have been millions of acres in geothermal lease applications by more than 150 companies and individuals.

As of February, 1978, there were 881,971 acres under lease with BLM. Fully 152,662 acres (or 17%) of this total, were within KGRAs; and the balance of 729,309 acres (or 83%), were non-KGRA leases.

All of the checkerboarded railroad lands are presently being evaluated by Phillips Petroleum Co., under an agreement with Southern Pacific. A significant percentage of the remaining private land in the northern and western sections of the State is held under lease by a number of companies.

The level of activity in Nevada is very high. There are 30 companies and groups, each of which hold 10,000-20,000 acres in Federal leases. DGE/DOE supported projects are now supplying and will provide for increasing momentum to exploration and development projects by means of several of its programs.

The Nevada Operations Research group is currently establishng aggressive, realistic scenarios, with emphasis on those which will come on line by the year 2020. To ensure that the site specific scenarios are truly usable to planners, the team is concerned not only with the technical data normally developed for resource assessment, but also the social, economic, institutional, and political elements. The Nevada Team has developed techniques for graphic representation of a vast amount of data and information which is available, and which must be considered in constructing the scenarios. To date three major categories, graphically portrayed on 1:250,000 scale AMS maps, are: (1) Environmental, (2) Exploration, and (3) Leasing. Many other important factors are being considered as well.

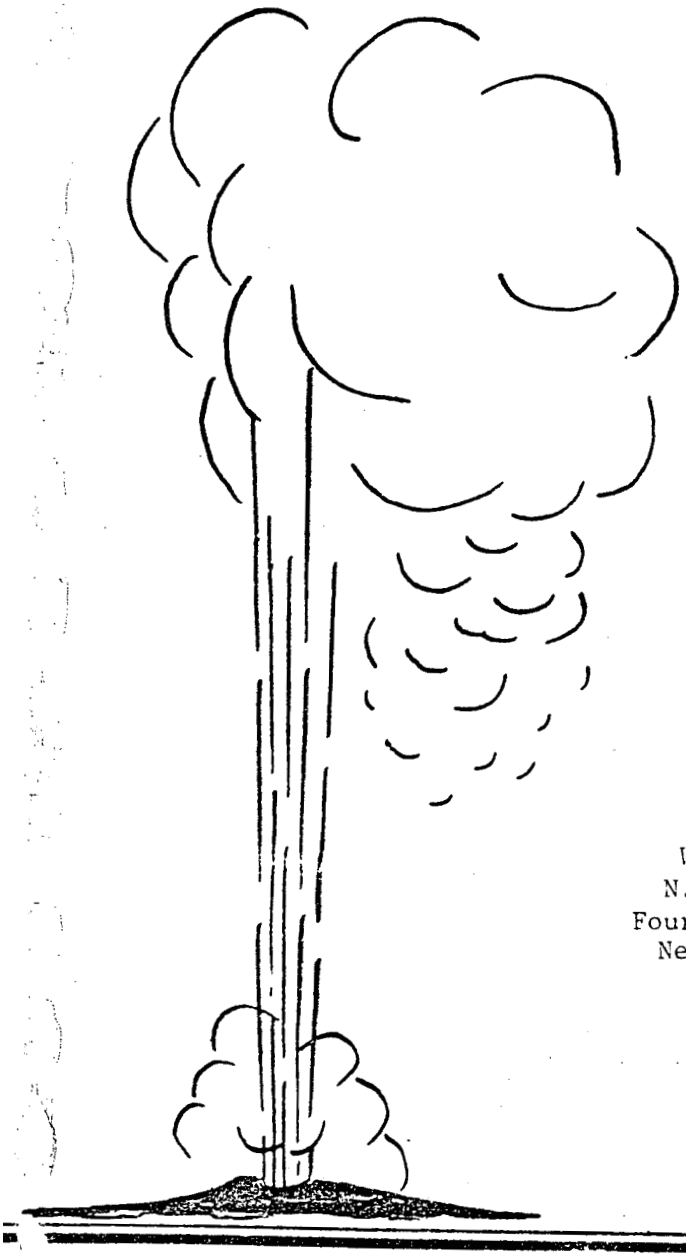
Nevada is experiencing a surge in population with an accompanying increase in energy demand. State planners concerned with energy, the environment, and other concerns connected with growth, will benefit extensively, and special studies elements of this Project. The results of the Operations Research studies will give the executive and legislative branches of the Nevada State government a means with which to plan and formualate policy in areas of land use planning, plant siting, inter- and intra-state energy coordination and cooperation, and other areas of concern.

ALO-3992-1

UTAH SOUTHWEST REGIONAL GEOTHERMAL DEVELOPMENT OPERATIONS RESEARCH PROJECT

Appendix 10 of

REGIONAL OPERATIONS RESEARCH PROGRAM
FOR DEVELOPMENT OF GEOTHERMAL ENERGY
IN THE SOUTHWEST UNITED STATES



Final Technical Report
June 1977 to August 1978

Utah State Enginner Office
Stanley Green
Lyle W. Wagstaff

January 1979

Work Performed under DOE Contract No. EG-77-S043992
N.M.Energy and Minerals Department Project No. 76-262
Four Corners Regional Commission Contract No. 672-066-075
New Mexico State University Sub-Contract No. 3104-X8

New Mexico Energy Institute at
New Mexico State University
Las Cruces, New Mexico 88003

U. S. DEPARTMENT OF ENERGY
Geothermal Energy

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TABLE OF CONTENTS

Introduction

Operations Research 1

Leasing 4
- State of Utah 4
- Federal Government 6
- Leasing In Utah 8

Drilling 15
- Temperature Gradient Drilling 15
- Geothermal Exploratory Wells 17
  - Roosevelt Hot Springs 18
  - Cove Fort/Sulphurdale 22
  - Thermo Hot Springs 23
  - Beryl/Escalante Desert 24
  - North Cove Fort 25
  - Box Elder County 25

Potential Geothermal Resource Areas 26

Possible Development Profiles 32
- Process of Creating Development Profiles 34
- Evaluation of Electrical Development Profiles 36
- Forecasted Development 45
- Direct Utilization Development Profiles 46
- Evaluation of Direct Utilization Development Profiles 51
- Procedure for Specific Direct Utilization Profiles 51
- Forecasted Development 53

Energy Production and Consumption in Utah 55

Economics 57

Institutional Analysis 60
- State Agencies 60
- Analysis of State Institutional Factors 70
- Federal Agencies 74
  - Pre-Lease Exploration 78
  - Competitive Leasing 78
  - Non-Competitive Leasing 79
  - Post-Lease Permits 80
  - Other Federal Involvement 81
- Analysis of Federal Involvement 82
- Private Industry Involvement 89
- Department of Energy Involvement 94
  - Industry Coupled Program 95
  - State Cooperative Program 96
  - Direct Applications Field Projects 96
  - Loan Guarantee Program 97

APPENDICES

Appendix A	Maps of Geothermal Areas in Utah
Appendix B	Development Profiles with Data and Assumptions
Appendix C	Utah State Government
Appendix D	Interagency Geothermal Streamlining Task Force Information
Appendix E	Resource Data
Appendix F	Financial Statement for Utah Operations/Research Study

FIGURES

Figure 1	Aggregated Scenario--Electrical Production from Geothermal Resources in Utah	37
Figure 2	Postulated Geothermal Direct Use Development Profile for Utah	50
Figure 3	Existing Geothermal Regulatory Process	76
Figure 4	Existing Geothermal Regulatory Process	77

TABLES

Table 1	Federal and State Geothermal Leases, Utah	11
Table 2	Federal Leasing in Utah--Status of Lease Sales on KGRA's	14
Table 3	Deep Geothermal Exploration Wells	19
Table 4	Potential Electrical Geothermal Prospects--Individual Possible Development Profiles	28
Table 5	Potential Geothermal Direct Utilization Prospects in Utah (Considered in possible development profiles)	30
Table 6	Potential Geothermal Direct Utilization Prospects in Utah (Not included in individual development profiles)	31
Table 7	Electricity Generation Resources	43
Table 8	Estimated Energy Capacities for Development Planning Profiles	44
Table 9	Direct Utilization Prospect Data Sheet	48
Table 10	Energy Production and Consumption in Utah, 1970-1975.	56
Table 11	Preliminary Assessment of Agencies and Permits Involved in Geothermal Development in Utah	62
Table 12	State and Local Agencies and Groups Involved in Geothermal Development	69
Table 13	Summary of Responsibility in the Federal Geothermal Leasing and Permitting Program	75
Table 14	Outline Summary of Options for Modification of the Federal Geothermal Leasing and Permitting Program (Preliminary proposals for purposes of discussion).	85
Table 15	Summary of State O/R Recommendations: Interagency Geothermal Streamlining Task Force Proposals	86
Table 16	Major Geothermal Developers in Utah	90

INTRODUCTION

The Southwest Regional Geothermal Operations/Research project was initiated to investigate geothermal development in the five states within the region: Arizona, Colorado, Nevada, New Mexico, and Utah. Although the region changed during the first year to include Idaho, Montana, North Dakota, South Dakota, and Wyoming, the project objectives and procedures remained unchanged.

The project was funded by the DOE/DGE and the Four Corners Regional Commission with participation by the New Mexico Energy Resources Board. The study was coordinated by the New Mexico Energy Institute at New Mexico State University, acting through a "Core Team." A "state" team, assigned by the states, conducted the project within each state.

This report details most of the findings of the first year's efforts by the Utah Operations/Research team. It is a conscientious effort to report the findings and activities of the Utah team, either explicitly or by reference. The results are neither comprehensive nor final, and should be regarded as preliminary efforts to much of what the Operations/Research project was envisioned to accomplish. In some cases the report is probably too detailed, in other cases too vague; hopefully, however, the material in the report, combined with the Appendices, will be able to serve as source material for others interested in geothermal development in Utah.

OPERATIONS/RESEARCH

Although geothermal energy has been used for some time in certain areas of the world, it is a relatively new industry in the United States. Electricity has been produced from geothermal resources at the Geysers area in California since 1960, but to date there are no other commercial geothermal power plants in the United States. Nevertheless, the country does have significant potential resources which could be used to produce electricity or to provide heat directly.

The awareness that the United States is not energy-independent has spurred interest in energy sources in addition to fossil fuels. Because of the increasing costs of energy and a national desire to be as energy-self-sufficient as possible, interest in geothermal energy has grown tremendously in the last four to eight years. The industry is still fledgling; and, as is the case for any newly developing industry, it has encountered substantial barriers. Thus the desire to utilize this important and valuable energy source has often been frustrated by cross-purposes and counterproductive regulatory measures.

The goals of the Department of Energy, Division of Geothermal Energy, are to foster the development of geothermal energy. The goals are expressed not in terms of accomplishments by the DGE but in terms of progress in geothermal development by the geothermal industry. This mission-oriented approach requires realistic assessments of both potential and impedance in order to set meaningful goals and define

specifically the steps required to reach them.

The purpose of the operations/research studies is to provide DGE with the information needed to set and reach the national goals of utilization of geothermal energy. The primary means of conveying this information will be the compilation of hydrothermal development profiles or scenarios. The purpose of the operations/research studies is to develop these profiles.

The essential elements of the development profiles are an assessment (or assumption if no estimate is available) of the resource characteristics, an analysis of the private and public actions needed to bring development to fruition, and an estimate of the time frame within which development is likely to occur. The assessment of the reservoir would be based on the best current information. The analysis of public and private actions would be quite detailed and would include input from the industry, state, federal, and local agencies, and other groups and individuals most directly involved. The institutional analysis would also include an evaluation of existing and potential impediments and recommendations for overcoming them.

The Southwest Regional Geothermal Operations/Research Study originally encompassed the southwest region (the states of Arizona, Colorado, Nevada, New Mexico, and Utah). The project was funded by the DOE, the Four Corners Regional Commission, and the New Mexico Energy Resources Board. The main contract was with the New Mexico Energy Institute at

New Mexico State University at Las Cruces.

The project was organized with a "state team" in each state to conduct the research for that state. The efforts of the state teams were coordinated by a "core team" at the New Mexico Energy Institute. The core team also set up a data bank on computer, conducted economic and sensitivity analyses, and aggregated and compiled the output from the state teams, both in terms of energy on-line and institutional factors.

In Utah, the study was assigned by the Governor to the Division of Water Rights, which is the primary regulatory agency for geothermal exploration and development in Utah. The Utah team consists of a team leader, Stanley Green, who is also Directing Appropriations Engineer for the Divison; a hydrologic engineer, Ward Wagstaff, whose primary responsibility is the operations/research project; and a secretary, Jayel White.

LEASING

State of Utah

State lands in Utah were officially opened to leasing for geothermal exploration and development in June, 1973, and geothermal leases were issued in August of that year. A few leases for geothermal resources on state lands had been issued in 1968 and 1971 on a special use basis.

In most townships, sections 2, 16, 32, and 36 are owned by the state. The state has also acquired some lands from other sources, e.g., transfer from the federal government. On some of these lands the federal government retained control of the mineral rights. Other state lands have been sold to individuals with the mineral rights reserved to the state; so in some cases the state owns surface rights but not mineral rights, and, in other cases, the state controls the mineral rights but not the surface rights.

Leases on state lands are handled by the Division of State Lands. Geothermal leases are issued for an initial period of ten years and can be extended. Rental for geothermal leases is $1.00 per acre, and the royalty is 10% (Utah: Geothermal Steam Lease and Agreement).

The geothermal lease entitles the lessee to access, exclusive drilling and exploratory rights, etc. The Rules and Regulations require that plans of operation and other data be submitted to the Division of State Lands.

If a discovery is made, it will be necessary to obtain a special use permit for building or other surface-disturbing activities from the Division.

The rules and regulations governing the issuance of leases of state lands in Utah state that lease applications will be considered in the order in which they are filed. Lands which become available for leasing, whether because they are newly acquired or because an existing lease is terminated for any reason, are issued by simultaneous filing procedures. This means basically that they are issued by sealed competitive bidding. The bid constitutes the first year's rental (minimum $1.00 per acre or part thereof), and the lease is issued to the highest "responsible, qualified bidder." In case of identical bids a public drawing is held (State of Utah Rules and Regulations Governing the Issuance of Mineral Leases).

The time required for the granting of a regular lease is from a few days to a week, and seldom more than about ten days. The Director of the Division of State Lands meets each Monday to consider leases. For leases granted under simultaneous filing procedures, the time required is up to 15 days. The bids are opened on the last Monday of each month and may be submitted until one working day prior.

To date, no applications for special use permits for the construction of power plants have been submitted, but it is estimated that the process would take about two months (Prince, 1978).

Federal Government

As of 1971, about 67.1% of the state of Utah was administered by the federal government, including Indian Lands. Geothermal leases for federal lands were first issued in 1974. Since that time considerable leasing has taken place, particularly in the west central and southwest parts of the state where federal land is found in higher proportions.

The federal leasing procedure is complex and restrictive. Obtaining a lease on federal lands takes at least six months; and many lease applications, particularly in some other states, have been pending since 1974 without action. After the leases have been approved, each step in the development must be approved, a process which may take from three to five months or longer for each step if environmental problems are encountered. The developer may also have to cope with severe restrictions or changing requirements.

An application to lease federal land is filed with the Bureau of Land Management (BLM). The surface management agency (BLM, U.S. Forest Service, Bureau of Reclamation) then conducts an Environmental Assessment (EAR) or, when the land is National Forest land, an Environmental Investigation (EIS). The various agencies involved provide input to the stipulations of the lease, which is subsequently issued by the BLM if the EAR/EIS is satisfactory.

The annual rental on federal geothermal leases is a minimum of $1.00 per acre or fraction thereof and may be higher. Beginning with the sixth year and continuing until the

production of geothermal resources, the rental is raised by $1.00 per acre each year (Federal Regulations on the Leasing of Geothermal Resources, § 3025.3-2 and 3205.3-3).

Once the lease has been issued its terms are administered by the USGS. Certain non-surface-disturbing activities such as geophysical surveys and shallow temperature gradient surveys may be permitted under a casual use or special use permit which are issued within 30 days. For major exploratory activities, such as deep exploratory wells, a plan of operation is filed with the USGS. A site-specific environmental analysis is conducted by the USGS, and if it proves satisfactory a permit is issued with stipulations. Again, the surface management agency may have input to the stipulations and joint approval rights with the USGS.

In the course of a geothermal development six plans of operation must be submitted to the USGS and approved by them. The first of these is the plan of exploration, which includes the deep exploratory wells and associated activity, and which may take up to a year for approval. As development proceeds, plans of operation must be submitted for the acquiring of one year's environmental baseline data, development of the geothermal field, injection, production, and utilization, each of which involves a site-specific environmental assessment and the granting of a permit. These later permits can probably be issued in three to five months (Bull, 1978).

A potential resource area can be declared a Known Geothermal Resource Area (KGRA) if (1) the USGS determines that

the geology of the area indicates the presence of a geothermal resource, (2) if a discovery is made nearby, or (3) if two or more parties file for geothermal leases on the same area (Federal Regulations on the Leasing of Geothermal Resources, § 3200.0-5). When an area is declared a KGRA the leases are issued by competitive bid and the annual rent is elevated.

Federal regulations state that the acreage limitation for a single lease is 2560 acres in a "reasonably compact area," with provisions for exceptions. The maximum acreage which any entity can lease within any single state, whether directly, by assignment, or part interest, is 20,480 acres. Leased lands which are included in a unit or cooperative plan are not included in the total acreage computations (Federal Regulations on the Leasing of Geothermal Resources, § 3201.2 and 3203.2).

Leasing in Utah

Extensive leasing has occurred in Utah, both on state and federal lands. Much private land has also been leased, but private lease records are not readily available, and analysis of private leases is not included in this report.

As part of the initial phase of this study, the state and federal lease records were compiled and integrated. The purpose of this exercise was to provide background information on the possible location of geothermal resources. In an attempt to determine specific sites as a basis for a "site-specific" approach to scenarios, sites were tentatively defined according to leased areas. Because this definition

was unrealistic in terms of the location of the resources and because it tremendously increased the amount of analysis necessary to produce meaningful scenarios, the leasing area definition of a site was dropped in favor of the "prospect" concept.

The leasing situation is not static. After the initial attempt to compile state and federal leases had been made, it was found that the information available to the study team had been incomplete. A second effort was made to compile the leases, and this information, current as of February 1, is regarded as more complete and reliable than the original information; still, there are several discrepancies, and the data are already outdated.

Nevertheless, the lease data proved valuable by providing a number of insights into the way geothermal development has been approached in the state. In many cases, lease patterns show up clearly as a speculative venture by the lessee. More serious developers tended to lease larger, more contiguous blocks of land. The speculative lessees tended to avoid KGRA lands, whereas major developers did not. The smaller lessees usually assigned their lease to major developers, and the major developers--exploration companies and oil companies--have done nearly all the drilling in the state, both temperature gradient holes and deep exploratory wells. Of course, one can really only speculate as to which lessees are speculators; but the patterns are interesting.

Another interesting aspect of the leasing patterns is the proportion of state land leased relative to the proportion

of federal land leased. Using 1971 figures, federally administered lands comprised 67.1% of the state, state-owned lands accounted for 6.8% of the state, and privately owned land accounted for 21.5%. If only state and federal lands are considered, 90.8% is administered by the federal government, and 9.2% by the state. The February figures for leasing, again excluding private lands, showed that 67.0% of the total state and federal lands leased in the state were federal lands, and 33.0% were state lands. This is a crude comparison, but it demonstrates that a higher proportion of state lands have been leased compared with federal lands. It also indicates that it would probably be a false assumption to estimate the acreage of private leases based on the proportion of private land to the total land area in the state; hence, no figures for private leases have been projected.

Due to the constant changes in leases, the limited function of lease data in the study, and the amounts of time involved in analyzing lease data, the lease information has not been updated since February. The federal lease information compiled at that time appears to be significantly different from lease information received from the BLM in June and dated in March. Both sets of information are presented, as Table 1 and 2.

TABLE 1

FEDERAL AND STATE GEOTHERMAL LEASES
UTAH
(As of February 1, 1978)

Operator	Federal Leases KGRA No.	Federal Leases KGRA Acreage	Federal Leases Non-KGRA No.	Federal Leases Non-KGRA Acreage	State Leases No.	State Leases Acreage
1. Agri-Empire					4	3457.67
2. Alta Energy Corporation			1	1931.28	1	1367.52
3. AMAX Exploration			3	3808.78	12	8535.15
4. American Geological Enterprises			5	6339.69		
5. American Geothermal Energy, Inc.	3	7579.19				
6. American Oil Shale Corporation					7	5566.46
7. Aminoil USA, Inc.	2	4067.46				
8. Amoco			1	1923.19		
9. Anderson, Stephen					3	3237.02
10. Armstrong Dale E.					1	760.00
11. Atlantic Richfield			7	11,735.63		
12. Barnes, Roy E.					4	2450.00
13. Barr Ronald C.					6	3678.57
14. Blankenship, Jack E.					1	1158.89
15. Bountiful City Corporation			1	40.00		
16. Bradshaw, Melvin					2	90.32
17. Brown, J.G.					3	4139.18
18. Chevron Oil Corporation	1	2532.68	11	19,698.65	16	13,363.31
19. Christensen, L. Daral, and Peterson, Hearid					1	80.00
20. Ciancanelli & Gillett			8	16,777.55		
21. Clinton Oil Corporation					1	638.32
22. Colman, William J.			3	5828.83		
23. Covello, J.W.					5	3532.23
24. Davon, Inc.			5	7773.16		

FEDERAL AND STATE GEOTHERMAL LEASES
UTAH
(As of February 1, 1978)

Operator	Federal Leases KGRA No.	KGRA Acreage	Non-KGRA No.	Non-KGRA Acreage	State Leases No.	State Leases Acreage
25. Earth Power Corporation			10	19,302.91	1	765.44
26. Energy Partners, 1974			8	17,226.58		
27. Fisher, Milton			3	5721.26		
28. Flying Diamond Oil Company			1	1920.00		
29. Folmar, Cecil J.			5	7853.63	2	1920.00
30. Geothermal Exploration Co.			5	8936.62		
31. Geothermal Kinetics			2	3083.36	9	13,633.12
32. Geothermal Power Company			1	640.00		
33. Geothermal Resources International	6	14,338.25	2	4645.23		
34. Getty Oil Company	1	1920.00				
35. Golding, Charles L.	2	3360.00	9	8483.91	9	9418.55
36. Gulf Oil Corporation			2	3552.34	16	19,581.54
37. Harper, Robert C.					4	4452.35
38. Hunt	2	2340.00	14	19,199.40	1	55.77
39. Intercontinental Energy					3	1748.72
40. Justice, Malcolm F. Jr.			1	2182.24	1	360.29
41. Ladd Petroleum Company			1	2560.00		
42. Magma Power Company					1	2000.00
43. McCormick, Sonja V.					1	2710.38
44. O'Brien Resources Corp.			6	11,661.91	2	2428.96
45. O'Brien/Thermal Power					3	2547.46
46. O'Brien/Altex					2	240.00
47. Pacific Energy Corporation			8	13,320.12		
48. Papulak, Kay			1	640.33		

FEDERAL AND STATE GEOTHERMAL LEASES
UTAH
(As of February 1, 1978)

Operator	Federal Leases KGRA No.	Federal Leases KGRA Acreage	Federal Leases Non-KGRA No.	Federal Leases Non-KGRA Acreage	State Leases No.	State Leases Acreage
49. Papulak, Milan S.			3	7360.86		
50. Phillips Petroleum Company	10	17,688.965	12	16,589.87	65	69,869.63
51. Pucket, R. E.					1	1000.00
52. Republic Geothermal	1	1200.58	15	29,768.77		
53. Resource Leasing Corporation					2	1293.44
54. Seltzer, Gary W.	1	1200.00	3	5759.37		
55. Steam Corporation of America			2	3416.50	4	1386.14
56. Stevenson			3	4547.85	3	1763.53
57. Supron	3	5486.79	5	11,042.86	5	2623.32
58. Thermal Power Company					11	11,513.89
59. Thermal Power/O'Brien/AMAX/ (VTN)					1	640.00
60. Thermal Resources, Inc.			6	12,323.11		
61. Thermex	2	3840.00	2	3737.65		
62. Union Oil of California	14	18,620.98	6	5037.90		
63. United States Geothermal Corp.			11	20,392.64		
64. Utah International			1	2077.00		
65. U. V. Industries					7	6259.02
66. Weiner, Ted			1	1381.00		
67. Western Geothermal, Inc.	2	1721.95				
68. Windsor, Trevar L.			4	8348.72		
TOTAL	50	66,447.045	199	340,011.35	221	210,559.65
		13.6%		53.4%		33.0%
Total State and Federal Leases 637,028.04 acres						

TABLE 2

Federal Leasing in Utah

Status of Lease Sales on KGRA's

	BLM	USFS
Total Federal Acres	83,215	15,572
Theoretically Available for Leasing	83,215	15,572
Acres Offered	78,966	10,852
Acres Bid On	77,277	10,852
Acres Accepted	77,277	10,852
Federal Acres Remaining for Lease	7,138	4,719

From Interagency Geothermal Streamlining Task Force, 1978.

DRILLING

The Utah Division of Water Rights is the regulatory agency for geothermal wells and development. As such, it has access to records including the locations of all legal temperature gradient wells and exploratory wells. Also on record at the Division are the well logs, temperature data, and other information. This information is proprietary and cannot be released without permission from the developer. As a result, the kinds of information which would be very useful in assessing potential resource areas cannot really be used.

A major problem in development forecasts for a truly specific site is the location, boundaries, and reservoir characteristics of the resource at that site. The initial approach of the Operations/Research study was to use lease information to define boundaries and drilling data to estimate the reservoir characteristics. However, lease boundaries are artificial and most of the drilling information is confidential. Hence, the site-specific approach evolved into a "prospect" approach, which is much more realistic and easier to work with but which is substantially less specific.

Temperature Gradient Drilling

Temperature gradient wells are narrow diameter holes drilled to determine temperature-depth relationships and to calculate the heat flow. Temperature gradient wells may be several thousand feet deep but are usually drilled only a few hundred feet. When completed, they consist of a narrow

diameter pipe or tube extending the length of the hole, sealed at the bottom and filled with water. The hole is filled in around the tube and the water in the tube is allowed to equilibrate to the ground temperature of the various geologic strata. A temperature probe is used to determine the temperature profiles through the length of the tube. The cost of a temperature gradient hole varies with depth, and may range from $40,000 to $60,000 for a hole a few thousand feet deep (Berge, 1978; Ward, 1978).

The rules and regulations governing exploratory drilling for geothermal resources state that permission must be obtained from the State Engineer in order to drill temperature gradient wells. Applications are made by letter, including the plan of operations; and permits are issued by letter. The permits are valid for six months and may be extended by request to the Division of Water Rights. The Division is to be notified when drilling will begin. Temperature data and well logs are to be submitted to the Division. When the survey is complete, the casings must be capped, or they may be pulled and the hole cemented (Utah, Rules & Regulations).

A total of 225 temperature gradient well applications have been filed with the Division of Water Rights. Often a whole series of wells will be included on one application. The data from the well need not be sent in until the survey on the well has been completed, and no notification is required if a well is not drilled. Hence, Division records do not show exactly how many temperature gradient wells have

actually been drilled. The situation is complicated by the fact that some temperature gradient wells have been drilled illegally, i.e., without the necessary permit from the state.

On federal lands, temperature gradient holes up to 2000 feet may be drilled under a special use license. If the holes are to go below 500 feet, a plan of exploration must be filed with the USGS. If the holes are to be drilled on land not leased by the developer, and the holes are less than 500 feet, a special use license may be obtained from the BLM or USFS.

Geothermal Exploratory Wells

Deep wells drilled to test for geothermal resources are larger diameter (up to 26 inches at the surface) and deeper (up to 10,000 feet) than other types of geothermal exploratory wells. The rigs are, of course, much larger; and the extra workers, equipment, and time involved make these wells much more expensive, from $600,000 to nearly $2,000,000 per well.

Deep exploratory wells must be approved by the State Engineer. Application is made by letter to the state, and a plan of operations must be submitted. The Rules and Regulations spell out in some detail the requirements for the plan of operations, fees, bonds, casing requirements, well spacing, directional drilling, blowout prevention equipment, logging, records, etc. The permit to drill is issued by letter within a few weeks (or faster, if necessary).

The State has regulations regarding blowout prevention

equipment (BOP or BOPE) tests. A test of the BOPE is required, and the Division should be notified so that Division personnel may observe the test.

Federal regulations specify that plans of operations be filed for deep drilling. Site-specific environmental assessments (EA or EAR) must be conducted, and the entire approval process may take up to a year. Because of the long approval time, most developers file a plan of operation which includes as many wells as is foreseen. Federal regulations for drilling are quite stringent and are explained in detail in the Federal Rules and Regulations and in the Geothermal Resources Operations Orders (GRO Orders).

To date, 17 deep geothermal exploration wells have been drilled in Utah and two are currently being drilled. The wells are summarized in Table 3. A short, general history of drilling in Utah follows.

Roosevelt Hot Springs

The first well drilled at Roosevelt Hot Springs was drilled by a railroad crew which was seeking fresh water. In 1968 an experimental geothermal well was drilled by private individuals which hit steam at about 280 feet.

In 1975 Phillips Petroleum Company drilled a deep test well (Well #9-1) on federal leases on the west side of the dome fault. The well was dry, but the temperatures were promising. Phillips then drilled a discovery well (Well #3-1) on the east side of the dome fault. However, after a few weeks the casing collapsed on Well #3-1 and Phillips drilled

TABLE 3

DEEP GEOTHERMAL EXPLORATION WELLS

Roosevelt Area

Phillips Petroleum Company

3-1 (1975)
North 2740 feet and East 2850 feet from the SW Corner of Section 3, T27S, R9W, SLB&M.

9-1 (1975)
South 1000 feet and West 2560 feet from the NE Corner of Section 9, T27S, R9W, SLB&M.

13-10 (1975)
South 1882 feet and East 200 feet from the NW Corner of Section 10, T27S, R9W, SLB&M.

25-15
South 2719 feet and East 1094 feet from the NW Corner of Section 15, T27S, R9W, SLB&M.

82-33 (1976)
South 1284 feet and West 77 feet from the NE Corner of Section 33, T26S, R9W, SLB&M.

54-3
SW¼SW¼NE¼, Section 3, T27S, R9W, SLB&M.

12-35
South 750 feet and East 100 feet from the NW Corner of Section 35, T26S, R9W, SLB&M.

Thermal Power Company

72-16 (1976)
South 990 feet and West 990 feet from the NE Corner of Section 16, T27S, R9W, SLB&M.

14-2 (1976)
South 2310 feet and East 350 feet from the NW Corner of Section 2, T27S, R9W, SLB&M.

24-36 (1977)
South 2310 feet and West 4290 feet from the NE Corner of Section 36, T26S, R9W, SLB&M.

Getty Oil Company

52-21
South 990 feet and West 2310 feet from the NE Corner of Section 21, T27S, R9W, SLB&M.

Cove Fort/Sulphurdale Area

Union Oil Company

Forminco No. 1
South 89°55'56" West 310.96 feet and South 821. 59 feet from the NE Corner of Section 29, T25S, R6W, SLB&M.

42-7
SE¼NE¼NW¼, Section 7, T26S, R6W, SLB&M.

31-33
NW¼NE¼NW¼, Section 33, T25S, R6W, SLB&M.

North Cove Fort Area

Caroline Hunt Trust Estate

CHTE 15-30
NW¼NW¼SW¼, Section 30, T24S, R6W, SLB&M.

Thermo Area

Republic Geothermal, Inc.

57-29 (1977)
East 3280 feet and South 4030 feet from the NW Corner of Section 29, T30S, R12W, SLB&M.

Beryl Area

McCulloch Oil Corporation, Geothermal Kinetics, Inc., and Utah Power and Light

MCO-GKI-UPL-DeArman #1 (1976)
North 431.78 feet and East 1645.83 feet from the SW Corner of Section 18, T34S, R16W, SLB&M.

State #1 (1976)
SE¼NE¼NW¼ of Section 22, T34S, R16W, SLB&M.

Jones #1-8 (1977)
Center of NE¼ of Section 8, T34S, R13W, SLB&M.

North Wasatch Front/Brigham City Area

Utah Power and Light

Utah Steam Venture #1-Davis (1974)
South 2510 feet and West 4950 feet from the NE Corner of Section 16, T10N, R2W, SLB&M.

Well #54-3 nearby, also a producing well. Later in 1975, Wells #12-35 and #13-10 were drilled, both producing wells; and Well #82-33, a dry hole, was drilled late in the year.

In the early fall of 1976, Phillips drilled Well #25-15, a producing well. Shortly thereafter, the Thermal Power Company drilled Well Utah State #14-2 on state land, also a producing well. In October of 1976, Thermal Power drilled a second well, Utah State #72-16, also on state land. This well was about 1245 feet deep and appears to be a very high producing well.

In late 1977, Thermal Power drilled a test well (Utah State #24-36), again on state land, in the northeast part of the prospect. The well was not producible. In early 1978, Getty Oil Company drilled a deep test well in the south part of the prospect (USL-52-21). The well test results have not yet been made public, but apparently the well could not be classified as a discovery well.

The wells drilled so far at Roosevelt, when combined with heat flow and other information, seem to indicate that the dome fault is the controlling feature at the prospect. The west edge appears to be the dome fault, and Wells #82-33 and #24-36 are apparently outside the reservoir boundaries. The Getty well at the south end of the prospect may or may not indicate a southern limit; when compared with heat flow data compiled and analyzed by Dr. David Chapman at the University of Utah, it appears that the heat flow does in fact decrease through the south part of the prospect.

As far as known, no extraordinary geological or technical problems have been encountered in the Roosevelt Prospect. The water is hot but comparatively low in TDS. The wells have ranged up to 6,000 to 7,000 feet, but drilling has not been particularly difficult.

The three Thermal Power wells and the Getty well were drilled with assistance from the DOE industry coupled case study program. This program essentially provides money for the drilling; in return, the data and information are made available to the DOE which releases it to the public.

Cove Fort/Sulphurdale

The Cove Fort/Sulphurdale Prospect has been considered a prime prospect for geothermal resources. An area of thermal alteration at Sulphurdale has been mined for sulphur for many years. The federal leases at Sulphurdale were issued by competitive bidding.

In the summer of 1976, Union Oil Company drilled an 1100 foot deep well on private leases (Forminco Well #1). Drilling was very difficult due to adverse geologic conditions, and the well eventually caved in.

The Cove Fort/Sulphurdale Prospect was unitized in January, 1977, with Union Oil Company as the operator and Phillips Petroleum Company and AMAX Exploration, Inc., as the other unit members. W. H. Hunt joined the unit in January, 1978.

As unit operator, Union drilled a second deep exploratory well in late 1977 (Cove Fort/Sulphurdale Unit Well #42-7). The well was drilled on federal leases several miles

north of the original well; but again, drilling was very difficult. The well was drilled with federal assistance under the Industry Coupled Case Study Program (the Forminco well data were also bought retroactively by the DOE), and the data from the well will be made public. However, it appears at this time that the well was not a discovery well.

Union is currently drilling another well (U.S.A. Well No. 31-33) in the Cove Fort/Sulphurdale area, somewhat between the other two wells. It is also being drilled with federal assistance through the DOE case study program.

The drilling problems at Cove Fort are apparently due to an extensive porous rock system which causes loss of circulation. More information on this condition will be available when the case study data are released. In any case, the geologic conditions make drilling very expensive. It is to be hoped that the problems may be overcome, and that as more drilling is done and more is learned about the geologic conditions, the developers and drillers will be able to cope more effectively with the particular difficulties encountered in this area.

Thermo Hot Springs

The Thermo Hot Springs area is a prime prospect for geothermal development, although it is estimated to have a lower electrical potential than the other major prospects in Utah (Roosevelt and Cove Fort). Notwithstanding, a considerable amount of geological and geophysical exploration has been conducted in this area by several developers, including

extensive temperature gradient surveys.

In late 1977, Republic Geothermal, Inc., drilled a deep exploratory well on federal leases a few miles from the hot springs (Well Escalante #57-29). Republic reported no significant drilling problems. Smith, et al.(1978), report that the well went to 7288 feet, that temperatures of 350°-400° F. (about 175°-205° C.) were encountered, that the natural flow rates are low, and that the fluid has a low salinity. Republic and other developers continue to investigate the area and more drilling will probably occur within the next few years.

Beryl/Escalante Desert

The area near Beryl and in the surrounding Escalante Desert holds some promise for geothermal resources. In February, 1976, McCulloch Oil in a joint venture with Utah Power and Light and Geothermal Kinetics drilled a deep exploratory well (MCO-GKI-UPL State #1). The well did not prove commercial, and a second well was drilled in April, 1976, several miles away (MCO-GKI-UPL - DeArman #1). In January, 1977, a third well was drilled (Jones #1-8) further east in the Escalante Desert.

None of the wells were suitable for electrical production, although good flows and boiling temperatures were encountered. The complete data from the McCulloch wells are not public. However, there is potential for direct utilization at the existing wells and further exploration of the Escalante Desert, possibly including exploratory wells, will probably occur in the next few years.

North Cove Fort

The Cove Fort geothermal prospect can be considered to cover a wide area. USGS Circular 726 assumed a default reservoir area to be 15 km^2 (USGS Circular 726). Other potential prospects appear to be generally associated with the Cove Fort anomaly.

The Caroline Hunt Trust Estate (CHTE) has rights to some private leases north of Cove Fort in the White Sage Flat-Dog Valley area. The Hunt Energy Corporation, which is handling exploratory activities for CHTE, is currently drilling a deep well on these lands (Well CHTE #15-30). The well is not completed, and data from the drilling operations have not yet been released. However, it appears that drilling in this area may be difficult, as has been the case at Sulphurdale.

Box Elder County

In 1974, Utah Power and Light and Geothermal Kinetics drilled a deep exploratory well (Utah Steam Venture No. 1) north and west of Brigham City in Box Elder County. The well did not prove to be commercial and was subsequently abandoned.

The geothermal resources in this area and along the Wasatch Front in general are quite plentiful in the low to moderate temperature range. As such, the potential for direct utilization is very good; but the electrical potential in this area appears to be slight.

POTENTIAL GEOTHERMAL RESOURCE AREAS

One major task of the Operations/Research study was to identify the potential geothermal resource areas within the state. This task was assigned specifically to resource assessment study groups in each state; however, in some of the states, including Utah, the resource assessment groups were not formed until the Operations/Research had been underway for some time. As a result the Operations/Research team was compelled to gather the resource data available in order to complete the tasks of cataloging resource areas and uses and projecting possible development forecasts.

One problem encountered in identifying potential resource areas was defining them. Initially the approach was to attempt to define them specifically on a geological-technological basis according to lessee. This approach provided useful background information but was inadequate because the only information actually available was the lease information. To develop scenarios for individual leases or lease goups without regard for other factors would not have been meaningful.

As the study progressed, the concept of a "prospect" evolved and became the basis for the scenarios which were eventually developed. The lease information was very important to this approach because it identified potential developers within a general area, and also was necessary in understanding certain rather specialized situations, e.g., the interactions between developers at Roosevelt Hot Springs.

The advantage of using prospects as the basis for scenarios is that it does not require as much specific information (which is usually unavailable) or as many specific assumptions; as a result it is more manageable and probably more accurate over the long term. The disadvantage is, of course, the lack of specificity in the analysis. Undoubtedly, as more specific information becomes available the basis for the scenarios will shift to more specific sites.

Electrical prospects within the state were determined on the basis of known resources (Roosevelt Hot Springs), industry interest as evidenced by exploratory drilling (Cove Fort/Sulphurdale, Thermo, and the North Cove Fort Area), and as evidenced by exploratory activities and geological indicators (West Cove Fort, Thermo, Black Rock Desert, and others). There is apparently information about seven specific areas of high heat flow in the Iron-Beaver-Millard Counties area (Ward, 1978), but this information is apparently proprietary and at any rate is a well-kept secret.

The prospects for which scenarios were prepared are listed in Table 4.

Direct use prospects are more difficult to define specifically. For the purposes of the study, hot springs or hot springs groups were considered prospects; the decision of whether to consider the springs separately or as groups was based on expected energy potential, geographical proximity, geologic similarity, and known development plans. In addition, some areas of fairly certain geothermal resources were included,

TABLE 4

Potential Electrical Geothermal Prospects

Individual Possible Development Profiles

Roosevelt Hot Springs Prospect

Phillips Petroleum Co./Rogers International, Inc.
Thermal Power Co./AMAX Exploration, Inc./O'Brien Resources/VTN
Getty Oil Co.*

Cove Fort/Sulphurdale

Union Oil Co. (acting as unit operator)

Thermo

Republic Geothermal, Inc.

North Cove Fort

Caroline Hunt Trust Estate/Hunt Energy Corp.

West Cove Fort/Black Rock Desert

Chevron Resources, Inc.
AMAX Exploration, Inc.

*Later information indicates that Getty will probably not develop independently.

e.g., electrical prospects such as Cove Fort, Thermo, West Cove Fort, Beryl, New Castle, etc.

An essential part of defining resource areas is to match energy needs with the resources. The study did not progress far enough to complete this phase; it is of very high priority for the first part of the second year efforts. This process is outlined in detail in the discussion of direct use scenarios.

Direct use resource areas as delineated for the first attempt at scenarios are found in Table 5.

A more complete listing of potential areas is found in Table 6. These are areas of less apparent potential or less likely prospects for development. They are nevertheless potential use areas and should not at this point be disregarded.

TABLE 5

Potential Geothermal Direct Utilization Prospects in Utah
(Considered in Possible Development Profiles)

Monroe Hot Springs/Red Hill Hot Springs/
Johnson Hot Springs

Crystal Hot Springs (South Salt Lake County)

Wasatch Hot Springs/Beck's Hot Springs/
Hobo Hot Springs

Midway

Ogden Hot Springs/Hooper Hot Springs/
Utah Hot Springs (Including Ogden
area and Hill AFB.)

Meadow Hot Springs/Hatton Hot Springs

Joseph Hot Springs

New Castle

Cove Fort/Sulphurdale

Thermo

Tintic

Beryl

Abraham Hot Springs

West Cove Fort

Black Rock Desert

Veyo Hot Springs

LaVerkin Hot Springs

Crystal (Madsen's) Hot Springs

TABLE 6

Potential Geothermal Direct Utilization Prospects in Utah
(Not included in individual development profiles.)

Blue Warm Springs
Bothwell Warm Springs
Castilla Hot Springs
Como Warm Springs
Cultler Warm Springs
Diamond Fork Warm Springs
Fish Springs/Big Springs/Wilson Hot Springs
Gandy Warm Springs
Goshen Warm Springs
Grantsville Warm Springs
Lincoln Point Warm Springs/South Utah Lake
Little Mountain Warm Springs
Livingston Warm Springs
Morgans Warm Springs/Russells Warm Springs
Radium Warm Springs
Richfield Warm Springs
Saratoga Hot Springs/Crater Hot Springs
Split Mountain Warm Springs
Stansbury Mountains--Big Warm Springs,
Burnt Springs, Horseshoe Springs, Iosepa
Springs, Muskrat Spring
Sterling Warm Springs
Stinking Hot Springs
Uddy Hot Springs
Warm Spring

Other Potential Areas

Cache Valley
Uintah Basin
Wendover/West Toole County

From: Mundorff, 1970.
DOE Regional Hydrothermal Development Presentation, 1978.

POSSIBLE DEVELOPMENT PROFILES

A principal objective of the Operations/Research Study is to develop meaningful, specific "development scenarios" or "possible development profiles." This has been accomplished in part, and the groundwork has been laid for an on-going effort to update and improve the planning forecasts and to make them a powerful tool for planning.

In theory, the procedure for creating scenarios is to obtain information from the sources most directly involved, use the information to develop a scenario, then repeat the cycle by adding details, checking back with the sources, revising the scenarios, and so forth, continuing in an iterative process. The sources should be as direct as possible; e.g., the industries, agencies, and individuals actually involved. The process would thus provide current information to the study and develop strong working relationships not only between the study team and the various sources but also among the sources.

Unfortunately, much of the information needed to make the scenarios very specific is either proprietary or unknown. Most geothermal developers are hesitant to estimate such parameters as reservoir capacities, depths, and other characteristics, or to provide firm time frames for exploratory drilling. They are also unwilling to speculate very much about promising but not widely known prospects. This reluctance is justifiable since public access to this type of information would probably damage the individual company's

competitive position. Often, too, the company has not yet developed this information; a good example is reservoir capacity, which usually is not determined until the power plants have been in operation for many years. In effect, this means that by the time all the information is available, there is no longer a need for forecasting.

This lack of definitive information makes it necessary to use assumptions. Where professional assumptions or estimates were available, they were used; but the study team frequently found it necessary to specify its own assumptions. Such assumptions are very seldom comfortable and there is seldom a consensus where specific numbers are involved. In addition, it frequently happens that some information can be released; but the supportive data are proprietary, so that the information may be valid but to all appearances is unsupported. Of course, there is also an inescapable subjectivity associated with such assumptions which usually causes judgment to be to some degree personal rather than professional; this problem is in reality fundamental and has frequently become apparent in the course of the study, not only in the assumptions but also in critiques of the assumptions.

In spite of these drawbacks, it is necessary to use assumptions in developing the scenarios. The approach which was considered most appropriate was to gather the best available information, synthesize it to a concise and organized form, propose the assumptions, and document and explain them fully. The process would then be repeated by confirming that the

assumptions are reasonable through contacts with the best possible sources, incorporating their input, and continuing through successive iterations.

Process of Creating Development Profiles.

The first step in development of the possible development profiles was to analyze the lease data and describe the lease areas in terms of size, contiguity, location, proximity to major resource areas, distance from populated areas, and developer interest as indicated by exploratory activities on or near the leases. This extensive body of information provides a broad base of back-up data and will eventually be developed even more fully.

As more information concerning geothermal prospects was gathered, the development patterns began to take shape. The first attempts at scenarios were based primarily on the work done by the MITRE Corporation for the Department of Energy. As more information relating to current developments at specific sites, problems encountered at individual prospects, and further plans for development, etc., became available, it was compiled and assimilated.

The first attempt at a development profile for a specific prospect was for Roosevelt Hot Springs. Data acquired from the developers were used as the basis for the preliminary scenario, and some aspects were, of course, extrapolated from known information.

The preliminary scenarios were then analyzed to refine the information and the format, and similar scenarios were

developed for other prospects, with emphasis on those developments which appeared to be most advanced with respect to exploration.

Based on information available April, 1978, the following preliminary scenarios were developed:

Roosevelt Hot Springs Prospect:	Phillips Petroleum, Rogers International, UP&L. Thermal Power Co., AMAX Exploration, Inc., O'Brien Resources, and VTN. Getty Oil Co.
Cove Fort/Sulphurdale:	Union Oil Co., Unit Operator.
North Cove Fort:	Caroline Hunt Trust Estate.
Thermo:	Republic Geothermal, Inc.
West Cove Fort/Black Rock Desert:	Chevron Resources, Inc. AMAX Exploration, Inc.

The major assumptions for these scenarios were the presence of a commercial reservoir, economic advantage of development, and lack of institutional restraints. It must be remembered that the assumptions are an integral part of the development profiles.

After the preliminary scenarios were developed, the various developers were contacted by phone and a few key points in each individual development profile were discussed. The input from these discussions were incorporated into the scenarios, which were then sent to the various developers for comments and further input.

The development scenarios and the associated assumptions are found in Appendix B. Again it must be emphasized that

the assumptions are an integral part of the profiles and are as important as the schematic charts themselves.

It should be noted that most of the developers had few comments on the scenarios which were sent to them. This was apparently because (1) the charts were quite general and lacked a high degree of detail; (2) the assumptions were spelled out perhaps too restrictively to invite comment; (3) it is difficult to discuss this type of material over the phone. It is likely that personal discussion would invite more criticism of the assumptions--which is what is needed--than a phone discussion. Of course, many people are somewhat reluctant to criticize someone else's assumptions if they seem reasonable, even though they disagree with them.

Once the scenarios had been developed, they were aggregated into a state-wide "power-on-line" scenario. This scenario is shown in Figure 1; the assumptions follow the scenario.

Evaluation of Electrical Development Profiles

The scenarios in their preliminary form are felt to represent the best available, current information in light of the assumptions. A discussion of the limitations of the scenarios would be lengthy and tedious, but a few aspects need to be brought out.

One of the most limiting assumptions is that of a commercial reservoir and an energy capacity. There is a wide range of capacity estimates, mainly because no definite information is available, because there are a variety of purposes for the

Figure 1

Aggregated Scenario--Electrical Production from Geothermal Resources in Utah

	tot MWe	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	2000
Roosevelt Prospect	400			50		50		50		50		100		100								
Cove Fort Sulphurdale	200					50		50		50		50										
West Cove Fort	200						50		50		50		50									
North Cove Fort	200						50		50		50		50									
Thermo	100							50		50												
Other Areas (Sevier Lake, Black Rock Desert, Delta Area	200								50		50		50	50								
TOTAL FOR YEAR				50		100	100	150	150	150	150	150	150	150								
CUMULATIVE TOTAL				50		150	250	400	550	700	850	1000	1150	1300								

Figure 1 (Continued)

ASSUMPTIONS USED IN SCENARIOS

April 1978

Roosevelt Hot Springs Prospect

1. The reservoir capacity at the Roosevelt Prospect was assumed to be 400 MWe. This figure is averaged between Phillips (1) and UP&L (2) planning estimates of 300 MWe, and Dr. Stanley Ward's estimate of 500 MWe (3). The heat flow data compiled by Dr. David Chapman also indicates about 300-500 MWe. In this respect 400 MWe is considered an optimistic and fairly realistic estimate.

2. According to Phillips and UP&L (1&2), the plants are planned to come on-line in 55 MWe units two years apart if feasible. The following assumptions were based on this information:

   A. The plants were generally assumed to come on-line two years apart.
   B. The later plants were assumed to be 100 MWe Plants. This presumes:
      (1) Adequate reservoir capacity.
      (2) Development by a single operator (unitization).
      It is possible that later plants might be 55 MWe plants on-line each year.

Cove Fort

1. Several factors will tend to retard development at Cove Fort (Sulphurdale).

   A. Drilling has been very difficult. It has taken a long time and considerable problems were encountered from a geological standpoint.
   B. Because of these problems with drilling, the wells drilled by Union have been very expensive.
   C. The presence of a viable reservoir has not yet been satisfactorily verified.

2. In spite of these setbacks, several ventures are proceeding (4). For purposes of the long-range scenario, the following separate ventures were assumed.

