DOE/ID/12101-3

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