   A. Sulphurdale--Union could have two areas here, one north of the freeway, one south. Because Union still appears to be progressing, the first plant was assumed to come on-line in 1984. The sites are left unspecified. This is an optimistic forecast, particularly in light of the difficulties mentioned above.

Figure 1 (Continued)

B. North Cove Fort (Dog Valley)--Hunt Energy Corp. is currently drilling on private lands several miles north of the Sulphurdale area. An optimistic forecast would put them on-line about 1985 or, at best, 1984. Of course, the controlling factor will be the discovery of a reservoir.

C. West Cove Fort Area--Several groups are conducting intensive exploratory activities in this area, although no deep wells have been drilled. Developers in this area are AMAX, Hunt, Chevron, Phillips, and others. An optimistic estimate could place at least one of these prospects on-line in 1985 (4). Because several developers are involved, the plants could come on-line in bunches; the assumption for the scenario was usually a plant each year.

3. Reservoir Quantities: Based roughly on various estimates of reservoir capacity, the following quantities were assumed:

   Sulphurdale 200 MWe.
   North Cove Fort 200 MWe.
   West Cove Fort 200 MWe.

   These assumptions appear to be optimistic but reasonable. Sulphurdale, North Cove Fort, and West Cove Fort were assumed to have 200 MWe capacity each. Again, these capacities are not scientific reservoir estimates but are useful for purposes of estimating development patterns.

4. Federal Programs and other incentives/assistance: It was assumed that optimistic estimates would be partially justified by the development of federal initiatives to accelerate and assist development in Cove Fort areas. Such programs were left unspecified but will probably include case study programs, technology transfer, and the reduction of institutional restrictions.

   Note: Cascading and multiple use systems will very likely be developed for some of these areas, most particularly in the Sulphurdale area where exhaust from the power plant may be used in sulphur mining or other industrial operations (4).

Thermo Prospect

1. Reservoir capacity was assumed to be 100 MWe. This is a moderately optimistic assumption. The rationale for this estimate was that the area involved might be larger than the 1.5 km^2 estimated by USGS Circular 726, although at this time there is little evidence to support this hypothesis.

Figure 1 (Continued)

2. Earlier scenarios estimated drilling to begin at Thermo in 1980 (6). Republic Geothermal drilled a deep well in late 1977. This would seem to indicate that development at Thermo could be advanced by as much as two years. Also, federal programs could make an earlier production date feasible for Thermo as well as for some of the Cove Fort areas. On the other hand, preliminary information from the Republic Well at Thermo does not seem to justify boundless optimism; hence, the first plant was estimated to produce power on-line about 1986, with another 50 MWe plant following two years later.

Figure 1 (Continued)

References

1. Phillips Petroleum Co., Verbal and written communications, February and March, 1978.

2. Dr. Val Finlayson, Director of Research and Development, Utah Power and Light Company, Salt Lake City, Utah. Personal Communication, March 28, 1978.

3. Dr. Stanley H. Ward, Chairman, Department of Geology and Geophysics, University of Utah, Salt Lake City, Utah. Personal Communication, March 28, 1978.

4. Kenneth Bull, U.S. Geological Survey, District Geothermal Supervisor, Salt Lake City, Utah. Personal Communication, April 4, 1978.

5. State and Federal Geothermal Leases, compiled by the Utah State Team, February, 1978.

6. MITRE Corporation, METREK Division, "Site Specific Analysis of Geothermal Development--Data Files of Prospective Sites." October, 1977.

projections, and because of differing interpretations of data which may or may not be public. In most cases the developers are more conservative in their capacity estimates, when they make estimates at all; consultants seem to be more optimistic in their estimates.

The Operations/Research personnel in some states have also been resource assessment personnel or had close access to them, but in other cases O/R personnel have been somewhat miscast in the role of resource capacity assessor.

The estimates used as capacity estimates are shown in Tables 7 and 8 . Table 7 contains the figures used for the DOE Regional Hydrothermal Development Plan, and Table 8 includes the figures used for the Operations/Research Scenarios. The primary difference between the estimates is that optimistic figures were used for the Regional plan, whereas for the Operations/Research project there was a need for assuming a specific capacity for a specific prospect and more conservative values were used. In some cases where no reservoir information was available a "reasonable default" figure of 200 MWe was used.

TABLE 7

ELECTRICITY GENERATION RESOURCE

(for 30 yrs >200° C)

	Proven Reserve (Measured) (MWe)	Potential Resource (Indicated) (MWe)	Inferred Resource (Geol-Geophys) (MWe)	TOTAL
Utah				
Roosevelt Hot Springs	100	200	200	500
Cove Fort Sulphurdale Black Rock Desert Thermo		500	1000	1500
Nevada				
Battle Mountain Heat Flow High		1000	2500	3500
New Mexico				
Valles Caldera	50	350	100	500
other Rio Grande Rift and Lightning Dock		200	800	1000
Idaho				
Eastern Snake River Plain			1000	1000
SUBTOTALS	150	2250	5600	8000
REGIONAL TOTAL			8000 MWe	

Undiscovered high grade reservoirs throughout the region may contribute an additional 8000 MWe.

From DOE/DGE Regional Hydrothermal Development Plan.

TABLE 8

Estimated Energy Capacities for Development Planning Profiles.

	Identified (MWe)	Indicated (MWe)	Inferred (MWe)
Roosevelt Hot Springs	100 (1)	200 (2)	200 (3)
Cove Fort/Sulphurdale		220 (4)	
North Cove Fort			200 (5)
West Cove Fort/Black Rock Desert			200 (5)
Thermo		20 (4)	80 (5)
Other Areas			200 (5)

(1) Estimate based on current plans by Phillips/Rogers/UP&L and Thermal Power/AMAX/O'Brien/VTN, each for a power plant on-line by 1982 at the Roosevelt prospect.

(2) Estimate for total power to 1983 from Roosevelt prospect by UP&L of 330 MWe (total: 312 MWe net output) for planning purposes.

(3) Additional potential to total of 500 MWe for Roosevelt prospect; estimate by Dr. Stanley Ward, also based on heat flow data analyzed by Dr. David Chapman.

(4) Estimates for electrical capacity at Cove Fort/Sulphurdale and Thermo Hot Springs of 221 MWe and 20 MWe for 30 years respectively, based on USGS Circular 726 and data analyzed by Chandler Swanberg and the Operations/Research Core Team at NMSU.

(5) Additional values for Cove Fort/Sulphurdale, North Cove Fort, West Cove Fort, Thermo, and other areas are default assumptions used for planning purposes. These are not scientifically based estimates but are assumptions, which appear optimistic but reasonable, to provide a framework for the possible development profiles. There are geologic indicators of potential resources in each of these areas, but the values for the capacity estimates are not based on these geologic indicators.

Forecasted Development

There is currently only one prospect in Utah where development is definitely planned, the Roosevelt Hot Springs prospect. Two power plants are planned for this prospect for 1982. One will be a combined effort by Phillips Petroleum (the unit operator), Rogers International, and Utah Power and Light; the other by a consortium formed by Thermal Power Co., AMAX Exploration, Inc., O'Brien Resources, and VTN, Inc. The Phillips group controls most of the land in the prospect because it holds most of the federal leases; the Thermal Power group controls several key sections of state land within the prospect. Unitization of the prospect is a possibility, in which case it is likely that only one plant would come on-line in 1982; another possibility is that the two groups could make a cooperative agreement and develop simultaneously and semi-independently; or the two developments could proceed completely independently from each other. At this time, both groups have expressed plans for independent development; therefore, the most prudent and diplomatic approach is to assume that both plants will come on-line in 1982.

Development at other sites is likely or possible, particularly Cove Fort/Sulphurdale and Thermo, where wells have already been drilled and where exploration is continuing, and where some information about the resource has been gathered. The North Cove Fort prospect, where the Hunt Energy Corporation is drilling, may also be developed. The other areas are either unknown or the information is confidential.

The most controlling factor in the development of these prospects will be the presence and characteristics of the reservoir. Of the three basic assumptions for the scenarios (commercial reservoir, economic advantage, and institutional cooperation) the reservoir capacity is more critical than the other two assumptions. However, it is the factor about which the least is known. Development will follow if, when, and where the commercial resources are found. The reason that this is significant is that to date, resources suitable for electrical production have been located only at the Roosevelt prospect -- in spite of exploratory efforts at several other sites.

As a result, all of the development profiles except for the Roosevelt prospect will be pushed back in time by the lack of discovery and will really not come into focus until the necessary resources are actually located.

The emphasis in the preliminary scenarios has been on the role of the developer. The involvement by other institutions, i.e., state and federal agencies, research groups, etc., has been analyzed on a general basis and is found in the discussion of institutional involvement.

Direct Utilization Development Profiles

Development associated with direct use application is more difficult to forecast than for electrical production. The reasons for this are varied: much more of the resource is suitable and available for use, so that prospects are much more numerous; development can occur much quicker and

on a much smaller level; a large number of uses are possible; location plays a much more nebulous role; potential developers are much more difficult to identify; and so on.

The initial thrust of the Operations/Research project in evolving development profiles was to identify existing known and potential resource areas. These areas included primarily hot springs areas; other areas of known or indicated hydrothermal resources, such as Beryl, New Castle, Tintic, and so forth, were also added.

Background data for the eventual development profiles were compiled through a process of gathering all available information on each prospect and summarizing it into prospect descriptions. The descriptions are found in Appendix B. A sample of a prospect description is given as Table 9. The sources of the data are also found in Appendix B.

Unfortunately, time restraints precluded the generation of detailed, meaningful direct use development profiles. The process which will be used to generate the profiles will be to match areas of energy demand to resource areas; this process, as now foreseen, will be described later in this section.

In lieu of the individual direct use development profiles, a very rough, very preliminary attempt at an aggregated scenario for the state was generated. Because of the short time involved, the lack of known plans for direct use development, the fact that much of the background data necessary for the

TABLE 9

Prospect: Monroe Hot Springs
(Also Red Hill, Johnson Hot Springs)

Resource Characteristics:

Surface Fluid Temperature: Monroe 76°C, Red Hill 77°C, Johnson's 25°C /6/

Subsurface Fluid Temperature: Monroe 120°C, Red Hill 135°C /1/

Total Dissolved Solids: Monroe 2750 ppm, Red Hill 2630 ppm, Johnson 428 ppm /6/.

Estimated Energy Potential: Monroe 38 MWt, Red Hill 43 MWt, Johnson 4 MWt for 30 years Total: 85 MWt /1/

Type of Overlying Rocks: Springs issue from tufa mounds along the base of the mountain/6/, grading west into alluvium in the valley.

Location of Prospect: Just east of Monroe, Utah; T25S, R3W, Sec. 11, 15, and 27 /6/.

Description: Series of hot springs issuing from hillside immediately east of Monroe City, at the base of a large mountain. The springs are along a north-south trending fault /6/.

Land Ownership: Mostly Private /2/. Some BLM and National Forest Lands east of the prospect /11/.

Land Use: Municipal, agricultural, range land, and forest land nearby.

Leasing: Some leasing in area. Limited leasing because most of the land is private/12/.

Activity:

The springs are presently being used by a spa for heating a swimming pool, showers, etc. The owners have expressed plans for eventually heating greenhouses and a motel complex.

The City of Monroe has received conditional approval on a proposal for a space heating system for the city. The first phase of this project would involve the heating of the South Sevier District High School; later the system would be expanded to heat homes in the city as well as several larger buildings in the city, a number of greenhouses, and several multiple unit complexes (motels and apartments).

direct use analysis had not been gathered (particularly industrial information), and some uncertainty about the proper procedure for developing the profiles, it was felt that at that point the individual scenarios would have been so speculative that they would not have been more meaningful than the rough aggregate. No attempt was made to forecast development of specific industries at specific sites. The approach used was to estimate a "curve of development" for each prospect or group of prospects. Although numbers were used to display this development, they are merely a rough, semi-informed estimate of the curve.

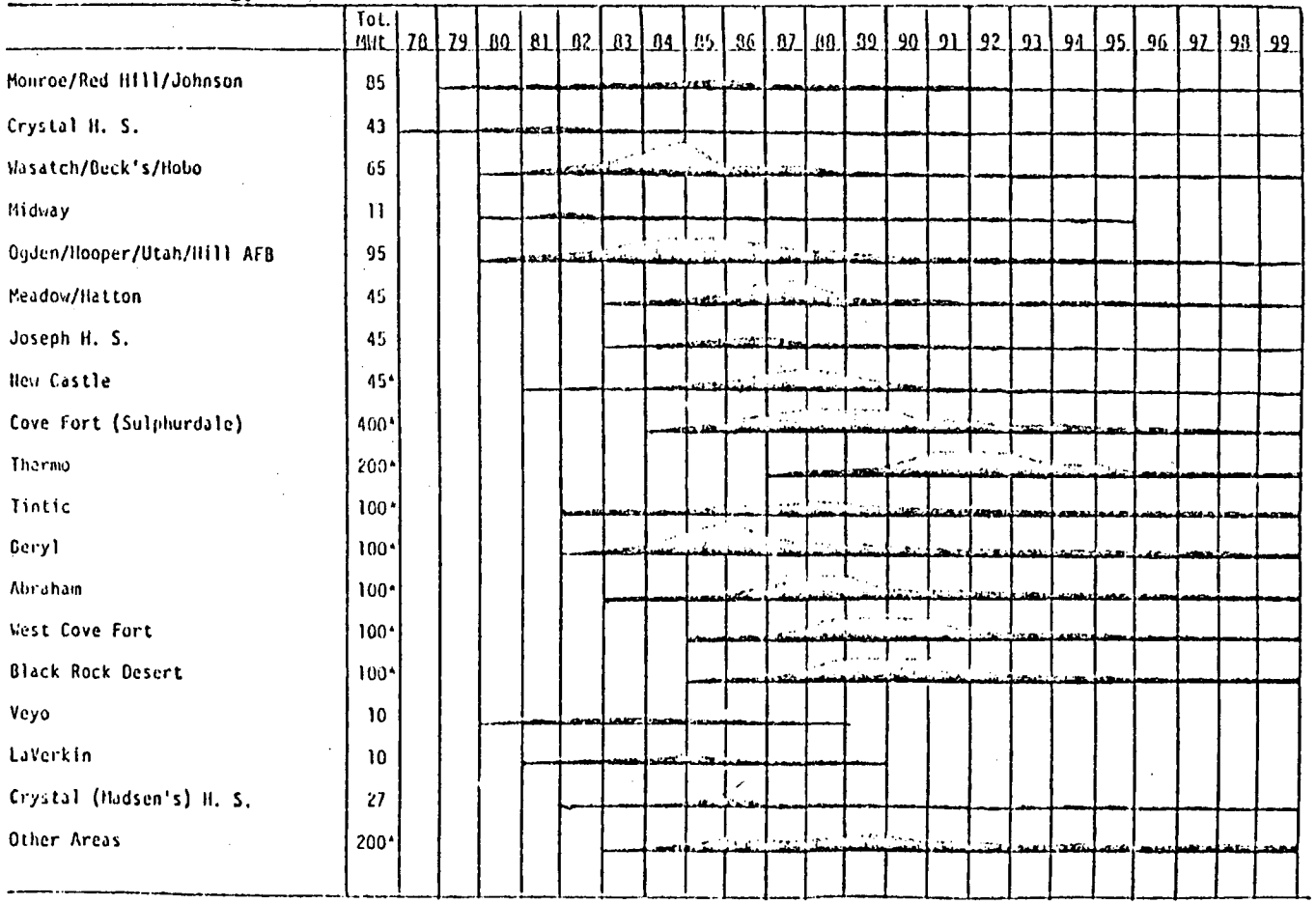
The aggregate scenario for direct use development is shown in Figure 2. This figure is a graphic version of the numerical aggregate found in Appendix B. The specific assumptions for each site are included as part of the prospect descriptions, which follow the aggregate in the appendix.

In some cases default reservoir capacities were simply assumed for areas of known or inferred resources where no indications of energy capacity were available. The purpose of these assumptions is not to estimate capacity but to take into account the presence of the resource. As data on temperatures and flow rate become available, estimates will be made.

Many of the spring areas and other areas were small in their estimated or assumed capacity and/or very remote. These springs and other prospects were grouped together in a

Figure 2

Postulated Geothermal Direct Use Development Profile for Utah
(New development each year, MWt)



* Default reservoir capacities assumed for planning purposes.

separate category, simply designated "Other Areas." A more complete list of some of the areas included in this category is found in Table 6.

Evaluation of Direct Utilization Development Profiles

For the reasons outlined above, the preliminary development profiles, as shown in the aggregate scenario, are not considered to be true forecasts but rather an estimate of the general pattern which might be expected for each area. Nevertheless, the background data as found in the individual data summary sheets are considered to represent a first but significant attempt to characterize the resource areas. The summary information is not complete nor up to date, since development occurs very rapidly. However, the summary sheets will provide a framework for a data file based on current information for each prospect or area.

Procedure for Specific Direct Utilization Profiles

A major priority for the second year's activities will be the generation of specific development profiles for lower and moderate temperature prospects. The following discussion outlines the general plan of procedure for developing the profiles, and generally follows the procedure developed by Barbara Coe of the Colorado State Team.

The first step has already been accomplished to a large degree -- that of cataloging and characterizing the resource areas in Utah. More data will be incorporated as they become available, especially from resource assessment studies.

Another major step will be to define energy uses and energy use areas. Various possible uses will be matched to the resource by location, temperature and quality of the resource, local potential for light or heavy industry, etc. An important part of this analysis will be the classification of the suitability of the resource for various potential uses. The objective will be to define as many potential uses as are foreseeable and to estimate the likelihood of development for each.

As the work of cataloging uses by area progresses, it will be important to establish contacts with those directly involved with the potential development. In cases of space heating, this would usually be communities; for other potential industries, such as mining, agricultural processes, greenhouses, institutional uses, etc., it will be much more difficult but nevertheless important to establish contacts.

The outcome of this research will hopefully be a delineation of development presently planned or under way, and also future or potential uses within the temperature and distance range of the resource area. When that has been accomplished, expert opinion will be sought as much as possible to estimate time frames for development.

The institutional analysis of direct use development is much more difficult because of the tremendous variability among individual projects. Nevertheless, an important part of the direct use development profiles will be a more detailed analysis of the institutional aspects involved, particularly

agencies, permits, legal problems, and recommendations. It is possible, for instance, that legal problems such as water rights will play an even more restrictive role in direct use development than in electrical development.

Forecasted Development

Direct use development can happen on a much smaller scale and hence much quicker than electrical development. As a result, direct use projects seem to pop up quickly and more and more frequently. A few firm plans are available; some rumors appear to be based on facts, but not firmly enough for publication.

The most firm plans at present involve the community of Monroe in central Utah, for which a DOE Program Opportunity Notice was granted. The project is a cost-share program whereby a large portion of the community will eventually be heated with geothermal energy, including houses, the South Sevier District High School, a church, the city hall and fire department, and a number of greenhouses, motels, and other commercial structures. The resource will be tapped by a well in the vicinity of the Monroe Hot Springs, run through a heat exchanger, and be reinjected on the opposite side of the fault from the springs area. The development is estimated to require about 1.07 MWt (3.2×10^{-5} Quads/year) (Monroe City, 1977), and the first phases are scheduled to be completed by about 1981 with expansion continuing beyond that date.

Plans for other developments are not so firm; in fact,

most are in the rumor stage. The Division of Water Rights has been approached by several developers who are applying for grants through the DOE Program Opportunity Notice program; it would probably be improper at this early planning stage to reveal much concerning them. Other inquiries have been made concerning small projects such as greenhouses and the heating of individual homes, but again, the plans are very preliminary.

In April 1978 the Utah Geological and Mineral Survey drilled some temperature gradient wells in the vicinity of Crystal Hot Springs, with financial assistance through the DOE State Cooperative Program. This led directly to the drilling of a geothermal well by the State Forester's Office, supposedly to be used for silviculture development. However, plans for this development may or may not have changed, or may change in a few weeks. Development in the area is fairly certain, but it is not completely resolved yet what that development will be.

ENERGY PRODUCTION AND CONSUMPTION IN UTAH

Utah is a state rich in energy resources. Some primary sources for energy in Utah are coal, hydroelectric, oil, natural gas, uranium, oil shale, tar sands, solar, and of course, geothermal resources.

Table 10 shows energy consumption, production, and net import or export in Utah for the years 1970-1975.

A major objective in the second year, as discussed in the section dealing with direct application scenarios, will be the identification of energy demands as related to the resource areas. This will require a much more in-depth analysis of energy production and consumption than is here given.

TABLE 10

Energy Production and Consumption in Utah, 1970-1975[1]
(Trillion BTU)

	Production					Consumption					Net Balance[2]	
Year	Oil	Natural Gas	Coal	Hydro	Total	Oil	Gas	Coal	Hydro	Total	Net Imports	Net Exports
1970	130.80	42.50	118.30	2.46	294.06	160.75	111.40	75.25	2.46	349.86	55.80	. . .
1971	132.30	43.60	115.70	2.60	294.20	181.24	109.70	74.83	2.60	368.37	74.17	. . .
1972	148.80	39.24	120.10	2.86	311.00	199.12	108.80	75.43	2.86	386.21	75.21	. . .
1973	183.00	42.50	137.50	3.13	366.13	205.88	114.30	98.93	3.13	422.24	56.11	. . .
1974	220.40	50.53	151.20	3.30	425.43	192.08	109.50	97.05	3.30	401.93	. . .	23.5
1975	224.10	52.53	172.50	3.56	452.69	201.60	109.60	83.20	3.56	397.96	. . .	54.73

1. Electrical consumption and production other than hydroelectric is assumed to be included in fuel consumption and so is not included in this analysis.
2. Does not include uranium.

From Hillar and Searle, 1976.

ECONOMICS

No specific economic analyses or feasibility studies have been conducted by the Utah Operations/Research team, although such studies may be part of the second year's activities. Hopefully, the second year's efforts will include rough cost/benefit analyses of some of the more specific recommendations. More sophisticated economic and sensitivity analyses may be run by the Core Team at New Mexico State University using the computer models which they have developed.

Based on discussions with industry and others, a few conclusions may be drawn concerning geothermal exploration and development. One is that at this time geothermal development is not profitable enough to encourage industry to invest at a rate high enough to meet the postulated DOE goals; at least, exploration to date has been slow compared with original projections by DOE and others. There are several reasons why this is so. One is that front-end costs such as leasing and exploration, especially wildcat drilling, are very high. This is compounded by the fact that, at least in Utah, geothermal is still a fledgling industry. This increases costs because of such factors as the distance which drill rigs must be moved, the learning phase of drilling in any new prospect where initial drilling is expensive (such as Cove Fort), the need for geophysical/geological exploration at new prospects, as well as the high first-year rental for KGRA leases. All of these costs will decrease as development

proceeds, i.e., drill rigs will be available in the general area, drilling will be more effective and relatively less costly as the developers learn about the geology of an area and how to cope with local geological problems, etc.

The problem of high exploratory costs has been addressed in part by the DOE Industry Coupled Case Study Program, which provides direct financial assistance to the developer in return for the information gathered through the exploratory work. This program has been effective in Utah, where the Roosevelt and Cove Fort prospects were studied intensively, including partial funding (either directly or retroactively) for four deep wells at Roosevelt and three at Cove Fort/Sulphurdale. It is fairly clear that the program was effective in accelerating the new drilling; the funding of wells retroactively undoubtedly was of assistance to the companies involved, but the impact of the released information is less direct and hence more difficult to assess.

Another problem which adversely affects the economics of geothermal exploration and development is the existing tax structure. There are at present no tax incentives for geothermal exploration and development. If significant tax incentives were offered, both on the state and federal levels, it might aid in accelerating exploration and development. A depletion allowance is one possibility, but there are other methods of supporting exploration and development, both for electrical and direct use applications, perhaps by write-off advantages.

It may be that a basic problem is that geothermal development is in many cases still only marginally profitable. The basic role of the profit motive has been pointed out by several developers.

The economic problems associated with direct use development are not yet as evident as those associated with electrical development. There are some obvious problems, again associated with high front-end costs such as drilling and retrofitting. Again, it is not unreasonable to suggest tax incentives for small alternate-energy operations such as geothermal direct use applications. Another possible form of assistance might be a loan or loan guarantee program, if it were tailored to the needs of small and moderately sized developers. To be effective, the loan applications would have to be simple enough and approval would have to be reasonable enough to encourage small developers to apply.

INSTITUTIONAL ANALYSIS

A major objective of the Operations/Research study was to define and analyze the public and private actions necessary to bring geothermal development to pass. This objective, like the development profiles, will require successive iterations in order to refine and update the information.

The Utah O/R team approached the task of defining institutional involvement by obtaining information from developers (in particular Phillips Petroleum Co.) and approaching various agencies directly. With the preliminary information on the agencies involved and the permits required, a tabulation of the information was made. The various agencies were then contacted to verify and enhance the preliminary list. From this information another table of data was made, which included the various agencies involved, the stage of development at which the permit is required, approximately how long it takes for the permit to be issued, and a brief discussion of the permit and permitting process. This information is found in Table 11.

State Agencies

The primary geothermal regulatory responsibility within the Utah state government lies with the Division of Water Rights. This authority was granted by the state legislature in Section 73-1-20, Utah Code Annotated, 1953, included here in its entirety.

> 73-1-20. Geothermal energy production--Regulation by division of water rights.--(1) The

> division of water rights is given jurisdiction and authority to require that all wells for the discovery and production of water to be used for geothermal energy production in the state of Utah, be drilled, operated, maintained, and abandoned in such manner as to safeguard life, health, property, the public welfare, and to encourage maximum economic recovery.
>
> (2) In carrying out its responsibility under this act, the division of water rights may utilize personnel, equipment, or other assistance of any division or department and may transfer funds to that division or department to reasonably compensate it for use of its personnel or facilities.

The legislation is brief and general. The Division of Water Rights has drawn up working Rules and Regulations for Geothermal Wells and Exploration. These rules and regulations have not yet been adopted but are being used as drafted at this time.

A preliminary list of state and local agencies involved in geothermal development is found in Table 12. Most of these are not involved in a regulatory capacity. It is certain that as development progresses more agencies and groups will be involved. This list includes only those who have already interacted or who have been contacted by the Operations/Research study team.

It is evident that several of the agencies could go in different sections of the list. It is also apparent that the role of each respective agency will vary from development to development, and many of the agencies listed may be involved in several ways in any given development; for instance, the Department of Business regulation issues the

Table 11

Preliminary Assessment of Agencies and Permits Involved in Geothermal Development in Utah

	Permit	Required Prior To:	Estimated Time For Issuance	Notes
County Agencies				
County Planning Commission (1,2)	Zoning	Depends on county zoning ordinances	Variable	Already accomplished in some counties
County Clerk (1)	Business License	Sale of electricity		
County Commission or Health Department (1,2,3)	Health Code Enforcement Building Inspection	Use of buildings	Varies	
State Agencies				
Division of State Lands (4,5)	Lease State Lands	Exploration or use of lands	Few Days to 2-3 weeks	May be competitive bidding in some cases but that does not significantly increase issue time
	Special Use Permit	Surface disturbance (Construction of plant)	Not known--possibly about 2 months	Has not yet been applied for in Utah
Department of Transportation (6)	Encroachment Permits	Use of state highway lands for utility lines	Few days	Would be necessary for use of or crossing of State Highway Rights of Way with utility lines such as power lines, water mains, sewage pipes etc.
	Oversized Vehicles Permit	Use of highway for oversized vehicles	About a day	
Division of Water Rights (7,8)	Permits for Thermal Gradient Wells	Drilling of thermal gradient wells	Few days to few weeks	Letter of approval
	Permit for Exploratory "Test" Wells	Drilling of exploratory wells	Few days to few weeks	Letter of approval

	Permit	Required Prior To:	Estimated Time For Issuance	Notes
Continued from:				
Division of Water Rights (7,8)	Notification of Reservoir Test	Reservoir tests		
	Appropriation of Water	Use of water	6 months or longer	May depend on how fast the developer wants approval
	Production and Injection Wells			Covered by Appropriation of water if included in the Plan of Operations
Environmental Health Services				
Bureau of Water Quality (3)	Construction Plan Review and Permit	Construction	About 2 months	Pre-planning workshop
	Public Water Supply Approval	Use of building	1 to 2 months	
	Draft and Certification of Discharge Permit (Sanitary)	Use of building	1 to 2 months	In conjunction with EPA which issues the permit
	Liquid Waste Disposal System Approval	Use of building	1 to 2 months	
Bureau of Air Quality (9)	Construction Plan Review and Approval	Construction	About 3 months	In conjunction with EPA
	Discharge Permit	Use of plant	About 3 months	Plant discharges
Bureau of Solid Waste Management (3)	Solid Waste Disposal			
Department of Business Regulation (10)	Certificate of Convenience and Necessity or Approval of Contract Between Utility and Electricity Producer	Sale of Electricty	3 to 4 months	Certificate of convenience and necessity if utility owns plant; if utility buys power, approval of contract is required

	Permit	Required Prior to:	Estimated Time For Issuance	Notes
Federal Agencies				
Bureau of Land Management (11,12,13)	Permit for Pre-Lease Operations	Non-surface disturbing exploratory activities on lands not leased by applicant	30 days	Includes geophysical/ geological exploration, temperature gradient surveys, etc., 30 day time limit for approval
	Issue Lease--BLM Lands			
	Conducts EAR Conducts KGRA Lease Sales Issues Lease		About 5 months Total: about 8 months (up to 18 months in Utah)	
	Plant Siting Permit	Plant Construction	Not known	None Approved yet
	Post-Lease Joint Approval with USGS of Plans of Operation			Site specific
U.S. Forest Service (11,12)	Special Use Permit for Pre-Lease Operations	Before exploratory activities on lands not leased by applicant	30 days	Includes geophysical/ geological exploration, temperature gradient surveys, etc., 30 day time limit for approval
	Issue Lease--Forest Service Lands	Before major exploratory activities	About 17 months or longer	Lease obtains rights to the resources
	Conducts EAR KGRA Land Sales Approves Lease			
	Joint Approval with USGS of Plans of Operation			

	Permit	Required Prior To:	Estimated Time For Issuance	Notes
U.S. Geological Survey	Administers Terms of Lease			
	Approves Permit for Exploratory Activities	Before non-surface disturbing activities	30 days	Includes geophysical/ geological activities, temperature gradient surveys, etc., 30 day time limit for approval
	Conducts Site-Specific Environmental Analysis and Approval of Plans of Operation			Plans of operation are site-specific
	Exploration	Before surface-disturbing activities	About 1 year	
	Environmental Baseline Data	Gathering of required 1-year's environmental baseline data	About 3 to 5 months	Must be completed at least one year before Plan of Production is submitted
	Development	Drilling and development of production wells	About 3 to 5 months	Define extent of field
	Injection	Drilling and development of injection system	about 3 to 5 months	
	Utilization	Construction of power plant	about 3 to 5 months	Sundry notices submitted for each phase. Includes contract and royalty breakdown.
	Production	Use of the resource for power production	about 3 to 5 months	Includes production data from wells and target date for completion
	Changes in Plans of Operation	Before implementation of changes in plans of operation	A few months	Sundry notices

	Permit	Required Prior To:	Estimated Time For Issuance	Notes
U.S. Environmental Protection Agency	Certify Air Discharge Permit		About 90 days	Air, water, solid waste permits are in conjunction with State Environmental Health Agencies.
	Issue Water Permit		About 90 days	
	Issue Solid Waste Disposal Permit		About 90 days	
	Review of EIS			
U.S. Fish and Wildlife Service	Advisory			Consults on lease sales (competitive and non-competitive), pre-lease and post-lease environmental analyses.
U.S. Department of Energy	Financial Assistance			
	State Cooperative Program		About nine months	
	Industry Coupled Case Study Program		About nine months	
	Loan Guarantee Program			
	Demonstration Programs			
	Development of Lease Stipulations			
	Issuance of Lease			

REFERENCES TO TABLE 11

Preliminary Assessment of Agencies and Permits Involved in Geothermal Development in Utah.

1. Chad W. Johnson, Beaver County Commissioner, Beaver, Utah. Personal communication, June 14, 1978.

2. Delaine McGarvey, Davis County Health Department. Personal communication, June 13, 1978.

3. Marvin H. Maxell, Ph.D., Environmental Health Scientist, Utah Bureau of Water Quality, Salt Lake City, Utah. Personal communication, May, 1978.

4. State of Utah, Rules and Regulations Governing the Issuance of Mineral Leases, issued by the Board of State Lands.

5. Donald G. Prince, Assistant Director, Division of State Lands, Salt Lake City, Utah. Personal communication, June 14, 1978.

6. Utah Department of Transportation, District 2, Encroachment Office. Personal communication, July 6, 1978.

7. State of Utah, Rules and Regulations of the Division of Water Rights for Wells Used for the Discovery and Production of Geothermal Energy in the State of Utah. March 1, 1978.

8. Stanley Green, Directing Appropriations Engineer, Utah Division of Water Rights, Salt Lake City, Utah. Personal communication, June, 1978.

9. Lynn Menlove, Public Health Engineer, Utah Bureau of Air Quality, Department of Social Services, Salt Lake City, Utah. Personal communication, May, 1978.

10. Ray L. Pruett, Utility Service Engineer; Clayton S. Hogstrom, Utility Rate Engineer; Victor N. Gibb, Real Estate Subdivision Inspector; Utah Division of Public Utilities, Department of Business Regulation, Salt Lake City, Utah. Personal communications, February 23 and June 23, 1978.

11. Kenneth Bull, District Geothermal Supervisor, U.S. Geological Survey, Salt Lake City, Utah. Personal communications, February to July, 1978.

12. Interagency Geothermal Streamlining Task Force, "Programs and Objectives of the Interagency Geothermal Streamlining Task Force" and associated information, June, 1978. Presented at Streamlining Workshop, Salt Lake City, Utah June 29, 1978.

13. Geothermal Steam Act of 1970 and Regulations on the leasing of Geothermal Resources. Published by the U.S. Geological Survey, U.S. Department of the Interior.

14. Draft Regional Hydrothermal Development Plan, Rocky Mountain/Basin and Range Region. Presented at Workshop, June 28, 1978. Material cited was explained at the workshop.

TABLE 12

State and Local Agencies and Groups
Involved in Geothermal Development

"Direct" Involvement

Utah State Legislature
Division of State Lands
Division of Water Rights
Bureau of Water Quality
Bureau of Air Quality
Bureau of Solid Waste Management
Department of Transportation
Department of Business Regulation
Utah Tax Commission
County Commissions
County Clerks
County Health Officers
County Tax Commission

"Advisory" or Consulting

Utah Geological and Mineral Survey
University of Utah Research Institute (UURI)
EG&G (Idaho Falls)
Utah Division of Water Rights
Various Consulting Firms

"Indirect" Involvement

Utah Energy Office
Utah Farm Bureau
State Building Board
Department of Development Services
Industrial Development Division
Office of Legislative Research
Foresters Office
Division of Oil, Gas, and Mining
Division of Health
Utah Department of Agriculture
Water User's Association
State Court System
Environmental Groups
Municipalities and Communities
Division of Wildlife Resources
State Planning Office

Certificate of Convenience and Necessity for a utility-owned power plant, and also issues carrier licenses to tank trucks which carry water to geothermal drill rigs. Of course, this type of complex involvement is very common.

A schematic diagram of the Utah State Government is shown in Appendix C. The path of authority for the Division of Water Rights and a schematic procedural flow diagram for the appropriation of water are also shown in Appendix C.

Analysis of State Institutional Factors

At this time, the institutional analysis for the state of Utah is only preliminary. Many unforeseen problems will undoubtedly arise, particularly with respect to direct use applications. Electrical developers are large and have done much advance research into potential institutional impediments; on the other hand, the smaller developers associated with many direct use projects often start from scratch and tackle problems as they arise. The result is that much of what is learned about institutional impediments to direct use comes from experience.

For electrical development, the major, foreseeable, possible impediments at the state level appear to be associated with water rights. This is not to say that water rights will be a problem, but that they appear most likely to be major, relative to other state requirements. Legal problems concerned with priorities of rights may arise as development progresses, particularly where the

ground water reservoir is connected to the geothermal reservoir. In prospects where several developers are drawing from the same reservoir, priority problems may also arise; however, at present it appears that these problems may take the form of unitization problems. This particular problem is as much an industry problem as a state problem, because it is based at least in part on administrative decisions by the involved developers.

A Unit would be formed at any particular prospect in order that the resource would be developed in a reasonable and beneficial manner. The advantages of unitization are numerous: orderly development, development based on the most advantageous geologic conditions rather than inter-lease competition, avoidance of water-rights disputes, sharing of costs and data, etc. The primary drawback is apparently that developers other than the unit operator are not able to fully determine development on their own leases. Federal regulations require unitization on federal lands.

The Utah Geothermal Rules and Regulations state:

> 2-6 Unit Agreements: At the request of any interested party or on his own initiative, the State Engineer may establish a unit plan or agreement for a geothermal area to prevent waste, protect correlative rights, and avoid drilling unnecessary wells. Proper notice to interested parties must be given and a hearing held before the State Engineer before the unit may be created.

It has not yet been determined by a court of law if the State Engineer does actually have the authority to enforce unitization; hopefully the question can be determined without lawsuits.

While it is foreseeable that legal actions could be taken if, for instance, unitization was enforced by the State Engineer, they could also arise if no unitization took place, e.g., legal struggles for the use of the water in a limited geothermal reservoir. The answer, of course, is voluntary unitization; but that is, as mentioned earlier, an administrative decision by the developers involved.

For direct use projects, water rights will also be a problem, but probably not for the same reasons. It appears that many low temperature basins are either connected to ground water basins or surface features such as springs or hot pots, where water is already appropriated. In some cases, it may be possible to use the geothermal water for heat and reinject it, but water required for other uses associated with the development may not be open to appropriation (it may still be available by purchase); in other cases, where hot springs are already being used for developments (usually spas), any withdrawal of the hot water may be protested. Potential problems are numerous; unfortunately, conflicts of this type are most likely to occur in the more populated areas, i.e., the Wasatch Front, where both population and resources are located but where most of the available gound water has already been appropriated.

There are, of course, other problems on the state level. Most of these involve lack of clarity of roles, overlap of responsibility, lack of clarity in some regulations, etc. Many of these problems exist because geothermal development is new in the state and it will take some time to sort out

responsibilities, make decisions on the most reasonable approach to regulations, and so forth. Most of these are not impediments as much as they are just a hassle, and many will be worked out in time.

An extensive and in-depth analysis of state laws, statutes, legislation, etc., coupled with workshops involving legislative bodies in each of the western states, has been undertaken by the National Conference of State Legislatures (NCSL). The purpose of this project is to aid the various states in analyzing existing institutional situations and in defining needed legislative changes, additions, and deletions, and then to act as advocate for the needed legislation. Utah has been chosen as a pilot state for the project; workshops will begin in August of this year. It is to be hoped that the O/R research and the NCSL Geothermal Policy project will be able to assist the states to define and prevent some of these problems before they arise.

Federal Agencies

The federal leasing and permitting system is very complex and often cumbersome. Leasing procedures were discussed on a general level in the section on leasing in Utah. This report will not deal with all the details of the federal leasing and permitting system; however, in order to define the perceived problems it will be necessary to discuss certain aspects in some depth.

The federal geothermal leasing and permitting system is administered primarily by the BLM and USGS in the Department of Interior, the U.S. Forest Service in the Department of Agriculture, and the Department of Energy. These agencies interact in various phases of the leasing/permitting process, and, under interagency cooperative agreements, each agency performs specific functions. Table 13 shows in brief summary form the various roles and interactions of the different agencies. Figures 3 and 4 show simplified flow diagrams of pre- and post-lease activities.

The federal leasing procedures have already been discussed in the section dealing with leasing in Utah. A complete, detailed discussion of the federal regulations, procedures, and practices would be volumous and beyond the scope of this particular report. The emphasis here will be on those aspects of the leasing procedure which are related to recommendations.

TABLE 13

Summary of Responsibility in the
Federal Geothermal Leasing and Permitting Program

BLM - Bureau of Land Management
DOE - Department of Energy
FS - Forest Service
FWS - Fish and Wildlife Service
GS - U.S. Geological Survey
IGCC - Interagency Geothermal Coordinating Council

Land Management Planning	BLM/FS
Pre-Lease BLM Exploration Permit or FS Prospecting Permit	BLM/FS (Primary) GS and FWS (Consulting)
Competitive Lease Sale Scheduling	BLM/FS/ GS/Industry/ IGCC
Pre-Lease Environmental Analysis	BLM and/or FS (Primary) GS and FWS (Consulting)
Competitive Lease Sales	BLM (Primary) FS/GS/FWS/DOE (Consulting)
Non-Competitive Lease Applications	BLM (Primary) FS/GS/FWS (Consulting)
Scheduling for Non-Competitive Leasing	BLM/FS (Primary) GS/FWS (Consulting)
Development of Lease Stipulations	BLM/FS/GS/DOE
Issuance of Lease	BLM/DOE
Post-Lease Environmental Analyses	GS (Primary) BLM/FS/FWS (Consulting)
Post-Lease Exploration Permit	GS (Primary) BLM/FS/FWS (Consulting)

Information presented by the Interagency Geothermal Streamlining Task Force, June 1978.

FIG. 3

EXISTING
GEOTHERMAL REGULATORY PROCESS
Principal Pre-Lease Activities

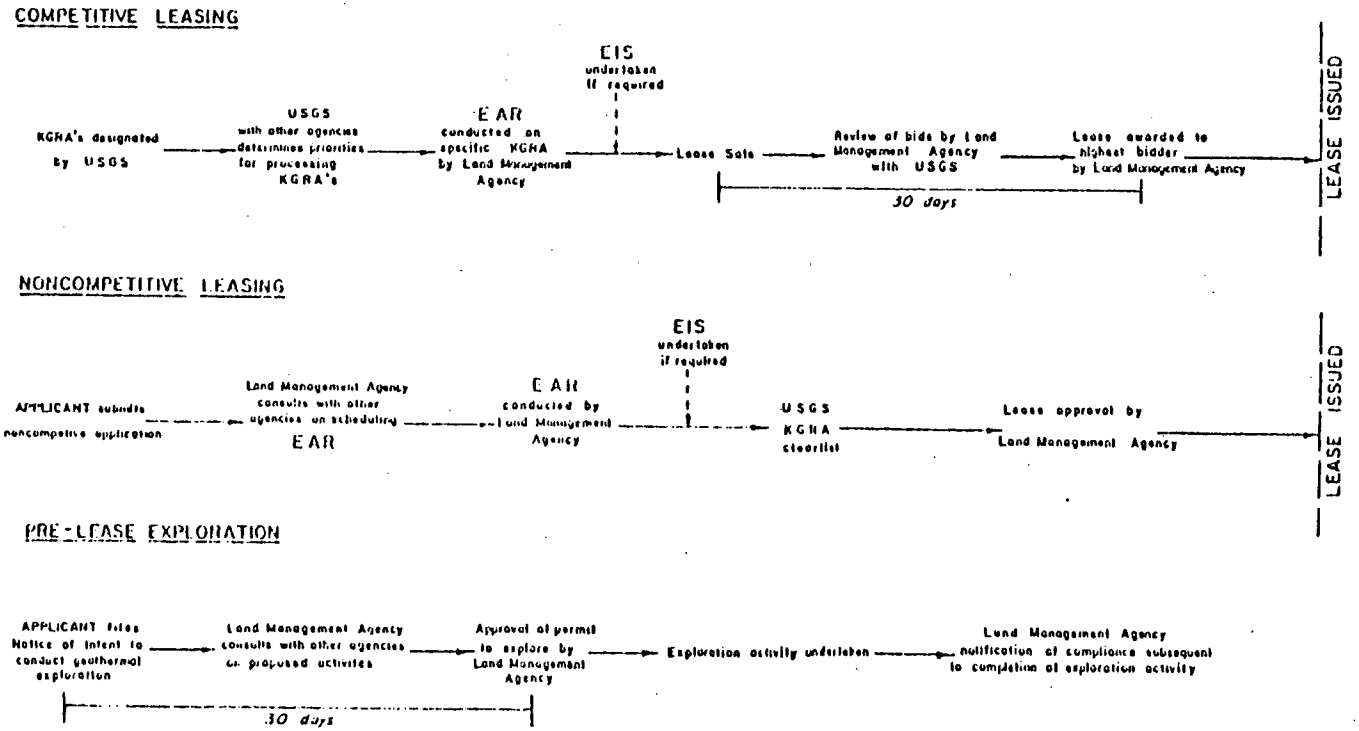
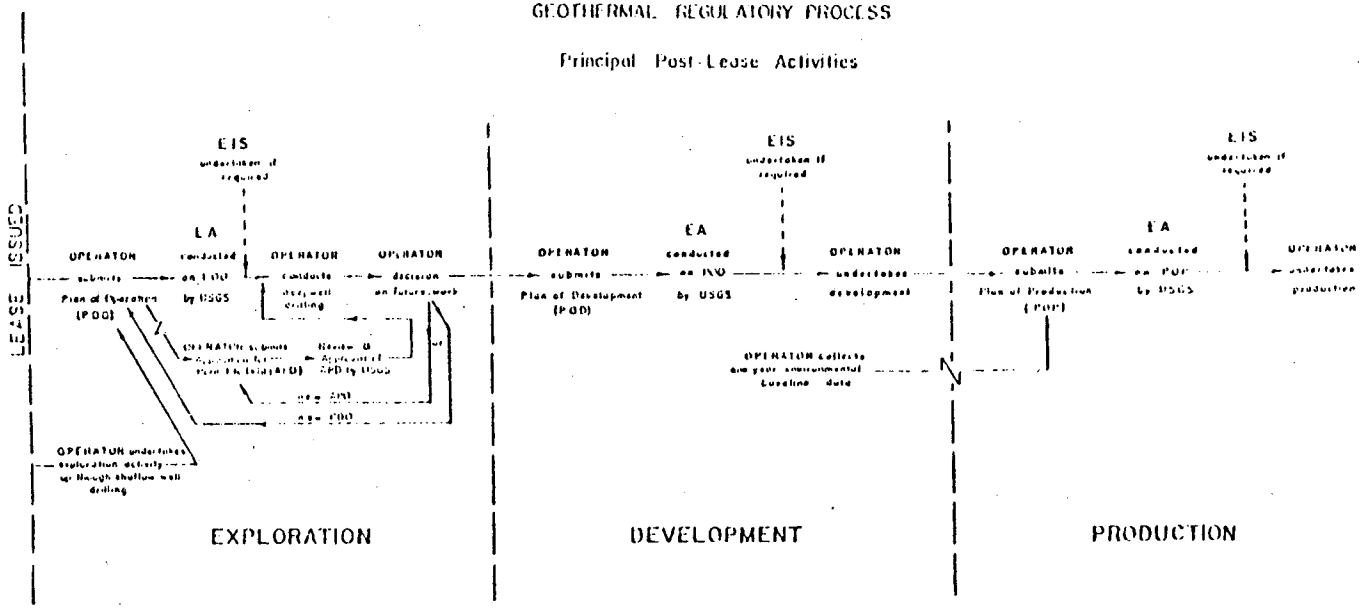


Fig. 4

EXISTING
GEOTHERMAL REGULATORY PROCESS

Principal Post-Lease Activities



Pre-Lease Exploration

Pre-lease exploratory activities such as geological/geophysical surveys or temperature gradient surveys may be conducted on federal lands under a casual use permit (BLM) or special use permit (USFS). Application is made to the surface management agency, which then has 30 days to approve the permit or explain to the applicant why it was rejected.

Competitive Leasing

Known Geothermal Resource Areas (KGRA's) are determined by the three methods mentioned earlier: geologic indications of resources, nearby discoveries, or competitive interest (other indicia may also be used). Competitive interest is defined basically as simultaneous filing for the same land. (Details are found in the federal regulations § 3200.0-5.)

If an area is designated a KGRA for geologic reasons or because of proximity to a discovery, the USGS in consultation with the other agencies determines the priority of processing the KGRA. An environmental assessment (EAR) is conducted on the specific lands in the KGRA by the surface management agency, usually either BLM or Forest Service. If the EAR indicates that an Environmental Impact Statement is necessary, it is conducted; if none is required, the results of the EAR are used to determine the lease stipulations. Input to the stipulations is provided by the other agencies, specifically by the USGS and the surface management agency.

The lands are then put up for sale and are advertised

by the BLM. Bids are received and reviewed by the surface management agency and the USGS. The lease is then awarded to the highest bidder by the surface management agency and the lease is issued by the BLM.

At present, there are no methods for declassifying lands from KGRA status. This means that the lands remain classified as KGRA even if no bids are received, and that subsequently they must be leased competitively regardless of the true industry interest or geothermal potential.

Non-Competitive Leasing

If a developer files for a lease on non-KGRA lands, and no other applications for the same land are filed within the same leasing period, the lease is processed as a non-competitive lease. Even so, the lease is not cleared as non-competitive until near the end of the approval process. Thus, an application which began as a non-competitive lease may be declared competitive before it is issued.

When an application for a non-competitive lease is submitted, the land management agency (usually BLM or USFS) consults with other agencies to schedule the EAR. The EAR is then conducted by the agency, and it is determined if an Environmental Impact Statement is necessary. The findings of the EAR or EIS are incorporated into the lease stipulations. Under current procedures, the lease is then sent to the regional USGS office where it is checked against the KGRA list. If it is at that time not KGRA land, it is sent back to the surface management agency for approval, and the lease is

issued by the BLM. Currently in Utah, it takes five months or longer for the EAR (probably longer on forest lands) and about three months for the subsequent administrative work; altogether a lease may be obtained in about eight months if no problems arise (Bull, 1978).

Post-Lease Permits

After the lease has been issued, the developer may obtain a permit for casual use (geological/geophysical exploration, temperature gradient wells, etc.) from the USGS. This post-lease exploration permit must be issued within 30 days, or the applicant must be informed why it was denied.

To obtain a permit for surface disturbing activities such as deep exploratory wells, the developer must apply by submitting a plan of exploration. The plan of operation must be fairly detailed and complete. Because of the long lead time for approval of plans of exploration, about one year (Bull, 1978), it is the usual practice by developers to apply for the maximum number of sites, i.e., exploratory wells, which are expected to possibly occur. The approvals apparently do not take significantly longer for a larger number of sites.

When the plan of operation is submitted, the USGS sends interested parties letters by way of announcement. Field investigations are then conducted and public comment is invited. The EAR's are carried out on a site-specific basis, i.e., proposed drill pad by drill pad. The results of the EAR's are incorporated into the stipulations attached to the

lease as conditions of approval. The plan of operation, with the stipulations, etc., is then submitted to the surface management agency and the USGS area supervisor for approval. The permits are then issued.

This procedure is carried out for each step of development. The various plans of operation which must be submitted are for exploration, development, injection, utilization, and production. (For explanations of the plans, see Table 11.) The plan of exploration is estimated to take about a year for approval, as mentioned above; subsequent plans may be approved in three to five months because much of the necessary information would be available from previous EAR's (Bull, 1978).

Other Federal Involvement

As seen from Table 11 and Table 13, other federal agencies involved in geothermal leasing, permitting, and development include the U.S. Fish and Wildlife Service, the Environmental Protection Agency, and the Department of Energy.

The U.S. Fish and Wildlife Service acts primarily as a consultant to the USGS and the other agencies. The Environmental Protection Agency is only remotely involved in the leasing and permitting process, but acts cooperatively with state and county health agencies for air and water discharge permits.

The Department of Energy acts somewhat as an advocate for geothermal development. It is involved in the development of lease stipulations and in the issuance of the lease.

The DOE also initiates programs to encourage geothermal development; i.e., case study programs, demonstration programs, loan guarantees, etc.

The Interagency Geothermal Coordinating Council was formed to promote coordination and cooperation between federal agencies. It plays an important role in simplifying procedures and reducing institutional impediments at the federal level, as discussed in the following section.

Analysis of Federal Involvement

It is generally agreed that federal regulations, procedures, and requirements impose significant encumbrances on geothermal development. Much of this impedance takes the form of delay in leasing and permitting; other impedance takes the form of restrictive stipulations or deliberate inaction on applications.

The Interagency Geothermal Coordinating Council (IGCC) represents virtually all the federal agencies which have anything to do with any phase of geothermal development. The purpose of the council is to coordinate geothermal-related activities by the member agencies. As a result of work by the council and other agreements, such as interagency memorandums of understanding, the leasing and permitting processes have been simplified somewhat by a reduction in the number of agencies with whom a developer must deal directly. (The other agencies may still be involved in the approval process.)

In spite of these preliminary efforts, the approval processes have remained cumbersome and slow. The IGCC was given

a mandate:

> "for assessing legal, environmental, regulatory, and other aspects of Federal, State, and local government policy as they relate to geothermal energy and for developing recommendations for changes and improvements in related laws, policies and procedures, and for examination of other institutional aspects of geothermal energy, including non-governmental aspects." (Interagency Streamlining Task Force, 1978.)

To assist the IGCC in this task, the Interagency Geothermal Streamlining Task Force was formed. The purpose of the Task Force is to develop specific recommendations to "streamline leasing and environmental review procedures to remove unnecessary barriers to development of geothermal resources" (Interagency Geothermal Streamlining Task Force, 1978). The Task Force has developed proposals and held workshops at several locations throughout the western states in order to collect public input on the recommended changes and improvements, as well as on problems and suggestions not covered by the proposals.

The result of this concentrated effort has been that most of the problems related to geothermal leasing and permitting on the federal level have at least been identified. This includes most of those identified as impediments by the Utah O/R team in the course of interviews and contacts with industry and governmental agencies.

One of the most consistently voiced concerns has been that of the general time lags involved in the federal procedures, both pre- and post-lease. The Streamlining Task Force has gone into considerable detail to define the areas where

unnecessary time lags occur, and has made a number of specific recommendations to correct these conditions. A summary outline of these preliminary proposals, which were drafted by the Task Force for the purpose of inviting comment, is found in Table 14; the complete Task Force Program and Objectives, with supplementary information distributed by the Task Force, is found in Appendix E.

As part of the effort to aquire public input to the recommendations and proposals, a workshop was held in Salt Lake City, Utah, on June 29, 1978, which was attended by representatives of the O/R teams from most of the states included in the original Southwest Region; i.e., Colorado, Nevada, New Mexico, and Utah. (Arizona representatives were not able to attend.) The result of this meeting was that specific recommendations were made by the states in support of the Task Force proposals. These recommendations are summarized in Table 15.

One subject which was not brought to issue by the task force was that of acreage limitations of federal leases. As explained earlier, there is a limit of 20,480 acres for any single developer within any given state.

The consensus among the industry contacted by the Utah O/R team was that the acreage limitations are not reasonable and form a barrier to accelerated geothermal development. The rationale for the acreage limitation was that it would encourage a wide spectrum of developers, including speculators, and that this would spur geothermal development. This was

TABLE 14

Outline Summary of Options for Modification of the Federal Geothermal Leasing and Permitting Program. (Preliminary proposals for purposes of discusssion.)

Option I

Improve the present system through changes in regulations and administrative procedures.

A. Use regional or areawide environmental analyses in pre-lease review and conduct site specific studies only during the post-lease permitting process.

B. Set time limits or timeframes (through administrative directive and/or regulations) for issuance of leases and permits.

C. Improve coordination in all phases of pre- and post-lease activities.

D. Improve uniformity and consistency of policies and procedures with respect to lease stipulations among the involved agencies.

E. Institute formal nomination procedures for KGRA's and non-competitive areas.

F. Allow no-surface-occupancy leases in wilderness study areas and other special areas where requested.

G. Modify KGRA regulations.

H. Allow issuance of non-competitive leases unless the area is in a KGRA at time of application.

I. Provide budgets in proportion to workloads, organizational needs, and priorities.

Option II

Base leasing decisions on areawide environmental assessment in combination with land management plan.

Option III

Provide for separate environmental analysis of exploration and development phases, with initial review of exploratory impacts only and comprehensive review only after a discovery is made.

TABLE 15

Summary of State O/R Recommendations:
Interagency Geothermal Streamlining Task Force Proposals

1. The states supported the three options proposed by the Task Force.

2. The states encouraged the elimination of competitive KGRA's. The competitive bidding system on KGRA lands was considered unreasonable, counter-productive in terms of benefits to the country, and an unnecessary barrier to geothermal development.

3. The states supported different methods of dealing with development of electrical versus non-electrical prospects. It was felt that the fundamental differences between direct use and electrical production warrant differences in regulations and administrative procedures.

4. The state teams generally supported Option III of the plan, which dealt with phased environmental studies, with the stipulation that the option be left as an elective choice open to the developer. It was also considered important that some sort of reimbursement be made available to the developer if substantial investments were made for exploratory work but further development was denied as a result of the comprehensive "second stage" environmental studies. This reimbursement could take the form of tax advantages, direct subsidies in whole or part, deductions from rentals for other leases, etc. It was also considered equitable that if a decision to deny development were later reversed, the original applicant should have priority in being able to develop the area.

5. Although it was not part of the Task Force proposal, it was felt that some states would benefit by having a geothermal consultant at the state level, possibly funded in part by the DOE. This individual could provide information services to the public and to the state governments, serve as an advisor to the state government (particularly the legislature), act as a liaison between the state, federal agencies, and industry, and perform other tasks to foster geothermal progress within the state.

6. Another recommendation by the state teams, which applied more to the states than federal agencies, was that the states should allow municipalities to incorporate as energy distributors, in order to allow for the use of geothermal energy on a community basis.

supposedly based on experience with oil, gas, and hydrocarbon exploration.

However, as geothermal exploration has proceeded, a few problems have come into focus. For one thing, the oil, gas, and hydrocarbon lease limits within any single state is 246,080 acres, more than twelve times the 20,480 acre geothermal lease limits (BLM Public Relations Office, 1978). Furthermore, small speculative developers seldom have enough financial backing to do their own exploratory work. (There is only record of two exploratory wells--one of which was a temperature gradient hole--drilled by individuals in Utah.) The speculators apparently do not intend to do exploration work on their own, but rather seek to lease likely prospects and then sublease or assign the lease to a major developer who has the capability for exploration. This may distribute the wealth among speculators, but it does not encourage development; in fact, it impedes development by further burdening the developers, who actually do the work.

If the speculative lessees do not assign the lease, the odds are against development. If the lease is assigned to a major developer who can do the exploratory work, the acreage applies to the total for the developer, and is subject to the limitations. The net effect is that the developers frequently must make decisions whether to keep leases or drop them, without being able to do enough exploration to justify the decision.

The recommendation of the Utah O/R team is that lease limits be re-evaluated. The degree of impedance due to lease

limitations is, quite frankly, not clear at all. However, it appears that modifications are justified. Such modifications might involve simply raising the limits; exempting some lands from the state total in a manner similar to the exemption for unitized lands, e.g., lands where significant exploration has taken place; or other alternatives.

An essential element of any efforts to accelerate geothermal development will be tax incentives, on both state and federal levels. Geothermal tax provisions are currently pending in a House/Senate conference committee. The tax provisions, which are long overdue, should help alleviate some of the financial pressure on the developers.

Private Industry Involvement

Private industry, of course, plays a fundamental role in geothermal development. It is really at the industry level that decisions are made as to whether the potential benefits, both long and short term, justify the expenses of exploration and development. Administrative decisions within an industry, often based on data unavailable outside the company, can drastically affect the rate or extent of development at a given prospect or over a given area. Development is usually directly dependent on the industries' ability to interpret geological information in order to locate resources.

The major developers in Utah, as indicated by exploratory wells (mostly temperature gradient wells) are shown in Table 16. Most of these developers are oil exploration companies. Some of them, such as Hydrosearch and Utah Power and Light, tried a few ventures several years ago and have not done much exploratory work since. The utilities which have shown interest to date are also listed; of course, Utah Power and Light is by far the major electrical utility in Utah. Also shown are a number of potential direct use projects which at this time seem most likely to be developed; however, so far only one project, Monroe City, is beyond the pre-planning stage.

A few barriers have come into focus on the private industry level. One of these has been alluded to earlier: the question of unitization. At the state level it is mostly

TABLE 16

Major Geothermal Developers In Utah

AMAX Exploration, Inc.
Chevron Resources Company
Geothermal Kinetics, Inc.
Geothermal Power Corporation
Hunt Energy Corporation
Nelson B. Hunt
Caroline Hunt Trust Estate
Getty Oil Company
Hydro-Tech Company
McCulloch Oil Company
O'Brien Resources Company
Phillips Petroleum Company
Republic Geothermal, Inc.
Thermal Power Company
Union Oil Company
Utah Power and Light

Utilities

Utah Power and Light Company
Bountiful Light and Power Company
Escalante Valley Electric

Potential Direct Use Developers

Monroe City
McCulloch Oil Company
Utah Forester's Office
Escalante Valley Electric

concerned with the rights to the resource; at the industry level, however, it takes on aspects related to a whole spectrum of inter-company negotiations, of which unitization is only a single manifestation. It is obvious that if companies would share data and technical know-how, geothermal development would proceed significantly more rapidly. But, private companies operate on a basis of complex motives, of which profit is certainly the most influential but not the only one. It should be recognized that the right of self-determination, though limited, is fundamental to the free enterprise system.

An impediment which is beginning to manifest itself but which has not yet fully impacted development is the availability of drill rigs. A number of developers have commented on the fact that geothermal drill rigs were difficult to contract, in a few cases because of added restrictions imposed by the DOE Case Study Program. Although there is at present no real scarcity of drill rigs, competition for the rigs with oil and gas exploration is keen. Geothermal exploration in Utah is at a disadvantage because oil rigs must be modified to accommodate blow-out prevention equipment. The rigs usually must be brought long distances to the geothermal fields in Utah (usually from New Mexico, Nevada, or possibly from Colorado or Northeastern Utah), and rig contractors prefer continuous contracts as opposed to single wells. If exploration continues at its present rate, enough rigs can probably be brought into the geothermal fields so that no shortage will occur. However, if exploration and development is to accelerate, particularly at rates required to meet energy goals,

drill rig unavailability may become more acute.

It has also been pointed out that if development throughout the region is to progress at hoped-for rates, a scarcity of drill rigs may manifest itself on a regional basis (Kingsolver, 1978).

Another problem at the industry level which must be faced is utility commitment to geothermal development. Utilities are by nature conservative about new energy sources. A number of developers have noted that when the utility is skeptical, it tends to make the developers more cautious because of uncertainty about the market.

This problem is particularly applicable to Utah. A few developers have indicated that they felt that the major utility in Utah, Utah Power and Light, may be overly conservative in their approach to geothermal energy. UP&L undertook exploratory activities several years ago which were very disappointing with respect to electrical production. At that time, UP&L withdrew from exploration, and has apparently been somewhat skeptical of potential electrical projects. They have, however, indicated that they would be willing to buy power from geothermal developments if it is economical; in the meantime, they require substantial evidence of a resource before committing themselves. They have also pointed out a need for more expertise in reservoir engineering to justify optimistic investments (Finlayson, 1978).

Because of the general reluctance by utilities to take risks with regard to geothermal reservoirs, and because the

federal loan guarantee program cannot be used by large companies, it appears that in many developments the power plant will be built by a smaller third company which would be brought in for just that purpose. This is the case at the Roosevelt Hot Springs prospect, where Phillips Petroleum will supply the steam; Rogers International will design, construct, and own the plant; and Utah Power and Light will buy the electricity. Under these arrangements the utility will have the option of purchasing the power plant after several years when the reservoir is fairly well proven.

Department Of Energy Involvement

As discussed previously, the Department of Energy, Division of Geothermal Energy (DOE/DGE) has responsibility for encouraging geothermal development in addition to its duties in the leasing/permitting process. As advocate, the DOE/DGE has set up a number of programs to assist the industry in bringing development to fruition.

In the initial phases of the DOE programs, assistance primarily took the form of research and development projects. The goal was to provide the basic technology needed to locate, recover, and utilize the resource. During the last few years the approach of the DOE has changed. The emphasis has shifted from technical research to a mission-oriented program in which the goals are the acceleration of commercial geothermal utilization.

In Utah, the four DOE direct assistance programs which have been most significant are the Industry Coupled Case Study Program, the State Cooperative Resource Assessment Program, the Direct Applications Field Projects Cost Share Program, and the Loan Guarantee Progam. In addition to these programs, the DOE has contracted with the University of Utah/University of Utah Research Institute, which will have lead responsibility for the planning and coordination of regional resource definition activities such as the State Cooperative Program. The DOE also indirectly funds the Operations/Research studies in the various states.

Industry Coupled Program

The Industry Coupled Case Study program has been mentioned earlier in connection with drilling in Utah. The program is designed to provide direct assistance to industry in return for data which then becomes public. Qualifying projects may include primarily deep exploratory well drilling, temperature gradient surveys, or one of a variety of geophysical/geological surveys. In Utah, some wells have been partially funded retroactively.

The guiding philosophy of the program, in addition to providing direct assistance and impetus to geothermal exploration has been to conduct a fairly intensive exploration program in a specific prospect. The program would thus result in a substantial amount of information covering a specific area. The advantage of this approach is, of course, that the geothermal potential of the area studied will be much better understood; the disadvantage is that the search for new potential areas takes a lower priority. There is apparently provision for funding of exploration in new prospects, but because funding is planned years in advance, there might be delay in providing assistance for new areas.

The case study program in Utah has been effective in accelerating exploration. Three new wells have been drilled with assistance from the program--the Getty well at Roosevelt and two wells by Union at Cove Fort/Sulphurdale. Without doubt these wells were drilled earlier than they would have been if no assistance had been available. In addition, data

from four wells was purchased retroactively--the three Thermal Power wells at the Roosevelt prospect and the first Union well (Forminco #1) at Cove Fort/Sulphurdale.

It may not be wise to judge the total success of the case study program until the third Union well is completed. However, the program has undoubtedly assisted the industry in the expensive and risky exploratory phases.

State Cooperative Program

The purpose of the state cooperative program is to compile data on moderate and low temperature resources, publish maps and reports detailing the resources, and to perform some on-site exploratory work, including drilling, at the highest priority sites. The program is visualized as a forerunner to a direct use industry coupled program, which is foreseen for about 1982.

In Utah, the state cooperative program has resulted in temperature gradient surveys of the Crystal Hot Springs prospect in South Salt Lake Valley, and the Midway prospect in the Heber Valley. At Crystal Hot Springs, the survey has resulted in several plans for direct use of the resource, although some of the plans are very unclear at this stage. The program also includes plans for surveys of the Beck's/Wasatch Hot Springs prospect, Utah Hot Springs, and other prospects along the Wasatch Front.

Direct Applications Field Projects

The field projects program provides cost share funds for

select, visible projects which demonstrate the feasibility of direct use applications. The projects are funded through Program Opportunity Notices (PON's).

Monroe City, a community along the Sevier River in Central Utah, applied for and was granted a PON for utilization of the geothermal resources at Monroe Hot Springs for space heating in the community. The total project is estimated to cost $1,589,029; the DOE will provide $924,029. The project will provide heat for the South Sevier School District High School, a city hall and fire station, a church building, a number of private homes, and several commercial ventures, i.e., motels, greenhouses, and apartments. The system will be expanded as it becomes economical and feasible. Although the PON has been granted, negotiations have not yet been finalized. The project definitely would not have been undertaken if the DOE funds had not been available.

Applications for the second PON were due in the middle of July, 1978. No specific plans are available at this time, but proposed developments may include Crystal Hot Springs, Beck's Hot Springs, and other prospects in Utah.

Loan Guarantee Program

The federal loan guaranty program was designed to provide some assurance to developers in the face of uncertain reservoir capacities and life spans. In effect, it is a form of reservoir insurance.

The two electrical developments in Utah which are in the firm planning stage (the Phillips/Rogers International

project and the Thermal Power/AMAX/O'Brien/VTN project, both at the Roosevelt prospect) have both made applications for the loan guarantee. Some of the other developers which were contacted by the Utah O/R team stated that the loan guarantee would be useful to them, but a significant number stated that they would not be able to use it.

There appears a double-edged sword built into the loan guarantee program. On the one hand, for a company which is quite large, as was the case with most of the developers mentioned above, the loan guarantee is useless because a large company cannot afford to default on a loan. Major utilities also cannot default. One solution to this problem is to bring in a smaller company to build and own the power plant. (Rogers International basically fulfills this function for the Phillips Petroleum/UP&L development.) However, the other side of the problem is that the loan applicant must come up with 25% of the total cost in order to qualify for the loan. For many small companies, this is very difficult.

There are several possible remedies for this situation. The simplest would probably be to allow the 25% to be applied to the total project. It would then include the wells and other work which had been completed earlier, and would allow the larger developers and the utilities to assist in the initial capital outlay (Berge,1978).

Another possible solution would be to use reservoir insurance. This has been suggested by several developers and utilities as being preferable to the loan guarantee (Finlayson,

1978; Public comment at DOE Regional Planning Meeting, June 28, 1978). Undoubtedly, a major revamping of the program would give rise to further problems yet unforeseen. These suggestions have almost certainly already come to the attention of the loan guarantee administrators.

The loan guarantee program was designed primarily for electrical projects or large direct-use projects. There is, however, a real need for loans or loan guarantees for small developers, usually direct users, who are faced with comparatively large initial costs just as the larger developers are. It would appear that some sort of simple, obtainable loan system needs to be initiated for these small users. The very minimum changes would involve simplification of the application procedures for the existing loan guarantee; other programs designed specifically with small developers in mind would be much more effective.

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APPENDICES

Appendix A	Maps of Geothermal Areas in Utah
Appendix B	Development Profiles with Data and Assumptions
Appendix C	Utah State Government
Appendix D	Interagency Geothermal Streamlining Task Force Information
Appendix E	Resource Data
Appendix F	Financial Statement for Utah Operations/Research Study

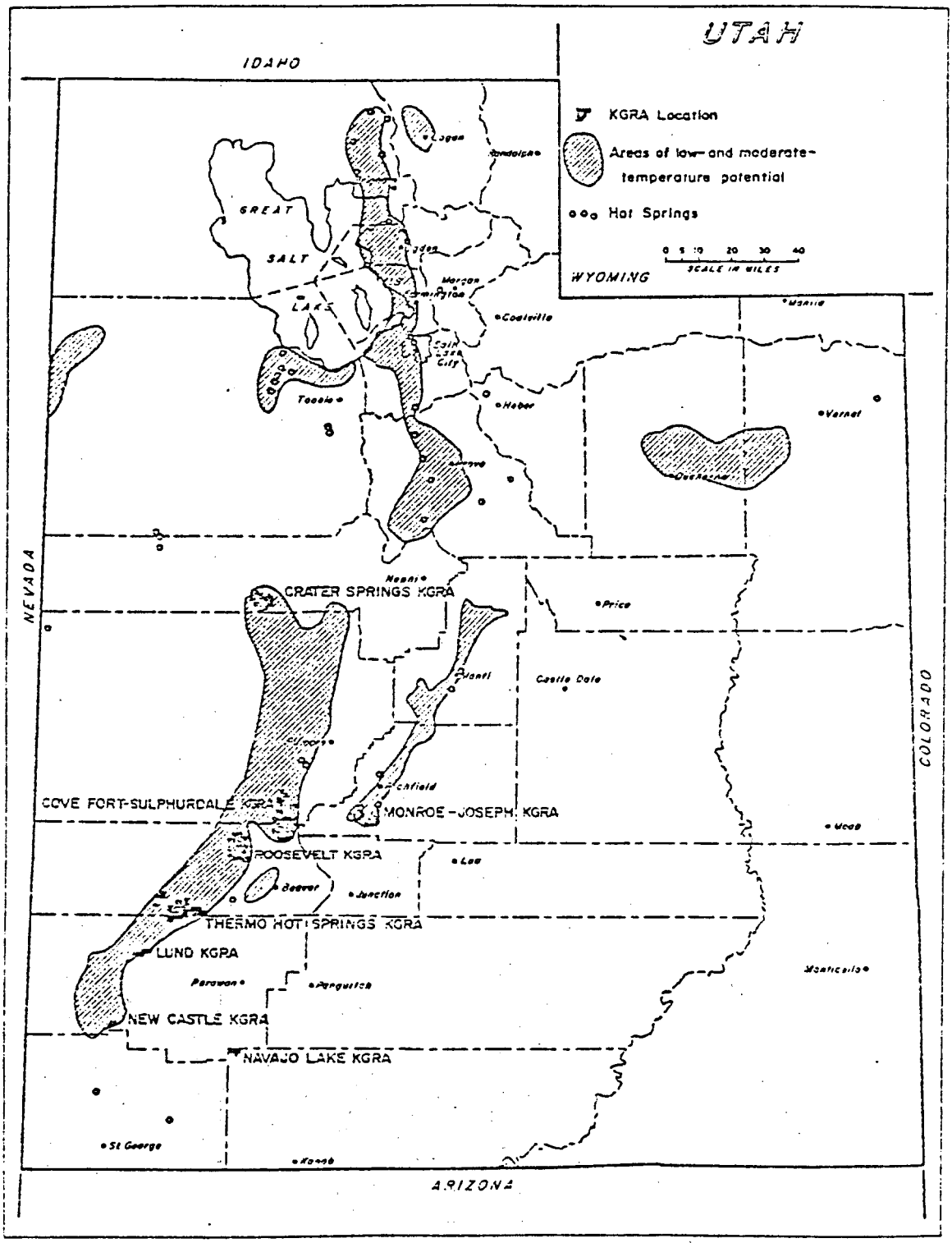
APPENDIX A

A-1 Map of Utah Geothermal Areas

A-2 Map of Milford Area and Roosevelt Geothermal Unit

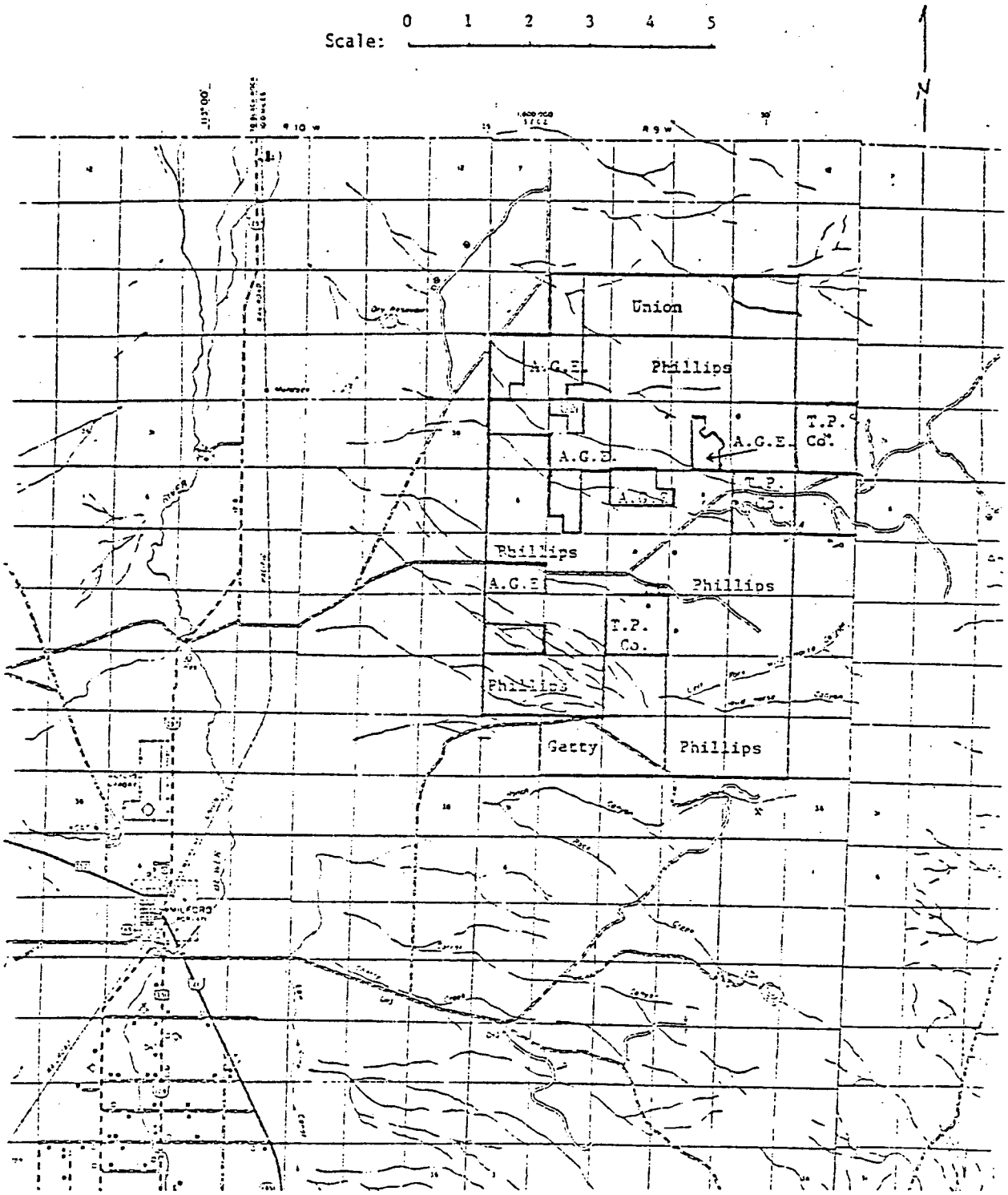
A-3 Map of Cove Fort/Sulphurdale Geothermal Unit

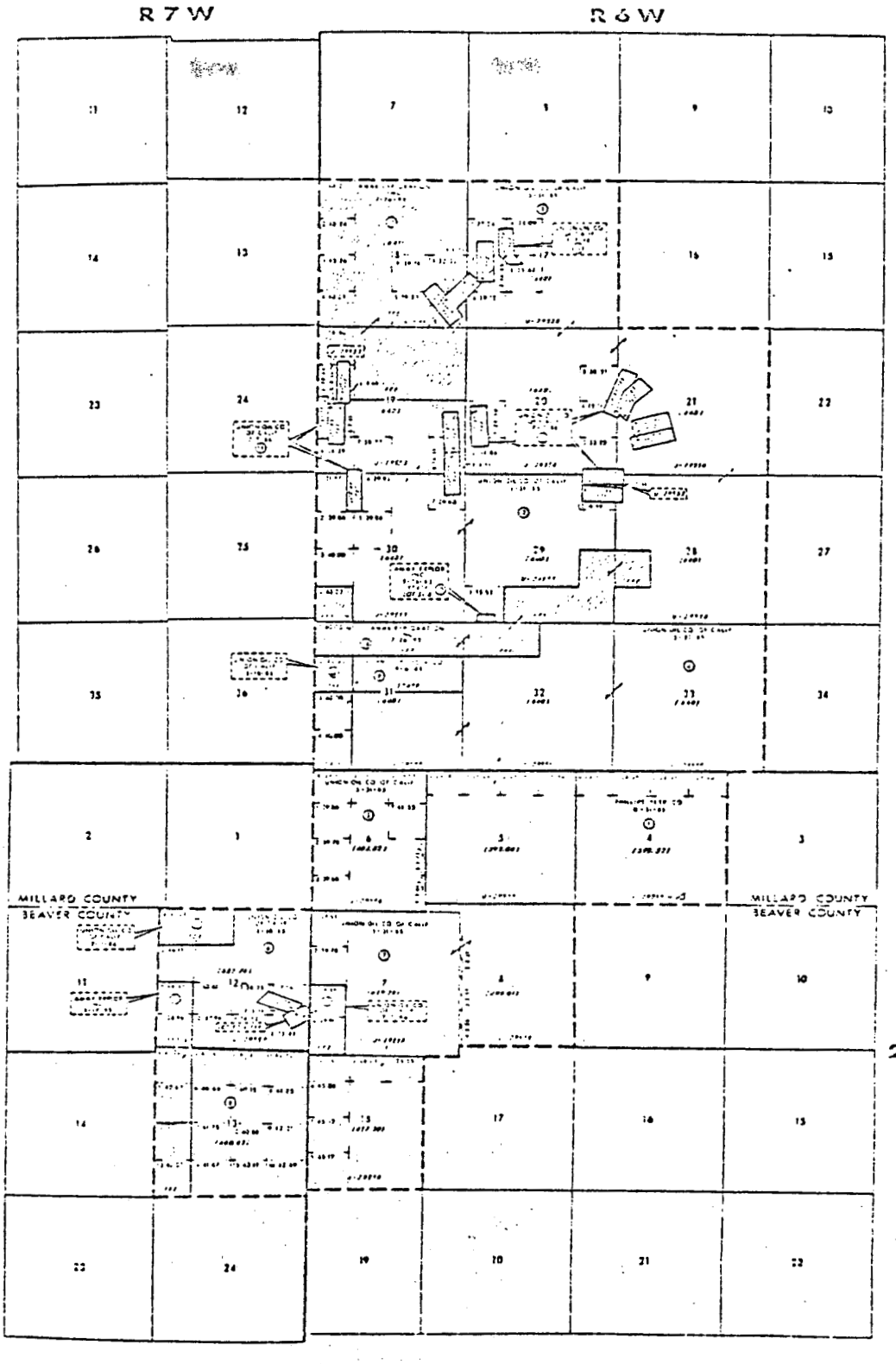
A-4 Map of Monroe City and the Sevier River Valley


UTAH
IDAHO
WYOMING
NEVADA
COLORADO
ARIZONA
KGRA Location
Areas of low- and moderate-temperature potential
Hot Springs
SCALE IN MILES
GREAT SALT LAKE
CRATER SPRINGS KGRA
COVE FORT-SULPHURDALE KGRA
MONROE-JOSEPH KGRA
ROOSEVELT KGRA
THERMO HOT SPRINGS KGRA
LUND KGRA
NEW CASTLE KGRA
NAVAJO LAKE KGRA
Logan
Randolph
Ogden
Morgan
Farmington
Coalville
Salt Lake City
Tooele
Heber
Provo
Manila
Vernal
Duchesne
Nephi
Price
Manti
Castle Dale
Richfield
Moab
Lee
Beaver
Junction
Parowan
Panguitch
Monticello
St George
Kanab

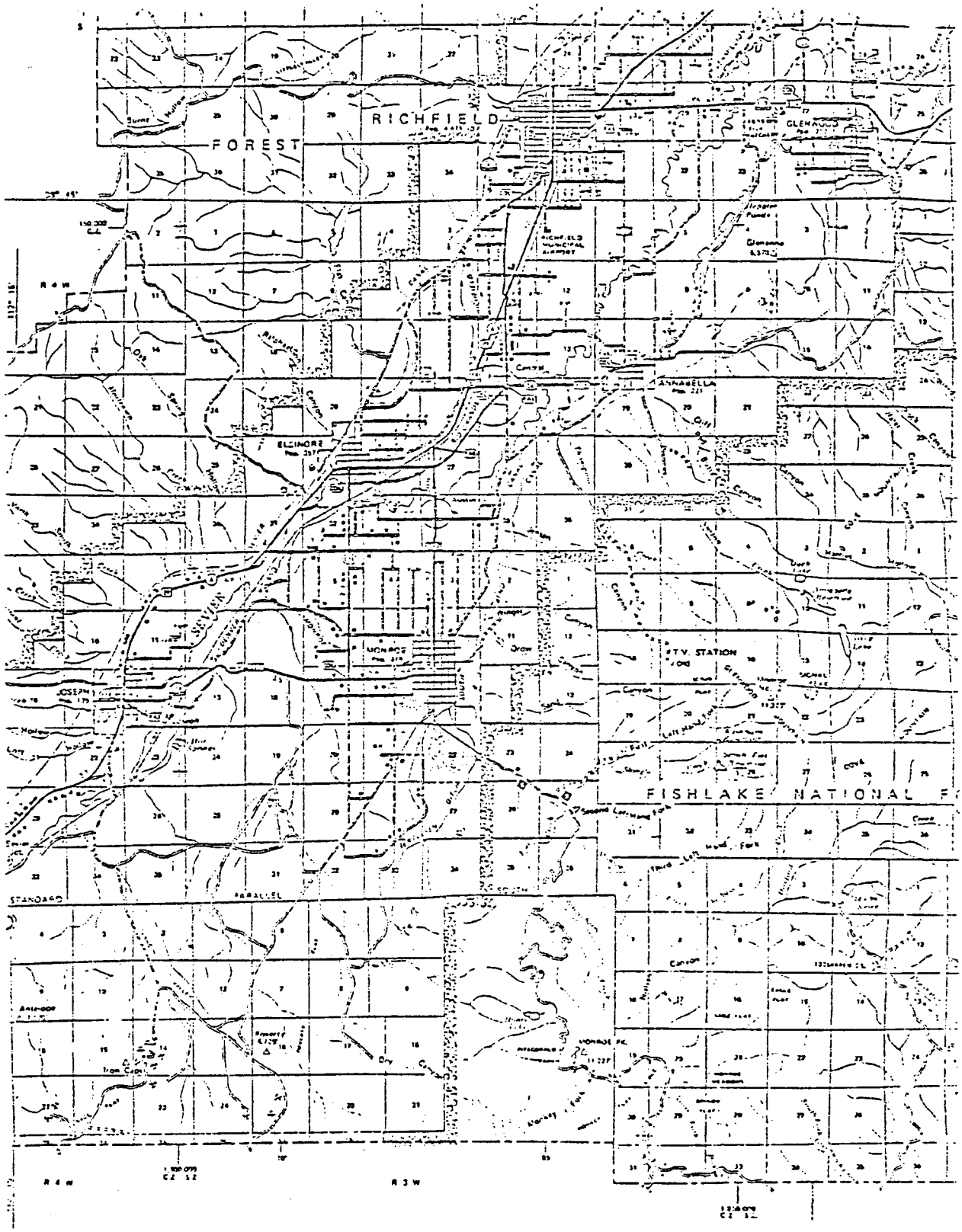
Milford Area and Roosevelt Unit

Scale: 0 1 2 3 4 5





COVE FORT - SULPHURDALE UNIT AREA


RICHFIELD
FOREST
ANNABELLA
ELSINORE
JOSEPH
MONROE
T.V. STATION
FISHLAKE NATIONAL F
STANDARD
PARALLEL
R 4 W
R 3 W

APPENDIX B

B-1 Aggregate Electrical Development Scenario

General Assumptions

B-8 Individual Electrical Development Scenarios

Roosevelt--Phillips Petroleum Co.

Roosevelt--Thermal Power Co./AMAX Exploration/ O'Brien Resources/VTN

Roosevelt--Getty Oil Co. (Out of date)

Cove Fort/Sulphurdale--Union Oil Co.

Thermo--Republic Geothermal, Inc.

North Cove Fort Area--Caroline Hunt Trust Estate

West Cove Fort--Chevron Resources

West Cove Fort--AMAX Exploration, Inc.

B-35 Aggregate Direct Use Scenarios

Schematic Aggregate of Direct Use Development, Utah

Numerical Aggregate of Direct Use Development, Utah

Assumptions Used in Direct Use Scenarios

Data Summary Sheets for Direct Use Scenarios.

Figure 1

Aggregated Scenario--Electrical Production from Geothermal Resources in Utah

	Tot. MWe	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	2000
Roosevelt Prospect	400			50		50		50		50		100		100								
Cove Fort Sulphurdale	200					50		50		50		50										
West Cove Fort	200						50		50		50		50									
North Cove Fort	200						50		50		50		50									
Thermo	100							50		50												
Other Areas (Sevier Lake, Black Rock Desert, Delta Area	200								50		50		50	50								
TOTAL FOR YEAR				50		100	100	150	150	150	150	150	150	150								
CUMULATIVE TOTAL				50		150	250	400	550	700	850	1000	1150	1300								

Figure 1 (Continued)

ASSUMPTIONS USED IN SCENARIOS

April 1978

Roosevelt Hot Springs Prospect

1. The reservoir capacity at the Roosevelt Prospect was assumed to be 400 MWe. This figure is averaged between Phillips (1) and UP&L (2) planning estimates of 300 MWe, and Dr. Stanley Ward's estimate of 500 MWe (3). The heat flow data compiled by Dr. David Chapman also indicates about 300-500 MWe. In this respect 400 MWe is considered an optimistic and fairly realistic estimate.

2. According to Phillips and UP&L (1&2), the plants are planned to come on-line in 55 MWe units two years apart if feasible. The following assumptions were based on this information:

   A. The plants were generally assumed to come on-line two years apart.
   B. The later plants were assumed to be 100 MWe Plants. This presumes:
      (1) Adequate reservoir capacity.
      (2) Development by a single operator (unitization).
      It is possible that later plants might be 55 MWe plants on-line each year.

Cove Fort

1. Several factors will tend to retard development at Cove Fort (Sulphurdale).

   A. Drilling has been very difficult. It has taken a long time and considerable problems were encountered from a geological standpoint.
   B. Because of these problems with drilling, the wells drilled by Union have been very expensive.
   C. The presence of a viable reservoir has not yet been satisfactorily verified.

2. In spite of these setbacks, several ventures are proceeding (4). For purposes of the long-range scenario, the following separate ventures were assumed.

   A. Sulphurdale--Union could have two areas here, one north of the freeway, one south. Because Union still appears to be progressing, the first plant was assumed to come on-line in 1984. The sites are left unspecified. This is an optimistic forecast, particularly in light of the difficulties mentioned above.

Figure 1 (Continued)

2. Earlier scenarios estimated drilling to begin at Thermo in 1980 (6). Republic Geothermal drilled a deep well in late 1977. This would seem to indicate that development at Thermo could be advanced by as much as two years. Also, federal programs could make an earlier production date feasible for Thermo as well as for some of the Cove Fort areas. On the other hand, preliminary information from the Republic Well at Thermo does not seem to justify boundless optimism; hence, the first plant was estimated to produce power on-line about 1986, with another 50 MWe plant following two years later.

Figure 1 (Continued)

B. North Cove Fort (Dog Valley)--Hunt Energy Corp. is currently drilling on private lands several miles north of the Sulphurdale area. An optimistic forecast would put them on-line about 1985 or, at best, 1984. Of course, the controlling factor will be the discovery of a reservoir.

C. West Cove Fort Area--Several groups are conducting intensive exploratory activities in this area, although no deep wells have been drilled. Developers in this area are AMAX, Hunt, Chevron, Phillips, and others. An optimistic estimate could place at least one of these prospects on-line in 1985 (4). Because several developers are involved, the plants could come on-line in bunches; the assumption for the scenario was usually a plant each year.

3. Reservoir Quantities: Based roughly on various estimates of reservoir capacity, the following quantities were assumed:

   Sulphurdale 200 MWe.
   North Cove Fort 200 MWe.
   West Cove Fort 200 MWe.

   These assumptions appear to be optimistic but reasonable. Sulphurdale, North Cove Fort, and West Cove Fort were assumed to have 200 MWe capacity each. Again, these capacities are not scientific reservoir estimates but are useful for purposes of estimating development patterns.

4. Federal Programs and other incentives/assistance: It was assumed that optimistic estimates would be partially justified by the development of federal initiatives to accelerate and assist development in Cove Fort areas. Such programs were left unspecified but will probably include case study programs, technology transfer, and the reduction of institutional restrictions.

   Note: Cascading and multiple use systems will very likely be developed for some of these areas, most particularly in the Sulphurdale area where exhaust from the power plant may be used in sulphur mining or other industrial operations (4).

Thermo Prospect

1. Reservoir capacity was assumed to be 100 MWe. This is a moderately optimistic assumption. The rationale for this estimate was that the area involved might be larger than the 1.5 km^2 estimated by USGS Circular 726, although at this time there is little evidence to support this hypothesis.

Figure 1 (Continued)

2. Earlier scenarios estimated drilling to begin at Thermo in 1980 (6). Republic Geothermal drilled a deep well in late 1977. This would seem to indicate that development at Thermo could be advanced by as much as two years. Also, federal programs could make an earlier production date feasible for Thermo as well as for some of the Cove Fort areas. On the other hand, preliminary information from the Republic Well at Thermo does not seem to justify boundless optimism; hence, the first plant was estimated to produce power on-line about 1986, with another 50 MWe plant following two years later.

Figure 1 (Continued)

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BASIC ASSUMPTIONS FOR SCENARIOS

Electrical Production from Geothermal Resources in Utah

1. Reservoir: For purposes of the planning scenarios, it was assumed that geothermal reservoirs would be discovered early at each prospect. (So far, the Roosevelt Hot Springs prospect is the only one where a geothermal reservoir has been verified). It was also assumed the reservoirs at each prospect will be commercial, with both adequate heat and adequate volume for electrical production. It was assumed that the reservoir will not be so deep or difficult to drill that exploration and production drilling is not economical.

   The following reservoir capacities were assumed, although there is as yet little evidence for these quantities:

Roosevelt Hot Springs:	400 MWe
Cove Fort/Sulphurdale:	200 MWe
West Cove Fort:	200 MWe
North Cove Fort:	200 MWe
Thermo:	100 MWe
Other Potential Areas:	200 MWe

   Most of these assumed capacities are probably high, particularly for the Cove Fort areas. These data will be adjusted as soon as more information becomes available.

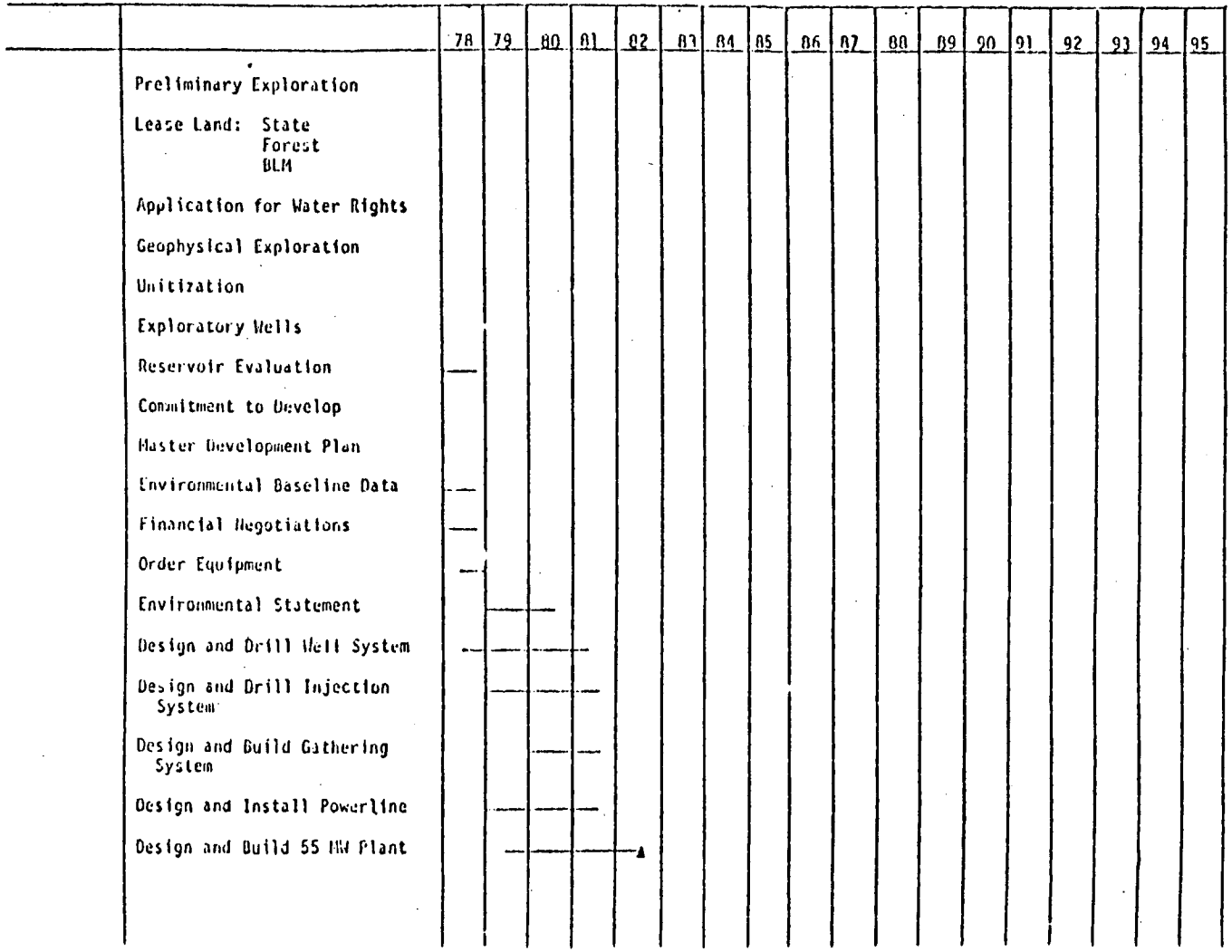
2. Economics: It was assumed for each prospect that development will be economically advantageous to the developers. This includes the assumptions that the reservoir will be commercial. Also, it was assumed that capital will be available to finance development. The power was assumed to be marketable, i.e., that the utilities (primarily Utah Power and Light) will agree to buy and/or wheel the power. It was also assumed that no further economical burdens will be placed on the developer by delays, environmental problems, etc. In addition, it was assumed that some federal assisance will be available to reduce the pressures of the other assumptions; not necessarily to fund the operations, but to provide some financial assistance through cost-share programs, loan or reservoir guarantees, tax incentives, reduction of institutional delays, etc.

3. Institutional: It was assumed for each prospect that no unforeseen delays or problems due to institutional factors will occur. This includes the assumption that permitting will be prompt and will not be more restrictive than past permitting.

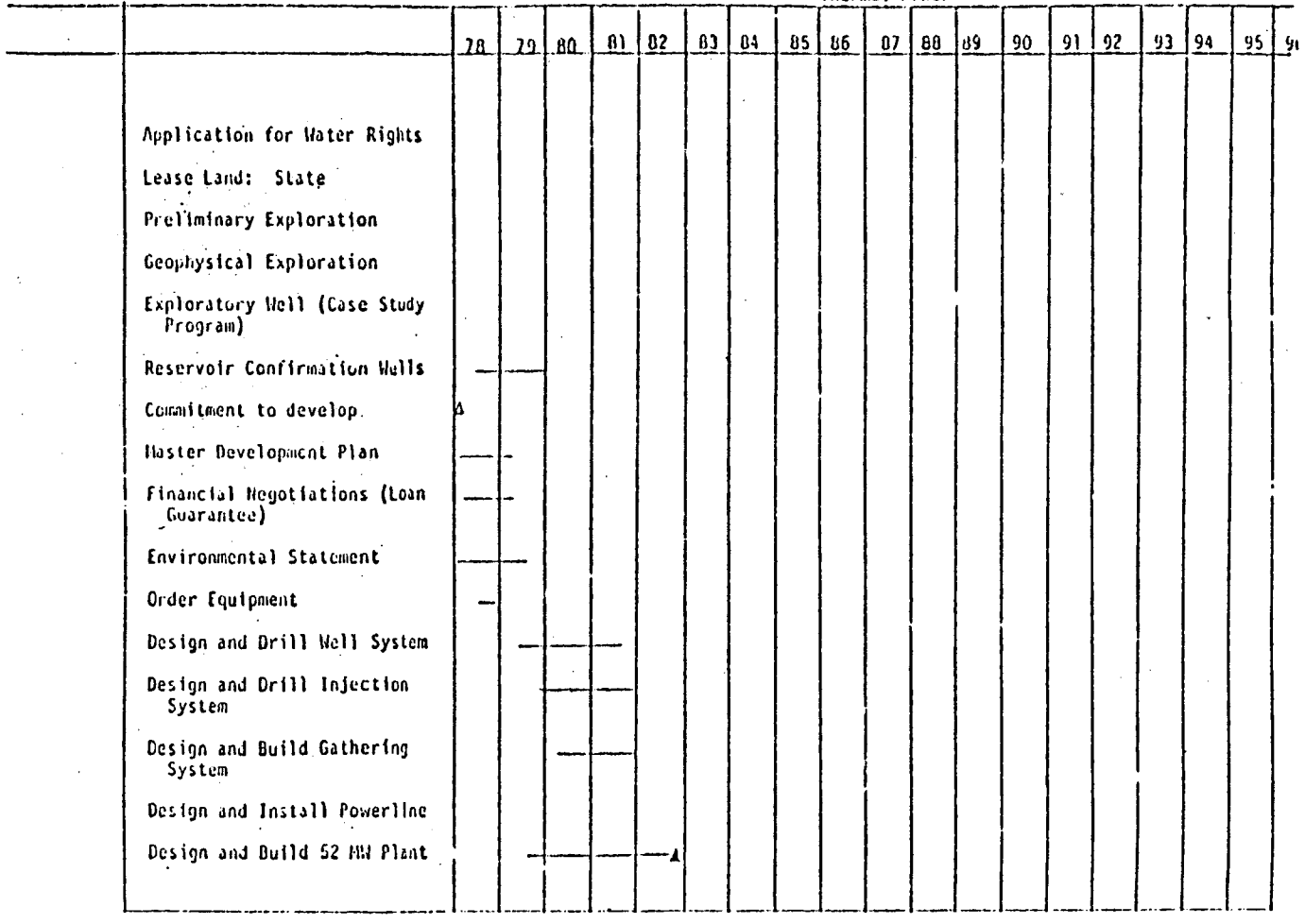
Continued

It was also assumed that new regulations which might restrict or retard development will not be added. Lawsuits and other legal actions were assumed not to accur, whether concerned with the environment, water rights, land disputes, mineral rights, or other potential issues. It was assumed that no delays will be imposed by State or local governments over such issues as water rights, zoning ordinances, building permits, discharge permits, etc. It was assumed that major environmental impact statements would not be required for any phase of development at any of the prospects.

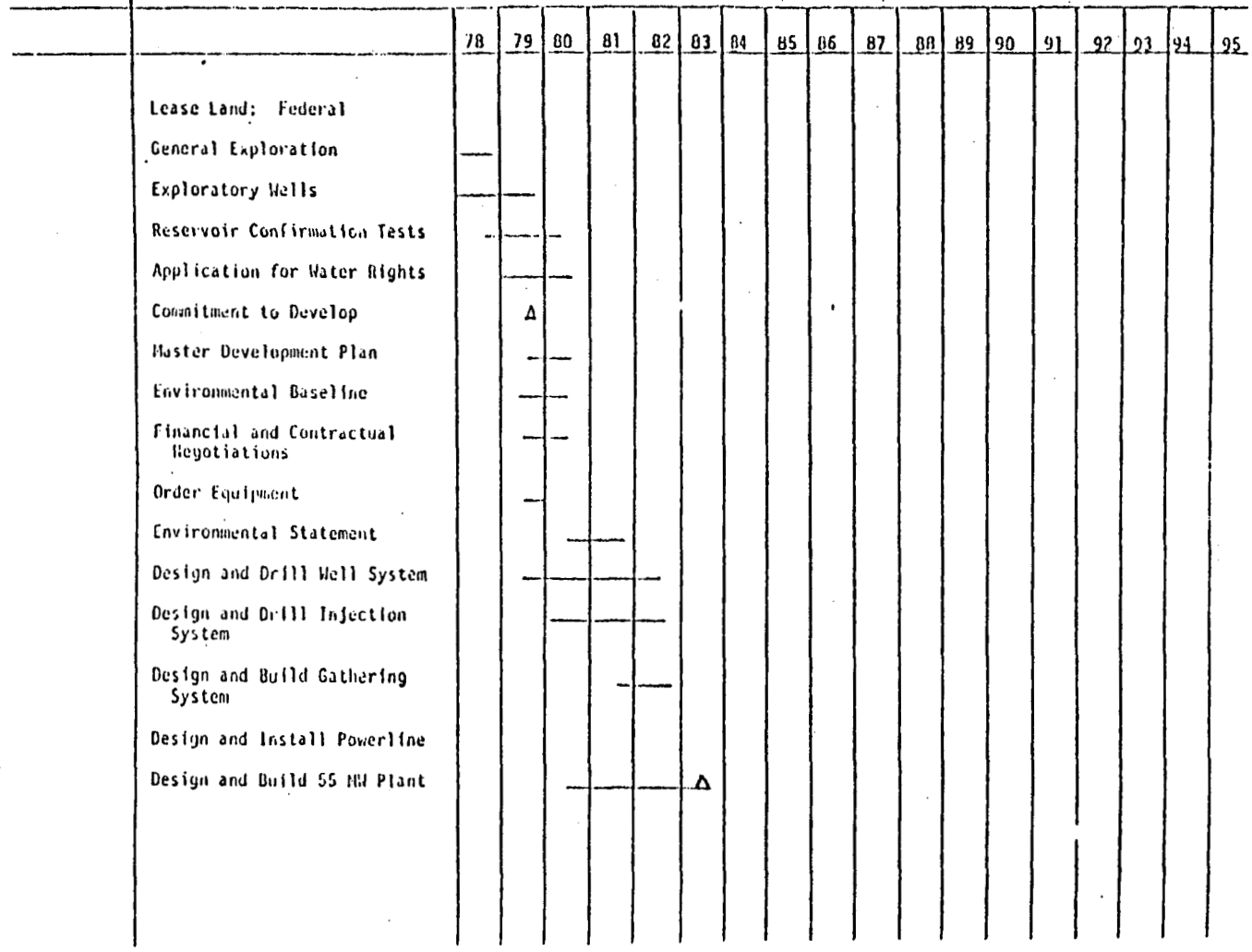
Possible Development Forecast: Roosevelt Prospect (Phillips Petroleum Co.)



Thermal Power



Possible Development Forecast: Roosevelt Prospect (Getty Oil Co.)



Summary: Getty

The federal leases held by Getty Oil Company are located near the south end of the Roosevelt prospect. The leased area is not large (three sections) but the dome fault, which apparently provides a system of conduits for the geothermal fluids, runs through the lease.

Extensive exploration and drilling has been done throughout the prospect by various developers. Getty recently finished drilling a deep exploratory well with federal assistance under the industry coupled case study program. The data from this well has not yet been made public.

The Roosevelt Prospect has been partially unitized. At this time only Phillips Petroleum and Union Oil Co. have joined the unit. Getty Oil Co. and the Thermal Power/ AMAX/O'Brien/VTN Consortium have not yet accepted the unit agreement. Whether or not Getty and the Consortium will join the unit and when they might do that is a matter that defies speculation at this time. The Proposed Geothermal Rules and Regulations for Utah, as issued by the Division of Water Rights, state that the State Engineer has the authority to enforce unitization, but there are legal questions which still need to be resolved. In any case, unitization by the State Engineer would be a possibility only after extensive, careful investigation and consideration.

For the purposes of the individual scenarios, Getty was considered a possibility for a plant by about 1983. This would assume that Getty did not join the unit but developed the field and built the power plant themselves. It was also assumed that only one power plant would be viable on the Getty leases. There is at this time no way to verify or negate either of these assumptions, but the whole scenario picture will be updated as soon as new information becomes available. For purposes of an aggregated scenario for the whole prospect, the Phillips forecasts were followed, as if Getty and the Consortium did join the Unit. These assumptions merely represent (hopefully) a fairly reasonable compromise between two very divergent possibilities.

If Getty does develop a power plant it probably will not use the loan Guarantee program inasmuch as it is a major developer. Development will depend very much on the economic advantage of the situation. On the other hand,

Continued

13. It was assumed that the design and construction of the plant would take about three years, and that the plant would be completed about 1983.

Getty--Specific Assumptions

1. It was assumed that general geophysical exploration will continue, particularly to locate further exploratory wells. Exploratory wells were assumed to be drilled for another one and a half to two years. This would require a good discovery well and that the confirming wells are also sucessful.

2. Reservoir confirmation tests were assumed to begin as the exploratory wells are tested and to continue for six months to one year after exploratory drilling has been completed.

3. Water rights were assumed to impose no significant delay in development, even though the application probably will not be acted upon until reservoir information has been gathered.

4. The commitment to develop was assumed to follow confirmation of the discovery. The reservoir has already been confirmed although its characteristics have not been completely investigated. This will probably make it possible for Getty's commitment to be fairly secure relatively early.

5. It was assumed that Getty would gather part of the required baseline data and acquire part of it from Phillips.

6. Financial and contractual negotiations were assumed to begin shortly before the commitment to develop was made, and were assumed to continue about a year.

7. It was assumed that the generating equipment would be ordered shortly after the commitment to develop was made.

8. The environmental statement was assumed to begin after all baseline data had been collected, and to extend about a year. Again, Getty should be able to get some data from Phillips.

9. It was assumed that design and drilling of the production wells would begin about the time that the commitment to develop was made, and that it would extend two to three years.

10. The injection system was assumed to trail the production well system by a few months.

11. The gathering system was assumed to be completed a few months after the production and injection systems were completed and to have taken a little over a year for design and construction.

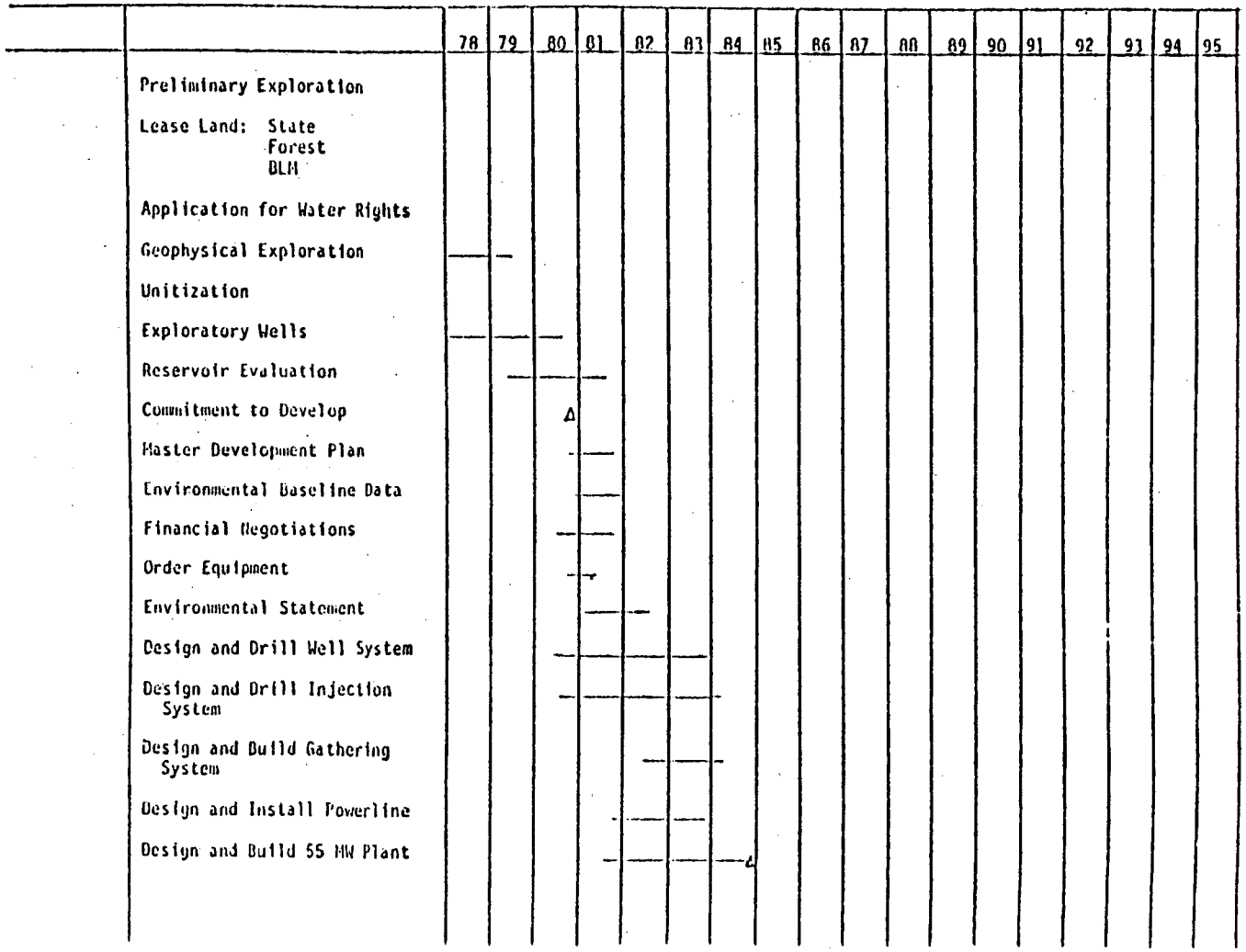
12. The power line will be constructed by Utah Power and Light, and the line built for the Phillips/Rogers plant will be used for subsequent plants.

Continued

Getty reported that their recent use of the case study program was a definite incentive to accelerate exploration.

No extraordinary drilling problems were encountered by Getty. Phillips plans to gather environmental data for their baseline study (contracted to Woodward/Clyde Consultants) and Getty would probably be able to negotiate for much of the information it needs to fulfill its own environmental requirements.

Possible Development Forecast: Cove Fort/Sulphurdale (Union Oil Co.)



Summary: Cove Fort/Sulphurdale Prospect (Union Oil Co.)

The vicinity of Sulphurdale near Cove Fort has been considered a major potential resource area in Utah. Although there are no surface springs, Mundorff (1970) reported active gas seeps and thermally altered areas. The Cove Fort/Sulphurdale prospect was estimated by USGS Circular 726 to contain about 274 MWe, and the MITRE Corp. cited an unidentified ERDA-DGE source which estimated 500-1500 MWe for the prospect.

In the summer of 1976, Union Oil Co. drilled an 1100 foot exploratory well on private leases. The well was plagued by drilling difficulties and eventually caved in.

The Cove Fort Unit was formed in January, 1977, by Union Oil Co., the unit operator, Phillips Petroleum Co., and AMAX Exploration, Inc.; W. H. Hunt joined January, 1978.

In late 1977, Union drilled a second deep exploratory well. Although the drilling went much deeper, it was once more very difficult. Final results from the well have not yet been made public. Union has recently begun drilling a third well at a site somewhat between the other two sites.

The difficult drilling at Cove Fort has made the wells thus far very expensive. All three of the wells at Cove Fort/Sulphurdale were partially funded through the DOE Industry-Coupled Case Study Program.

Specific Assumptions: Cove Fort/Sulphurdale (Union Oil Co.)

1. Most of the preliminary exploration, leasing of land (from the state of Utah, BLM, U.S. Forest Service, and private owners), and negotiations for unitization were assumed to be completed.

2. It was assumed that the appropriation of water through the Division of Water Rights will not cause delay, and that the Division will not act on the application until the reservoir had been fairly well established.

3. It was assumed that a discovery well will be drilled during 1978 which would trigger development. Each non-producing well which is drilled will set the whole scenario back in time. It was assumed that confirming wells will be drilled within a period of 1-1½ years following the initial discovery.

4. It was assumed that reservoir evaluation tests will begin after the reservoir has been confirmed and will continue as subsequent producing wells are brought in. In addition to major tests on the individual wells, the long-term reservoir test may last more than a year.

5. It was assumed that the commitment to develop will be made when several producing wells have been drilled and tested and the reservoir is fairly well confirmed, although reservoir tests will continue after the decision point. It was assumed that the tests results will convince the utilities of the viability of the project.

6. The master development plan was assumed to be initiated at about the time of the commitment to develop, and was assumed to take about a year to complete.

7. The gathering of one year's environmental baseline data was assumed to begin about the time that the commitment to develop is made. The whole process will probably last a year and several months because approval from the USGS is necessary; however, these preliminary processes will probably be initiated before the utility is convinced. Baseline data will be necessary only for the federal lands, but will probably be gathered for the whole area enclosed by the unit boundaries.

8. Financial negotiations were assumed to begin a short time before the actual commitment to develop is made. These negotiations will probably involve the unit operator and other unit members, the utility, the power producer (if a smaller go-between company is brought in as was the case at Roosevelt), and eventually the DOE if the loan guarantee is used. Financial negotiations were assumed to be completed after about a year.

Continued

9. It was assumed that it will be necessary to order some of the generating equipment three to four years before the facility is completed.

10. The environmental statement was assumed to begin as the baseline study ends and to continue for about 1½ years. U.S. Forest Service involvement could extend the time necessary to complete the environmental statement.

11. The design and drilling of the well system was assumed to take a little over three years to complete. This extended time was assumed in order to take into account difficult drilling conditions known to exist in the Cove Fort area. Although the scenario is meant to reflect a fairly "optimistic--realistic" situation, the geology in the Cove Fort Area is known to be difficult to drill.

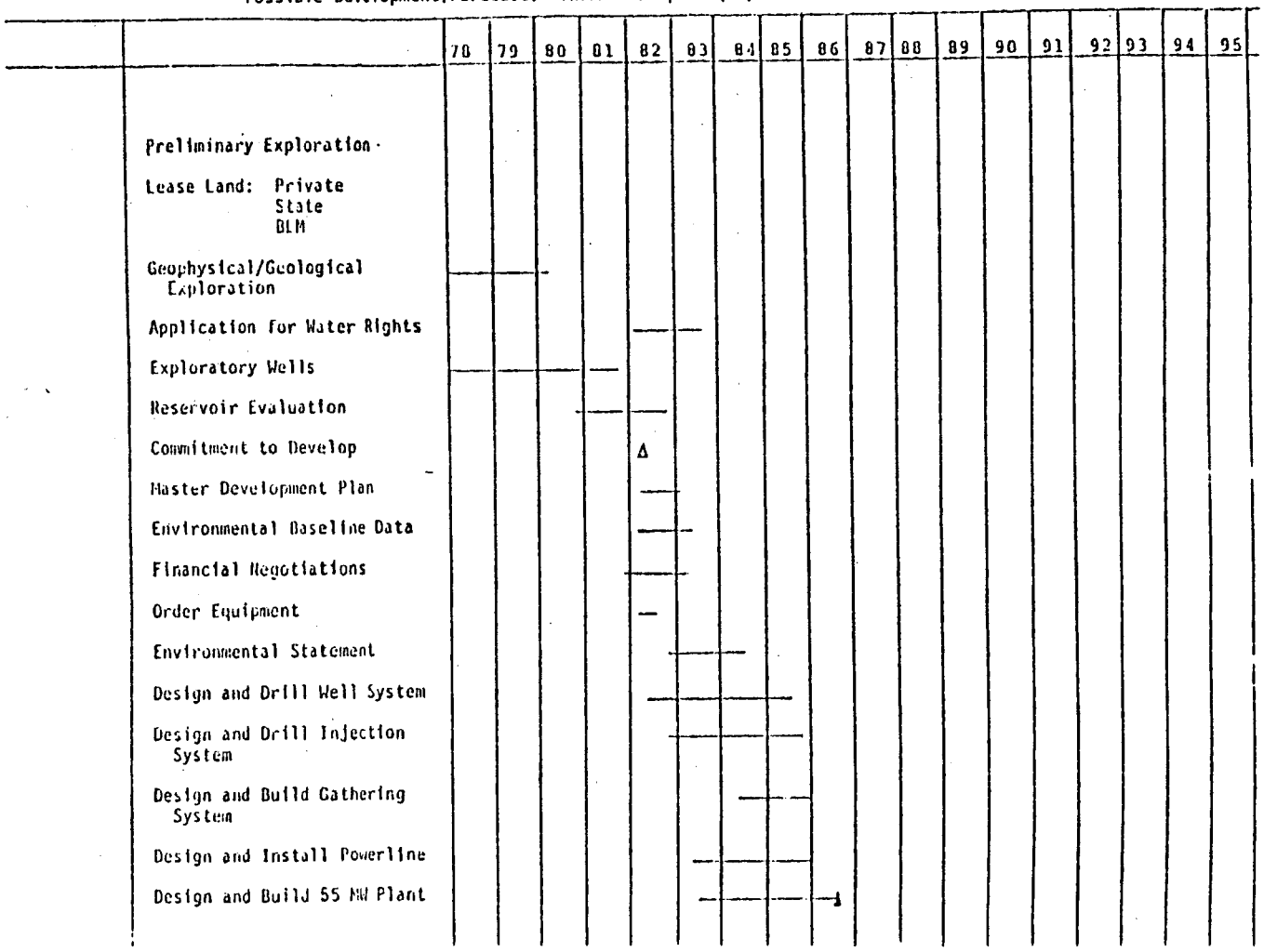
12. The design and construction of the injection system was assumed to begin a few months after the production well system and to continue until after the production well system has been completed.

13. The design and construction of the gathering system was assumed to last from 1½-2 years, and to be completed a few months after the injection system was completed.

14. Two power lines presently pass through the Cove Fort/Sulphurdale area, a 46 KV line and a 138 KV line. If the discovery at Cove Fort/Sulphurdale is not too large, these power lines might suffice. If discoveries are also made in the north Cove Fort and West Cove Fort areas, it may be necessary to construct power lines to connect these areas into the network.

15. The design and construction of the power plant was assumed to take about three years, and was assumed to be completed about 1984.

Possible Development Forecast: Thermo Prospect (Republic Geothermal, Inc.)



Summary: Republic Geothermal at Thermo, Utah

Republic has drilled one well in the Thermo area. The well has not yet been completely tested and is currently suspended.

Republic Geothermal is a smaller company than many of the major developers, and specializes in geothermal exploration and development. Republic is heavily involved with two power plants in the Imperial Valley in California, and at this time the Thermo prospect carries a somewhat lower priority.

The information from the well at Thermo has not yet been made public. Indications are that the well shows some promise. No extraordinary geological difficulties were encountered.

The prospect at Thermo is somewhat isolated. This causes more expense in moving drill rigs into the area and also means that a power line would have to be constructed to carry power to the network. Most of the prospect is in the flatlands of the Escalante Desert, which will possibly ease environmental constraints.

Specific Assumptions: Republic Geothermal at Thermo, Utah

1. It was assumed that some geophysical exploration will still be necessary to evaluate drilling prospects and locate the well sites. This activity will probably not be intense for a while, and will probably extend over a year or more until Republic is ready to resume intense exploration.

2. Water Rights are assumed to present a minimal problem although approval will probably not be granted until development is fairly well along.

3. The well which has been drilled has not yet been fully tested, and Republic has voiced no firm plans for further drilling. It was assumed that drilling will not take place immediately and that it will be somewhat spaced out over a period of several years. This phase of development could be altered to accelerate or retard over-all development.

4. Reservoir evaluation was assumed to begin as producing wells are drilled and to continue for about a year while producing wells are used to analyze the reservoir characteristics.

5. The commitment to develop was assumed to occur after a number of producing wells have been drilled and the reservoir has been evaluated, possibly about 1982.

6. The master development plan was assumed to extend about a year beyond the time the commitment to develop is made or about 1982.

7. The Environmental Baseline Data Program was assumed to begin as soon as development becomes likely, or would begin about the time that the commitment to develop is made.

8. Financial negotiations were assumed to begin several months before a commitment to develop was made, and to continue for about a year.

9. It was assumed that it would be necessary to order the generating equipment about four years before the plant was scheduled for completion. This was estimated to be done around mid-1982.

10. The environmental statement was assumed to overlap with the gathering of baseline data. It was assumed to continue about a year and a half. The vegetation and terrain is fairly homogenous, mostly flat desert with salt brush and greasewood.

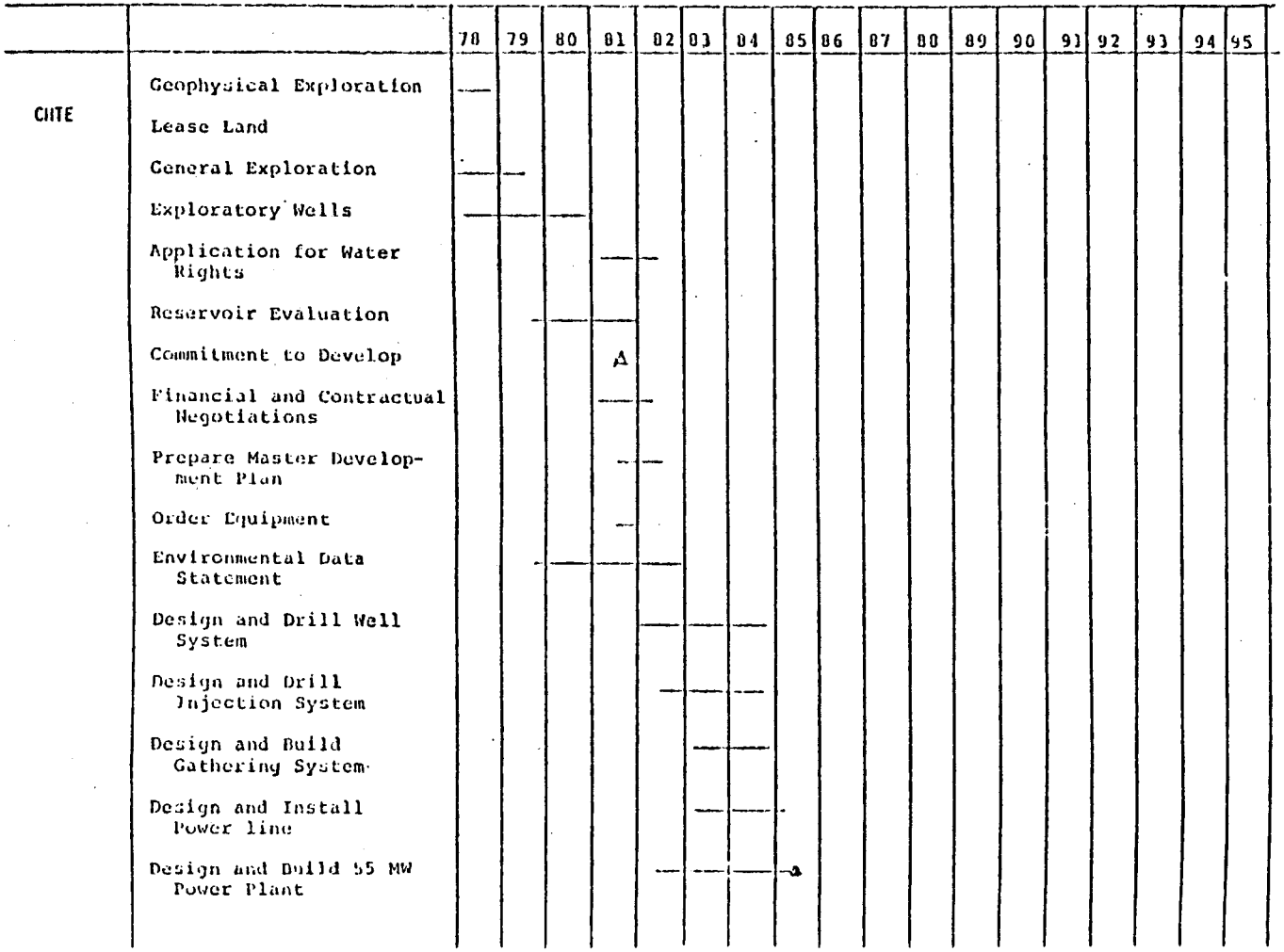
Continued

The area has also been covered as part of a ground-water flow study by the USGS. These factors would possibly simplify the environmental analysis of the area.

11. It was assumed that the design and drilling of the well system would take about two and a half to three years. The time frame would be somewhat flexible. The design and drilling of the injection system would probably begin shortly after the production system is begun, and the gathering system would last about a year and a half and would be completed near the same time as the injection system.

12. Republic already has experience in building power plants and is more likely to constuct their own plant than many developers would be. Construction would probably last two and a half to three years, and would possibly be completed about 1986.

Possible Development Forecast: North Cove Fort Prospect (Caroline Hunt Trust Estate)



Summary: Hunt Energy Corporation--North Cove Fort Prospect

The Caroline Hunt Trust Estate holds geothermal leases on fee lands in the Dog Valley/White Sage Flat area north of the Cove Fort Unit. Hunt has conducted geophysical and temperature gradient surveys of the area and is presently drilling a deep exploratory well.

The area of most interest to Hunt is a hilly juniper and sagebrush area south and west of Kanosh. The fee lands are bordered by National Forest lands to the east and by BLM lands several miles west. Depending on the results of the exploration, these federal lands may eventually be associated with the prospect.

It appears in general that dilling in the Cove Fort Area is not easy, but information from the Hunt well has not yet been made public. Hopefully, it will be possible to avoid some of these difficulties in later wells, but because the difficulties appear to be associated with the general geology of the region, it was assumed that they would be encountered in most drilling. At this point, the reservoir characteristics are still unknown, and any estimate of reservoir capacity must be considered more to be an assumption, rather than a forecast.

Hunt is a large, well established company, and like other major companies and utilities would have little use for a loan guarantee program; however, money available through a bottom-hole information program such as the case study program could be useful to them.

Hunt Energy Corporation--Specific Assumptions

1. It was assumed that most of the leasing for the area has already taken place, and that most but not all of the geophysical exploration has taken place.

2. It was assumed that, given a discovery at the first well, exploratory drilling would continue for about two and a half to three years. The general rule of thumb of about two years for exploratory drilling modified somewhat to take difficult drilling conditions into account.

3. Hunt has filed for water rights in this area. Although the water rights will probably not be acted upon until more is known about the reservoir, it is unlikely that the development will be held up by the appropriations process.

4. The reservoir evaluation was assumed to continue about two years, overlapping with the later stages of exploratory drilling. Assuming that the reservoir proved suitable, the evaluation would lead to a commitment to develop about three to four years after discovery, or about 1981.

5. Financial negotiations were assumed to begin shortly before the commitment to develop was made, and would probably continue about a year or so.

6. The master development plan would probably continue about a year following the commitment to develop.

7. Shortly after the decision to develop has been made, the generating equipment should be ordered, since there is now a three to four year interval for generating equipment.

8. The Hunt leases are on private leases but, because of the proximity to federal lands, Hunt will probably fulfill the federal requirements for environmental studies. This environmental statement would include the one year baseline study, which would probably begin after the discovery was confirmed. The major environmental report probably would not begin until the commitment to develop was fairly secure.

9. The design and drilling of the well system were estimated to take two to two and a half years, possibly longer because of difficult drilling conditions in the Cove Fort Area.

10. The design and construction of the injection system was assumed to begin a few months after the production well system was begun, and to continue until a short time after the production well system is completed. It is likely that the

Continued

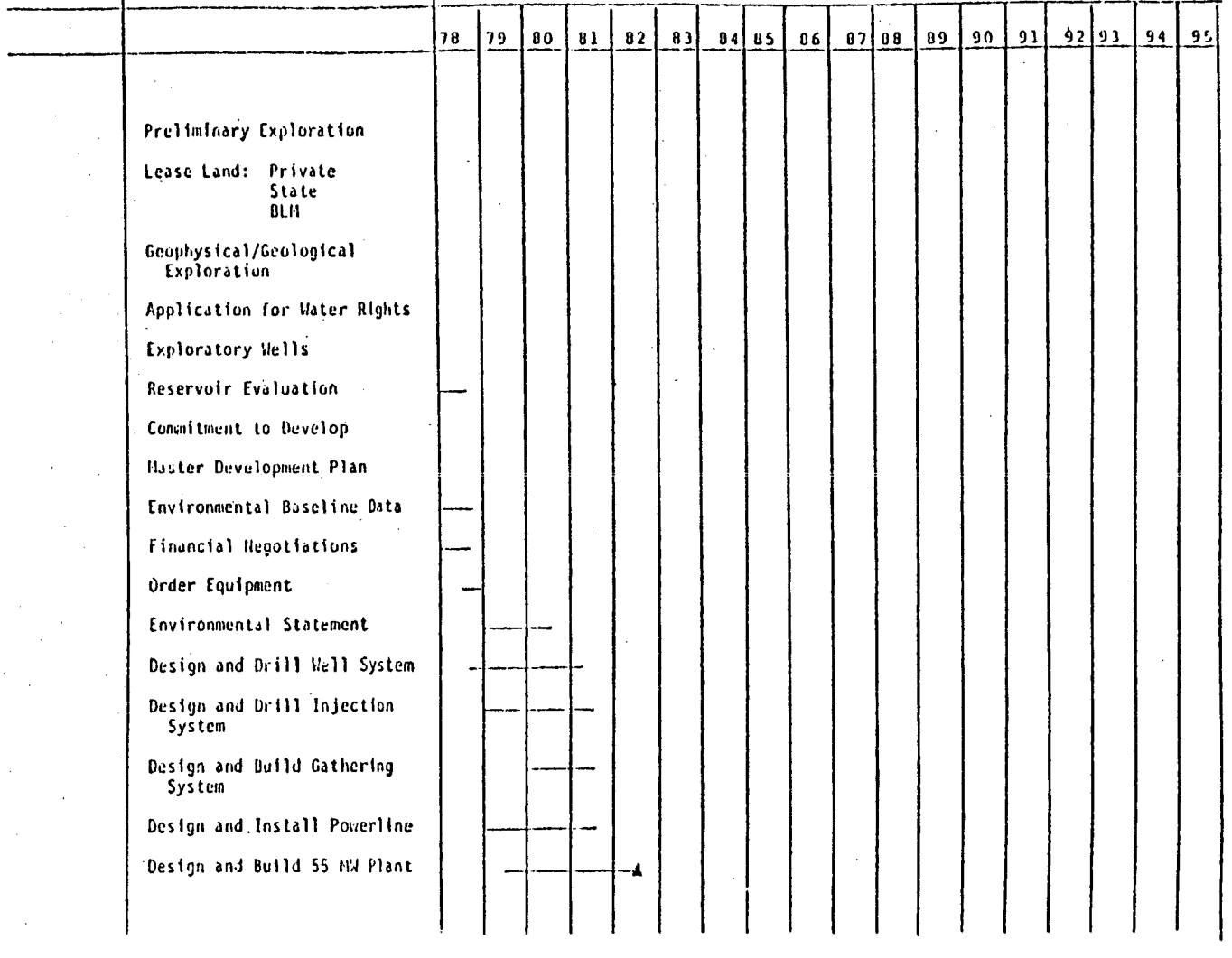
same drilling difficulties encountered in the production drilling will slow the injection system somewhat.

11. It was assumed that the design and construction of the gathering system will take about two years, and that it will be completed several months after the production well system has been completed.

12. Utah Power and Light has a 138 KV powerline near Cove Fort, about six miles south of the Hunt prospect. In addition, if Roosevelt and Cove Fort begin producing power, UP&L may build a power line serving these areas even closer to the Hunt Prospect.

13. Construction and design of the power plant was assumed to take about three years, with the actual construction taking about two years. The power plant was estimated to be completed about 1985.

CHEVRON RESOURCES CO.--WEST COVE FORT AREA



Summary: West Cove Fort Prospect (Chevron Resources Co.)

No deep exploratory drilling has been done in the desert area west of Cove Fort and north of the Roosevelt prospect. However, several groups have done exploratory work in that area, including geophysical investigations and temperature gradient surveys. The area is covered mostly by lake deposits with scattered late Tertiary volcanic outcroppings. Meadow and Hatton warm springs occur along the east edge of the desert.

Chevron Resources has extensive holdings through this area, including a large contiguous block of state, federal, and fee leases. Chevron has conducted exploratory work, but as mentioned above, no exploratory wells have been drilled and no reservoir has been verified.

For purposes of the planning scenarios, it was assumed that a commercial discovery will be made. This does not constitute an estimate by the developer but rather is an assumption for planning purposes. It was assumed that if a commercial discovery were made and no unforeseen technical or institutional problems arose, a power plant could come on line within five to seven years of the discovery.

Specific Assumptions: West Cove Fort (Chevron Resources Company)

1. It was assumed that most of the preliminary exploration and the leasing of state, private, and federal lands has been completed.

2. It was assumed that geophysical and geological exploration, including temperature gradient wells and stratigraphic holes, will continue for a few years. These exploratory activities were assumed to continue after the initial exploratory wells have been drilled.

3. It was assumed that deep exploratory drilling will begin later in 1978. This assumption implies no commitment or planning on the part of Chevron Resources. Its only purpose is to provide a frame of reference and a starting point for the development scenario. Again, this does not imply that Chevron has any specific plans to drill in any area at any time.

4. The reservoir evaluation was assumed to take place over about a 1½ year period after two or three wells have been drilled confirming the discovery well. This includes intensive well tests and long-term reservoir tests.

5. The commitment to development was assumed to come at a point after the reservoir has been fairly well verified and the utility is convinced of the economic advantage of the project, about two to three years after the discovery well.

6. The master development plan was assumed to be initiated at about the time that the commitment to develop is made, and was assumed to extend about a year.

7. The gathering of one year's environmental baseline data was assumed to begin as the commitment to develop becomes secure.

8. Financial negotiations were assumed to begin at the time of the commitment to develop, perhaps somewhat previous, and to continue for about a year, perhaps less.

9. It was assumed that some of the generating equipment will be ordered three to four years before the facility is scheduled for completion, or shortly after the commitment to develop.

10. The environmental statement was assumed to take about 1-1½ years to complete, and was assumed to begin about the time that the baseline environmental data had been completed.

11. The designing and drilling of the production well system was assumed to begin six months to one year after the commitment to develop and to continue about 2½ years.

Continued

It was assumed to be completed about a year before the facility is scheduled for completion.

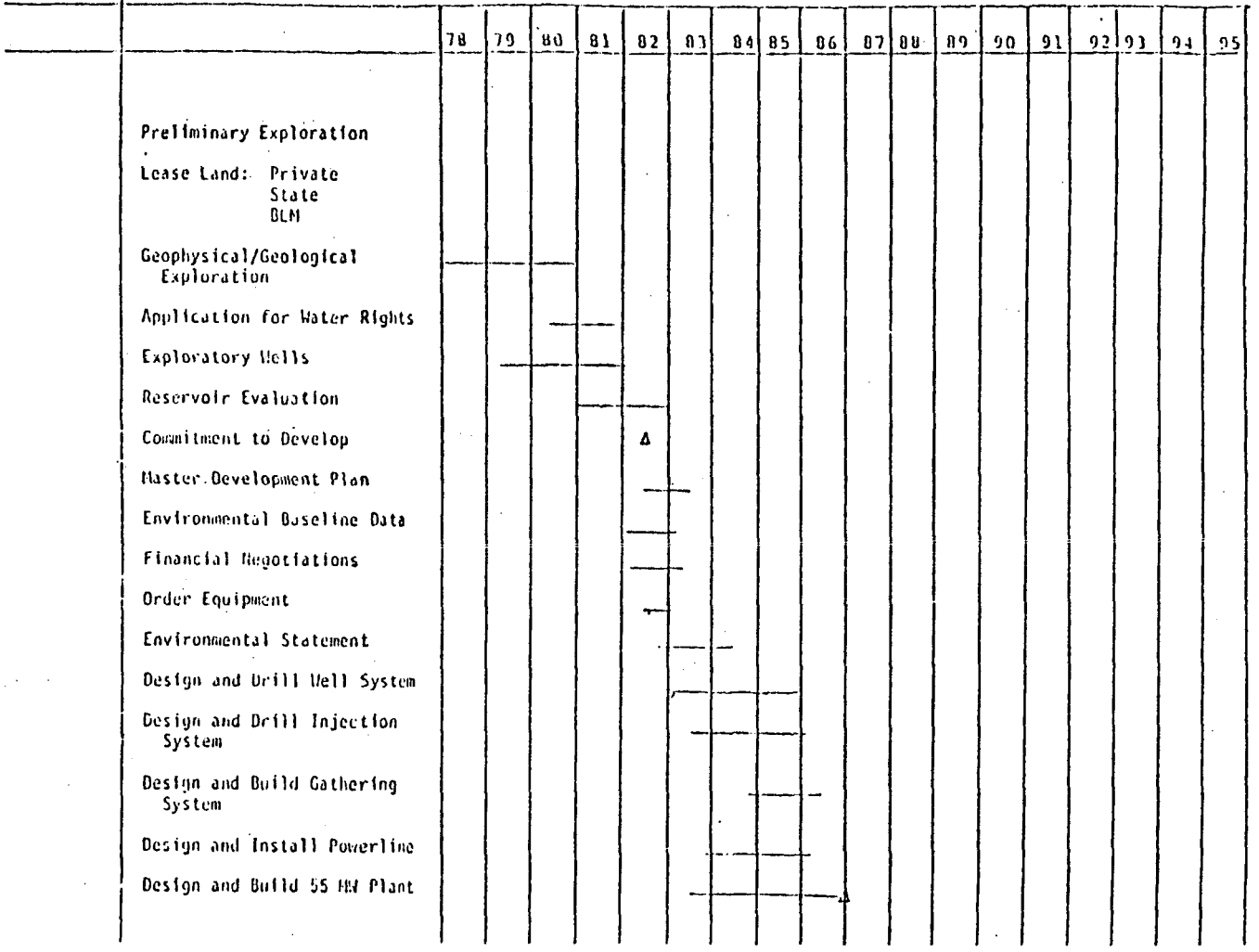
12. The injection system design and drilling was assumed to begin a few months after the production well system and to continue until a few months after the production well system is completed, or about two years.

13. The design and drilling of the gathering system was assumed to take about 1-1½ years and to be completed a few months after the completion of the injection system.

14. There are no power lines through this area at the present time. If the power line to the Roosevelt prospect goes to the existing line at Cove Fort by the shortest route, it will be necessary to build another line for any West Cove Fort prospects. If the power line from Roosevelt goes north, it could well pass through the West Cove Fort area and reduce the required power line distances for prospects north of Roosevelt. For purposes of the scenario, it was assumed that a new power line will be necessary and that it will take about 2½-3 years to complete.

15. The design and construction of the power plant was assumed to take about three years; the completed plant was assumed to come on line about 1985.

Possible Development Forecast: West Cove Fort Area (AMAX Exploration, Inc.)



Summary: West Cove Fort Area (AMAX Exploration, Inc.)

No deep exploratory drilling has been done in the desert area west of Cove Fort and north of the Roosevelt prospect. However, several groups have done exploratory work in that area, including geophysical investigations and temperature gradient surveys. The area is covered mostly by lake deposits with scattered late Tertiary volcanic outcroppings. Meadow and Hatton warm springs occur along the east edge of the desert.

AMAX Exploration, Inc., has scattered lease holdings throughout the West Cove Fort/North Roosevelt area and extensive leases in the Thermo area. AMAX has conducted some geophysical and geological exploratory work, particularly temperature gradient holes. No exploratory wells have been drilled on AMAX's holdings in either area, and no reservoir has been verified.

For purposes of the planning scenarios, it was assumed that a commercial discovery will be made. This does not constitute an estimate by the developer but rather is an assumption for planning purposes. It was assumed that if a commercial discovery were made and no unforeseen technical or institutional problems arose, a power plant could come on line within six to eight years of the discovery.

Specific Assumptions: West Cove Fort Area (AMAX Exploration, Inc.)

1. It was assumed that most of the preliminary exploration and the leasing of state, private, and federal lands has been completed.

2. It was assumed that geophysical and geological exploration including temperature gradient wells and statigraphic test holes will continue for several years. These exploratory activities were assumed to continue after the initial exploratory wells have been drilled.

3. It was assumed that deep exploratory drilling will begin late in 1978 or 1979. This assumption implies no commitment or plans on the part of AMAX Exploration. Its only purpose is to provide a frame of reference and a starting point for the development scenario. Again, this does not imply that AMAX has any specific plans to drill in any area at any time.

4. The reservoir evaluation was assumed to take place over about a two-year period after three to five wells have been drilled confirming the reservoir. This includes intensive well tests and long-term reservoir tests.

5. The commitment to development was assumed to come at a point after the reservoir has been fairly well verified and the utility is convinced of the economic advantage of the project, about two to three years after the discovery well.

6. The master development plan was assumed to be initiated at about the time that the commitment to develop is made, and was assumed to extend about a year.

7. The gathering of one year's environmental baseline data was assumed to begin as the commitment to develop becomes secure.

8. Financial negotiations were assumed to begin somewhat before the commitment to develop is made and to continue for about a year.

9. It was assumed that some of the generating equipment will be ordered three to four years before the facility is scheduled for completion, or shortly after the commitment to develop.

10. The environmental statement was assumed to take about 1-1½ years to complete, and was assumed to begin about the time that the baseline environmental data had been completed.

11. The design and drilling of the production well system was assumed to begin six months to one year after the commitment to develop and to continue about 2½ years. It was assumed to be completed about a year before the facility is scheduled for completion.

Continued

12. The injection system design and drilling was assumed to begin a few months after the production well system and to continue until a few months after the production well system is completed, or about two years.

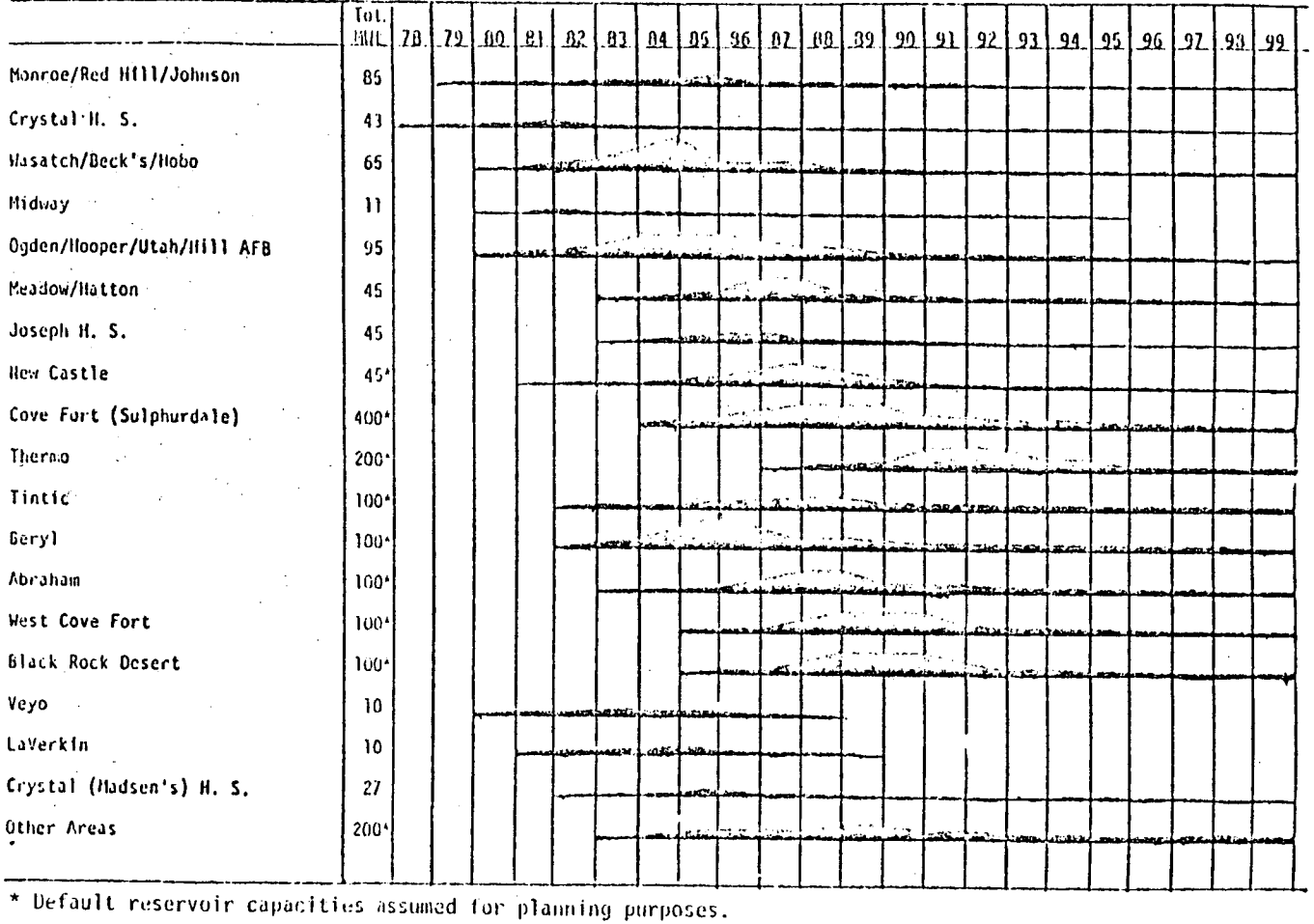
13. The design and drilling of the gathering system was assumed to take about 1-1½ years and to be completed a few months after the completion of the injection system.

14. There are no power lines through this area at the present time. If the power line to the Roosevelt prospect goes to the existing line at Cove Fort by the shortest route, it will be necessary to build another line for any West Cove Fort prospects. If the power line from Roosevelt goes north, it could well pass through the West Cove Fort area and reduce the required power line distances for prospects north of Roosevelt. For purposes of the scenario, it was assumed that a new power line will be necessary and that it will take about 2½-3 years to complete.

15. The design and construction of the power plant was assumed to take about three years; the completed plant was assumed to come on line about 1987.

Postulated Geothermal Direct Use Development Profile for Utah
(New development each year, MWt)

Approximate Scale I_o^{10MWt}



* Default reservoir capacities assumed for planning purposes.

AGGREGATED SCENARIO--DIRECT UTILIZATION OF GEOTHERMAL RESOURCES IN UTAH

	Tot. MWt	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99
Monroe/Red Hill/Johnson	85		1	1	1	2	2	3	4	2	2	1	1	1	1		1		1		1		1
Crystal H. S.	43	1	1	2	4	2	2	1	1	1	1	1		1		1		1		1		1	
Wasatch/Beck's/Hobo	65			1	3	5	10	15	5	5	5	2	2	1	1	1	1		1		1		1
Midway	11			1	2	1	1	1		1		1		1		1		1					
Ogden/Hooper/Utah/Hill AFB	95			2	3	5	10	10	10	7	5	5	3	2	2	2	2	2	1	1	1	1	
Meadow/Hatton	45						1	2	4	10	10	3	2	2	1	1	1	1		1		1	
Joseph H. S.	45						1	2	4	4	2	2	1	1	1	1	1		1		1		1
New Castle	45[A]					1	1	2	4	7	10	8	4	2	1	1		1		1		1	
Cove Fort (Sulphurdale)	400[A]							2	4	7	10	10	10	5	5	3	3	3	3	3	3	2	2
Thermo	200[A]										1	2	4	10	10	10	5	5	3	3	3	3	2
Tintic	100[A]					2	2	2	4	4	5	5	4	3	3	3	3	3	3	3	3	2	2
Beryl	100[A]					2	4	10	15	10	5	5	5	4	3	3	3	3	2	2	2	2	2
Abraham	100[A]						1	1	2	6	10	10	5	4	4	3	3	3	3	3	2	2	2
West Cove Fort	100[A]								2	2	6	10	10	10	5	3	3	2	2	2	2	2	2
Black Rock Desert	100[A]								2	2	6	10	10	10	5	3	3	2	2	2	2	2	2
Veyo	10			1	1	2	2	1	1	1	1												
LaVerkin	10				1	1	2	2	1	1	1	1											
Crystal (Madsen's) H. S.	27					1	1	2	4	2	2	1	1		1		1		1		1		1
Other Areas	200[A]						1	2	4	4	4	6	6	4	4	2	2	2	2	2	2	2	2
Total for Year		1	2	8	15	24	41	58	71	76	86	83	68	61	47	38	32	29	25	24	24	21	20
Cumulative Total		1	3	11	26	50	91	149	220	296	382	465	533	594	641	679	711	740	765	789	813	834	854

Continued

	Tot. Mkt	2000	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
Monroe/Red Hill/Johnson	85		1		1		1		1		1		1		1		1		1		1	
Crystal H. S.	43	1		1		1		1		1		1		1		1		1		1		1
Wasatch/Beck's/Hobo	65		1		1		1		1													
Midway	11																					
Ogden/Hooper/Utah/Hill AFB	95	1		1		1		1		1		1		1		1		1		1		1
Meadow/Hatton	45	1		1		1		1		1												
Joseph H. S.	45		1		1		1		1		1		1		1		1		1		1	
New Castle	45[A]	1																				
Cove Fort (Sulphurdale)	400[A]	2	2	2	1	1	1	1	1	1	1	1		1		1		1		1		
Thermo	200[A]	2	1	1	1	1	1		1		1		1		1		1		1		1	
Tintic	100[A]	2	1	1	1	1		1		1		1		1		1		1		1		1
Beryl	100[A]	1	1	1	1	1	1	1	1		1		1		1		1		1		1	
Abraham	100[A]	2	2	1	1	1	1	1		1		1		1		1		1		1		1
West Cove Fort	100[A]	2	2	1	1	1	1	1	1		1		1		1		1		1		1	
Black Rock Desert	100[A]	2	2	1	1	1	1	1		1		1		1		1		1		1		1
Veyo	10																					
LaVerkin	10																					
Crystal (Hadsen's) H. S.	27		1		1		1		1		1		1		1		1					
Other Areas	200[A]	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Total for Year		19	17	13	13	12	12	11	10	9	9	8	8	8	8	8	8	8	7	8	7	8
Cumulative Total		873	890	903	916	928	940	951	961	970	979	987	995	1003	1011	1019	1027	1035	1042	1050	1057	1065

Low Temperature Geothermal Uses: General Assumptions

1. The reservoir energy potentials for most of the sites (the spring areas) were taken from the Core Team estimates of reservoir thermal potential. These estimates are based on the following assumptions:

   A. Reservoir temperatures were taken from chemical or physical data in USGS Circular 726 /8/ and as provided by Dr. Swanberg /1/.

   B. A standard reservoir volume was assumed, as used in USGS Circular 726, of 2.25 km^3 /8/.

   C. Stored heat and thermal potential are calculated from these values with weighting factors from USGS Circular 726. This factor is the recovery factor, 0.06, found on p.116 /8/.

2. Any postulated development is, of course, dependent on the presence of suitable resources. Development in most cases was assumed to be gradual at first. Rates of development and relative magnitudes of energy use were estimated from the following factors:

   A. Known plans for development, as ascertained through literature or verbal communications (see references).

   B. Probable or potential uses, such as greenhouses, mining, etc.

   C. Proximity to areas of potential use, or conversely, relative isolation.

   D. General potential of the prospect, including such factors as temperature, heat content, flow, dissolved solids, etc.

   The potential MWt (for 30 years) was proportioned over a seemingly reasonable period based on the above factors.

3. As an approximate quideline, rates and magnitudes of development were based loosely on an estimate of about 1 MWt for a greenhouse of 2050 m^2 /2/.

4. Some areas which were not included in the Core Team Report were assigned a reservoir potential on a purely arbitrary basis. These capacities are noted with an asterisk (*) on the scenarios and other places.

5. The most probable sites were treated individually. The potential for the rest of the state, incuding less likely known sites and currently unknown sites, were assigned an arbitrary value (see the assumptions for this prospect).

6. Estimates are admittedly optimistic. Neither individual magnitudes nor rates can be considered to be reflections of the real situation. The scenarios usually reflect more what <u>could</u> be rather than what <u>will</u> be, even according to present plans.

Continued

7. Individual scenarios are not intended to be accurate reflections of real development as much as a basis for the aggregated scenarios. Thus, the aggregated scenarios are probably of more worth than the individual scenarios.

8. The estimated development times have been estimated without regard to development lag times or institutional factors, for the following reasons:

   A. Institutional factors are still very vague and vary greatly. Time will not permit extensive scenarios for each individual site at this point in the study.

   B. Even if average lag times were known for the specific steps required at each site, the procedure for developing scenarios would involve estimating a date for development and then working backwards. At this point, the basic results would be the same.

   C. It is to be hoped that the "semi-continuous" approach to the scenarios makes up for some of the specific inaccuracies in the time schedules.

9. It was assumed for all cases that development will be reasonably feasible from economic and technical standpoints.

10. Dissolved solids data are averages of the samples cited in WRB-13 (Reference 6).

Prospect: Monroe Hot Springs
(Also Red Hill, Johnson Hot Springs)

Resource Characteristics:

Surface Fluid Temperature: Monroe 76°C, Red Hill 77°C, Johnson's 25°C /6/

Subsurface Fluid Temperature: Monroe 120°C, Red Hill 135°C /1/

Total Dissolved Solids: Monroe 2750 ppm, Red Hill 2630 ppm, Johnson 428 ppm /6/.

Estimated Energy Potential: Monroe 38 MWt, Red Hill 43 MWt, Johnson 4 MWt for 30 years Total: 85 MWt /1/

Type of Overlying Rocks: Springs issue from tufa mounds along the base of the mountain /6/, grading west into alluvium in the valley.

Location of Prospect: Just east of Monroe, Utah; T25S, R3W, Sec. 11, 15, and 27 /6/.

Description: Series of hot springs issuing from hillside immediately east of Monroe City, at the base of a large mountain. The springs are along a north-south trending fault /6/.

Land Ownership: Mostly Private /2/. Some BLM and National Forest Lands east of the prospect /11/.

Land Use: Municipal, agricultural, range land, and forest land nearby.

Leasing: Some leasing in area. Limited leasing because most of the land is private /12/.

Activity:

The springs are presently being used by a spa for heating a swimming pool, showers, etc. The owners have expressed plans for eventually heating greenhouses and a motel complex.

The City of Monroe has received conditional approval on a proposal for a space heating system for the city. The first phase of this project would involve the heating of the South Sevier District High School; later the system would be expanded to heat homes in the city as well as several larger buildings in the city, a number of greenhouses, and several multiple unit complexes (motels and apartments).

Assumptions:

1. Geothermal Resources are at this time being used to heat a spa and resort. The Monroe City development will probably drill a well late in 1978 or early in 1979. Use of the water will begin shortly thereafter to heat the school.

2. The development outlined in the Monroe proposal was assumed to utilize about 8 MWt, and will be developed up to about 1981.

3. Development beyond 1981 will likely continue. Some of the development will be in houses and homes, but it will probably include more greenhouses and other agricultural/light industrial uses.

4. Development will probably depend a lot on reservoir characteristics, which will not be accurately determined until development actually begins. Thus, the development will probably proceed step-wise over a number of years.

Prospect: Crystal Hot Springs

Resource Characteristics:

Surface Fluid Temperature: 58°C /6/

Subsurface Fluid Temperature: 80°C /3/

Total Dissolved Solids: 1520 ppm /6/

Estimated Energy Potential: 43 MWt for 30 years /1/

Type of Overlying Rocks: Unconsolidated valley fill. Bedrock at fairly shallow depths. Volcanic rocks underlie the fill /6/.

Location of Prospect: South end of Salt Lake Valley, near "Point of the Mountain." Area near T4S, R1W, Sec. 12, NW¼ /6/.

Description: Series of Hot Springs discharging into clear pools and ponds.

Land Ownership: Some private (Mr. Dunyon)/3/; also, the state owns some land in the immediate vicinity, including the State Prison Complex.

Land Use: Some agricultural, few greenhouses, fish culture, State Prison; Div. of Forestry has some land just south of the prison which maybe used for silviculture /3/.

Leasing: No state or federal leases; lands unavailable for leasing.

Activity: Some discharge from the springs is used by Mr. Dunyon for use in raising tropical fish /3/.

During January and February, 1978, the Utah Geological and Mineral Survey drilled a series of temperature gradient wells near the site under the State Cooperative Program.

In connection with the temperature gradient holes, the Utah Division of Forestry plans to drill a test well near the prison which, if producible, could be used to heat greenhouses. Eventual uses in the area could include more greenhouses, heating for housing developments, and space heating for the State Prison.

As a result of the temperature gradient survey, the State Forester's Office drilled a well to be used as a source of heat for a silviculture project.

Assumptions:

1. It is assumed that development will begin slowly as the reservoir parameters are explored. If the reservoir proves adequate, more greenhouses will be added and the prison will consider space heating. Because construction of houses or retrofitting of the prison will take some time, the peak of the development will probably be spread over several years. After the main peak of utilization has passed, additional development will probably occur as the limits of the reservoir are explored.

2. No attempt has been made to represent accurately the magnitudes of heat necessary for heating the prison. The estimated available energy has merely been apportioned over a reasonable interval.

3. The estimated development times have been estimated without regard to development times or institutional factors, for the following reasons:

   A. Institutional factors are still very vague and vary greatly. Time will not permit extensive scenarios for each individual site.

   B. Even if average lag times were known for the specific steps required at each site, the procedure for developing scenarios would involve estimating a date for development and then working backwards. At this point, the basic results would be the same.

   C. It is to be hoped that the "semi-continuous" approach to the scenarios makes up for some of the specific inaccuracies in the time schedules.

Prospect: Wasatch Hot Springs/Beck's Hot Springs/Hobo Hot Springs /3/

Resource Characteristics:

Surface Fluid Temperature: Wasatch 42°C, Beck's 56°C /6/

Subsurface Fluid Temperature: Wasatch 120°C /1/, Beck's 90°C /1/

Total Dissolved Solids: Beck's 13,400 ppm, Wasatch 7220 ppm /6/

Estimated Energy Potential: Wasatch 38 MWt/30 years, Beck's 27 MWt/30 years /1/.

Type of Overlying Rocks: Both springs issue near the contact between Quaternary Valley fill and Paleozioc limestones /6/.

Location of Prospect: Salt Lake Valley near the north end of Salt Lake City. T1N, R1W; Beck's, Sec. 14, SW¼SE¼. Wasatch, Sec. 25, NW¼SE¼ /6/.

Description: Hot springs along Wasatch Fault, along east edge of Salt Lake Valley between Salt Lake City and Bountiful City.

Land Ownership: Mostly private (within city) /11/.

Land Use: Grades from residential and commercial near Wasatch Springs to light and heavy industry north from Beck's Springs.

Leasing: No federal or state leases in the vicinity of the springs.

Activity:

At one time, Wasatch H.S. and Beck's H.S. were used for spas. However, neither is presently being used, and Beck's is discharging large amounts of hot water to a canal leading to Great Salt Lake. Some warm waters in the area are used for washing gravel by gravel companies in the area.

Assumptions:

1. Although the hot springs discharge is not being used at this time, the proximity of the springs to the city center and industrial areas makes them prime targets for development. Several parties have inquired about the use of warm water in the area for space heating. For these reasons, development is expected to begin within the next

Continued

few years, and to continue thereafter as interest grows. At least two buildings in Salt Lake City area are using heat pump applications in connection with heating and cooling. (The buildings are the LDS Church Office Building in the downtown area and the International Center near the Salt Lake Airport) /3/. Because of the general area of the springs much of the development was assumed to be primarily light industrial or large space heating uses.

2. Development rates, times, and magnitudes are arbitrary but reasonable estimates.

Prospect: Midway Hot Springs

Resource Characteristics:

Surface Fluid Temperature: 45°C /1,6/

Subsurface Fluid Temperature: 43°C /3/

Total Dissolved Solids: 1770 ppm /6/

Estimated Energy Potential: 11 MWt (based on surface temp.)/1/

Type of Overlying Rocks: The springs issue from calcerous tufa about 70 ft. thick, underlain by alluvium /6/.

Location of Prospect: In the area of T3S, R4E, Section 26, 27, 34, 35, in the northwest corner of the Heber Valley /6/.

Description: Numerous hot springs with tufa mounds. The springs drain into Snake Creek above Midway.

Land Ownership: Mostly state and private lands /11/.

Land Use: Mostly agricultural, also residential, and recreational (Wasatch Mountain State Park, etc.).

Leasing: Some state and/or federal leasing in Heber Valley, but not in the vicinity of the springs /12/.

Activity:

Several of the large springs have been used for several years as water for swimming pools and resorts.

There have been a few inquiries regarding the use of geothermal fluids for space heating; however, nothing is definite or specifically planned at this time.

The Utah Geological and Mineral Survey drilled five temperature gradient holes in the Midway area in April and May, 1978. Water at a temperature of 109°F (43°C) was encountered. The tufa was found to be underlain by alluvium, which in turn was underlain by fractured quartzite. One of the temperature gradient wells hit artesian pressure, and flowed at a rate of 400-600 gpm. Springs in the area of the hole were affected almost immediately, indicating very rapid communication within the aquifer.

Assumptions:

1. Midway H.S. are near the small town of Midway, but there are at this time only a school and town hall which could be major users of geothermal heat. Development would probably take the form of greenhouses and/or housing developments such as apartments or condominiums.

Continued

There is a fish hatchery near Midway but it is several miles from the hot springs area. Development was estimated to begin about 1980 on a small scale and to extend over several years.

2. Development rates, times, and magnitudes are arbitrary but reasonable estimates.

Prospect: Ogden Area: Ogden H.S., Utah H.S., Hooper H.S., Hill AFB

Resource Characteristics:

Surface Fluid Temperature: Ogden H.S. 58°C, Hooper H.S. 60°C, Utah 58°C /6/

Subsurface Fluid Temperature: Ogden H.S. 110°C, Hooper H.S. 105°C, Utah H.S. 95°C /1/

Total Dissolved Solids: Ogden H.S. 8700 ppm, Hooper 8800 ppm., Utah 18,600 ppm /6/

Estimated Energy Potential: Ogden H.S. 34 MWt/30 yr., Hooper H.S. 32 MWt/30 yr., Utah H.S. 29 MWt/30 yr. Total 95 MWt/30 yr /1/.

Type of Overlying Rocks: Ogden H.S. rise along a fault in Precambrian rocks; Hooper H.S. rise from Quaternary Valley fill; Utah H.S. issue in an area of complex faulting in Cambrian rocks /6/.

Location of Prospect: Ogden H.S. T6N, R1W, Sec. 23, SW¼SW¼; Hooper H.S. T5N, R3W, Sec. 27, SW¼; Utah H.S. T7N, R2W, Sec.14, SW¼SE¼. Generally east, west, and north of Ogden respectively /6/.

Description: Various hot springs; Utah H.S. is used for greenhouses, Ogden is a diffuse spring area, Hooper is not used at the present time /3,6/.

Land Ownership: Mostly private. Hooper H.S. is near the wildlife refuge /11/. Hill AFB is federal reserve land /7/.

Land Use: Mostly municipal. The actual spring areas are away from the city. Hooper is in an agricultural area, and Utah H.S. is in an agricultural and light industrial area.

Leasing: No federal or state leases in this area /12/. (No federal or or state lands) /11/.

Activity: Utah H.S. is currently being used to heat greenhouses by the Allen Plant Co. and another company/3/. There is a lot of iron in the water /3,6/. There appear to be plans for further development.

Ogden H.S. was used as a resort, now is being discharged as runoff. The water is hot, but the source is diffuse, posing possible tapping problems. Water is quite mineralized /3/.

Continued

Hooper water is hot, but the spring is some distance from population areas and is currently not being used /3/.

Hill AFB at Ogden contracted to EG&G to do a study on the possibility of heating buildings on the base with geothermal fluids /7/. No particular geothermal resources are known to be beneath the base, but a major fault does run through the base area and might possibly provide a conduit for hot fluids beneath the base.

Assumptions:

1. The magnitude of the resource was assumed to be equal to the sum of the estimated potential for the three spring areas. This assumption is obviously not accurate since the estimate was applied over the whole area, including Hill AFB. However, no other data is available. Again, magnitudes, times, and growth rates are only rough guesses.

2. Development was assumed to start small, with existing uses (resorts and greenhouses), and to begin in the early 80's as the feasibility of geothermal uses are proven. Development of geothermal heating for Hill AFB was assumed to be possible and feasible, so that development there would begin about 1982 to 1984, an optimistic estimate. Because most of the buildings would require retrofitting, etc., development at the air base was assumed to proceed step-wise over a number of years.

Prospect: Meadow/Hatton Hot Springs

Resource Characteristics:

Surface Fluid Temperature: Hatton H.S. 38°C /1,6/, Meadow 41°C /6/

Subsurface Fluid Temperature: Meadow H.S. 105°C /1/

Total Dissolved Solids: Meadow 4800 ppm, Hatton 4760 ppm /6/

Estimated Energy Potential: Meadow 37 MWt/30 yr., Hatton 8 MWt/30 yr. /1/

Type of Overlying Rocks: The springs are in valley fill of Tertiary or Quaternary age; There are Quaternary basalt flows within a few miles of the Springs /6/.

Location of Prospect: Near Meadow and Hatton in Beaver Co. Meadow H.S. T22S, R6W, Sec. 26, SW¼SW¼; Hatton, T22S, R6W, Sec. 35, SE¼SE¼ /6/.

Description: The spring areas are west of Hatton in a semi-arid range area. Hatton spring no longer flows /6/.

Land Ownership: Mostly private, some federal lands in area /11/.

Land Use: Agricultural, range and desert.

Leasing: State and federal leasing in area /12/.

Activity: Meadow Hot Springs is a relatively new spring, now being used for stock watering /3/.

Hatton Hot Springs no longer flows /6/.

Assumptions:

1. Meadow and Hatton Hot Springs are some distance from the towns of Meadow and Hatton /3,6/. Because of this slight isolation, development of the spring areas per se will probably not occur until the early or mid 1980's, and probably will start out with a few greenhouses or similar agricultural or light industry.

2. Immediate area of the springs is of questionable geothermal potential because of the relatively low temperature of the spring water, the low silica content, and the similarity in chemical quality to the ground water in a fairly large surrounding area /6/.

Continued

However, the springs are in an area of late Tertiary and Quaternary volcanic flows. Some lands in the area have been leased for Geothermal development. It is likely therefore that the geothermal potential of the area is not confined to the springs area. This leads to the possibility that geothermal development could occur much nearer to the cities of Meadow, Hatton, and Kanosh, and perhaps over a larger area. However, because this type of development would require drilling and is somewhat more risky, it would probably be delayed until the middle or late 1980's and may be related to attempts to locate resources suitable for electrical production.

3. The estimates of magnitude of recoverable energy for the area is the sum of the estimates for the springs, even though the potential extends beyond the spring area. Development rates, times, and relative magnitudes are arbitrary but reasonable estimates.

Prospect: Joseph Hot Springs

Resource Characteristics:

Surface Fluid Temperature: 64°C /6/

Subsurface Fluid Temperature: 162°C /1/

Total Dissolved Solids: 5100 ppm /6/

Estimated Energy Potential: 45 MWt/30 yr. /1/

Type of Overlying Rocks: Joseph Hot Springs issues from a tufa mound over the Dry Wash fault. Immediately east of the fault there are extensive volcanic outcroppings of late Tertiary age. On the other side of the fault are unconsolidated Quaternary deposits /6,13/.

Location of Prospect: T25S, R4W, Section 23, Southeast of the town of Joseph in Sevier County, Utah /6/.

Description:

Land Ownership: Mostly private in the valley, surrounded by BLM land east of the main valley /11/.

Land Use: Agricultural, range land, and rural residential.

Leasing: Leasing has occurred in the immediate area of the springs and of the town of Joseph /13/.

Activity: Spring Area, very low discharge. No known development activity.

Assumptions:

1. Joseph Hot Spring has a relatively low discharge. On the one hand, this may indicate a lower recharge rate (suggested by Ref. 3); on the other hand, it may be due to sealing action by precipitates and may be a pressurized system (suggested by Ref. 5). Although the evident recharge area is not as large as that of Monroe Hot Springs a few miles away, the Joseph Hot Springs are located on a long fault, which may extend up along the Sevier River /6/. It is quite apparent that the magnitude of the resource will only be determined by exploratory drilling. For the purposes of the scenario, the estimated magnitude of the resource as determined by USGS Circular 726 was used /1,8/. Development rates, times, and magnitudes are reasonable estimates only.

Continued

2. The hot springs area is about a mile from Joseph. In order to make a community space heating system feasible, it would pretty much be necessary for larger heat loads to be located at the far end of a distribution line. This would put the load about 1½ miles from the spring area. Three factors might change this situation:

   A. Wells might be drilled away from the springs area. However, this would involve more geophysical exploration and because of the greater risk, might not be feasible at all.

   B. Greenhouses or other similar industry might be located between the springs and the town. Although this would be more feasible, it would not provide the loads in the city which would make space heating for residences feasible.

   C. It may become feasible to transport the heat longer distances.

   In any of these cases, development would probably not gain very much momentum before the mid-1980's.

Prospect: New Castle

Resource Characteristics:

Surface Fluid Temperature:

Subsurface Fluid Temperature: 100-110°C

Total Dissolved Solids: Relatively low /3,4,5,9/.

Estimated Energy Potential: Not known; assumption of 40 MWt/30 yr. for planning purposes.

Type of Overlying Rocks: Most of the valley is overlain by Quaternary alluvium; within a few miles of New Castle there are outcroppings of late Tertiary volcanic rocks and Tertiary granites.

Location of Prospect: About T36S, R15W /11/.

Description: Agricultural area, with water wells which have hot water at shallow depths.

Land Ownership: Large block of state land to the east of New Castle, federal lands to the south and southwest, private lands to the west /11/.

Land Use: Agricultural, range land, and rural residential.

Leasing: Some leasing has occurred on state and federal lands in the vicinity of New Castle /12/.

Activity: A well which was drilled to provide water for irrigation hit hot water at shallow depths. The water is presently cooled and used for irrigation.

Assumptions:

1. The New Castle area is at present a moderate priority for temperature gradient exploration under the State Cooperative Program /3,4/. There are few dwellings in the area, but possibilities for light industry exist (greenhouses, crop drying, extending growing season). The water is very low in dissolved solids. Because one well has already been drilled and other exploratory work is planned, development may come in the early 1980's. The primary drawback would be the isolation of the area.

Prospect: Cove Fort (Sulphurdale)

Resource Characteristics:

Surface Fluid Temperature:

Subsurface Fluid Temperature:

Total Dissolved Solids:

Estimated Energy Potential: Not known; assumption of 400 MWt/30 yr. for planning purposes.

Type of Overlying Rocks:

Location of Prospect: West Central Utah near Cove Fort, about T25S, R6&7W. Commonly known as The Cove Fort or the Cove Fort Sulphurdale area.

Description: Low hills grading into mountains, sagebrush/juniper regime, quite arid.

Land Ownership: Some private, BLM, and National Forest.

Land Use: Range and forest.

Leasing: Extensive leasing of state and federal lands /12/.

Activity: Union has drilled two wells in this area, one of which caved in, and is now drilling a third well. The possibility exists that the area will not yield resources which would be suitable for electrical generation. Whether or not electrical generation is possible there is a good potential for direct utilization at the prospect. Drilling has been difficult, however, and may be too expensive for small projects.

A. Inquiries have been made and plans may be underway to use a cascading system. Potential uses would be greenhouses or other industrial uses /5/.

B. A specific use may be at the sulphur mining operations at Sulphurdale, where heat is required for the sulphur extraction process /5/.

Continued

Assumptions:

1. Although there may be some institutional restraints (part of the probable geothermal field is on Forest Land) /5/, the possibility of industrial use of geothermal heat appears good. The industrial use will probably coincide with the production of electrical power /5/.

2. The magnitude of the power in use will depend primarily on the resource. The estimate of 400 MWt for 30 years is an assumption based on estimates of the electrical potential for the area /9/.

3. It is assumed that once the geothermal resource has been proven that industrial use will be added in fairly large increments on a fairly regular basis.

Prospect: Thermo

Resource Characteristics:

Surface Fluid Temperature:

Subsurface Fluid Temperature:

Total Dissolved Solids:

Estimated Energy Potential: Not known; assumption of 200 MWt/30 yr. for planning purposes.

Type of Overlying Rocks:

Location of Prospect: West and south of Minersville, about T30&31S, R12&13W /11/.

Description: Mostly desert flat area, scrub vegetation.

Land Ownership: Mostly BLM, some state and federal land /12/.

Land Use:

Leasing: State and federal lands have been leased extensively /12/.

Activity: Republic Geothermal, Inc., has drilled a deep geothermal well in the area which is still being tested. Geophysical and temperature gradient exploration has also taken place quite extensively by Republic, AMAX, Chevron, and other developers.

Assumptions:

1. Although there have been no specific plans expressed for either cascading systems or purely industrial use, it is very likely that the resource will be suitable to direct utilization. This development will probably not occur until the mid or late 1980's for the following reasons:

   A. The general development of the Thermo area is several years behind the development for the Roosevelt and Cove Fort areas; this would put development at about the mid-1980's.

   B. The Thermo area is quite isolated and this fact will probably account for some retardation of development.

2. The magnitude of the heat potential for this prospect is an assumption and hopefully reasonable; the development times, rates, and magnitudes are more arbitrary estimates.

Prospect: Tintic

Resource Characteristics:

Surface Fluid Temperature:

Subsurface Fluid Temperature:

Total Dissolved Solids:

Estimated Energy Potential: Not known; assumption of 100 MWt/30 yr. for planning purposes.

Type of Overlying Rocks: Alluvium, tertiary pyroclastics /13/.

Location of Prospect: T10&11S, R2&3W, south of Utah Valley in the center part of the state.

Description: The area is of volcanic origin and is mined extensively for metalliferous minerals. Hot water issues from the Burgin Mine and is discharged to a stream. It runs several miles down the canyon and is ponded in an evaporation pond.

Land Ownership: Private, BLM, and some state lands /11/.

Land Use: Some mining; agriculture in the valley area.

Leasing: Some state and federal lands leased /12/.

Activity: The Burgin Mine discharges hot water down from the Tintic Mountains to an evaporation pond. No use is presently made of the heat from the water. Some interest in the area has been expressed by exploration companies, and some leasing (state and federal) has taken place. Phillips Petroleum recently drilled a deep temperature gradient hole in the Tintic Mountains.

Assumptions:

1. Even though Kennecott, which uses the Burgin Mine, has at present no specific plans for utilization of the geothermal fluids which are discharged from the mine, it was assumed that Kennecott would become interested in the development of the resource, or that they would cooperate with a second party which could develop the resource. The water discharged from the mine could be either put through heat exchangers for industrial use near the mine or piped out of the mountains to sites where the terrain is more suitable to construction. There are no towns or housing areas near the mining area, but the presence of Goshen Warm Springs may indicate a general distribution of the resource through the valley.

2. The magnitude of the heat potential for this prospect was assumed for planning purposes; development time, rates, and magnitudes are arbitrary estimates.

Prospect: Beryl

Resource Characteristics:

Surface Fluid Temperature:

Subsurface Fluid Temperature:

Total Dissolved Solids:

Estimated Energy Potential: Not known; assumption of 100 MWt/30 yr. for planning purposes.

Type of Overlying Rocks: Mostly Quaternary alluvium and lake bed sediments /13/.

Location of Prospect: Southern Utah. South and west of Thermo Hot Springs; T33&34S, R16W, and surrounding area /11/.

Description:

Land Ownership: Mostly private, some state and federal lands /11/.

Land Use: Farming, rural, and residential.

Leasing: State and federal lands in the area have been leased /12/.

Activity: Utah Power and Light, in conjunction with McCulloch Oil and Geothermal Kinetics, drilled three deep exploratory wells in the general vicinity of Beryl. Although the wells were not suitable for electrical production, they were very suitable for low temperature uses /5,9,10/. Interest in the Beryl area has also been expressed by other parties /4/.

Assumptions:

1. The Beryl area is quite isolated, a factor which would tend to retard development. Development, when it occurs, will almost certainly be industrial, since there are so few buildings in the area which could be heated. On the other hand, three wells have already been drilled, and the companies involved are considering low temperature use /10/. For these reasons, development was estimated to begin in the early 1980's. Because industrial use is most likely, development was estimated to come on-line in moderately large increments.

2. The magnitude of heat content used for the scenario was assumed for planning purposes; the development times, rates, and magnitudes are arbitrary estimates.

Prospect: Abraham (Baker) Hot Springs

Resource Characteristics:

Surface Fluid Temperature: 82°C /6/.

Subsurface Fluid Temperature: 125°C /1/.

Total Dissolved Solids: 3500 ppm /6/.

Estimated Energy Potential: 39 MWt/30 yrs /1/. Assumption of heating capacity of the springs and surrounding area, for planning purposes: 100 MWt/30 yrs.

Type of Overlying Rocks: The springs issue from a tufa mound near a Quaternary basalt flow /6/.

Location of Prospect: The springs are located at T14S, R8W, Section 10 and 15 /6/; the surrounding area is all a potential resource area.

Description: The Abraham Hot Springs issues from a tufa mound near Fumarole Butte, an old volcanic vent (Quaternary basalt) /6/. Most of the water discharges to a slough area in the desert bottom.

Land Ownership: Mostly BLM, some state and private /11/.

Land Use: Mostly desert, some range, etc.

Leasing: KGRA area. Extensive leasing of federal and state lands /12/.

Activity: Leasing, geophysical exploration, and temperature gradient exploration has taken place in the area of the Abraham Hot Springs. Some of the discharge from the Springs is used for a spa-type resort. The heat content of the resource may be less than is now apparent (absence of boiling temperatures, relatively low silica content, large water discharge)/6/; drilling will probably be necessary to define the resource potential.

Assumptions:

1. The Abraham Springs area is quite isolated. However, the discharge from the springs themselves is copious and hot. Beyond use for bathing, development at the springs and in the surrounding area will probably be primarily light industrial. Development is estimated to begin in the mid-1980's and to gain momentum as more uses become feasible, technical and economical. Development may also be related to mining in the area.

Prospect: West Cove Fort Area

Resource Characteristics:

Surface Fluid Temperature:

Subsurface Fluid Temperature:

Total Dissolved Solids:

Estimated Energy Potential: Not known; assumption for planning purposes: 100 MWt/30 yr.

Type of Overlying Rocks: Alluvium, late Tertiary basalt and basaltic andesite flows /13/.

Location of Prospect: North of the Roosevelt Prospect. West of the Cove Fort area. About T24&25S, R7&8W /11,12/.

Description: Area of extensive volcanic activity; desert shrubland.

Land Ownership: Mostly BLM, some state and private /11/.

Land Use: Some agriculture; mostly range and desert.

Leasing: Extensive leasing on state and federal lands /12/.

Activity: Extensive leasing, with geophysical and temperature gradient exploration /12,14/.

Assumptions:

1. It appears that there are several possible areas for electrical production in Utah and the area near Black Rock or the "West Cove Fort Area" is a possible prospect. If water can be found at depth, the area could be a potential low-temperature geothermal prospect whether or not the resource is suitable for electrical production. The scenario is based on the assumption that hot water can be located in sufficient quantities to make development feasible.

2. The estimate of a resource potential of 100 MWt/30 yr. is an assumption for planning purposes; the development times, rates, and magnitudes are arbitrary estimates.

Prospect: Black Rock Desert.

Resource Characteristics:

Surface Fluid Temperature:

Subsurface Fluid Temperature:

Total Dissolved Solids:

Estimated Energy Potential: Not known; assumption for planning purposes: 100 MWt/30 yr.

Type of Overlying Rocks: Lake bed sediments, Quaternary basalt, and late Tertiary basalt and basaltic andesite flows/13/.

Location of Prospect: West of Cove Fort area, about T23&24S, R7&8W /12/.

Description: Area of extensive volcanic activity; desert shrubland.

Land Ownership: Mostly BLM, some state and private lands/11/.

Land Use:

Leasing: Extensive leasing on state and federal lands/12/.

Activity: Extensive leasing, with geophysical and temperature gradient exploration /12,14/.

Assumptions:

1. It appears that there are several possible areas for electrical production in Utah, and the area in the Black Rock Desert is a possible prospect. If water can be found at depth, the area could be a potential low-temperature geothermal prospect whether or not the resource is suitable for electrical production. The scenario is based on the assumption that hot water can be located in sufficient quantities to make development feasible.

2. The estimate of a resource potential of 100 MWt/30 yr. is an assumption for planning purposes; the development times, rates, and magnitudes are arbitrary estimates.

Prospect: Veyo, LaVerkin

Resource Characteristics:

Surface Fluid Temperature: Veyo 42°C, LaVerkin 42°C /1,6/.

Subsurface Fluid Temperature:

Total Dissolved Solids: Veyo 396 ppm , LaVerkin 9580 ppm /6/.

Estimated Energy Potential: Veyo 10 MWt/30 yr., LaVerkin 10 MWt/30 yr. /1/.

Type of Overlying Rocks: Veyo, Quaternary basalts. LaVerkin, Paleozoic limestone, along Hurricane fault /6/.

Location of Prospect: Veyo, the springs are at T40S, R16W, Sec. 6, NW¼SE¼SW¼, about 18 miles north-northwest of St. George in southern Utah. LaVerkin springs are at T41S, R13S, Sec. 25, about 18 miles east-northeast of St. George /6/.

Description:

Land Ownership: Veyo: private land immediately around Veyo; some state lands nearby, BLM controls most of the surrounding area /11/.
LaVerkin: Also mostly private, BLM lands nearby /11/.

Land Use:

Leasing: Some leasing in the Veyo area /12/.

Activity: Veyo Hot Springs is currently used as a swimming pool and spa. LaVerkin (Dixie) Hot Springs issue from the bed and banks of the Virgin River near LaVerkin.

Assumptions:

1. Veyo: It would be reasonable to expect that some further development will occur at Veyo even though the magnitude of the resource available appears to be limited. Interest has been expressed in including the area as part of the temperature gradient survey under the State Cooperative Program /9/. Development would probably not be of great magnitude; but it could come in the mid-1980's. Use will probably be space heating or light industrial (greenhouses, etc.). Development rates, times and magnitudes are arbitrary but reasonable estimates.

Continued

LaVerkin: These springs discharge directly into the Virgin River, and recovery and collection might be difficult. It would certainly require exploration and probably test wells to determine if the reservoir has potential. In any case, development probably will not come until mid or late 1980's. Development times, rates, and magnitudes are arbitrary but reasonable estimates.

Prospect: Crystal Hot Springs (Madsen's, Honeyville)

Resource Characteristics:

Surface Fluid Temperature: 56°C /6/

Subsurface Fluid Temperature: 90°C /1/

Total Dissolved Solids: 42,100 ppm /6/

Estimated Energy Potential: 27 MWt/30 yr. /1/

Type of Overlying Rocks: The springs issue from Paleozoic rocks along the Wasatch fault zone /6/, in Quaternary alluvium /13/.

Location of Prospect: The springs are located at about T11N, R2W, Sec. 29, NE¼SE¼, in Box Elder Co., about 10 miles north of Brigham City /6/.

Description: Hot springs, used for spa, along the Wasatch fault on the west face of the Wasatch Mountains. The flow from the springs flows in Salt Creek, which flows through an agricultural area /6/.

Land Ownership: Mostly private. Forest lands in the area to the east, in the mountains.

Land Use: Mostly agricultural. The town of Honeyville is a few miles south of the spring area /6/.

Leasing: No leasing of state or federal lands in area /12/.

Activity: Crystal Hot Springs is presently used for a swimming pool, and the possibility exists for space heating /3/.

Assumptions:

1. It was assumed that interest in the geothermal potential will grow, and it seems reasonable that development will start in the early or mid-1980's.

2. It was assumed that the resource is adequate for space heating or light industry; development time, rates, and magnitudes are arbitrary but reasonable estimates.

Prospect: Other Areas (Includes other springs and other potential areas).

Assumption: The main assumption was that the other areas are generally remote and/or of small magnitude. Development at most of these areas will probably be after the mid-1980's, and will probably come in small increments. Again, the magnitudes used for the scenario are only a reasonable estimate.

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APPENDIX C

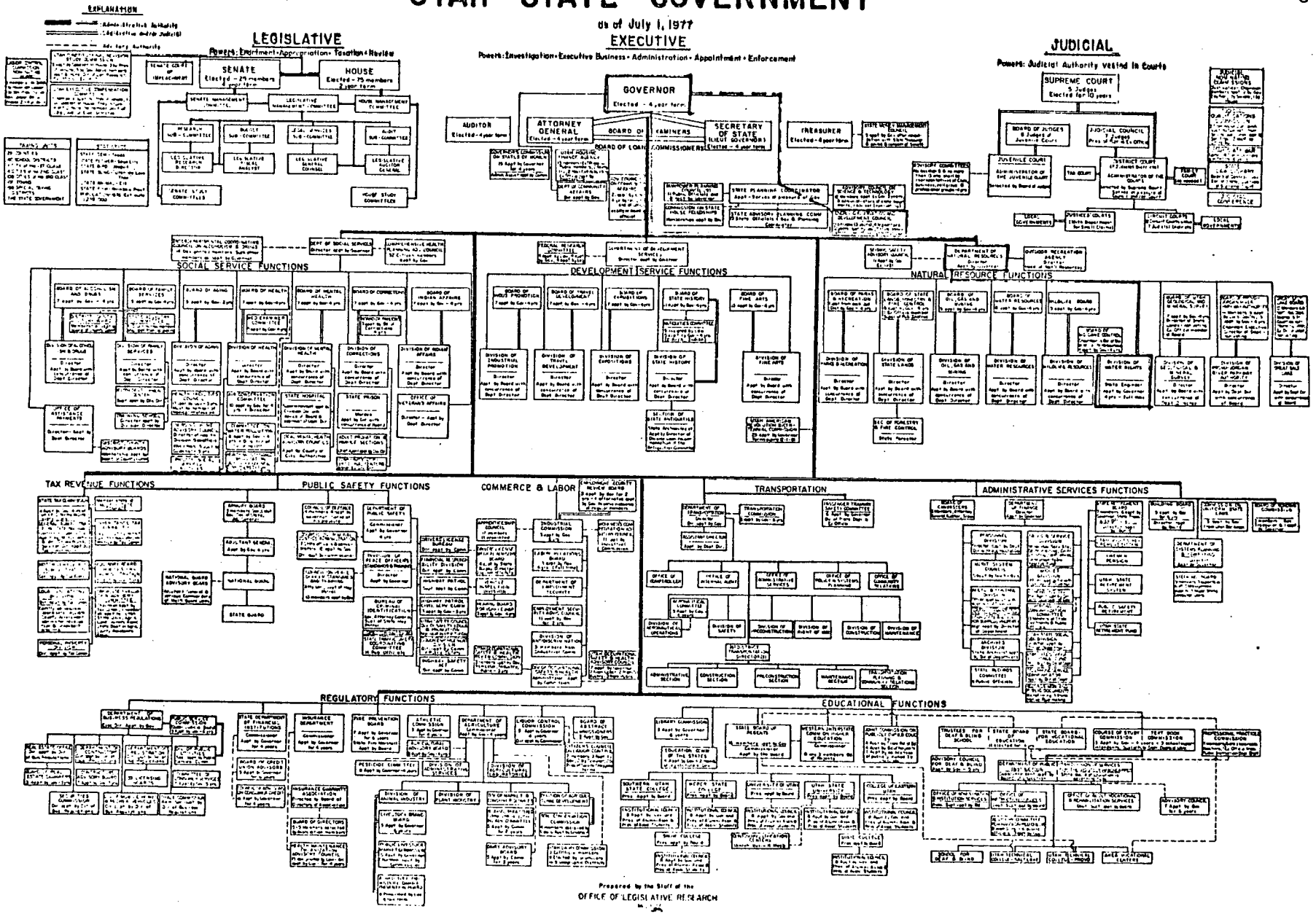
C-1 Diagram of Utah State Government

C-2 Diagram of Utah Division of Water Rights

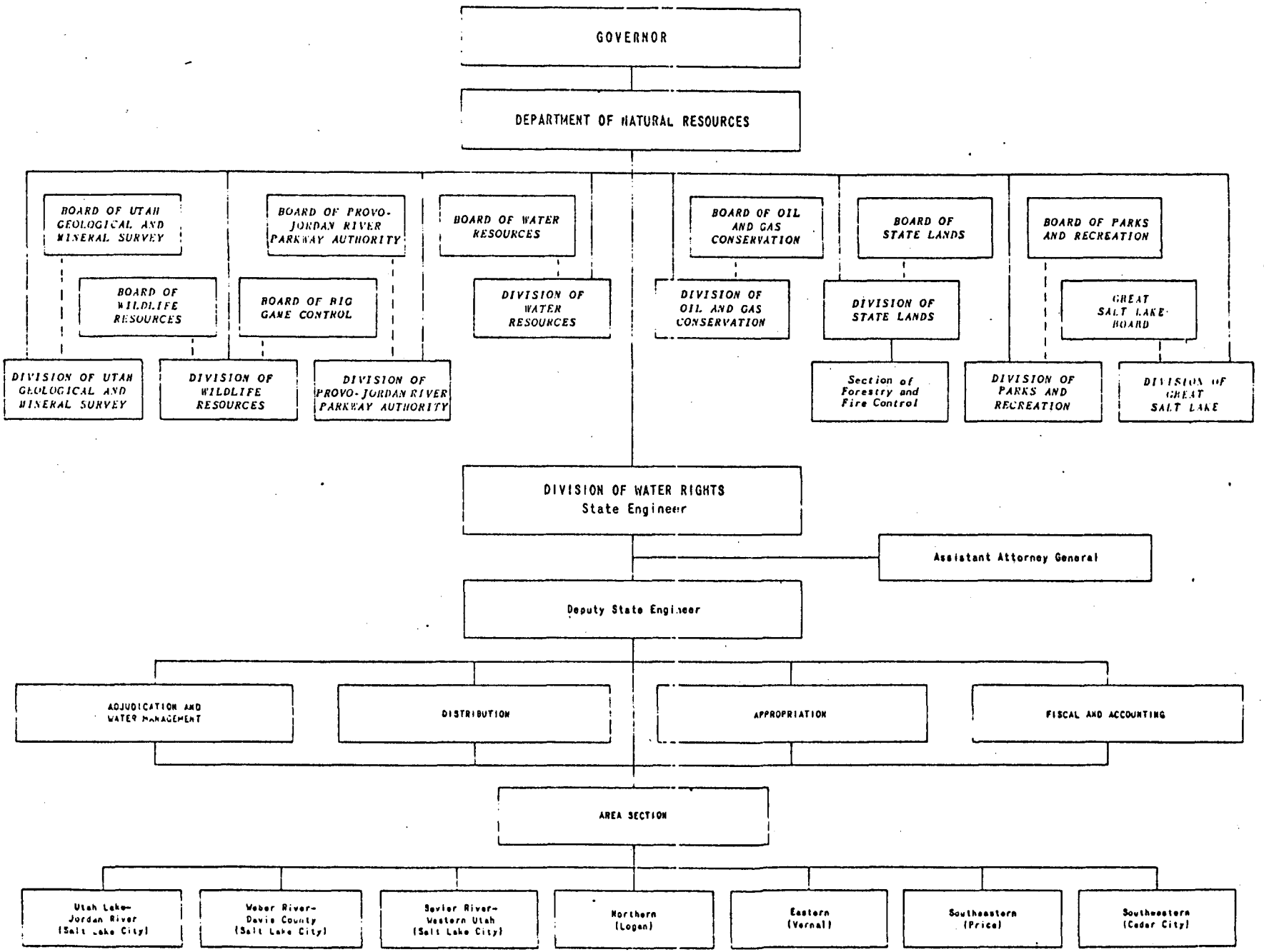
C-3 Procedural Flow Chart for the Utah Division of Water Rights

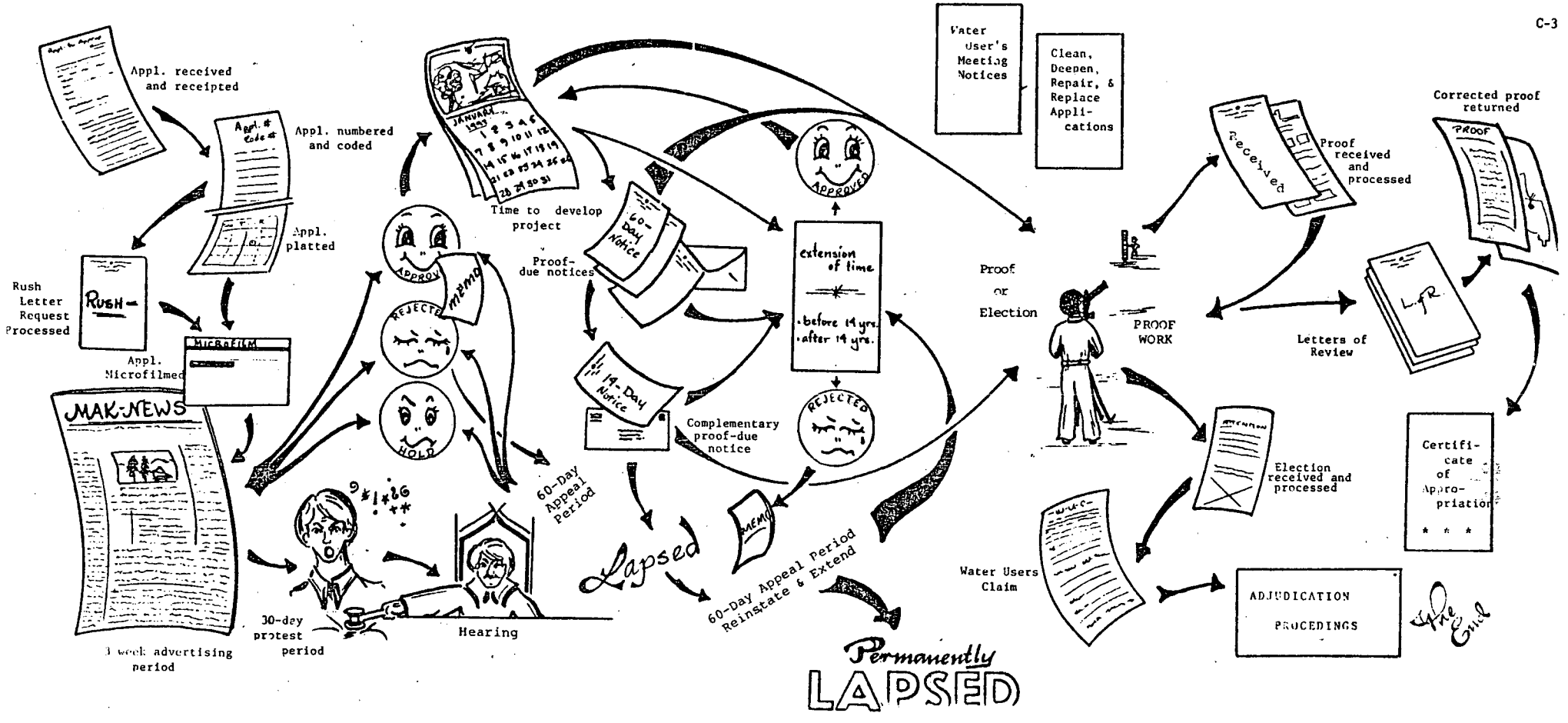
UTAH STATE GOVERNMENT

as of July 1, 1977



Prepared by the Staff of the
OFFICE OF LEGISLATIVE RESEARCH


GOVERNOR
DEPARTMENT OF NATURAL RESOURCES
BOARD OF UTAH GEOLOGICAL AND MINERAL SURVEY
BOARD OF WILDLIFE RESOURCES
BOARD OF PROVO-JORDAN RIVER PARKWAY AUTHORITY
BOARD OF BIG GAME CONTROL
BOARD OF WATER RESOURCES
DIVISION OF WATER RESOURCES
BOARD OF OIL AND GAS CONSERVATION
DIVISION OF OIL AND GAS CONSERVATION
BOARD OF STATE LANDS
DIVISION OF STATE LANDS
BOARD OF PARKS AND RECREATION
GREAT SALT LAKE BOARD
DIVISION OF UTAH GEOLOGICAL AND MINERAL SURVEY
DIVISION OF WILDLIFE RESOURCES
DIVISION OF PROVO-JORDAN RIVER PARKWAY AUTHORITY
Section of Forestry and Fire Control
DIVISION OF PARKS AND RECREATION
DIVISION OF GREAT SALT LAKE
DIVISION OF WATER RIGHTS
State Engineer
Assistant Attorney General
Deputy State Engineer
ADJUDICATION AND WATER MANAGEMENT
DISTRIBUTION
APPROPRIATION
FISCAL AND ACCOUNTING
AREA SECTION
Utah Lake-Jordan River (Salt Lake City)
Weber River-Davis County (Salt Lake City)
Sevier River-Western Utah (Salt Lake City)
Northern (Logan)
Eastern (Vernal)
Southeastern (Price)
Southwestern (Cedar City)


Appl. received and receipted
Appl. numbered and coded
Appl. platted
Rush Letter Request Processed
RUSH
Appl. Microfilmed
MICROFILM
MAK-NEWS
3 week advertising period
30-day protest period
Hearing
APPROV
REJECTED
HOLD
MEMO
60-Day Appeal Period
JANUARY
Time to develop project
Proof-due notices
60-Day Notice
19-Day Notice
Complementary proof-due notice
Lapsed
60-Day Appeal Period Reinstate & Extend
Permanently LAPSED
APPROVED
extension of time
• before 19 yrs.
• after 19 yrs.
REJECTED
Water User's Meeting Notices
Clean, Deepen, Repair, & Replace Applications
Proof or Election
PROOF WORK
Water Users Claim
Received
Proof received and processed
Letters of Review
L&R
Election received and processed
ADJUDICATION PROCEDINGS
Corrected proof returned
PROOF
Certificate of Appropriation
* * *

APPENDIX D

D-1 Program and Objectives of the Interagency Geothermal Streamlining Task Force

D-17 Supplementary Information Distributed by the Interagency Geothermal Streamlining Task Force

June 1978

PROGRAM AND OBJECTIVES OF THE INTERAGENCY GEOTHERMAL STREAMLINING TASK FORCE

The Interagency Geothermal Streamlining Task Force was formed to assist the Interagency Geothermal Coordinating Council (IGCC) in carrying out its mandate:

> "for assessing legal, environmental, regulatory, and other aspects of Federal, State, and local government policy as they relate to geothermal energy and for developing recommendations for changes and improvements in related laws, policies and procedures, and for examination of other institutional aspects of geothermal energy, including non-governmental aspects."

Specifically, the Task Force is developing recommendations to IGCC for appropriate action to implement the President's commitment to Congress that:

> "The Departments of the Interior and Agriculture will streamline leasing and environmental review procedures to remove unnecessary barriers to development of geothermal resources."

This objective was included in the President's comprehensive energy program submitted to Congress in April 1977. The commitment was prompted by the fact that although the Geothermal Steam Act was passed nearly seven and one-half years ago, there is still no commercial production of this resource on Federal lands.

There are many reasons for the lack of a viable geothermal industry -- such as the unknowns of the resource, the less-than-perfect technologies for utilizing and disposing of it, high-risk capital investment, and inequitable tax* and price structures. However, it is widely believed that the cumbersome Federal leasing and permitting program constitutes a major deterrent to timely development. As long as the inhibiting influence of the regulatory program clouds the rate of development on Federal lands, the effects of other impediments cannot be fully and accurately assessed.

The Geothermal Streamlining Task Force has undertaken a study which includes 1) a comprehensive analysis of the elements of the present

*New geothermal tax provisions are pending in a House/Senate conference committee and are described in a Comparative Committee Print entitled "Conference Comparison of the Energy Tax Provisions of H.R. 5263."

program designed to identify the sources of delay and quantify delays which are actually occurring; and 2) to determine the potential effects upon program performance of a series of options for program modification. The effectiveness of alternative options will be assessed in terms of their relative ability to support the Department of Energy's projected geothermal power-on-line schedule while adequately protecting the public interest and the environment.

The study will also incorporate input provided by the public, industry, environmental groups, and state agency officials through a series of workshops to be held in the western states in June. The schedule for these meetings is being finalized and is being widely publicized in order to obtain the broadest participation possible. The public meetings have been announced in the Federal Register.

The Task Force has developed a series of options for modifying the geothermal leasing and permitting program, described below, and comment on them will be requested from the above groups. In addition, suggestions for additional alternatives will be solicited.

The discussion of the options is preliminary and tentative and has not been reviewed by the attorneys of the Department of the Interior, the Department of Agriculture, or the Department of Energy. It is intended only to focus, for purposes of further discussion, on the problems which generated the suggestions for change and the remedial effects which may be exerted by the proposed options.

Option I

Improve the present system through changes in regulations and administrative procedures.

The Task Force is concentrating the largest bulk of its effort on Option I since improvements developed in the present system will almost certainly benefit the workability of any other option as well. This approach would maintain the basic features of the pre- and post-lease environmental reviews, but would increase the efficiency and uniformity of this major program function. Program modifications which will be considered include, but are not limited to, the following:

A. Use regional or areawide environmental analyses in pre-lease review and conduct site specific studies only during the post-lease permitting process.

The use of regional areawide analysis in the pre-lease situation would tend to reduce manpower/budget requirements and timeframe of performance. This approach would first permit more dependence on existing or in-progress Management Framework Plans of the Bureau of Land Management (BLM) or Land

Management Plans of the Forest Service (USFS), (which are discussed below under Option 2), or other resource-inventory type documents. This use of such documents is consistent with the new draft Council on Environmental Quality (CEQ) guidelines for implementing the National Environmental Policy Act (NEPA) (December 12, 1977) which encourage "integrating the requirements of NEPA with other planning and environmental review procedures required by law or by agency practice so that all such procedures, to the fullest extent possible, run concurrently, rather than consecutively." The draft guidelines would also require agencies to use "program, policy, or plan environmental statements and tiering from statements of broad scope to those of narrower scope to eliminate repetitive discussions of the same issues." While actual environmental statements per se are not necessarily at issue in this proposed program modification, it is felt that the language of this mandate is equally applicable to other types of environmental review documents.

In the absence of an existing plan, more generalized data gathering would still reduce time requirements and manpower utilization, freeing personnel for other work. Site specific studies at the post-lease stage would then identify the particular sensitivity of areas proposed for drilling, roads, and other permanent surface features.

Pending determination by the Solicitor of the Department of the Interior, this approach appears to be consistent with the BLM regulations on pre-leasing procedures. Section 3200.6, CFR Title 43, requires the Director, when an area is initially considered for geothermal leasing, to request reports from other interested agencies describing the resources contained "within the general area and the potential effect of geothermal resources operations upon the resources of the area and its total environment." (Emphasis added.)

The subsequent paragraph dealing with environmental impact evaluation, prior to final selection of tracts for leasing, calls for evaluation of the potential effects on the various resources of the entire area. There is no specifically stated requirement for site specific evaluation.

History shows that less than 1 out of 25 lease applications may be expected to result in any surface disturbing operations. Thus, the low intensity pre-lease broad based assessment proposed in this approach would be appropriate to the majority of lease application areas. Detailed site specific environmental analyses would be done on the relatively few leases that would undergo surface disturbing exploration or development as a prelude to actual operation.

The major advantages of utilizing fewer environmental analyses of broader scope are:

- Less overlapping and redundancy and thus lessened manpower, time, and dollar requirements.

- Lower printing and publications costs

This approach is used by BLM in Nevada on geothermal lease applications and USFS oil and gas leasing in North Dakota on the Little Missouri Grasslands. Estimated time and dollar savings are at least 60% when compared to the "piece mealing" methods used in other areas such as BLM California and USGS Washington-Oregon.

This option is in accord with current U.S. Forest Service policy under the National Forest Management Act. A policy decision on the part of other agencies would be required.

B. Set time limits or timeframes (through administrative directive and/or regulations) for issuance of leases and permits.

The draft CEQ guidelines for implementing NEPA note that while the Council considers universal time limits for the entire NEPA process too inflexible, it encourages all Federal agencies to "set limits if an applicant for the proposed action requests them, provided they are consistent with the purposes of NEPA and other essential considerations of national policy."

The only action in the geothermal pre- and post-lease approval process which is subject to a time constraint under the existing regulations is the Notice of Intent (NOI) to conduct exploration operations which the authorized officer is directed to approve or disapprove within 30 calendar days. This offers precedent for imposition of time limitations on other actions in the process.

A major advantage of this approach is that adherence to a realistic mandated schedule determined according to the criteria set forth in the draft CEQ guidelines would serve to generally reduce the length of time required for each action in the leasing and permitting process, although a precise estimate of time savings cannot be made at this time. It is felt, however, that when faced with realistic deadlines the backlogging of applications would diminish. Another advantage is that the approach would provide for more uniformity in processing schedules, an occurrence which would enhance more efficient developer planning. Failure to meet the scheduled timeframe would require a report of accountability to the applicant. In summary, this approach makes the process timing sensitive and visible.

A disadvantage is that the approach would require increased budgets and manpower in some BLM/FS field offices and in the responsible GS office.

On the other hand, it would at the same time provide a more concrete basis for projecting budget/manpower needs than the present system which tends to function, at lease in some office, in response to available resources rather than to needed resources. In other words, this program modification would provide a mechanism for establishing firm priorities.

C. Improve coordination in all phases of pre- and post-lease activities.

Since the geothermal program is jointly implemented by BLM, USFS, and U.S. Geological Survey (USGS) with still another review element in the Fish and Wildlife Service (FWS), there is significant opportunity for process delay in routine steps such as repetitive notifications, approvals, signatures, and transmittals. Improving the coordination between these agencies for the purpose of expediting the leasing and post-lease programs is consistent with the similar objective established for the Geothermal Energy Coordination and Management Project in the related area of geothermal research, development, and demonstration. The Project is composed of members from a number of involved departments and agencies, including the Departments of the Interior and Agriculture. P.L. 93-410, the Geothermal Energy Research, Development and Demonstration Act of 1974 and P.L. 95-238, Department of Energy Act of 1978 -- Civilian Applications, give to the Project the overall responsibility for the provision of effective management and coordination with respect to the Nation's geothermal research, development, and demonstration (RD&D) program.

The Project is directed to "make such recommendations for legislation or administrative regulations as may from time to time appear to be necessary to make Federal leasing, environmental, and taxing policy for geothermal resources consistent with known inventories of various resource types, with the current state of technologies for geothermal energy development, and with current evaluations of the environmental impacts of such development, and with current evaluations of the environmental impacts of such development." While the streamlining goal of the Task Force does not fall under the RD&D program umbrella per se, consistency in coordination in the regulatory program is warranted. There appear to be several methods for accomplishing this goal.

One is to establish in each agency field level coordinators for the geothermal program. A previous related study found that developers in general feel that program performance improves as the process becomes more localized -- i.e., that their needs are better attended by responsible personnel on the scene who are already intimately familiar with the locale, its resources, and problem areas. This situation would be further enhanced by the presence of personnel of all responsible agencies with geothermal activities as their primary program concern who could interact locally.

The need for such personnel is especially apparent at the regional level in some regions of the USFS, and a multi-regional coordinator located

at the center of activity is badly needed. It would be desirable that USFS and BLM coordinators be housed at the same location (Boise appears most logical) so as to facilitate communications.

Another potential approach to improved coordination is to consider modifying the existing Memorandum of Understanding (MOU) so as to establish guidelines for interagency cooperation among the Departments of Energy, Interior, and Agriculture in implementing the geothermal program. The MOU is the basis for the large bulk of the steps shown in Figures 1 and 2 which indicate the numerous opportunities for process slippage. Forest Service activities, which are not included in the MOU and are not shown in Figures 1 and 2 add other comment, approval, and transmittal steps to the process when forest lands are involved in KGRA lease sales and non-competitive lease applications.

Specific steps should be taken by the Departments to identify time limits for communication between their agencies. For example, KGRA clearlisting should require no more than 10 working days, and responses on approval of a Plan of Operation should also reach USGS within a similar timeframe.

The groups within the agencies charged with the writing of regulations and directives for the geothermal program should be adequately staffed and funded so that badly needed minerals program management may be carried out in a timely fashion. The need for a higher priority in manpower funding is exemplified by the fact that the geothermal power plant siting regulations were 2 years in preparation. With adequate manpower, such regulations could be proposed within 6 months.

D. Improve uniformity and consistency of policies and procedures with respect to lease stipulations among the involved agencies.

Two separate steps appear to offer the best potential for optimum improvement through this route. The first is to establish uniform policy and guidelines for special lease stipulations. In current practice, the surface management agencies sometimes attach stipulations which are unacceptable to the USGS Area Geothermal Supervisor's office and considerable time may be lost in negotiating the final stipulations. Uniform policy agreed to in advance by the involved agencies could reduce the frequency of this source of delay and alleviate to some extent developer uncertainty on special stipulations.

Another means of increasing interagency efficiency is to standardize special lease stipulations of similar nature and intent -- i.e., archaeological, endangered species, etc. The reasoning here is that past experience indicates some "one-upmanship" or pride of authorship in writing stipulations which creates unnecessary confusion and requires legal review of word changes. Not only should this delaying situation be avoided but the standardized stipulations should be expressed in

language immediately comprehensible to all levels of government and industry personnel who must be concerned with them. The potential for delay in erroneous interpretation or time wasted in seeking the correct interpretation is readily evident.

Revision of the geothermal lease form to incorporate standardized stipulations appears to be the best method for implementing this change which would avoid repetitive legal review of word changes. At the same time the lease form could be combined with the application form (as is now the case in oil and gas leases) which would save an estimated 30 days per application and eliminate one form.

No disadvantages in this approach are foreseen. Its implementation would require 2 man months and no changes in regulations or policy.

E. Institute formal nomination procedures for KGRA's and non-competitive areas.

The BLM regulations provide for receipt of nominations, or public expressions of interest in leasing certain described areas, either on an individual voluntary basis or upon the Secretary's call for nominations to lease. This provision has never been implemented, however, in that BLM has neither prepared an approved form (43 CFR, 3220.2) for receiving nominations nor issued calls for nominations (3220.1). It has instead treated non-competitive lease applications as nominations and has entertained requests for lease sales through letter correspondence or oral communication.

A formal nomination procedure would probably not have substantial effect on non-competitive areas, but an advantage could possibly accrue if such a procedure were used to identify, on the basis of expressed industry interest, the priority areas for completion of baseline studies needed to expedite competitive lease or no-lease decisions and in turn guide the location of competitive lease sales. A common industry justification for lack of development is that much of the land it considers most promising is not available under the present system. If this assertion is valid, development would be expedited by prioritizing activity in the areas which industry's nominations indicate are most likely to be developed if the acreage is made available.

In past experience, the less environmentally-sensitive prospect areas, and therefore the easiest to study, have often been investigated first only to generate little or no interest in the subsequent lease sale. In those instances, the effort would have been more productive if it had been applied to the more promising areas.

The success of this program change would hinge on industry's willingness to submit nominations and on amendment of the existing procedures for

classifying land as KGRA's. Developers have previously stated their reluctance to nominate acreage because of their fear that nominations would result in an increase in KGRA designation.

Potential advantages of this proposal would be to focus agency attention on competitive areas industry feels most desirable and to effect a minor time savings in developing planning priorities. Costs of this proposal would be negligible, and since some benefit might accrue, it is recommended that the involved agencies attempt to solicit nominations for planning purposes.

F. Allow no-surface-occupancy leases in wilderness study areas and other special areas where requested.

Some benefits would be gained from issuance of no-surface-occupancy leases in areas of mixed land ownership (areas composed of intermingled tracts of federal, private, and state lands), or in wilderness study or other special areas where leases on the federal lands cannot be issued.

If no leases are issued on the Federal portions pending the outcome of the study, any operator proceeding to discovery on adjacent or nearby non-Federal land risks facing a KGRA designation of the Federal tracts (43 CFR 3200.0-5k(2)). He would then be faced with competitive bidding as his only access to desired tracts in the Federal acreage if the land is not locked into no-lease status. In view of the fact that his own discovery would tend to attract other serious bidders, he risks losing to competitors those lands which are primarily valuable because of his own discovery.

A no-surface-occupancy lease could benefit him in two ways. First, it would protect his competitive interest throughout the study and decision-making period and, second, depending on engineering and economic feasibility, make recovery of the resource from this type of lease achievable through directional drilling. Certain types of non-surface disturbing activities would be allowed as appropriate on the particular lands under this type of lease.

The potential disadvantage of this approach to industry is that the lessee takes the risk of being unable to develop the lands that he has leased. Thus, there is potential for future litigation if a discovery is made. In addition, supervision of the lease by surface management agencies would be required which would not be necessary if the land were not leased. The additional costs and workload appear minimal, however, and the proposal is consistent with current law and regulation.

G. Modify KGRA regulations.

KGRA's are classified by geologic criteria and also by "competitive interest" (43 CFR 3200.0-5(k)(3)), caused by overlapping of applications filed within the same period. Lands in either type of KGRA can only be leased through competitive bidding. A recent study of all geothermal leases issued shows that the pace of competitive leasing is far behind that of non-competitive. The most recent summary shows that 1081 non-competitive leases have been issued on over 1.85 million acres of land, as compared to 239 competitive leases on 339,000 acres. Bids received number less than half the tracts offered, and about 30 percent of the sales have produced no bids at all. The total number of tracts of interest was even less than the number of bids received since multiple bids were made on the same tracts in some cases.

The reasons for this situation are not clear at present. They may reflect developer contention that the desirable tracts are not being offered, as discussed above, or the cost of competitive leases vs. non-competitive may be an inhibiting factor. The numbers do indicate, however, that the existence of KGRA's, which by definition should be more desirable than non-KGRA lands, are impeding the pace of leasing. Thus, the potential effect of amendments to the BLM regulations (43 CFR, 3200.0-5(k)) to change KGRA criteria is being investigated.

Three approaches are under consideration. They include:

- Reclassification of geologic KGRA's and competitive interest areas after they have been through unsuccessful lease sales.

- Abolish the competitve interest regulations (43 CFR, 32.00.0-5(k)(3)). The competitive interest concept is an impediment to an orderly non-competitve leasing program, and has caused delay in leasing with little financial return to the government.

- Provide for direct thermal utilization areas, to encourage use of low temperature geothermal waters.

There are several rationales for separate treatment of direct thermal utilization, or non-electric use of the resource, as opposed to electric power production. First, the requirements of the resource itself are different — temperature, pressure, and reservoir size requirements are less demanding for most direct uses than for power generation although in some cases a purer resource is required — and the type and degree of environmental impact will vary with the use. In general, the potential impacts from power production or industrial use may be expected to be more severe than those associated with domestic or agricultural use.

In addition, many if not most municipalities would be precluded, by their charters or financial responsibility requirements, from bidding on competitively-offered tracts. Thus, the most likely users of direct heating systems could not gain access to the resource on a KGRA, which in some instances might be designated because of a municipality discovery on adjacent or near-by state or private lands.

Since some of the geologic KGRA's and competitive interest areas draw no bids on being offered several times, it appears that revision of the criteria for classification in the regulations is needed -- i.e., the current KGRA standards may or may not be realistic in the light of present knowledge.

Reclassification of KGRA's and competitive interest areas lies under the authority of USGS and its area geologists. To date, no KGRA or competitive interest area has ever been reclassified.

Advantages of modifying the KGRA regulations would be more orderly development and more efficient use of the resource. Time would be saved in that leases could come on line more rapidly. No disadvantages are recognized, and costs and impacts upon manpower would be minimal.

H. Allow issuance of non-competitive leases unless the area is in a KGRA at time of application.

In present practice, non-competitive leases are not issued if the acreage involved is in a designated KGRA when the adjudication process is completed, and the applicant has signed the lease form. The KGRA clear list report is the last step in the procedure before the lease is issued, and the lease may be rejected at this late point on the basis of the clear list report. When this happens, the adjudicatory effort has been wasted. If the above change were effected, a change in KGRA status during the adjudicatory process would not affect issuance of the lease.

This approach would alleviate applicant uncertainty as to possible classification of lands during the adjudication process, and would allow applicants to commence exploration on adjacent non-Federal lands without risk of having the applied-for lands classified as a KGRA as a result of his work. Elimination of the clear list report would also speed up lease issuance.

The disadvantages of the approach include a potential loss of revenue due to loss of bonus-bids and decreased rentals, and the fact that legal modification and changes in regulations may be required. No staffing or direct budget impact are seen.

I. Provide budgets in proportion to workloads, organizational needs, and priorities.

The new draft regulations to implement NEPA require all agencies to "have sufficient capability, including personnel and other resources," to comply with Section 102 of the Act and Executive Order 11514, Protection and Enhancement of Environmental Quality. The geothermal programs of the involved agency field offices have commonly been short of this goal in their share of overall budgets.

Specifically, the pace of environmental assessment preparation and the various types of land management planning has been impeded by the inadequate budgets, and it is felt that a budgetary remedy must be a primary focus of any streamlining effort. The minerals management effort has historically been underfinanced and understaffed.

Option II

Base leasing decisions on areawide environmental assessment in combination with land management plan.

This option is based primarily on the existence of the planning requirements imposed by the Federal Land Policy and Management Act of 1976 (P.L. 94-759) and the National Forest Management Act of 1976 (P.L. 94-588) on BLM and the Forest Service, respectively.

The former requires BLM to prepare and maintain on a continuing basis an inventory of all public lands and their resource and other values, giving priority to areas of critical environmental concern. Just such a priority has been needed in the geothermal program, as discussed above, so that lease or no-lease decisions can be made on this type of area which includes geothermal among its resources. The inventory itself does not preclude leasing since the Act states that: "The preparation and maintenance of such inventory or the identification of such areas shall not, of itself, change or prevent change of the management or use of public lands." (Section 201(a)). The use of public lands is covered by a further requirement for formulation of plans "which provide by tracts or areas for the use of the public lands." These plans are to cover all public lands regardless of whether such lands have been previously classified, withdrawn, set aside, or otherwise designated for one or more uses. (Section 202(a)). No completion date is mandated for these plans.

The National Forest Management Act directs the Secretary of Agriculture to incorporate the standards and guidelines provided by the Act for National Forest System Resource Planning (Section 6) into plans for units of the system" as soon as practicable after enactment..." and to "attempt to complete such incorporation for all such units by no later than

September 30, 1985." Until such time as a unit is subject to a plan developed in accordance with the Act, its management may continue under existing land and resource management plans.

The various plans completed under this relatively new legislation, or previously, will provide "on-the-shelf" information for application in planning competitive geothermal lease sales and in processing non-competitve lease applications. Such information is necessary, it is believed, before the geothermal program can move on with sufficient speed for prudent development and with appropriate environmental safeguards.

Where the land management plans have been completed, Option 2 is actually in effect. Many of the forest management plans are completed or near completion and all National Forest Plans are to be completed by 1983, and will be fully operational under this system by 1985. In Nevada, where an initial land plan has been completed for most areas by BLM, leasing has proceeded very rapidly. Where land management plans are not complete, or where the existing plan does not consider geothermal energy production and utilization, two alternatives are available:

- Completing or amending the land management plan to consider geothermal development with environmental assessment as appropriate.

- Designing an environmental assessment specifically for incorporation into the management plan at the next revision. This process would recognize the existing plan's limitations while providing supplementary information which could fulfill needs on a limited area for immediate leasing decisions. The area to be considered would be the area which might reasonably be assumed to be affected prior to scheduled revision of the plan.

The comprehensive nature of the data gathering done in construction of the land management plan will reduce the pre-lease and post-lease data gathering and environmental review requirements considerably.

The advantage of this option is that it makes full use of the land management plans as they are now being developed, and makes allowance for the consideration of all resources and uses in their proper perspective on the lands in question. With an adequate land management plan, the additional environmental analysis needed to implement any action on those lands can be done very rapidly and cheaply. In the overall picture, this method is more effective with respect to manpower and dollars.

The disadvantage is that initially this process would require longer front end delay.

Option III

Provide for separate environmental analysis of exploration and development phases, with initial review of exploratory impacts only and comprehensive review only after a discovery is made.

At present, most pre-lease environmental analyses assume the "worst-case" level of potential impact -- that of full scale development for power generation. However, the potential impact of the exploratory phase alone is minor compared to full development, and on a large majority of leases activity will cease with exploration and restoration of the site because no exploitable resource will be found.

Thus, it is felt that efficiency in time and manpower utilization can be achieved, and the environment adequately protected, by applying the environmental review in the pre-lease period to exploration alone. One proposed method of implementing this policy would be through issuing leases granting full rights for the exploration and testing phases, but conditional rights only to commercial development contingent upon further detailed environmental analysis. It is believed that development rights could be held in abeyance in the lease through the use of special lease stipulations.

This approach stems from recent consideration of issuing oil and gas leases in potential wilderness ("roadless") areas. At an April 18, 1978, meeting in Denver attended by representatives of the Department of the Interior and industry, it was proposed by the Department that leases be issued with the restriction, via a special lease stipulation, that exploratory wells only could be drilled, with production and full-scale development contingent upon whether the acreage is eventually excluded from the Wilderness System. The important concept here is that a "two-stage" lease is contemplated to be legally accomplished with a special stipulation in the lease and no change in existing law.

If the concept proves workable, it should likewise prove applicable for any geothermal leasing situation where separation of the two phases would be advantageous. Pending further review, the basic approach appears feasible without amending the Geothermal Steam Act although 43 CFR 3200.0-6 may require modification to make this option feasible.

In addition, in order to permit the lessee to identify the resource and determine whether it is commercially exploitable, the two-stage concept envisions redefining "exploration operations" to include the drilling and testing of one or more deep wells. If an exploitable discovery were made, the special stipulation for development would not be removed until a comprehensive environmental review, considering the nature of the resource and the plans of the lessee indicated the suitability of the area for development.

In addition to achieving efficiency and providing adequate environmental protection, any version of Option 3 adopted must also consider the lessee's right to develop -- i.e., such a program must be implemented in a manner which will encourage development. Present thinking envisions this option as an elective choice approach, with a one-stage lease still available to developers if they prefer the existing system.

This option would reduce time spent in pre-lease, environmental assessment, and would require no more time for post-lease analysis than at present since these post-lease analyses are being done in sufficient detail now. The biggest time saving might occur in sensitive areas although these areas represent the greatest chance for denial or limitation of development.

The major advantage which would accrue to the lessee is that after discovery and testing, the extent and potential value of the resource is much better known, and positively located in relation to surface values, making management trade-off value analysis much more knowledgeable and easier -- i.e., both the surface and subsurface values are now known.

The principal disadvantages to the lessee include the potential for unreasonable denial of development and the adverse economics of being unable to develop a commercially viable resource.

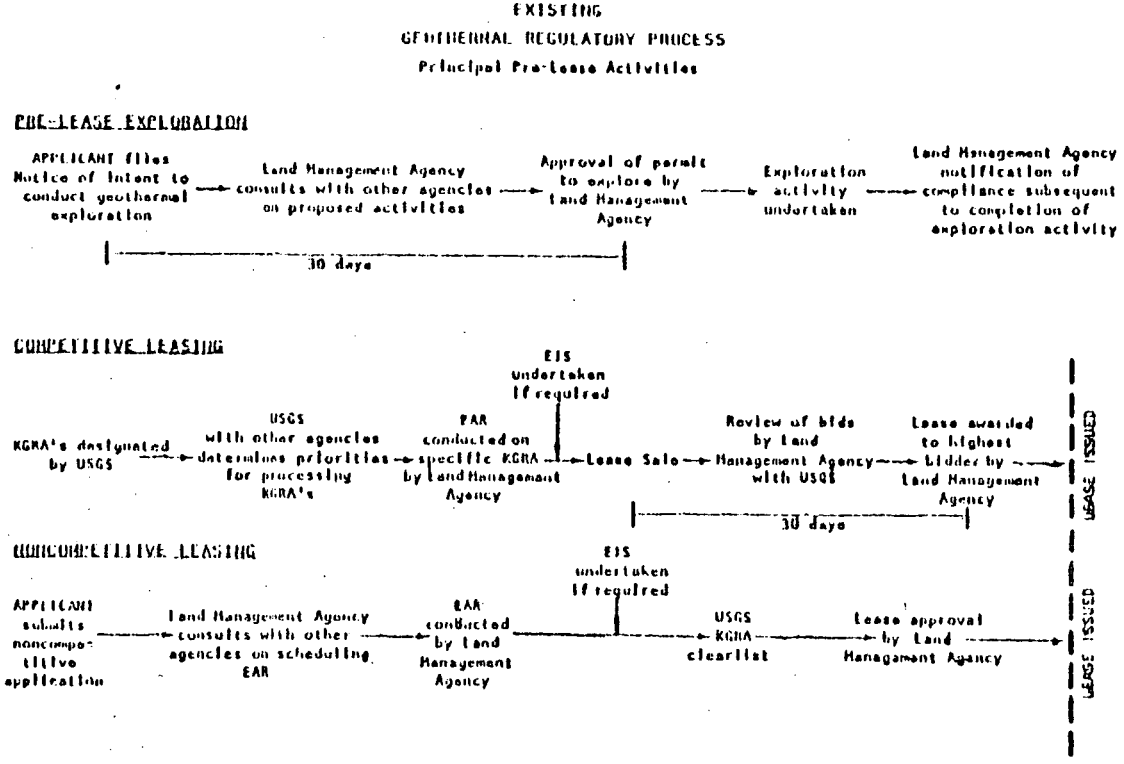
Written comments should be addressed to:

Winston B. Short
Chairman
Geothermal Streamlining Task Force
Interior Building
19th & E. Streets
Washington, D.C. 20240

EXISTING

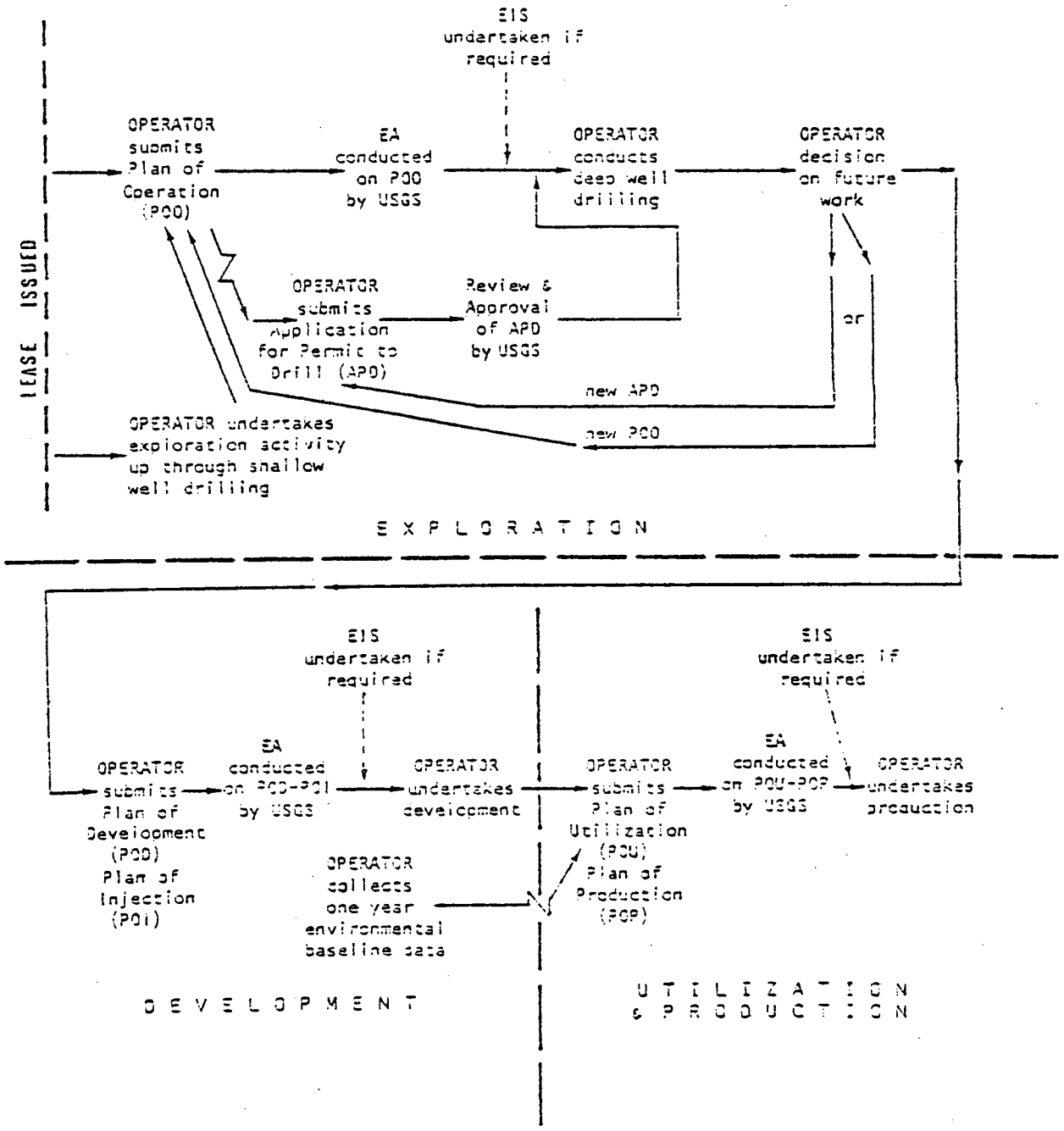
GEOTHERMAL REGULATORY PROCESS

Principal Pre-Lease Activities



EXISTING

GEOTHERMAL REGULATORY PROCESS
Principal Post-Lease Activities



Sample Leasing EAR Schedule

Field Inventory – Data Analysis	6 Months
Drafting and Internal Review	5 Months
State Office Review	2 Months
Public Review	3 Months
Publication	1 Month
	17 Months

Expected Annual Federal Regulatory Workload

(Preliminary)

(Moderate Growth Scenario)

	1977	1980	1985	1990
Leases	200	200	300	600
Well Permits	100 (20)	75	400	1,000
Power Plants	2	5	30	150

ENVIRONMENTAL REVIEW

PATH OF FEDERAL GEOTHERMAL PROGRAM

Environmental Reviews	Impacts Considered
Programmatic EIS - BLM	Exploration - Development (Generic)
Land Management Plan - BLM - FS	Exploration - Development (Area-Wide)
Pre-Lease EAR - BLM - FS	Exploration - Development (Area-Wide)
Plans of Operation - USGS	Phased - Site - Specific
Exploration (Initial)	
Exploration (Subsequent)	
Development	
Injection	
Utilization	
Siting License (BLM)	
Permit to Construct and Operate	
Production	Site - Specific

STATUS OF LEASE SALES ON KGRA'S

State	Total Federal Acreage		Theoretically Available For Leasing		Acres Offered		Acres Bid On		Acres Accepted		Federal Acres Remaining for Lease	
	BLM	FS	BLM	FS	BLM	FS	BLM	FS	BLM	FS	BLM	FS
Ariz.	3,240	0	3,240	0	780	0	0	0	0	0	3,240	0
Calif.	387,374	394,582	353,054	394,582	90,167	0	40,235	0	39,449	0	313,605	394,582
Colo.	19,045	1,780	11,271	1,513	11,271	0	5,036	0	5,036	0	6,235	1,513
Idaho	103,500	42,500	52,500	40,500	48,500	0	32,000	0	32,000	0	20,500	40,500
Mont.	8,861	29,170	8,861	29,170	320	1,280	0	0	0	0	8,861	29,170
Nev.	326,802	4,160	326,802	4,160	201,988	2,560	148,163	0	145,682	0	181,120	4,160
N. Mex.	190,320	1,316,004	190,320	1,224,004	101,693	29,375	62,482	18,050	62 48?	18,050	127,838	1,205,954
Oregon	198,495	62,125	198,495	61,605	155,910	0	68,873	0	63,911	0	129,210	61,605
Utah	83,215	15,572	83,215	15,572	78,966	10,852	77,277	10,852	77,277	10,852	7,138	4,719
Wash.	0	19,001	0	13,187	0	0	0	0	0	0	0	13,187
Wyo.	0	0	0	0	0	0	0	0	0	0	0	0
TOTALS	1,320,852	1,884,894	1,227,758	1,784,293	689,595	44,067	434,066	28,902	425,837	28,902	797,747	1,755,390

BLM NONCOMPETITIVE GEOTHERMAL LEASING
AS OF DECEMBER 31, 1977

	NO. OF APPLICATIONS	NUMBER ISSUED	NUMBER PENDING
ARIZONA	57	4	17
CALIFORNIA	674	10	260
COLORADO	86	43	7
IDAHO	564	111	164
MONTANA	33	6	1
NEVADA	1399	409	129
NEW MEXICO	574	85	146
OREGON	657	102	189
UTAH	497	208	57
WASHINGTON	0	0	42
WYOMING	19	0	56
EASTERN STATES	0	0	0
TOTALS	4560	978	1068

JUNE 1978

CHRONOLOGICAL MILESTONES IN THE FEDERAL GEOTHERMAL LEASING AND PERMITTING PROCESS

- GEOTHERMAL STEAM ACT (P.L. 91-581) PASSED 12/24/70
- IMPLEMENTING BUREAU OF LAND MANAGEMENT AND U.S. GEOLOGICAL SURVEY REGULATIONS BECAME EFFECTIVE 1/1/74 (43 CFR, GROUP 3200 AND 30 CFR, PARTS 270 AND 271)
- GENERIC ENVIRONMENTAL IMPACT STATEMENT COMPLETED 10/73
- FIRST ENVIRONMENTAL ANALYSIS RECORD COMPLETED, SURPRISE & WARNER VALLEY, CA TRANSMITTAL TO STATE OFFICE 1/24/75
- FIRST NON-COMPETITIVE APPLICATIONS FILED 1/74
- FIRST LEASE SALE HELD 1/22/74 (CA)
- FIRST NON-COMPETITIVE LEASE ISSUED 1/16/75 (NV)
- FIRST ENVIRONMENTAL ANALYSIS COMPLETED 8/26/74 (USGS, CA, GEYSERS)
- FIRST PLAN OF OPERATION (EXPLORATION) APPROVED 9/6/74
- FIRST DRILLING PERMIT ISSUED 9/9/74
- FIRST PLAN OF OPERATION (DEVELOPMENT) RECEIVED 10/18/77 (REPUBLIC EAST MESA)
- FIRST PLAN OF OPERATION (INJECTION) RECEIVED 10/28/77 (REPUBLIC EAST MESA)
- FIRST PLAN OF OPERATION (UTILIZATION) RECEIVED 6/23/77 (MAGMA EAST MESA)
- FIRST PLAN OF OPERATION (PRODUCTION) EXPECTED 9/78

FOREST SERVICE NON-COMPETITIVE GEOTHERMAL LEASING
AS OF DECEMBER 31, 1977

	NO. OF APPLICATIONS	NUMBER ISSUED	NUMBER PENDING
ARIZONA	67	1	55
CALIFORNIA	397	0	169
COLORADO	73	0	34
IDAHO	317	1	208
MONTANA	55	0	11
NEVADA	13	3	15
NEW MEXICO	42	0	27
OREGON	378	3	218
UTAH	106	10	35
WASHINGTON	277	0	100
WYOMING	121	4	19
EASTERN STATES	12	11	0
TOTALS	1858	33	891

JUNE 1978

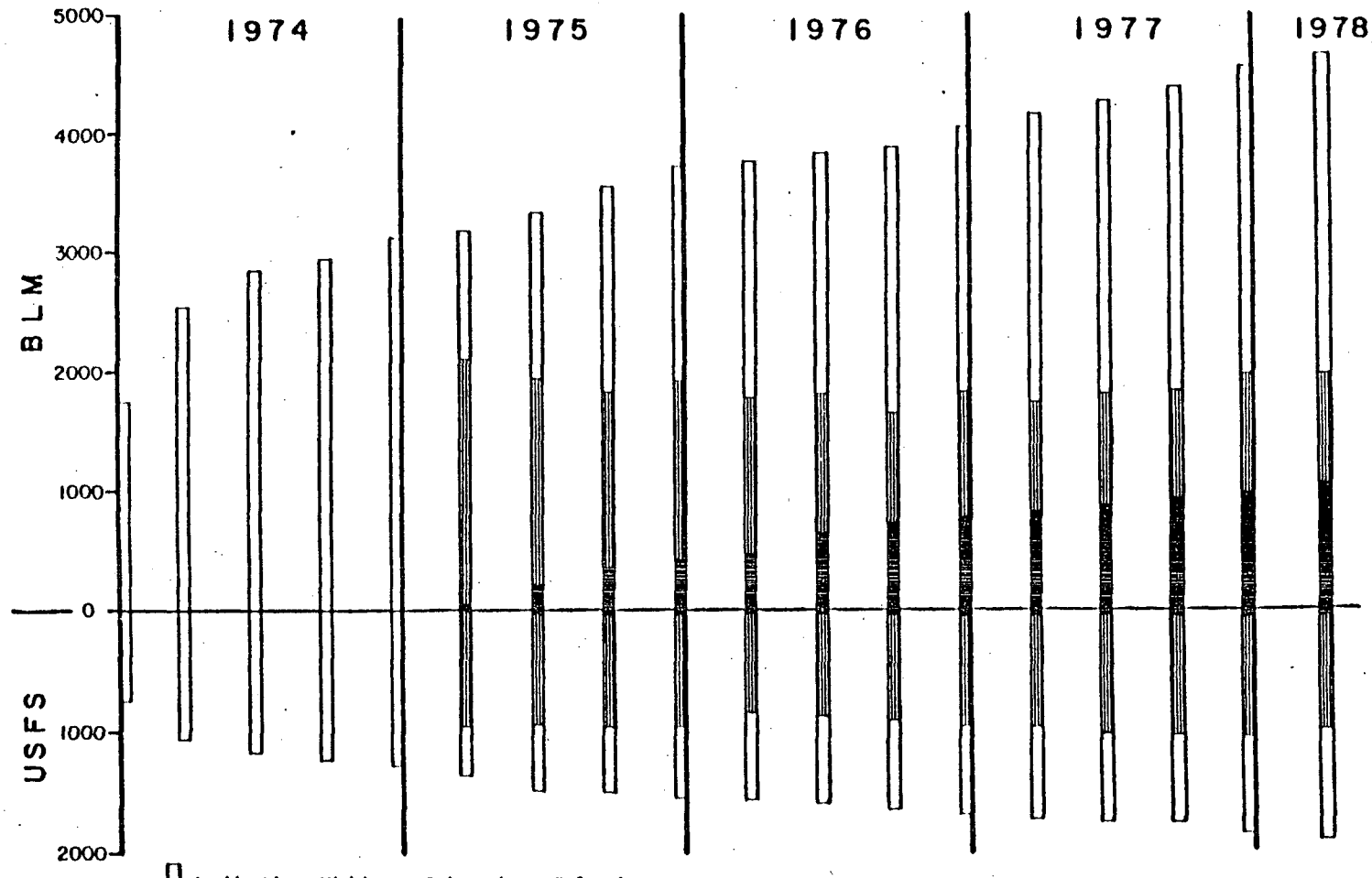
CUMULATIVE

SUMMARY OF NON-COMPETITIVE GEOTHERMAL LEASING

(BY QUARTER FROM 1974 TO PRESENT)

JUNE 1978

		BUREAU OF LAND MANAGEMENT				FOREST SERVICE			
	MONTH	TOTAL APPLS.	APPLS. WITHDRAWN, REJECTED OR REFUSED	APPLS. PENDING	LEASES ISSUED	TOTAL APPLS.	APPLS. WITHDRAWN, REJECTED OR REFUSED	APPLS. PENDING	LEASES ISSUED
	1	1744				712			
	3	2542				1038			
1974	6	2870				1172			
	9	2965				1211			
	12	3117				1273			
	3	3188	1077	2087	24	1359	420	939	0
1975	6	3334	1394	1720	220	1430	505	925	1
	9	3560	1722	1462	376	1467	520	942	5
	12	3711	1794	1491	426	1526	569	943	14
	3	3766	1979	1339	448	1552	706	831	15
1976	6	3827	2022	1164	641	1596	733	848	15
	9	3880	2231	924	725	1640	740	885	15
	12	4066	2259	1021	786	1604	740	925	19
	3	4163	2418	933	812	1715	744	952	19
1977	6	4290	2487	918	885	1753	745	989	19
	9	4395	2575	881	939	1765	746	988	31
	12	4560	2580	1002	978	1858	813	1012	33
1978	3	4649	2685	924	1040	1882	885	956	41

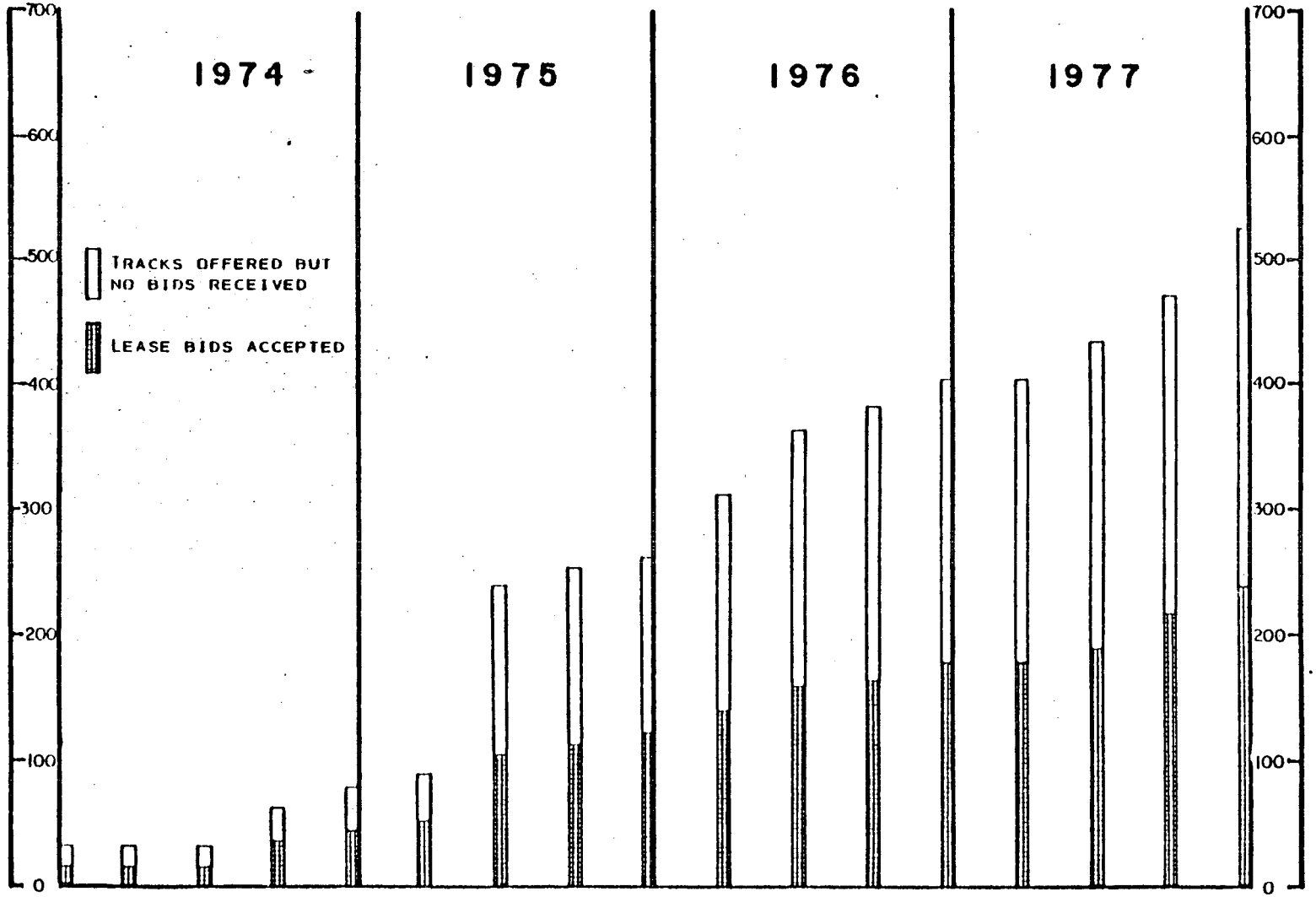


SUMMARY OF NON-COMPETITIVE GEOTHERMAL LEASING

JUNE 1978

AGE OF NON-COMPETITIVE LEASE APPLICATIONS STILL PENDING (as of 4/78)

State	5 mo. or less		6-11 mos.		12-17 mos.		18-23 mos.		24-35 mos.		36 mos. or more		Totals	
	BLM	USFS	BLM	USFS	BLM	USFS	BLM	USFS	BLM	USFS	BLM	USFS	BLM	USFS
Ariz.	3	0	2	27	11	0	0	0	2	26	7	1	25	54
Colo.	0	0	0	0	0	0	0	0	0	0	9	27	9	27
Calif.	11	10	16	17	42	0	9	3	27	18	177	123	282	171
Idaho	44	1	46	17	1	0	9	1	27	52	62	143	189	214
Mont.	0	0	0	0	0	0	0	0	0	0	2	12	2	12
Nev.	35	1	18	0	3	0	4	0	17	1	197	8	274	10
N. Mex.	23	6	11	5	24	0	0	0	8	3	144	28	210	42
Oreg.	10	17	10	7	13	25	10	17	40	28	144	424	227	518
Utah	16	1	22	1	23	9	11	6	9	3	135	41	216	61
Wash.	0	20	0	0	0	0	0	0	8	16	0	3	8	39
Total	142	56	125	74	117	34	43	27	138	147	877	810	1442	1148



SUMMARY OF COMPETITIVE GEOTHERMAL LEASING

(BY QUARTER FROM 1974 TO PRESENT)

JUNE 1978

CUMULATIVE
SUMMARY OF COMPETITIVE GEOTHERMAL LEASING

	Month	Total Tracts Offered	Tracts Offered But No Bids Received	Lease Bids Accepted
1974	1	33	15	18
	3	33	15	18
	6	33	15	18
	9	65	27	38
	12	80	33	47
1975	3	91	35	56
	6	240	132	108
	9	253	138	115
	12	262	139	123
1976	3	313	171	142
	6	365	204	161
	9	382	215	167
	12	405	226	179
1977	3	406	227	179
	6	434	243	191
	9	471	253	218
	12	523	284	239

June 1978

SUMMARY OF ENVIRONMENTAL AND CONSERVATION LAWS IMPACTING THE FEDERAL GEOTHERMAL LEASING AND PERMITTING PROGRAM

GEOTHERMAL STEAM ACT OF 1970

NATIONAL ENVIRONMENTAL POLICY ACT OF 1969

FEDERAL LAND POLICY AND MANAGEMENT ACT OF 1976

NATIONAL FOREST MANAGEMENT ACT OF 1976

FISH AND WILDLIFE COORDINATION ACT

ENDANGERED SPECIES ACT OF 1973

NATIONAL HISTORIC PRESERVATION ACT OF 1966

FEDERAL WATER POLLUTION CONTROL ACT, AS AMENDED

CLEAN AIR ACT, AS AMENDED

RESOURCES CONSERVATION AND RECOVERY ACT

NOISE CONTROL ACT OF 1972

COASTAL ZONE MANAGEMENT ACT OF 1972

WILD AND SCENIC RIVERS MANAGEMENT ACT

OTHER CONSERVATION STATUTES WHICH LIMIT OR PRECLUDE DEVELOPMENT ON WILDERNESS, WILDLIFE REFUGES, AND OTHER PROTECTED LANDS

APPENDIX E

E-1 Utah Geothermal Sites (Electric)

E-2 Utah Geothermal Sites (Non-Electric)

UTAH GEOTHERMAL SITES (ELECTRIC)

SITE	LAT	LONG	RESERVOIR VOLUME (CUBIC KM)	TEMPERATURE (° C)	STORED HEAT (10x10 CALS)	RECOVERABLE HEAT (MW CENTURIES)	ELECTRIC POTENTIAL (MW FOR 30 YEARS)
ROOSEVELT HS	38 30	112 49	11.00	250	1.128	37	125
COVE FORT-SULPHURDAL	38 36	112 33	22.50	200	2.497	66	221
THERMO HS	38 11	113 12	2.25	105	.229	6	20

NEW MEXICO ENERGY INSTITUTE PSL AA
FEBRUARY 1, 1978

UTAH GEOTHERMAL SITES (NON-ELECTRIC)

SITE	LAT	LONG	RESERVOIR VOLUME (CUBIC KM)	TEMPERATURE (° C)	STORED HEAT (10E18 CALS)	THERMAL POTENTIAL (MW CENTURIES)	THERMAL POTENTIAL (MW FOR 30 YEARS)
JOSEPH HS	38 38	112 11	2.25	140	.169	13	45
RED HILL HS	38 32	112 9	2.25	135	.162	13	43
CRYSTAL HS	40 30	111 58	2.25	135	.162	13	43
ABRAHAM HS	39 37	112 43	2.25	125	.148	12	39
WASATCH HS	40 45	111 55	2.25	120	.142	11	38
ROOSEVELT(COOPER) HS	38 31	112 12	2.25	120	.142	11	38
OGDEN HS	41 14	111 58	2.25	110	.128	10	34
STERLING SPR	41 35	112 14	2.25	110	.128	10	34
MEADOW HS	38 50	112 31	2.25	105	.121	10	32
HOOPER HS	41 9	112 12	2.25	105	.121	10	32
UTAH HS	41 24	112 2	2.25	95	.108	9	29
BECKS HS	40 47	111 56	2.25	90	.101	8	27
CRYSTAL H.S.	40 40	112 0	2.25	90	.101	8	27
WILSON HS	39 55	113 40	2.25	61	.062	5	16
MIDWAY HS	40 31	111 28	2.25	45	.040	3	11
SARATOGA HS	40 20	111 53	2.25	44	.039	3	10
UDDY HS	41 51	112 9	2.25	43	.038	3	10
CRATER HS	40 20	111 53	2.25	43	.038	3	10
LAWLERIN HS	37 13	113 16	2.25	42	.036	3	10
VEYO HS	37 19	113 42	2.25	42	.036	3	10
HONAKER HS	41 42	114 7	2.25	42	.036	3	10
CASTILLA HS	40 3	111 29	2.25	40	.034	3	9
HATCH HS	38 57	112 27	2.25	38	.031	2	8
RADIUM(MADISON) HS	38 13	112 55	2.25	33	.024	2	6
LINCOLN POINT WS	40 1	111 50	2.25	32	.023	2	6
SPLIT MOUNTAIN WS	40 27	109 15	2.25	30	.020	2	5
FISH SPRINGS	39 52	113 25	2.25	29	.018	1	5
CANDY WS	39 27	113 58	2.25	27	.016	1	4
MORGANS WS	40 24	112 25	2.25	27	.016	1	4
BLUE WS	41 50	112 24	2.25	27	.016	1	4
WARM SPR	41 48	113 35	2.25	27	.016	1	4
WARM SPR-UTAH LAKE	40 14	111 46	2.25	25	.013	1	4
JOHNSONS WS	38 36	112 15	2.25	25	.013	1	4
CORP HS	41 5	111 40	2.25	25	.013	1	4
GEARHSVILLE	40 38	112 31	2.25	24	.012	1	3
RUSSELS WS	40 22	112 27	2.25	22	.009	1	3
RICHFIELD WS	38 45	112 5	2.25	22	.009	1	3
DIAMOND FORK WS	40 5	111 22	2.25	20	.007	0	2
GOSHEN WS	39 57	111 44	2.25	20	.007	0	2
STERLING SPR	39 12	111 32	2.25	19	.005	0	1
BUG WS	40 52	112 36	2.25	18	.004	0	1

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FEBRUARY 1, 1978 .

APPENDIX F

F-1 Financial Statement for the Utah Operations/Research Study

FINANCIAL STATEMENT FOR
THE UTAH GEOTHERMAL OPERATIONS/RESEARCH PROJECT

The following is the financial statement for the Utah portion of the Southwest Regional Geothermal Operations/ Research Project. It is current as of June 30, 1978. Because of the 60-day extension (until August 12, 1978), there will be further expenses accounted to the project fund which are not reflected here.

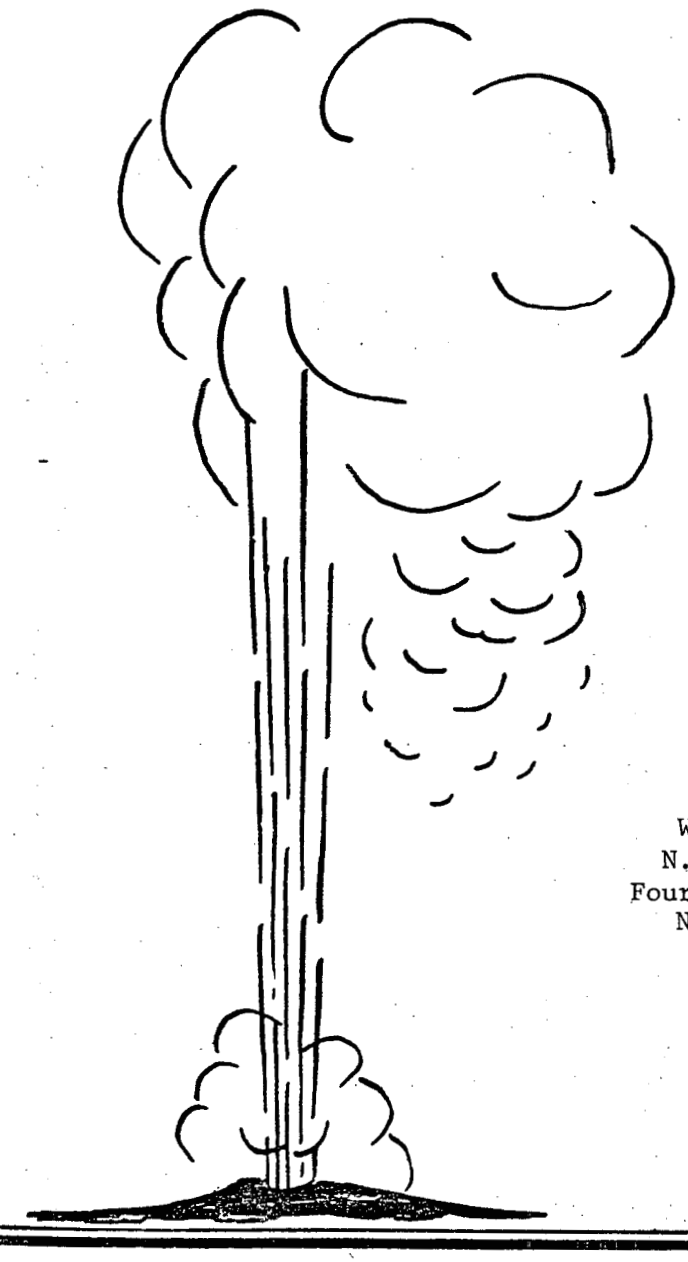
	Allotted Funds	Expended June 30, 1978
Payrolls	$24,000	$15,529.12
Travel	4,000	1,0 8.03
Capital Expense	12,500	70.63
Capital Outlay	1,500	1,173.00
Total	$42,000	$17,840.78

ALO-3992-1

NEW MEXICO SOUTHWEST REGIONAL GEOTHERMAL DEVELOPMENT OPERATIONS RESEARCH PROJECT

Appendix 9 of

REGIONAL OPERATIONS RESEARCH PROGRAM
FOR DEVELOPMENT OF GEOTHERMAL ENERGY
IN THE SOUTHWEST UNITED STATES



Final Technical Report
June 1977 to August 1978

New Mexico Energy and
Minerals Department
Thomas A. Ortiz
Dennis Fedor

January 1979

Work Performed under DOE Contract No. EG-77-S043992
N.M. Energy and Minerals Department Project No. 76-262
Four Corners Regional Commission Contract No. 672-066-075
New Mexico State University Sub-Contract No. 3104-X7

New Mexico Energy Institute at
New Mexico State University
Las Cruces, New Mexico 88003

U. S. DEPARTMENT OF ENERGY

Geothermal Energy

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NEW MEXICO SOUTHWEST REGIONAL GEOTHERMAL DEVELOPMENT OPERATIONS RESEARCH PROJECT

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REGIONAL OPERATIONS RESEARCH PROGRAM FOR DEVELOPMENT OF GEOTHERMAL ENERGY IN THE SOUTHWEST UNITED STATES

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TABLE OF CONTENTS

	Page
INTRODUCTION	1
GEOTHERMAL POTENTIAL IN NEW MEXICO	4
STATUS OF GEOTHERMAL DEVELOPMENT	8
Current Situation	8
Leasing	12
GEOTHERMAL LEASING PROCEDURES	22
Private Land	22
State Land	22
Federal Land	24
Indian Land	25
State Regulatory Authority	25
GEOTHERMAL RESOURCE ASSESSMENT AND SCENARIO DEVELOPMENT	27
Albuquerque	31
Animas	33
Jemez Springs	39
Kilbourne Hole	43
Las Alturas	49
Oho Caliente	52
Radium Springs	55
San Ysidro	60
Socorro	63
Truth or Consequences	68
Valles Caldera	71
STATE OF NEW MEXICO ENERGY SUMMARY	79
CONSTRAINTS TO GEOTHERMAL DEVELOPMENT	82
LEGAL AND INSTITUTIONAL FACTORS AFFECTING GEOTHERMAL DEVELOPMENT	85
SUMMARY AND CONCLUSIONS	88
REFERENCES	90
APPENDICES	92
1. State Geothermal Energy Plan	92
2. Geothermal R & D Projects	96
3. Regional Federal-Sponsored Activities Attended by the New Mexico State Team	102

TABLES

No.		Page
1.	Current Use of Geothermal Energy in the State	10
2.	Steps for Geothermal Resource Development	11
3.	Controlling Agencies of N. M. Surface Area	14
4.	Leasing Status of State Lands in New Mexico	15
5.	Federal Active Non-Competitive Geothermal Leases in New Mexico	16
6.	Federal Competitive Geothermal Leases	17
7.	State of New Mexico Geothermal Leases	18
8.	Geothermal Developers/Lessees/Utilities in New Mexico	21
9.	Geothermal Resource Development Schedule Categories	28
10.	New Mexico High Temperature Resource Prospects	29
11.	New Mexico Low and Moderate - Temperature Resource Prospects	30
12.	Postulated Site Development Schedule - Animas Valley	37
13.	Postulated Site Development Schedule - Kilbourne Hole	47
14.	Postulated Site Development Schedule - Radium Springs	58
15.	Postulated Site Development Schedule - Socorro	67
16.	Postulated Site Development Schedule - Valles Caldera	75
17.	Composite Scenarios for Direct Utilization of Geothermal Resources in New Mexico	77
18.	Composite Scenarios for Geothermal Power Generation in New Mexico	78
19.	Review of State Legislation	87
20	Some Potential Uses for Geothermal Resources in New Mexico	89

FIGURES

No.		Page
1.	New Mexico Geothermal Resource Areas	3
2.	Terrestrial Heat-flow Contour Map of New Mexico	5
3.	Geothermal - Volcanism Relationship	6
4.	Geothermal Base Data Map	7
5.	Geothermal Leasing Procedure for State Lands	23
6.	Albuquerque Geothermal Resource Area	32
7.	Animas Geothermal Resource Area	34
8.	Jemez Springs Geothermal Resource Area	40
9.	Kilbourne Hole Geothermal Resource Area	44
10.	Las Alturas Geothermal Resource Area	50
11.	Ojo Caliente Geothermal Resource Area	53
12.	Radium Springs Geothermal Resource Area	56
13.	San Ysidro Geothermal Resource Area	61
14.	Socorro Geothermal Resource Area	64
15.	Truth or Consequences Geothermal Resource Area	69
16.	Valles Caldera Geothermal Resource Area	72
17.	New Mexico Energy Consumption	79
18.	Total New Mexico Energy Production	80
19.	Estimated Future New Mexico Energy Production	80
20.	Energy Consumption in New Mexico by Supply Source to the Year 2020	81

EXPLANATION AND ACKNOWLEDGMENTS

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Numerous individuals provided information and assistance for this study. Their help is greatly appreciated. While it is not possible to list everyone here, special mention should be made of the Members of the State Advisory Team:

Dan Nutter, Chief Engineer, N.M. Oil Conservation Division, EMD

Jack Kennedy, Division Director, N.M. State Land Office

George Scudella, Energy Coordinator, N.M. Environmental Improvement Division, HED

Anthony Garcia, N.M. Public Service Commission

Emery Arnold, Director, Mining and Minerals Division, EMD

Dr. Frank Kottlowski, Director, N.M. Bureau of Mines & Minerals

Art Martinez, Public Service Company of New Mexico

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H.M. Stoller, Geothermal Energy Technology Dept., Sandia Laboratories

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Al Utton, Professor of Law, University of New Mexico

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Jim Querry, Bureau of Land Management, Santa Fe

Marshall Reiter and William Stone, New Mexico Bureau of Mines

Dr. Allen Sanford, New Mexico Institute of Mining & Technology

Dr. R. San Martin, Director, New Mexico Energy Institute

Dr. Chandler Swanberg, New Mexico State University

Carl Ulvog, New Mexico Oil Conservation Division, EMD

A. F. Veneruso, Sandia Laboratories

INTRODUCTION

This final report describes the findings and conclusions of the New Mexico Team during the first project year of the Southwest Regional Geothermal Development Operations Research Project. The purpose of this project is to help realize a goal of the U.S. Department of Energy, Division of Geothermal Energy (DOE/DGE), "to accelerate the actual commercial utilization of geothermal energy." This was done by:

1) Identifying the potential for development of geothermal energy in the five-state regions of Arizona, Colorado, New Mexico, Nevada and Utah.

2) Identifying the actions needed to accomplish that development.

Funding was provided to the prime contractor, the New Mexico Energy Institute, by the DOE/DGE, assisted by the Four Corners Regional Commission and the New Mexico Energy and Minerals Department (formerly Energy Resources Board) Each state arranged for a subcontractor. In New Mexico the subcontractor is the New Mexico Energy and Minerals Department, with its staff members comprising the State Team. The team is led by Thomas A. Ortiz, Director of the Energy Resources Development Division in the New Mexico Energy and Minerals Department. Working with Mr. Ortiz are the energy consultants of the division: Dennis Fedor and Gary Carlson and also the staff members of the Mining & Minerals Division/EMD, Kay Hatton and Wes Horner. The latter three have, in part, assisted in different phases of the project.

The state team has contacted federal, state and local government entities involved in geothermal energy development including legislative bodies, universities, utilities, both national laboratories of Sandia and LASL, and members of the general public. Geothermal developers and academic researchers in the state were contacted in order to determine the extent of speculative projections and development plans for any of the potential geothermal resource areas.

Numerous field trips were made to ascertain the degree of geothermal potential and activity. These included BLM inspection trips to Socorro and Radium Springs and investigations of the San Ysidro, Jemez Springs and Soda Dam thermal areas.

This project has stimulated much interest and planning in many sectors of the state. Some state agencies including the Energy and Minerals Department have initiated effort to create legal, institutional and economic inducements in state energy policies and plans in order to stimulate geothermal development.

The state team was responsible for drawing up the state policies for geothermal energy in the State Energy Plan. A number of recommendations have been made in the State Energy Plan which include income tax credit for geothermal systems (outfitting and retrofitting) and a public awareness outreach program. Other accomplishments were: state position paper for the National Governor's Energy Production Conference held in February; reviewed and responded to the Bureau of Land Management's environmental assessment report on geothermal leasing in the Silver City area; reviewed and responded to BLM's inquiry for

an EAR in the Ojo Caliente area. The state team and EMD has given support to PNM/Union Oil proposal for DOE funding through the geothermal demonstration plant program. It also is supporting the geothermal depletion allowance in the National Energy Plan.

The state team has participated in promoting interest in and reviewing the state research and development geothermal programs. The number of these programs have increased noticeably during the past six months.

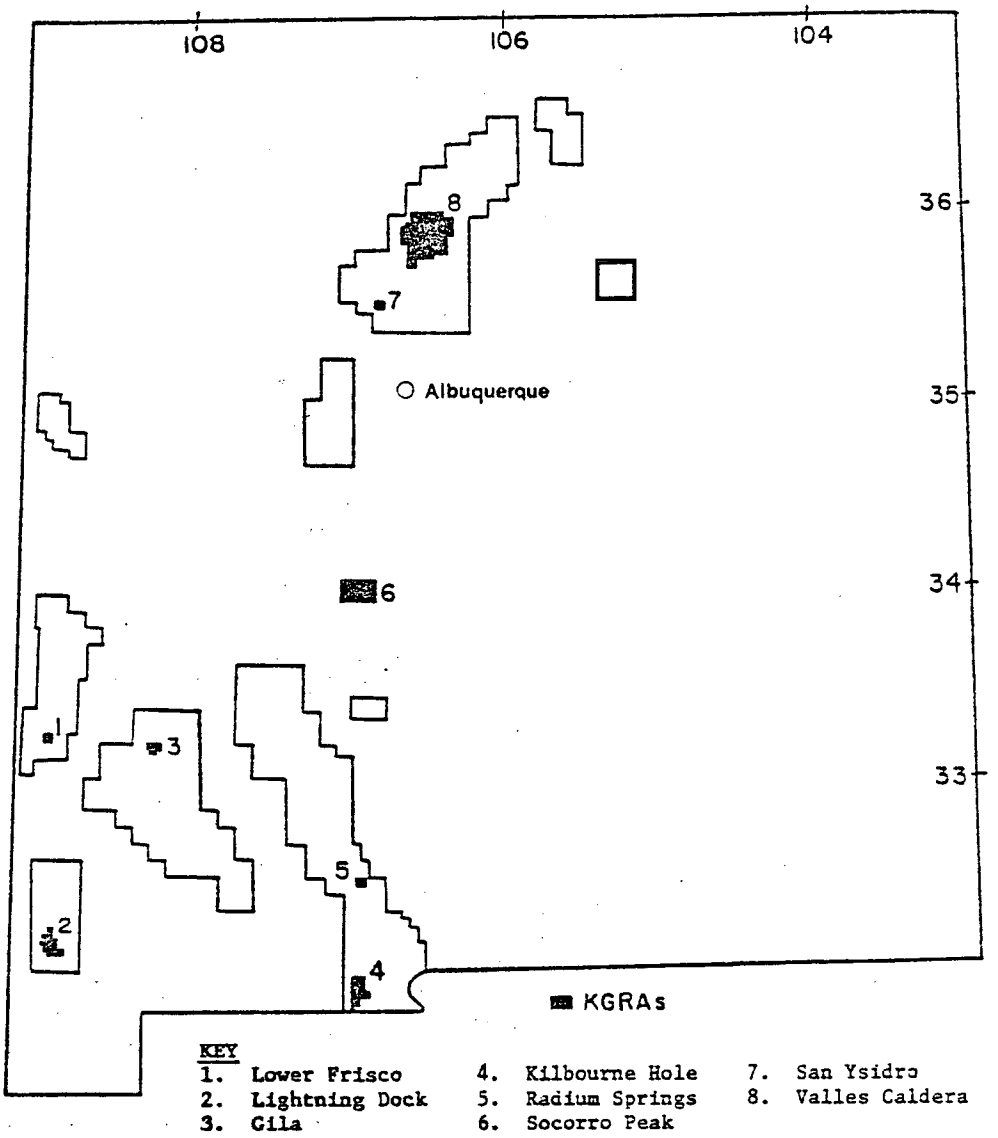


Figure 1. New Mexico Geothermal Resource Areas

GEOTHERMAL POTENTIAL IN NEW MEXICO

The State of New Mexico exhibits virtually all known kinds of potential geothermal resources and will soon have the nation's first commercial-scale plant to use underground reserves of hot water which is located in the Jemez Mountains.

The State has many visible manifestations such as geologically recently active volcanoes, lava fields and it also has over a hundred hot springs. In general, nearly all of these are confined to the two major geothermal areas in New Mexico. These are the Rio Grande Rift, and the southwestern portion of the state.

The Rio Grande Rift is a linear structural fault zone which literally bisects the state in a north-south direction. This rift extends through many areas of volcanism and mountain building and generally parallels or occupies the geographic position of the state's major river.

Because it is a series of faulted troughs or basins, many small volcanoes and fissure flows mark the boundaries at several localities. Numerous warm and hot springs, having temperatures greater than 65°F, are found along the faults which border the trough. Apparently, ground water circulates into zones of hot rock and then finds a convenient conduit to the surface along the faults. According to the heat flow data complied by Reiter and others (1975), a high heat flow ridge coincides with the western boundary of this rift. The heat flow here is greater than 2.5 HFU (normal average is 1.5 HFU)-as shown in Figure 2. The Rio Grande Basin from Colorado to Texas is filled with relatively unconsolidated sands, gravels and clays eroded from nearby mountain uplifts that are thousands of feet thick in many regions. These sediments are saturated with ground water that, at depth, can be expected to exhibit features of geothermal high temperature systems. With most of the state's population occupying this zone, the implications of commercial development are obvious.

The source of heat from most of the commercial geothermal power station in the world can be traced to fairly recent igneous activity associated with fault zones.

In New Mexico, warm and hot springs are for the most part in areas of obvious volcanism. Figure 2 shows where igneous rocks of Quaternary and Pliocene ages crop out in the state. Many volcanic cones dot the state's landscape. The preliminary state geologic maps (Dane and Bachman, 1957, 1958, 1961; Bachman and Dane, 1962) show the location of these cones in considerable more detail than is possible here. Because New Mexico has so many fairly recent volcanoes, the prospects of finding and developing hydrothermal water and steam, are good, and could become the major energy used to generate power in the state.

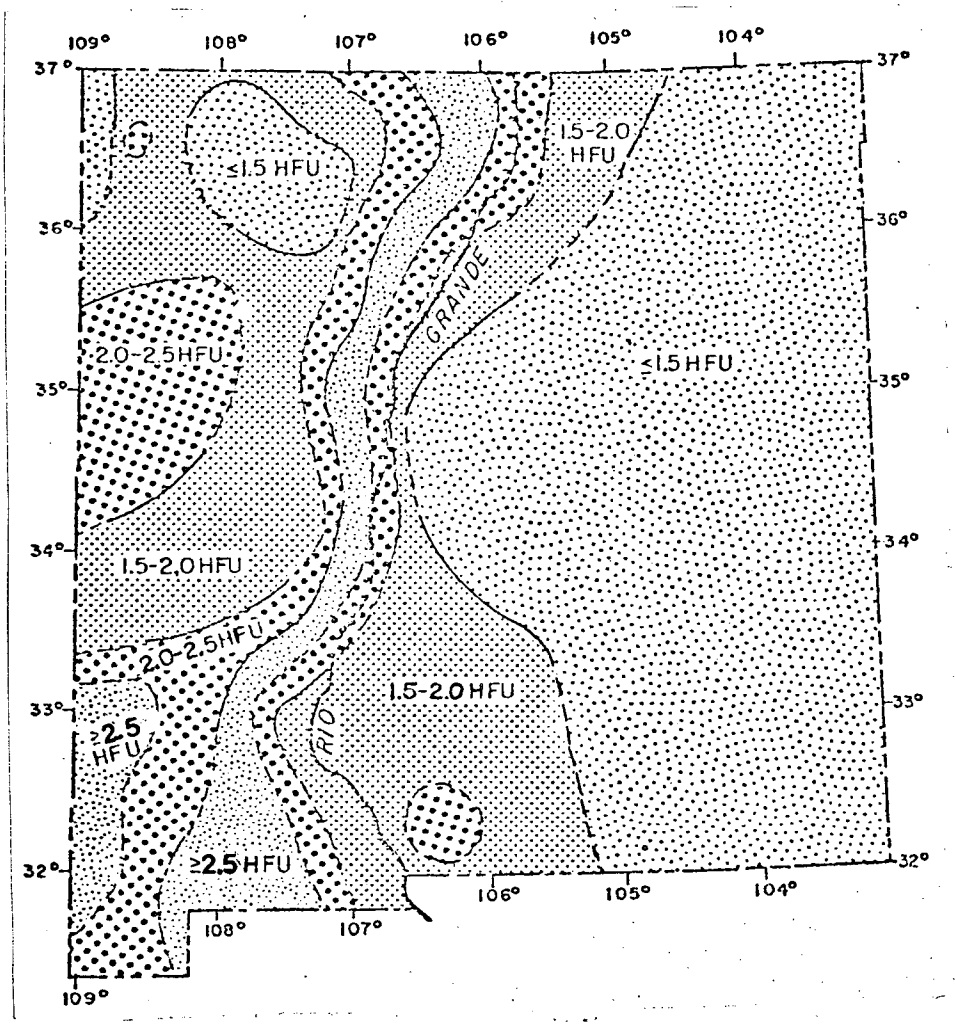


FIGURE 2 - - Terrestrial heat-flow contour map of New Mexico. Contour interval = 0.5 hfu (modified from Reiter and others, 1975).

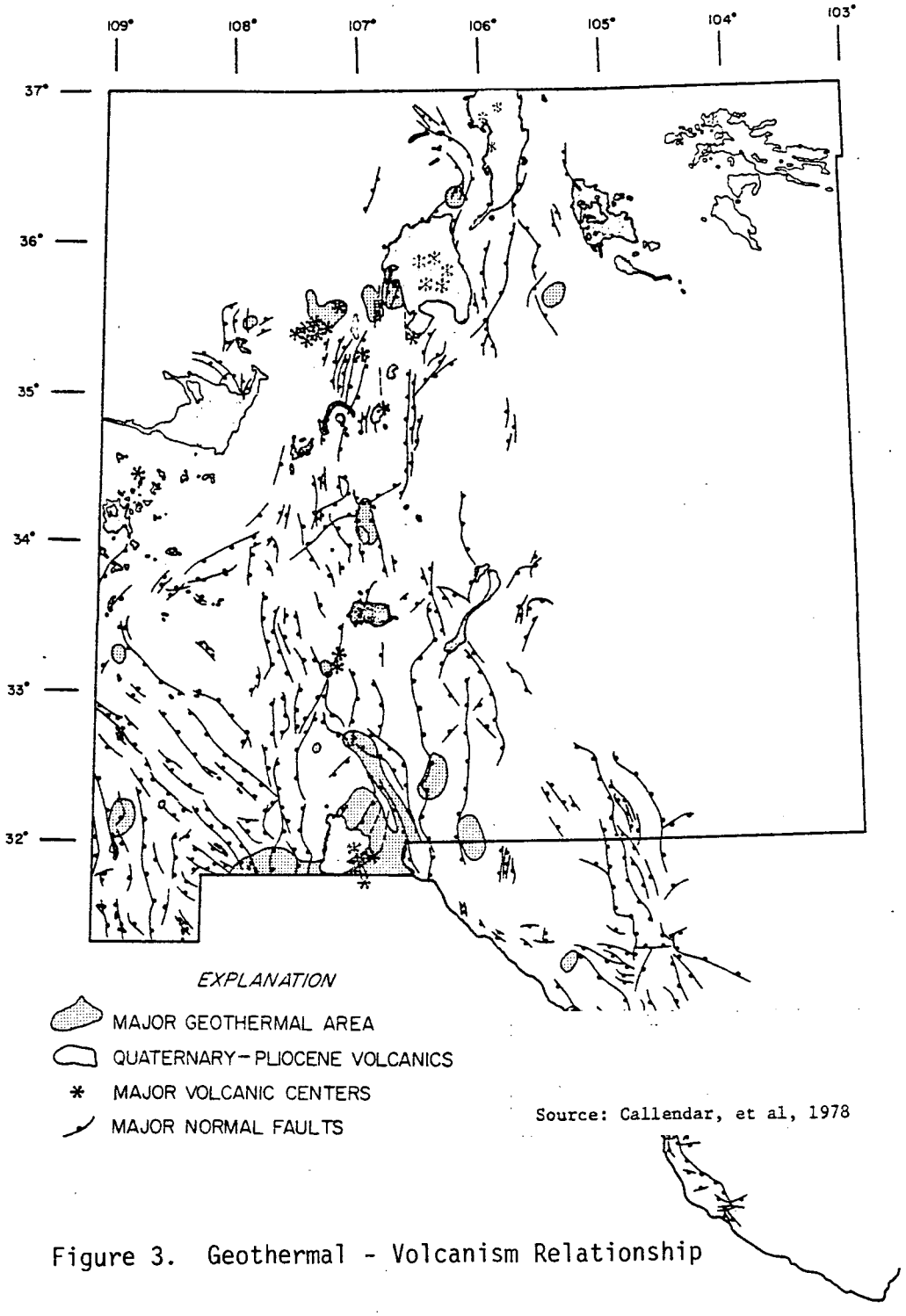


Figure 3. Geothermal - Volcanism Relationship

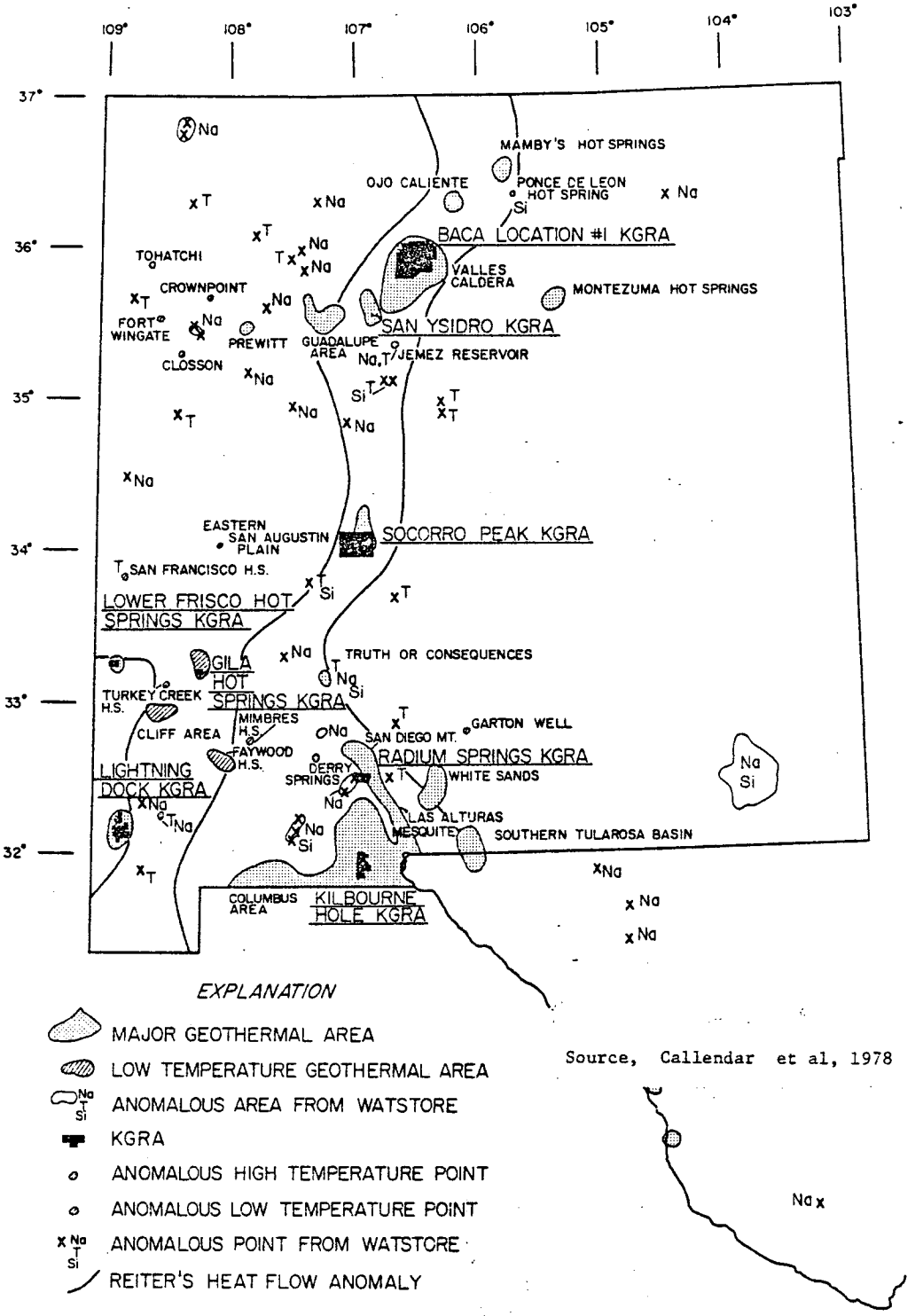


Figure 4. Geothermal Base Data Map

STATUS OF GEOTHERMAL DEVELOPMENT

Current Situation

Until recent years, New Mexico's heat resource was used only in resort spas, where the discharging waters of hot springs or the deposits they build attract tourists. Some small use is also made of hot springs as water supplies for irrigation, livestock or communities, but these uses do not take advantage of thermal properties of the water. In some instances, the anomalous temperature of the water detracts from its use.

Although a great amount of interest exists in New Mexico's geothermal resource, there are relatively few situations where it has been practically applied. There are only a few buildings in New Mexico presently using geothermal energy for space heating or cooling. No where in the state is geothermal energy currently used to generate electricity on a commercial basis although Union Oil will put its first plant on line in 1982. A listing of the current uses of geothermal energy in the state is in Table 1.

Due to the strong interest expressed by private industry, the federal government, the State of New Mexico and municipal governments, a multitude of projects are under way aimed at using the enormous capabilities of this energy resource.

One of the most promising state geothermal areas lies in the Valles Caldera, an ancient volcano in the Jemez Mountains West of Los Alamos (Baca Location No. 1 KGRA). Here, Union Oil Company of California drilled wells ranging in depth from 6,000 to 9,000 ft. and cost from $500,000 to $1,000,000 per well. Of the 17 tests drilled to date, 6 are reported to have produced hot water and/or wet steam with temperatures of about 495°F. Public Service Company of New Mexico, the state's largest electric utility, has joined with Union Oil Company in submitting a proposal to the U.S. Department of Energy for a 50 MW geothermal generation facility. Funding has recently been approved and the plant should be producing by 1982.

Other drilling activity in the state includes operations by Sunoco Development Company, Amax Exploration, Chevron Oil, Sandia Laboratories and the State of New Mexico. Each of these entities has already started drilling or is about to start drilling operations utilizing hydrothermal systems. In addition, a number of other entities hold geothermal leases which are expected to eventually lead to drilling programs.

In addition to the hydrothermal system projects, a major experiment also is underway utilizing hot, dry rock. Los Alamos Scientific Laboratory is coordinating this project, the only one of its kind in the United States, at a site near Fenton Lake. Here, cool water is pumped deep into the ground, heated by fractured rocks and recovered as steam. The project has resulted in numerous technical achievements including the development of the nation's only hot, dry rock generating facility in the nation. In September 1977, a 4 megawatt thermal energy extraction loop was operated for approximately 100 hours. This experiment has attracted international attention. LASL and the Italian National Electrical Agency have agreed to cooperate in geothermal research on reservoir stimulation. West Germany, Austria, and Japan may join in a partnership with LASL in the HDR project.

Currently, LASL is enlarging the facilities at Fenton Lake that will include larger piping and pumping capacities. New tests are expected to start before September and energy extraction should achieve at least 10 megawatts thermal. New drilling that go 4,000 feet deeper into hotter rock will begin in the early part of 1979.

TABLE 1

CURRENT USE OF
GEOTHERMAL ENERGY IN THE STATE

SPACE HEATING:	Animas Valley Truth or Consequences (Yucca Lodge) Gila Hot springs Albuquerque (Sandia Savings Building)
GREENHOUSES:	Jemez Springs Silver City Animas Valley
RESORT SPAS AND BATHOUSES:	Faywood Springs Radium Springs Jemez Hot Springs Gila Hot Springs Ojo Caliente San Antonio Warm Spring Mamby's Hot Spring Upper San Francisco Hot Spring Mimbres Hot Springs
SWIMMING POOLS:	Truth or Consequences: Carrie Tingley Hospital Yucca Lodge Faywood Hot Springs: Southwestern Services to Handicapped Children and Adults Radium Hot Springs Health Resort Ojo Caliente Mineral Springs Co. Jemez Hot Spring (Village operated) Ponce de Leon Hot Springs (private) Montezuma Hot Springs (private)
WATER SUPPLY:	San Antonio Spring (home) Socorro (Community) Gila Hot Springs (Ranch and Lodges) Animas Valley (Ranches) Las Alturas (Subdivision) Kennecott Warm Springs (Kennecott Copper Co.) Apache Tejo Hot Springs (Kennecott Copper Co.)

TABLE 2

STEPS FOR GEOTHERMAL RESOURCE DEVELOPMENT

MINIMUM TIME	ACTIVITY
2 mo.	PRELIMINARY EVALUATION OF AREAS
	OBTAIN LEASES
2 mo.	BLM
3 mo.	USFS
7-8 mo.	State
?	Fee
	PERMITS FOR GRADIENT HOLES
2 mo.	State
3 mo.	USGS
1 mo.	USFS
2 mo.	CONTRACT FOR DRILLING
½	DRILL GRADIENT HOLES & EVALUATE
3 mo.	REASIBILITY AND ENGINEERING STUDIES
	OBTAIN FINANCING FOR EXPLORATORY WELLS
1 mo.	Loan
6 mo.	Bond Issue
6 mo.	Government
	PERMITS FOR EXPLORATORY WELLS
2 mo.	State - OCD, Engineer
3 mo.	USGS
1 mo.	USFS
2 mo.	City or County (if necessary)
2 mo.	HIRE DRILLING CONTRACTOR
1 mo.	DRILL EXPLORATORY WELL
1 mo.	EVALUATE POTENTIAL OF RESOURCE
1 mo.	OBTAIN WATER RIGHTS IF NECESSARY
1 mo.	SECURE MARKET OR ESTABLISH HEATING/COOLING DISTRICT
	OBTAIN FINANCING FOR DEVELOPMENT
1 mo.	Loan
6 mo.	Bond Issue
6 mo.	Government
2 mo.	PERMITS FOR DEVELOPMENT
3 mo.	R.O.W. FOR PIPELINES
2 mo.	CONTRACT FOR CONSTRUCTION OF FACILITIES
6 mo.	INSTALL SYSTEM
1 mo.	OBTAIN FINANCING FOR PRODUCTION WELLS
1 mo.	Loan
6 mo.	Bond Issue
6 mo.	Government
	PERMITS FOR PRODUCTION, DISPOSAL, ETC.
2 mo.	State
15 mo.	USGS
1-18 mo.	USFS
6 mo.	County or City
2 mo.	HIRE DRILLING CONTRACTOR
1 mo.	DRILL ONE WELL

Source: Coe, B, 1978

LEASING

Leases for geothermal development are currently being granted on Federal, State, and private lands within New Mexico. At present, the U.S. Geological Survey (USGS) has designated eight "Known Geothermal Resource Areas" (KGRA's). KGRA's serve to define areas of active interest.

Six of the eight New Mexico KGRA's are classified by the USGS as being in the intermediate and high temperature hot water convection system range. The eight KGRA's and associated temperatures are:

1) Baca Location No. 1, Sandoval County, 240°C (464°F).

2) Radium Hots Springs, Dona Ana County, 130°C (266°F).

3) Lower Frisco Hot Springs, Catron County 150°C (320°F).

4) Gila Hot Springs, Grant County, 125°C (257°F).

5) Lightning Dock, Hidalgo County, 170°C (388°F).

6) San Ysidro Hot Springs, Sandoval County, 80°C.

7) Kilbourne Hole, Dona Ana County, 155°C (311°F).

8) Socorro Peak, Socorro County, 72°C (161°F).

Baca No. 1 and Socorro Peak were designated KGRA's by USGS because of geologic evidence. The others were designated KGRA's because of competitive interest as defined by the simultaneous filing of the lease applications where the lands applied for in two separate applications overlapped each other by half or more. Each KGRA (leased by competitive bid) along with its buffer zone of marginal interest (non-competitive), many contain Federal, State, or private lands.

The distinction between KGRA leases and non-KGRA leases is that the former requires bonus bidding between competing entities for the lease. Geothermal leases outside KGRA's are issued to the first applicant to file for them and pay the first year's rental of $2 per acre.

Presently, all but two of these KGRA's have been opened for Federal leasing of the geothermal resources. Lower Frisco Hot Springs and Gila Hot Springs KGRA's are closed to Federal leasing right now. The U.S. Forest Service will soon complete Environmental Statements on geothermal leasing in these areas and will make a decision to lease or not to lease them.

To date, 40 competitive leases governing 28,698 ha. (70,911 ac.) and 45 non-competitive leases on 35,812 ha. (88,490 ac.) have been let on public lands. In addition, 186 non-competitive lease applications are still pending in New Mexico on approximately 150,185 ha. (371,098 ac.) of Federal lands and on State and private lands with minerals reserved to the Federal government.

The State of New Mexico also had issued geothermal leases on 63,374 acres. The State conducted lease sales on August, 1974, March 1975, July 1975 and October 1975; however, bids were received only for lands within or near indicated thermal anomalies and these lands were subsequently leased. The State Land Office has not issued any state leases since 1975. Neither the State nor the Federal Government keep records concerning the leasing of geothermal resources on private lands. Although some private holdings have been leased, many land owners are refraining from leasing to see what develops on leased lands adjacent to their property.

Indicative of increasing interest in New Mexico's geothermal potential are the prices received as bonuses at the BLM sale in May 1977. Aminoil, USA bid $133.76 per acre for 2,810 acres offered in the Baca Location No. 1 KGRA, an amount greater than many very competitive oil and gas leases receive.

TABLE 3

CONTROLLING AGENCY

NEW MEXICO GEOTHERMAL SURFACE AREA

Controlling Agency	Explored Sites[1] (Acres)	Unexplored Sites[2] (Acres)	Totals
Federal			
Public (BLM)	203,162	61,600	264,762
National Forest	59,821	9,000	68,821
Military		7,000	7,000
National Park/Mounment		1,000	1,000
Indian	30,000	4,000	34,000
State	87,709	3,000	90.709
Private	183,208	20,500	203,708
TOTAL	563,900	106,100	670,000
Number of Sites	18	41	59

[1]Explored sites include 8 KGRA's plus current leases outside the 8 KGRA; plus 10 other sites.

[2]Unexplored sites are probable surface area subject to exploitation (in most cases default value of 1000 acres is assumed) plus pending leases. As exploration continues, it can be expected that the site size of unexplored sites will expand.

TABLE 4

LEASING STATUS OF STATE LANDS IN NEW MEXICO

Acres Available	Acres Accepted	Remaining for Lease	Number of Leases Issued
13,000,000*	63,374	12,936,626	147

*All state land is available even though it might not be suitable for geothermal development.

LEASING STATUS OF FEDERAL LANDS IN NEW MEXICO

Federal Agency	Acres Theoretically Available	Acres Offered	Acres Bid on	Acres Accepted	Remaining For Lease
Bureau of Land Management	190,320	101,693	62,482	62,484	127,838
Forest Service	1,224,004	29,375	18,050	18,050	1,205,954

FOREST SERVICE NON-COMPETITIVE GEOTHERMAL LEASING AS OF 12/77 IN NEW MEXICO

Number of Applications	42
Number Issued	0
Number Pending	27

BUREAU OF LAND MANAGEMENT NON-COMPETITIVE GEOTHERMAL LEASING AS OF 12/77 IN NEW MEXICO

Number of Applications	574
Number Issued	85
Number Pending	146

AGE OF FEDERAL LAND NON-COMPETITIVE LEASE APPLICATIONS STILL PENDING AS OF 4/78

Agency	5 Months or less	6-11 Months	12-17 Months	18-23 Months	24-35 Months	36 Months or More	Totals
Bureau of Land Manage-ment	23	11	24	0	8	144	210
Forest Service	6	5	0	0	3	23	42

TABLE 5

FEDERAL ACTIVE NON-COMPETITIVE GEOTHERMAL LEASES
IN NEW MEXICO AS OF MARCH 30, 1978

LESSEE (OR ASSIGNEE)	ACRES	TOWNSHIP & RANGE	DATE ISSUED
Jack F. Grimm	2,560.00	T. 26 S., R. 1 E.	6-11-75
(Assignee)	2,508.36	T. 25&26 S., R. 1 E.	6-11-75
	1,195.85	T. 25 S., R. 1 E.	6-11-75
Jack F. Grimm	1,176.80	T. 25 S., R. 1 E.	6-11-75
	2,127.10	T. 25 S., R. 1 E. & T. 26 S., R. 1 E.	6-11-75
Oxy Petroleum Corp.	1,200.00	T. 15 N., R. 1 E.	1-07-77
Lamar Hunt	2,560.00	T. 28 S., R. 2 W.	5-29-75
(Assignee)	2,560.00	T. 28 S., R. 2 W.	5-29-75
	2,557.96	T. 28 S., R. 2 W.	5-29-75
	1,918.20	T. 28 S., R. 2 W.	5-29-75
	2,560.00	T. 28 S., R. 2 W.	5-29-75
Caroline Lewis Hunt	1,230.92	T. 27 S., R. 1&2 W.	5-30-75
(Assignee)	2,160.00	T. 27 S., R. 2 W.	5-30-75
Norma Knobel Hunt	2,422.02	T. 29 S., R. 1 W.	5-29-75
(Assignee)	2,302.36	T. 29 S., R. 2 W.	5-29-75
	1,662.66	T. 29 S., R. 1&2 W.	4-28-76
	1,919.90	T. 29 S., R. 1&2 W.	5-29-75
Aminoil USA, Inc.	965.97	T. 23&24 S., R. 19 W.	12-28-76
Aminoil USA, Inc.	1,280.00	T. 24 S., R. 19 @.	12-28-76
	518.00	T. 23&24 S., R. 19 W.	11-30-76
	1,931.24	T. 24 S., R. 19 W.	11-30-76
U.S. Geothermal Corp.	1,285.32	T. 26 S., R. 19 W.	1-07-77
U.S. Geothermal Corp.	1,029.253	T. 25 S., R. 12 W.	1-07-77
Thermal Resources, Inc.	1,320.00	T. 25 S., R. 19 W.	1-07-77
Earth Power Corp.	533.68	T. 26 S., R. 19 W.	12-28-76
Lamar Hunt	2,560.00	T. 28&29 S., R. 2 W.	5-29-75
W. H. Hunt	2,549.86	T. 26 S., R. 1 W.	5-29-75
(Assignee)	2,538.66	T. 26 S., R. 1 W.	5-29-75
	2,492.96	T. 26 S., R. 2 W.	5-29-75
Nelson Bunker Hunt	2,400.00	T. 26 S., R. 2 W.	5-29-75
Hugo W. Schoellkopf, Jr.	2,440.00	T. 27 S., R. 2 W.	5-29-75
(Assignee)	2,558.56	T. 27 S., R. 2 W.	5-29-75
	2,240.00	T. 27 S., R. 2 W.	5-29-75
	2,398.36	T. 27&28 S., R. 2 W.	5-29-75
Nancy B. Hunt	1,280.00	T. 28 S., R. 2 W.	5-29-75
Nelson Bunker Hunt	2,494.92	T. 26 S., R. 2 W.	5-29-75
(Assignee)	2,551.72	T. 26 S., R. 2 W.	5-29-75
	2,384.78	T. 26 S., R. 2 W.	5-29-75
	2,400.00	T. 26 S., R. 2 W.	5-29-75
	1,935.25	T. 26 S., R. 2 W.	5-29-75
	2,474.41	T. 26 S., R. 1&2 W.	5-29-75
Chevron Oil Co.	640.00	T. 27 S., R. 20 W.	12-28-76
Phillips Petroleum Co.	2,527.36	T. 27 S., R. 1 E.	5-27-77
	2,544.80	T. 27 S., R. 1 E.	5-27-77
Sun Oil Co. (Delware)	1,453.84	T. 15 N., R. 3 W. & T. 15 N., R. 4 W.	7-28-77
	83.48	T. 15 N., R. 3 W.	8-19-77

TABLE 6

FEDERAL COMPETITIVE GEOTHERMAL LEASES

AS OF APRIL 21, 1978

LESSEE	ACRES	TOWNSHIP & RANGE	DATE ISSUED
Anadarko	1,919.52	T. 27 S., R. 1 W.	6-26-75
	2,246.63	T. 27 S., R. 1 W.	"
	1,943.72	T. 27 S., R. 1 W.	"
	1,280.00	T. 27 S., R. 1 W.	"
	2,560.00	T. 27 S., R. 1 W.	"
	1,950.08	T. 27 S., R. 1 W.	"
	1,916.32	T. 28 S., R. 1 W.	"
	2,089.84	T. 28 S., R. 1 W.	"
	2,570.34	T. 28 S., R. 1 W.	"
Earth Power Corp.	1,885.42	T. 24 S., R.19 W.	9-2-76
Amax Exploration, Inc.	2,239.47	T. 25 S., R.19 W.	8-12-76
Amax Exploration, Inc.	1,686.98	T. 18 N., R. 4 E.	7-18-77
	2,183.86	T. 18 N., R. 4 E.	7-19-77
Amax Exploration, Inc.	1,108.50	T. 21 N., R. 4 E.	7-19-77
Amax Exploration, Inc.	963.47	T. 21 N., R. 4 E.	7-19-77
	2,118.22	T. 21 N., R. 5 E.	7-19-77
Amax Exploration, Inc.	1,993.26	T. 21 N., R.3&4E.	11-30-77
Phillips Petroleum Co.	2,560.00	T. 25 S., R.19 W.	9-2-76
	2,338.37	T. 25 S., R.19 W.	9-2-76
Phillips Petroleum Co.	1,362.65	T. 18 N., R. 3 E.	6-28-77
Phillips Petroleum Co.	1,702.05	T. 18 N., R. 3 E.	6-28-77
	2,024.95	T. 18 N., R. 3 E.	6-28-77
Aminoil USA, Inc.	1,235.72	T. 25 S., R.19 W.	12-2-76
	1,271.64	T. 25 S., R.19 W.	12-2-76
Aminoil USA, Inc.	2,088.95	T. 18 N., R. 3 E.	7-25-77
Aminoil USA, Inc.	1,665.80	T. 19 N., R. 3 E.& T. 20 N., R. 3 E.	7-25-77
Aminoil USA, Inc.	1,114.33	T. 20 N., R. 3 E.	7-25-77
Aminoil USA, Inc.	1,235.45	T. 21 S., R. 1 W.	1-5-78
	2,177.14	T. 19&20,R. 2&3E.	1-5-78
	1,685.00	T. 20 N., R. 3 E.	1-5-78
	1,719.50	T. 20 N., R. 3 E.	1-5-78
Aminoil USA, Inc.	2,390.02	T. 3 S., R. 1 W.	4-4-78
Aminoil USA, Inc.	661.25	T. 3 S., R. 1 W.	4-4-78
Aminoil USA, Inc.	2,046.85	T. 3&4S., R. 1 W.	4-4-78
Aminoil USA, Inc.	1,920.00	T. 3 S., R. 1 W.	4-4-78
Chevron USA, Inc.	1,003.41	T. 21 S., R. 1 W.	1-11-78
Chevron USA, Inc.	224.19	T. 21 S., R. 1 W.	1-11-78
Texaco, Inc.	1,158.90	T. 21 S., R. 1 W.	11-30-77
Sunoco Energy Development Co.	2,072.99	T. 4 S., R. 1 W.	2-14-78
	2,565.08	T. 3&4S., R. 2 W.	2-14-78

TABLE 7

STATE OF NEW MEXICO GEOTHERMAL LEASES

LESSEE	COUNTY	ACRES	DATE ISSUED
Amax Exploration, Inc.	Sandoval	29.30	12-29-75
Amax Exploration, Inc.	Hidalgo	2,540.47	12-29-75
Amax Exploration, Inc.	Hidalgo	320.00	12-15-77
" " "	"	320.00	08-14-74
" " "	"	120.00	08-14-74
" " "	"	160.00	08-14-74
" " "	"	320.00	08-14-74
" " "	"	640.00	08-14-74
" " "	"	80.00	08-14-74
" " "	"	640.00	08-14-74
" " "	"	636.20	08-14-74
" " "	"	636.28	08-14-74
" " "	"	640.00	08-14-74
" " "	"	480.00	08-14-74
" " "	"	263.64	08-14-74
" " "	"	526.92	08-14-74
" " "	"	320.00	08-14-74
" " "	"	480.00	08-14-74
" " "	"	160.00	08-14-74
" " "	"	400.00	08-14-74
" " "	"	640.00	08-14-74
" " "	"	280.00	08-14-74
" " "	"	400.00	08-14-74
Jack A. Grimm	Dona Ana	640.00	09-15-77
Calvert Geothermal Res., Inc.	Hidalgo	760.00	11-15-77
" " " "	"	278.66	11-15-77
" " " "	"	1,180.44	11-15-77
" " " "	"	729.99	11-15-77
" " " "	"	440.00	11-15-77
" " " "	"	122.28	11-15-77
" " " "	"	640.00	09-18-73
" " " "	:	1,271.84	09-18-73
Chevron USA, Inc.	Dona Ana	639.36	08-14-74
Fogelson, E E	Dona Ana	240.00	08-14-74
" " "	Sierra	640.00	08-14-74
" " "	"	160.00	08-14-74
" " "	"	160.00	08-14-74
" " "	"	320.00	08-14-74
" " "	Socorro	640.00	08-14-74
" " "	"	640.00	08-14-74
" " "	Sandoval	640.00	03-12-75
" " "	"	640.00	03-12-75
Aminoil USA, Inc.	Grant	400.31	08-14-74
" " "	"	360.00	08-14-74
" " "	"	160.00	08-14-74
" " "	"	120.00	08-14-74
" " "	"	480.00	08-14-74
" " "	"	320.00	08-14-74

Aminoil USA, Inc.	Grant	320.00	08-14-74
" " "	"	640.00	08-14-74
" " "	Hidalgo	640.00	08-14-74
" " "	"	640.00	08-14-74
" " "	"	320.00	08-14-74
" " "	"	640.00	08-14-74
" " "	"	480.00	08-14-74
" " "	"	640.00	08-14-74
" " "	"	640.00	08-14-74
" " "	"	640.00	08-14-74
" " "	"	640.00	08-14-74
" " "	"	637.72	08-14-74
" " "	"	40.00	08-14-74
" " "	"	480.00	08-14-74
" " "	"	40.00	08-14-74
" " "	"	441.79	08-14-74
" " "	"	160.00	08-14-74
" " "	"	40.00	08-14-74
" " "	"	640.00	08-14-74
" " "	"	160.00	08-14-74
" " "	"	640.00	08-14-74
" " "	"	640.00	08-14-74
" " "	"	40.00	08-14-74
" " "	"	520.00	08-14-74
" " "	"	640.00	08-14-74
" " "	Grant	40.00	03-12-75
" " "	"	440.00	03-12-75
" " "	"	162.89	03-12-75
" " "	"	87.16	03-12-75
" " "	"	640.00	03-12-75
" " "	"	120.00	03-12-75
" " "	"	403.52	03-12-75
" " "	"	82.06	03-12-75
" " "	"	200.00	03-12-75
" " "	"	40.00	03-12-75
" " "	Hidalgo	560.00	03-12-75
" " "	"	640.00	03-12-75
" " "	"	158.11	03-12-75
" " "	"	403.04	03-12-75
" " "	"	160.00	03-12-75
" " "	"	200.00	03-12-75
" " "	"	480.00	03-12-75
" " "	"	637.40	03-12-75
" " "	"	200.00	03-12-75
" " "	"	80.00	03-12-75
" " "	"	160.00	03-12-75
" " "	"	640.00	03-12-75
" " "	"	40.00	03-12-75
" " "	"	160.00	03-12-75
" " "	"	640.00	03-12-75
" " "	"	640.00	03-12-75
" " "	"	640.00	03-12-75
" " "	"	640.00	03-12-75
" " "	"	640.00	03-12-75

Aminoil USA, Inc.	Hidalgo	640.00	03-12-75
" " "	"	480.00	03-12-75
" " "	"	640.00	03-12-75
" " "	"	640.00	03-12-75
Wolter, Emmet E.	"	640.00	08-14-74
" " "	"	642.08	08-14-74
" " "	"	80.00	08-14-74
" " "	"	320.00	08-14-74
Antweil, Alan J.	Rio Arriba	585.52	08-14-74
Supron Energy Corp.	Grant	640.44	03-12-75
" " "	"	80.00	03-12-75
" " "	"	40.00	03-12-75
" " "	"	161.46	03-12-75
" " "	"	160.00	03-12-75
" " "	"	40.00	03-12-75
" " "	"	599.44	03-12-75
" " "	"	200.00	03-12-75
" " "	"	160.00	03-12-75
" " "	"	40.00	03-12-75
" " "	"	400.00	03-12-75
" " "	"	40.00	03-12-75
" " "	"	40.00	03-12-75
" " "	"	120.00	03-12-75
" " "	"	420.83	03-12-75
" " "	"	640.00	03-12-75
" " "	"	407.17	03-12-75
" " "	"	40.00	03-12-75
The Cherokee & Pittsburg Coal & Mining	Sandoval	640.00	03-12-75
" " " "	"	640.00	03-12-75
" " " "	"	644.08	03-12-75
" " " "	"	640.00	03-12-75
" " " "	"	589.11	03-12-75
" " " "	"	640.00	03-12-75
" " " "	"	640.00	03-12-75
Kelly, John M.	Socorro	640.00	03-12-75
" " "	"	640.00	03-12-75
" " "	"	64.27	03-12-75
" " "	"	640.00	03-12-75
" " "	"	640.00	03-12-75
Covello, J. W.	"	640.00	03-12-75
Gulf Oil Corp.	"	550.56	03-12-75
" " "	"	640.00	03-12-75
" " "	"	320.00	03-12-75
" " "	"	640.00	03-12-75

TABLE 8

GEOTHERMAL DEVELOPERS/LESSEES/UTILITIES IN NEW MEXICO

Amax Exploration, Inc.
Aminoil USA, Inc.
Anadarko Oil Company
Calvert Geothermal Resources, Inc.
The Cherokee & Pittsburg Coal & Mining
Chevron Oil Company
Deuterium Geothermal Corporation
Earth Power Corporation
Fogelson, E.E.
Grimm, Jack F.
Gulf Oil Company
Hunt Energy Company
Kelly, John M.
Oxy Petroleum Company
Public Service Company of New Mexico
Phillips Petroleum Company
Sun Oil Company (Delware)
Supron Energy Corporation
Texaco, Inc.
Thermal Resources, Inc.
U.S. Geothermal Corporation
Union Oil Co. of California
Walter, Emmet E.
Wright, Hoover

GEOTHERMAL LEASING PROCEDURES

Private Land

There are no statutes or regulations specifically concerning geothermal leases of private land. Therefore, any such lease could be obtained by direct negotiation with the owner of the geothermal resources. Determination of the owner is often difficult since much of New Mexico's land has been sold with the reservation of mineral rights in a previous owner. In any event, once the owner of the geothermal resources has been determined and located, and the lease negotiated, then a copy of the lease must be filed with the county clerk for the county or counties in which the land is located.

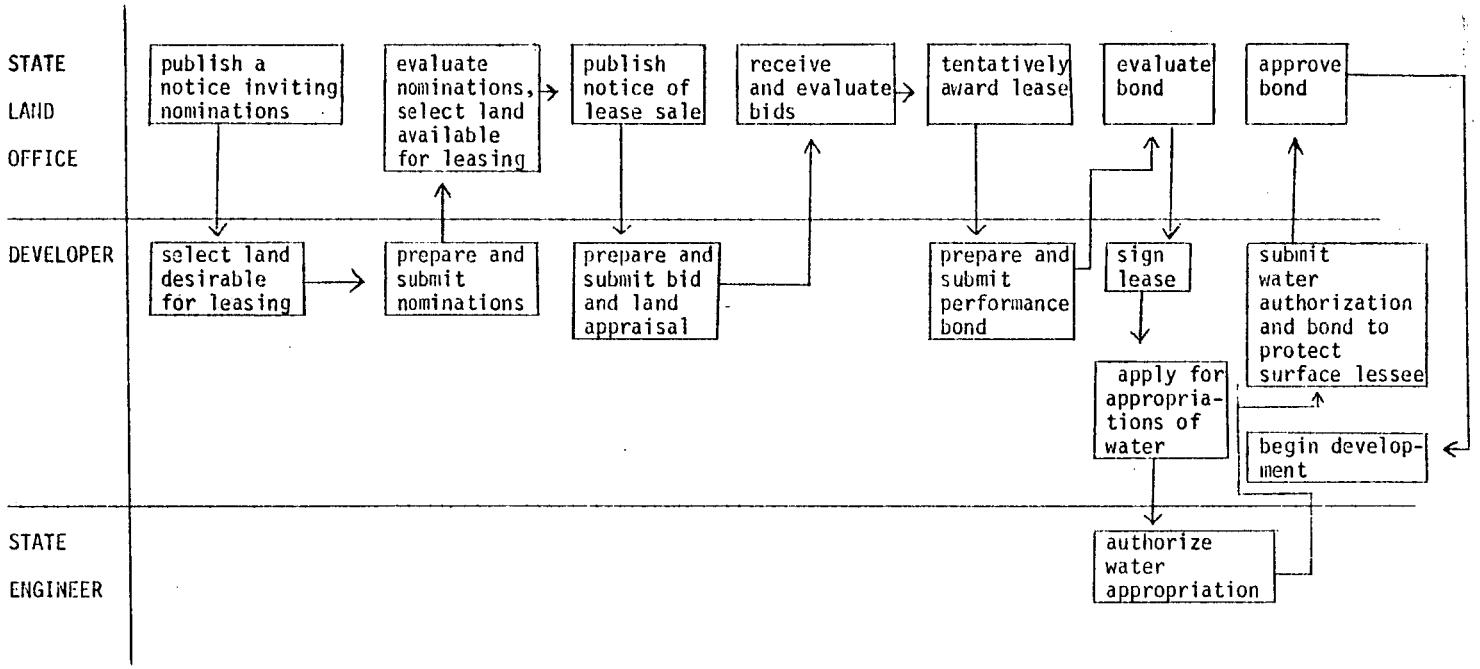
State Land

Geothermal leases of state land are controlled by the Geothermal Resources Act, discussed above, and rules and regulations adopted by the Commissioner of Public Lands pursuant to that act. Initial procedures for obtaining a geothermal lease depend upon the status of the specific land desired for leasing. If the land is under the jurisdiction of a stage agency other than the Commissioner of Public Lands or under the jurisdiction of a school district, then application for the lease cannot be made until the agency or school district has requested that the Commissioner make the land available for leasing. Likewise, if the land surface has been sold by the state prior to 1967 with mineral rights (but not geothermal rights) reserved to the state, then the surface patentee or contract purchaser must first be consulted. If the land has been classified by the Commissioner as a "known geothermal resources field", then a base can be obtained only by competitive bidding at a public auction. Also, land withheld for other reasons may not be subject to leasing. A developer can determine the land status by checking the tract books of the State Land Office.

The Geothermal Resources Act gives the Commissioner broad powers in issuing geothermal leases. Under the act, he may withhold any land from leasing and may reject any application for a lease at any time before a lease is issued. He also has the power to require competitive bids for leases or may issue leases on merely a priority of application basis. By Order No. 1-1974, the Commissioner has ruled that all applications for geothermal leases will be rejected and that such leases will only be obtainable through competitive bidding. Therefore, since the date of that order (March 26, 1974) all state lands have been withheld from priority leasing and are leased only by competitive bidding at a public auction.

The procedures for obtaining a lease are shown in Figure 4. The Commissioner initiates a lease sold by publishing a notice asking for nominations that certain land be obtainable for leasing. Pursuant to the notice, a developer will determine what land he desires to lease and the status of the land and will submit a nomination for that land to the Commissioner. Upon receipt of the nominations, the Commissioner evaluates the land nominated in order to determine which tracts of land will bring the maximum benefit to his trust beneficiaries. After such determinations, he will publish a notice that the tracts of land are available for geothermal leasing by competitive bidding. Application for a lease is made upon forms prescribed by the Commissioner and must be accompanied by an application fee, the first year's rental, the bonus offered and an appraisal of the value of the land for geothermal lease purposes.

Figure 5. Geothermal Leasing Procedure for State Lands



The lease is awarded to the developer offering the highest bonus.

No lease may be issued until a performance bond is filed with the Commissioner to guarantee payment of royalties. The amount of royalties is specified in the lease but may be waived, or reduced by the Commission in order to promote development. Leases are for an initial term of five years with a right to renew for another five years. They also are assignable and may be used for collateral security. After a lease is issued, the Commissioner retains a broad power over geothermal development and protection of both surface and subsurface resources.

No geothermal lessee of state lands may begin operations until he has filed a bond with the Commissioner in order to protect the surface lessee. Also, if the geothermal lessee plans to appropriate water for use in geothermal development, then no operations may be commenced until a copy of a written authorization from the State Engineer to appropriate water is filed with the Commissioner.

Federal Land

The foundation of the federal geothermal leasing program is the Geothermal Steam Act of 1970. The act authorizes the Secretary of Interior to dispose of federal lands to develop geothermal steam found within the public, withdrawn and acquired lands, as well as land that has been conveyed subject to the reservation of mineral rights. The act provides two primary ways to obtain leases: competitive bid sales, and non-competitive applications. A non-competitive lease is free except for certain procedural expenses such as filing fees. A bonus fee is required to obtain a lease in competitive sale. Whether or not competitive bidding occurs depends if the land is located within a Known Geothermal Resource Area (KGRA).

A third way to obtain a geothermal lease is to convert an interest previously obtained under other statutes such as the Mineral Land Leasing Act of 1920. This "grandfather" right was rather controversial during the legislative evolution of the 1970 act.

The Department of Interior has assigned the responsibility for geothermal leasing to two agencies, the Bureau of Land Management and the U.S. Geological Survey. The BLM has the authority to issue and enforce leases, while the U.S.G.S. manages the actual lease operations. This division of responsibility is similar to the arrangements in other leasing programs.

The 1970 act provides for a preliminary lease term of ten years, but the lessee may obtain an extension of up to forty years by achieving production of steam in commercial quantities. After this term expires, the lessee has a preferential right to renew for additional forty year terms. A five year extension of the original ten year primary term is available if the lessee is diligently engaged in drilling operations when the tenth year ends. The 1970 act states that royalties must not be less than ten percent or more than fifteen percent of the value of the steam or any other form of heat or energy. The 1970 act also establishes an annual rental payment of not less than one dollar per acre.

Indian Land

Ownership of Indian lands is theoretically vested in the federal government. Therefore, any geothermal lease is between the United States and the developer, with the tribe consenting to the lease and receiving royalty benefits. However, in actual practice, geothermal leases are obtained by direct negotiation between the developer and the applicable Indian tribe. After the lease agreement has been made, it is then submitted to the Secretary of Interior or his designee, usually the BIA supervisor of the particular tribe, for his approval.

STATE REGULATORY AUTHORITY

Oil Conservation Division

Primary responsibility over geothermal development rests with the Oil Conservation Division under the authority of the Geothermal Resources Conservation Act. The Commission has broad authority under the act to prevent waste and protect correlative rights and has adopted extensive regulations to exercise its authority.

Under the act and its regulations, the Division requires bond, permits and comprehensive reports to be submitted by developers and may regulate virtually all aspects of development and production. The jurisdiction of the Oil Conservation Division applies to all geothermal developments on private or state lands and applies to leases on federal land to the extent that such jurisdication is not inconsistent with United States regulations.

Energy and Minerals Department

The Energy and Minerals Department has broad powers concerning all aspects of energy development within New Mexico. The Department is composed of the Energy Resources Development Division, Mining and Minerals Division, Energy Conservation and Management, and Oil Conservation Division. Its duties include maintaining complete records of energy activity in the state and it may subpoena records and individuals. As noted above, specifically concerning geothermal development, Energy & Minerals Department has the power to review the decisions of the Oil Conservation Division. Also, every producer must notify the Division within five days of the completion of any well capable of producing geothermal energy in commercial quantities.

State Engineer

In addition to the regulatory functions of the Oil Conservation Division of the Energy & Minerals Department, any developer desiring to drill a geothermal well within a declared underground basin from which water as a gas or liquid, will be withdrawn must first obtain a permit from the State Engineer to drill and appropriate the geothermal resources. New Mexico statutes and regulations promulgated by the State Engineer set forth the procedures necessary to obtain

a permit to appropriate water, as well as license requirements for well drillers. The construction, repair and plugging of water wells are also regulated by the State Engineer.

State Land Commissioner

As discussed above, any geothermal development on state land is also subject to the jurisdiction of the State Land Commissioner. The Commissioner retains a large amount of control over surface and subsurface conditions, as well as production, even after the issuance of a lease.

Environmental Improvement Division

The Environmental Improvement Division of the Health and Environment Department, is responsible for environmental management and protection throughout the state. Concerning geothermal development, the Division has regulatory authority over air quality, radiation control, noise control and occupational health and safety. The Environmental Improvement Division also serves as the staff for the Water Quality Control Commission which regulates aspects of water quality. Neither the Environmental Improvement Division nor the Water Quality Control Commission has yet enacted regulations specifically relating to geothermal development.

RESOURCE

GEOTHERMAL RESOURCE ASSESSMENT AND SCENARIO DEVELOPMENT

The chief objective of this project has been to develop and refine site-specific scenarios for all potential geothermal resources in the state.

These geothermal resource areas were identified by studying the records of geothermal leases on public lands obtained from state and federal agencies. Subsequently, discussions were held with lease holders to learn about the current status and future plans. Additional information and ideas for future development plans were gleaned through various publications and conversations with community groups and potential users. These publications included catalogs of hot springs and wells, pertinent geophysical data, and documents on historical geologic activity.

The information was complied and interpreted into the standard format of General Description, Site Map, Resource Characteristics, Development Status and Activity, Serious Development Problems and Development Schedule. The resource areas were organized into categories in order to simplify the scenario preparation (see Table 9). Only for those sites in which there has been considerable activity and interest, has a development schedule been predicted. The following sites with significant leasing and development have been processed:

Albuquerque
Animas (Lightning Dock)
Jemez Springs
Kilbourne Hole
Las Alturas
Ojo Caliente
Radium Springs
San Ysidro
Socorro
Truth or Consequences
Valles Caldera

TABLE 9

GEOTHERMAL RESOURCE DEVELOPMENT SCHEDULE CATEGORIES

JULY 1978

1. Significant Commercial Activity -
   Baca Location No. 1 (Valles Caldera)

2. Activity - Leases or Development
   A. Possible Power Generation Sites:
      Animas (Lightning Dock)
      Kilbourne Hole
      San Ysidro
      Radium Springs
      Socorro

   B. Possible Direct Application (Low and Moderate Temperature):
      Jemez Springs
      Animas
      Ojo Caliente
      Faywood
      Socorro
      Radium Springs
      Los Alturas

3. No Activity or Interest
   A. High Potential:
      Cliff-Gila-Riverside
      Albuquerque Basin
      Gila Hot Springs
      Truth or Consequences
      Tularosa Basin
      Anthony - Mesquite
      Lower San Francisco H.S.

   B. Moderate Potential:
      Playas
      Rincon
      Montezuma
      Jornada del Muero
      Hueco - S. Tularosa
      Las Palomas
      Mamby H.S.
      Deming
      Mimbres H.S.
      West Mesa

   C. Low Potential:
      Ponce de Leon
      Aleman
      Closson
      Crownpoint
      Derry
      White Sands

TABLE 10

NEW MEXICO HIGH-TEMPERATURE RESOURCE PROSPECTS[a]

	Lat.	Long	T surface (°C)	T SiO2 (°C)	T NaKCa (°C)	T subsurface (°C)
Areas Sampled:						
Baca Location No. [b]	35°43'	106°32'	87	177	234	240
Lightning Dock[b]	32°08.5'	108°50'	99	160	167	170
Guadulape Area	35°30'	107°15'	35	156	177	170
Columbus Area	31°45'	107°30'	31	135	195	155[c]
Kilbourne Hole[b]	31°45'	106°50'	28	133	200	155[c]
Lower Frisco H.S.[b]	33°15'	108°47'	49	132	148	150
Radium Springs [b]	32°30'	106°55.5'	50	118	223	130[c]
Mamby's H.S.	36°31.6'	105°40.6'	41	116	168	125[c]
San Diego Mountain	32°38'	106°58'	warm	105	233	125[c]
Mesquite-Berino	32°10.0'	106°40.0'	31	112	175	120[c]
Las Alturas	32°15.0'	106°46.0'	43	109	179	120[c]
Truth or Consequences	33°08.1'	107°15.2'	45	96	180	100[c]
Derry Spring	32°47.6'	107°16.6'	33	83	156	100[c]
Areas from WATSTORE:						
Southern Tularosa Basin	32°05'	106°05'	71	--	--	150
White Sands (Town)	32°25'	106°25'	54	114	160	150
North of Socorro	34°20'	106°50'	41	110	166	150
Prewitt Area	35°26'	107°53.0'	46	100	200	150
Jemez Reservoir	35°20'	106°40'	warm	120	150	150
Lordsburg	32°13.7'	108°30.7'	33	91	151	150

[a] Source: Swanberg, 1978

[b] KGRA

[c] Estimated subsurface temperature in the 150-200°C range if mixing models are applied to the silica data.

TABLE 11

NEW MEXICO LOW-AND MODERATE-TEMPERATURE RESOURCE PROSPECTS[a]

	Lat.	Long	T surface (°C)	T SiO_2 (°C)	T NaKCa (°C)	T subsurface (°C)
Ojo Caliente	36°18.3'	106°03.0'	56	122	161	130
Montezuma H.S.	35°39.2'	105°17.4'	59	122	140	130
Ponce de Leon	36°19.4'	105°36.5'	34	106	92	105
San Ysidro[b]	35°35'	106°50'	52	89	160	100
Turkey Creek H.S.	33°06.5'	108°29.0'	74	117	68	L.T.
Gila H.S.[b]	33°10'	108°10'	66	129	77	L.T.
Closson	35°15.5'	108°19.4'	61	95	51	L.T.
Fort Wingate	35°30'	108°35'	61	--	--	L.T.
Mimbres H.S.	32°44.9'	107°50.1'	58	107	75	L.T.
Faywood H.S.	32°33.3'	107°59.7'	54	97	78	L.T.
Tohatchi	35°55.3'	108°34.7'	39	66	82	L.T.
San Francisco H.S.	33°49.8'	108°47.9'	37	97	52	L.T.
Crown Point	35°41.6'	108°08.4'	37	60	80	L.T.
E. San Augustin Plain	34°00.5'	108°05.5'	35	108	53	L.T.
Socorro[b]	34°05.0'	106°57.0'	34	61	72	L.T.
Garton Well	32°46.8'	106°09.9'	34	63	100	L.T.
Cliff Area	32°52.6'	108°35.0'	31	85	53	L.T.
Albuquerque Area	35°05'	106°45'	30	--	--	L.T.

[a] Source: Swanberg, 1978,
[b] KGRA

ALBUQUERQUE WBS 7061

General Description

Albuquerque lies in the Rio Grande rift, which is recognized as one of the major geothermal resource areas in the United States. Although there are no hot springs or similar surface manifestations in the immediate vicinity of the city, the proximity of young volcanoes, abnormal temperatures in nearby water and oil wells, and high heat flow to the west of the city testify to a yet undetermined resource. A type of geothermal direct thermal application is currently operating in the Sandia Savings Building in Albuquerque where two wells are used for supplying cool and warm waters for the heating and cooling systems.

A substitution of geothermal energy for space heating, water heating, cooling, industrial processing, etc. could satisfy a large portion of Albuquerque's projected development. This development is planned to the west of the current urban area into the region considered to be of higher geothermal potential.

Some wells drilled on the West Mesa have warm temperatures (83°-88°F.) but whether these temperatures increase to useable levels with increasing depth will be determined in the near future.

30.3 Development Status and Activity

Currently, there is no leasing, drilling, or exploration. A proposed project by an UNM geophysicist will hopefully provide a thorough evaluation of the resource potential.

30.4 Severe Development Problems

None are anticipated.

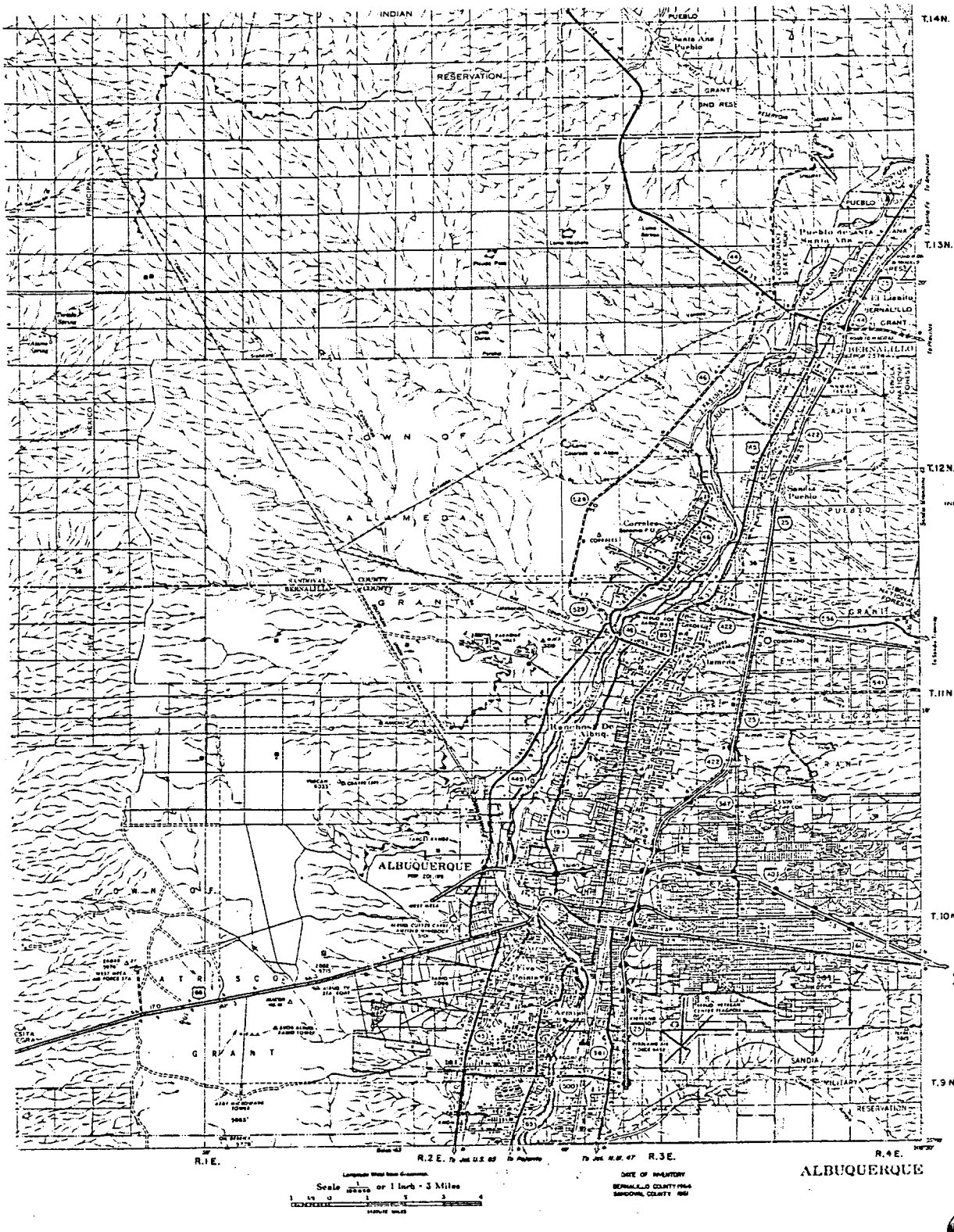


Figure 6. Albuquerque Geothermal Resource Area

ANIMAS WBS 7002

General Description

The Animas Valley area is located in central Hidalgo County in the extreme southwestern corner of the state. It is situated south of Interstate 10 and includes the Villages of Cotton City and Animas. Both villages have a population of less than 200 and heating needs are served by propane, butane, and natural gas.

The nearest town, lordsburg, has a population of 5,200 and it is six miles northeast of the valley. At Lordsburg, the Community Public Service Company operates a 55 MW power generating plant which uses primarily natural gas and small quantities of oil. Conceivably, CPS could be the potential utility for geothermal power generation.

The land in this valley is somewhat evenly divided among the state, federal, and private ownerships and is used for ranching and irrigated farming.

The best potential users of geothermal energy are the area residents who are very enthused and receptive to geothermal development particularly, direct-thermal use. According to what is known, the largest geothermally-heated greenhouse in the United States is located here with 100,000 sq. ft. of space for vegetables and crops. The heat source are the "section 7 hot wells" first drilled in 1948 and located near the community of Cotton City. The Animas Valley resource area also includes the Lightning Dock KGRA.

The Hidalgo County Farmer Coop has recently petitioned the Southwestern New Mexico Resource, Conservative, and Development Council for a feasibility study for a major geothermal dehydration plant. In July of 1978, the New Mexico Energy and Minerals Department funded a NMSU R & D project that will include a study of geothermal crop-drying. This research program is called, "Use of Geothermal for Agribusiness Development in Southwestern New Mexico." One important objective will be to design agricultural processing equipment and determine the cost of using geothermal water. This hopefully will assist the local farmers in achieving their goal in geothermal chil-pepper drying plants.

30.2 Resource Characteristics - LIGHTNING DOCK (ANIMAS)

Surface Fluid Temperature: 99°C in 95 foot well

Subsurface Fluid Temperature: 170°C

Total Dissolved Solids: 1120 ppm

Estimated Energy Potential: Inferred: 100 MW/30 years
Indicated: 20 MW/30 years

Type of Overlying Rock: Alluvium over tertiary volcanics

Estimated Depth from Top of Reservoir: Well struck steam at 88 feet

Estimated Size of Reservoir: 2.25 km^3

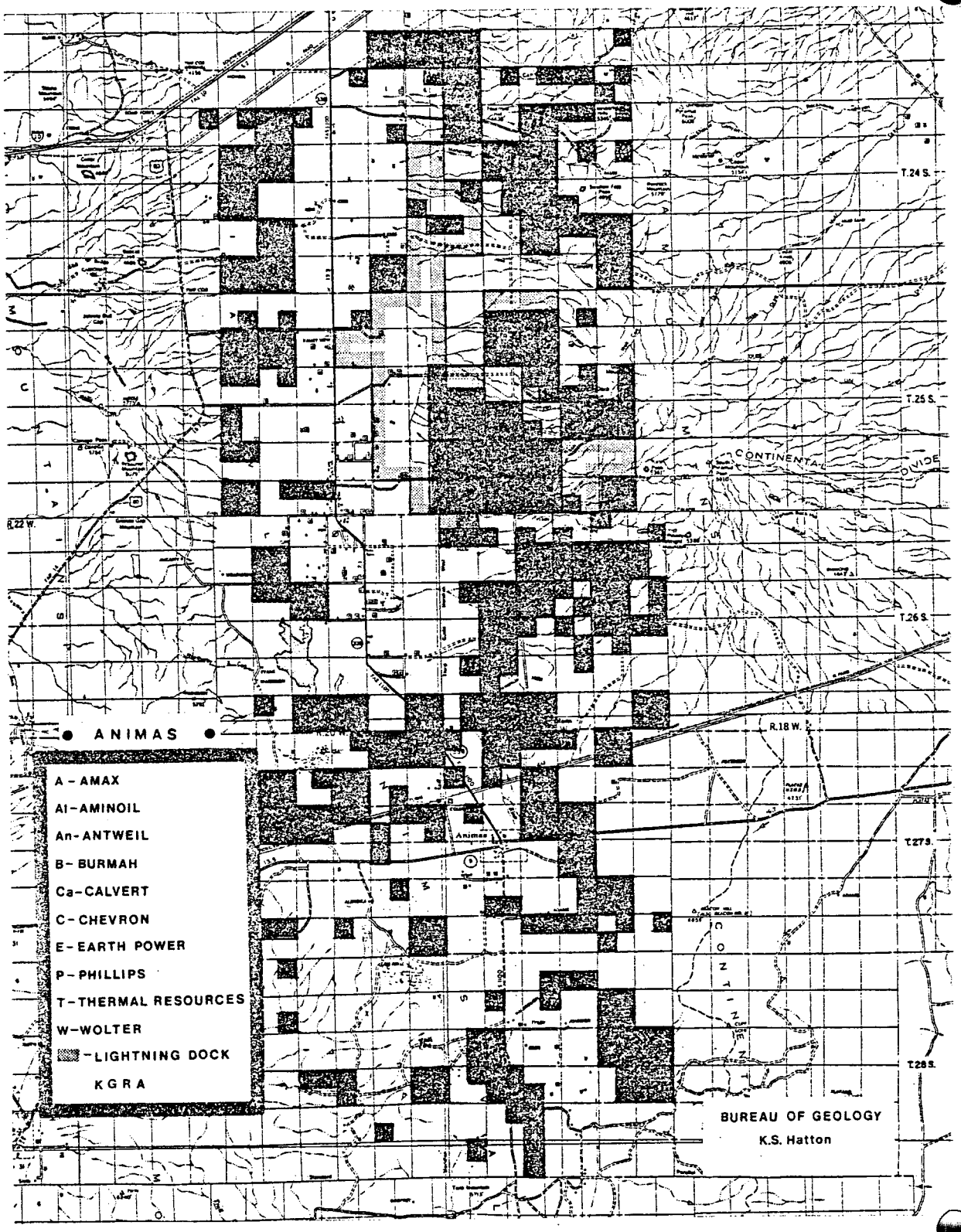


Figure 7. Animas Geothermal Resource Area

Site Location: T.25S., R.19W., Section 7

Latitude: 32° 8.5'N Longitude: 108° 50.W

County: Hidalgo

Land Ownership: State, federal, private

Land Use: Ranching and irrigated farming

Description of KGRA: Parts of T.24 and 25S., R.19 and 22N. Totaling 23,552 acres

Leasing Status: About 43,000 acres of federal lands have been leased in and around the KGRA.

About 33,120 acres of state lands have been leased in and around the KGRA.

Within the KGRA there are 12 federal leases.

30.3 Development Status and Activity

The following companies have drilled or will be drilling temperature gradient holes:

Aminoil	14
Chevron	8
Phillips	19
Amax	17

Amax plans to reenter an old oil well to run temperature survey. Chevron will make a dipole-dipole survey. The main lease holders are Burmah O&G, Chevron, Amax, Calvert-Geothermal, Aminoil, Phillips and Geothermal Resources. Current drilling activity is concentrated in T.27S., R20W., (West of Animas) and in T.25S., R.19W., (East of Cotton City). Steam and hot water was discovered while drilling an irrigation well in T.25S., R.19W., Section 7. There are no hot springs in the area.

The geothermal reservoir has not been proven yet. However, there are already several non-electric applications. These involve the space-heating of two ranches which includes several greenhouses. The area farmers and ranchers hope to plan a geothermal crop-drying plant this summer.

30.4 Severe Development Problems

The geohydrologic studies seem to indicate extensive mingling of the groundwater by a local geothermal anomaly. Although the temperature of this resource is high (170°C) the reservoir may be too limited for power generation unless extensive exploration indicate otherwise.

Despite the eagerness and enthusiasm shown by the area farmers and ranchers, they lack capital and direction to carry out plans they envision for crop-drying operations. Hopefully, the Hidalgo County Farmer's Coop will obtain the necessary incentives from all levels of government to exploit the geothermal resource.

30.5 Development Scenarios

Two scenarios, electric and direct use, were developed. The amount of power potential identified so far is quite low, at least 20 MW (electric). The inferred potential is 100 MW. Following the testing of the thermal gradient, the scenario will be adjusted according to the available information. The outlook for non-electric application is good, considering the attitude and planning of the local communities. One or more agricultural drying plants should be operational by 1980 or 1981.

Table 12

POSTULATED SITE DEVELOPMENT SCHEDULE
ANIMAS VALLEY

WBS 7002

OPERATING ENTITIES	ACTIVITY	1977	1978	1979	1980	1981	1982	1983	1984	1986	1990	1995	2000	2020
Developer	Conducts casual reconnaissance exploration	———	———											
BLM, State	Leases Land	———	———	———										
USGS	Makes environment assessment	. 1975												
USGS, State	Approves plan of operation and issues permit to explore	— —	—	—										
Developer	Conducts geophsical work and drills T.G. holes	—	———	———	—									
USGS	Makes EA for drilling deep exploratory wells			———	———									
USGS, State	Gives permission to drill				.									
Developer	Drill deep exploratory wells				———	———								
Developer	Conducts Feasibility Study					———								
Developer	Water rights application with State Engineer					—								
USGS	Makes EA for development						———							
	Gives permission to develop						.							
Developer	Drills development wells and runs production tests						———	———						
PSC	Certifies plant and site							—						
	Issue permits								.					
USGS	Approves plan of operation for production							—	———					

POSTULATED SITE DEVELOPMENT SCHEDULE
ANIMAS VALLEY

WBS 7002

OPERATING ENTITIES	ACTIVITY	1977	1978	1979	1980	1981	1982	1983	1984	1986	1990	1995	2000	2020
Utility	Obtains R.O.W. for Power Line								——					
Utility	Plant Construction								——	——				
Utility	Puts power on line										20 MW △——	10MW △——		

JEMEZ SPRINGS WBS 7006

General Description

The Jemez Springs area is centered around the hot springs in San Diego Canyon about two miles south of Soda Dam and twelve miles north of Jemez Pueblo. The population of the community is about 500 and it is entirely dependent on wood and propane for heating purposes. The several hot springs in this area have a top temperature of 169°F.

The present uses of geothermal energy involve a hot spring resort spa with bathhouses and swimming pools, and a greenhouse run by a Buddhist colony. The village, in conjunction with Coupland, Moran & Associates, have submitted a proposal to DOE for a district heating system in 1977. Unfortunately, the proposal was rejected. Nevertheless, the potential still remains for space heating, small agribusiness and wood products processing by geothermal energy. New plans for development are forthcoming soon. The development and use of geothermal energy would have an important effect on the economic development of the region.

The Jemez Springs area is bordered on the east side by the Baca Location No. 1 KGRA.

The San Diego Canyon, which includes Jemez Springs, is flanked on three sides by the Santa Fe National Forest situated on the volcanic uplands. Also, it is bordered on the east by the Baca Location No. 1 KGRA.

Soda Dam, a huge natural hot spring deposit, is also part of the geothermal area and is located one mile north of the village. The springs of this feature discharge at a maximum temperature of 115°F. These hot springs belong to the Forest Service and is used by the public for recreation. No commercial development is anticipated. However, the Forest Service, LASL, New Mexico Energy and Minerals Department, and the New Mexico Highway Department are all interested in restoring the dam and the spring flow to its original condition.

30.2 Resource Characteristics - JEMEZ SPRINGS

Surface Fluid Temperature: 73°C

Subsurface Fluid Temperature: 135°C

Total Dissolved Solids: 2100 ppm

Estimated Energy Potential: 12 MW centuries (thermal)
155.25 X 10^{15} calories

Type of Overlying Rock: Alluvium over Permian Sands and Shales

Estimated Depth from Top of Reservoir:

Estimated Size of Reservoir: 2.25 km^3 (assumed)

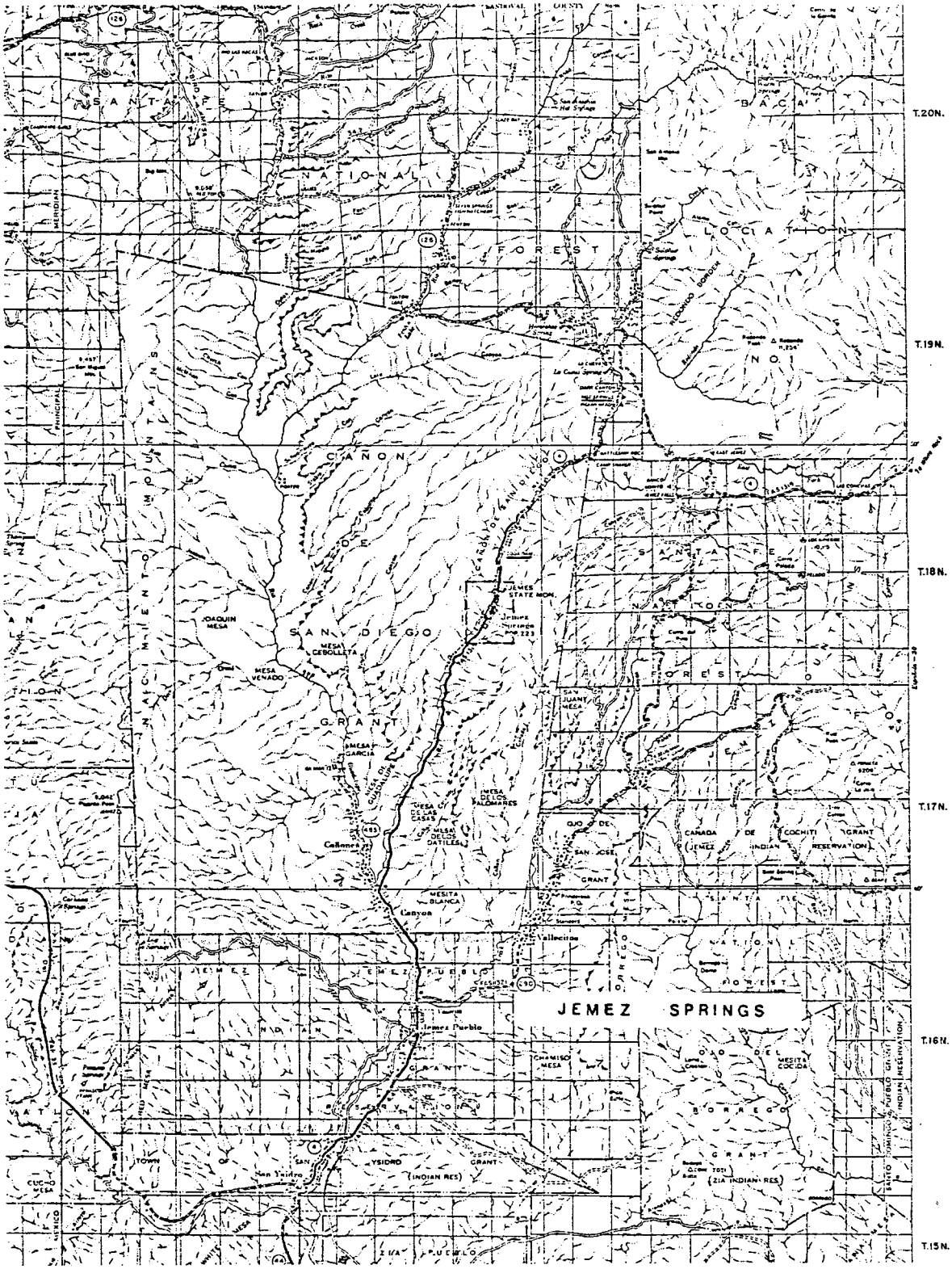


Figure 8. Jemez Springs Geothermal Resource Area

Site Location: T.18N., R.2E., Section 23

Latitude: 35°-47'N Longitude: 106°-4W

County: Sandoval

Land Ownership: Hot Springs is on village property. Village is located in Canon de San Diego grant.

Land Use: None

Description of KGRA: Baca Location No. 1, KGRA lies two miles to the East.

Leasing Status: Sun Oil controls most of the fee owned geothermal mineral rights in the San Diego grant, which includes T.17, 18, 19N., R.1&2E. This area lies immediately southwest of Baca Location No. 1.

Calvert Geothermal Resources filed on 7680 acres and Sun filed on 4000 acres of federal land in T.18N., R.2E. in January 1974. These blanket filings may pay off, since the ownership of the mineral rights is established.

East of Jemez Springs, in the lower part of the Baca Location #1 KGRA, T.18&19N., R.3&4E., the following hold leases, awarded at the competitive sale last May, (1977):

Amax	3871 acres
Phillips	5089 acres
Aminoil	2089 acres

30.3 Development Status & Activity

Although no commercial development is taking place, the Village of Jemez Springs is optimistic on its potential. Last year, the engineering firm of Coupland, Moran & Associates, 200 Altez, S.E., Albuquerque, New Mexico, put together a proposal for a project to utilize the geothermal resources of the area for space heating and domestic heating of hot water for the Village of Jemez Springs. The project would cost $3,510,119.80, of which DOE would pay $3,142,373.50. The proposal was rejected by DOE San Francisco office, December 27, 1977. However, some modification of the project probably will surface this summer.

30.4 Severe Development Problems

It appears doubtful that the project proposed by Coupland, Moran & Associates will ever become a reality, unless most of it is funded by some government organization. Perhaps there would be an eventual pay out if agribusiness and wood products processing operation used the heat energy on a more or less continuous basis, perhaps, through cogeneration.

But first it must be determined if the resource exists in sufficient quantity. This can be determined only by drilling, which in itself can be a large expense. Once the resource is proven, perhaps capital will be attracted to utilize the heat.

The New Mexico Energy and Minerals Department is presently seeking a funding source to conduct the drilling phase of this program.

KILBOURNE HOLE WBS 7004

General Description

The Kilbourne Hole geothermal area is located in Dona Ana County south of Las Cruces, immediately west of the Rio Grande Valley; its southern and extends into Mexico. It is a large area of dry desolate country containing lava flows, cinder cones and widely scattered ranch houses.

Kilbourne Hole itself is a maar, a crater-like feature probably caused by steam explosion near the surface, resulting from groundwater coming into contact with a molten intrusive mass. There are several such crater-like depressions in the area, which along with the volcanics attest to a time of high geothermal activity.

The size of the heat source is unknown, but geochemically derived subsurface temperatures are as high as 200°C (Na-K-Ca geochemistry). The KGRA itself occupies 25,133 acres in townships twenty-seven and twenty-eight south, range 1 west. The land is mostly federally owned.

There has been considerable interest in the area, as demonstrated by the geophysical surveys and geothermal gradient holes drilled. Some of the major companies that hold leases and/or have active exploration programs in the area are Anadarko, Phillips, Petroleum, and the Hunt Energy Corporation.

Las Cruces and El Paso, both less than forty miles away, could provide a market for any electricity generated. El Paso Electric Company could conceivably be the potential utility in this area including the Rio Grande Valley which has a population of about 500,000. Direct use, such as heating or processing, may be possible in the Rio Grande Valley to the East, depending on the need and pipeline problems. The Valley is largely dependent on an agriculture economy with natural gas for energy. Any input by geothermal energy will greatly enhance the stability and growth of the economy.

Because there are no known reserves at this time, the potential energy there is estimated.

30.2 Resource Characteristics - KILBOURNE HOLE

Surface Fluid Temperature: 45°C - 83°C

Subsurface Fluid Temperature: 155°C

Total Dissolved Solids: 4900 ppm

Estimated Energy Potential: Inferred 50 MW for 30 years
Indicated 20 MW for 30 years

Type of Overlying Rock: Volcanic

Estimated Depth from Top of Reservoir:

Estimated Size of Reservoir: 3.5 km^3 (assumed)

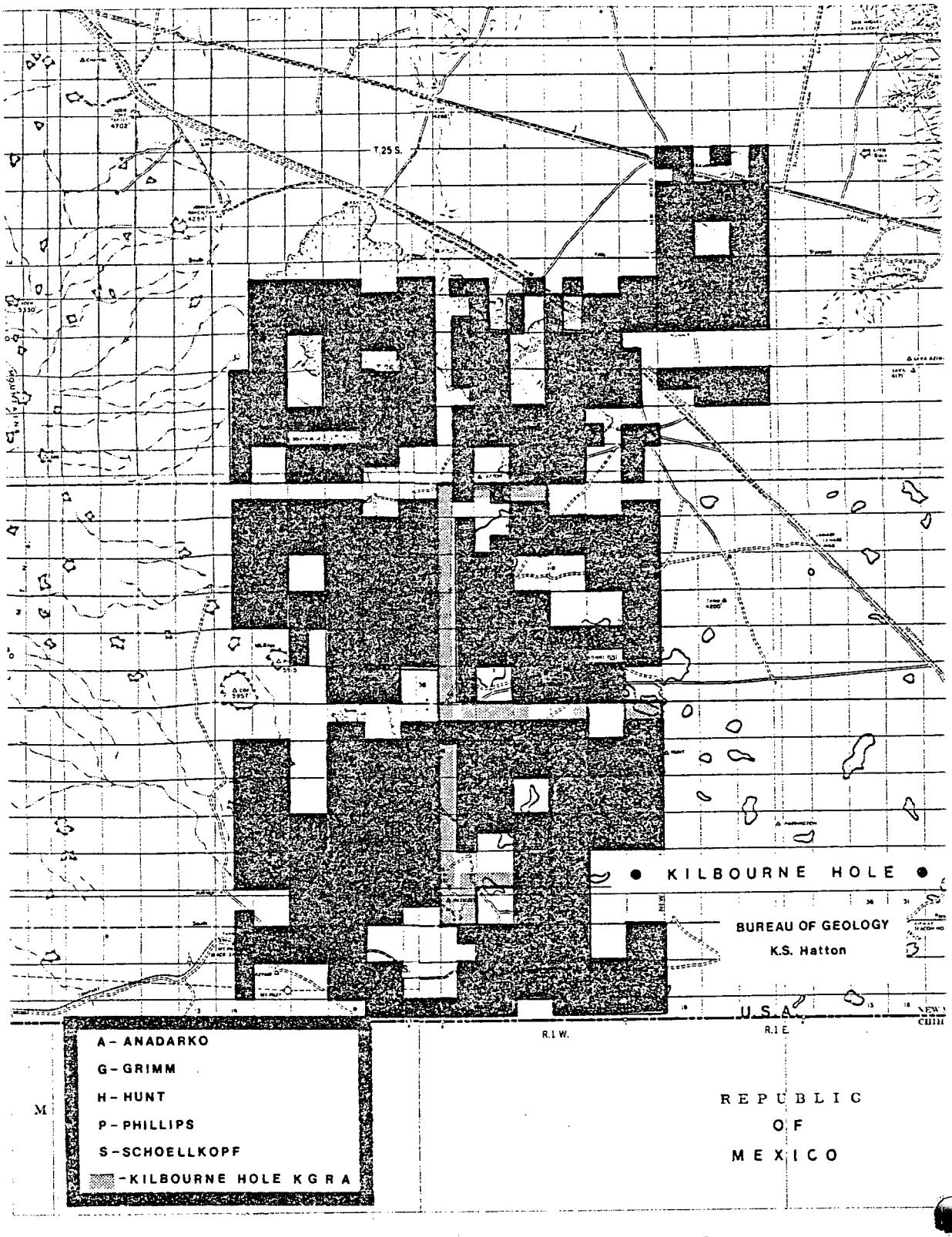


Figure 9. Kilbourne Hole Geothermal Resource Area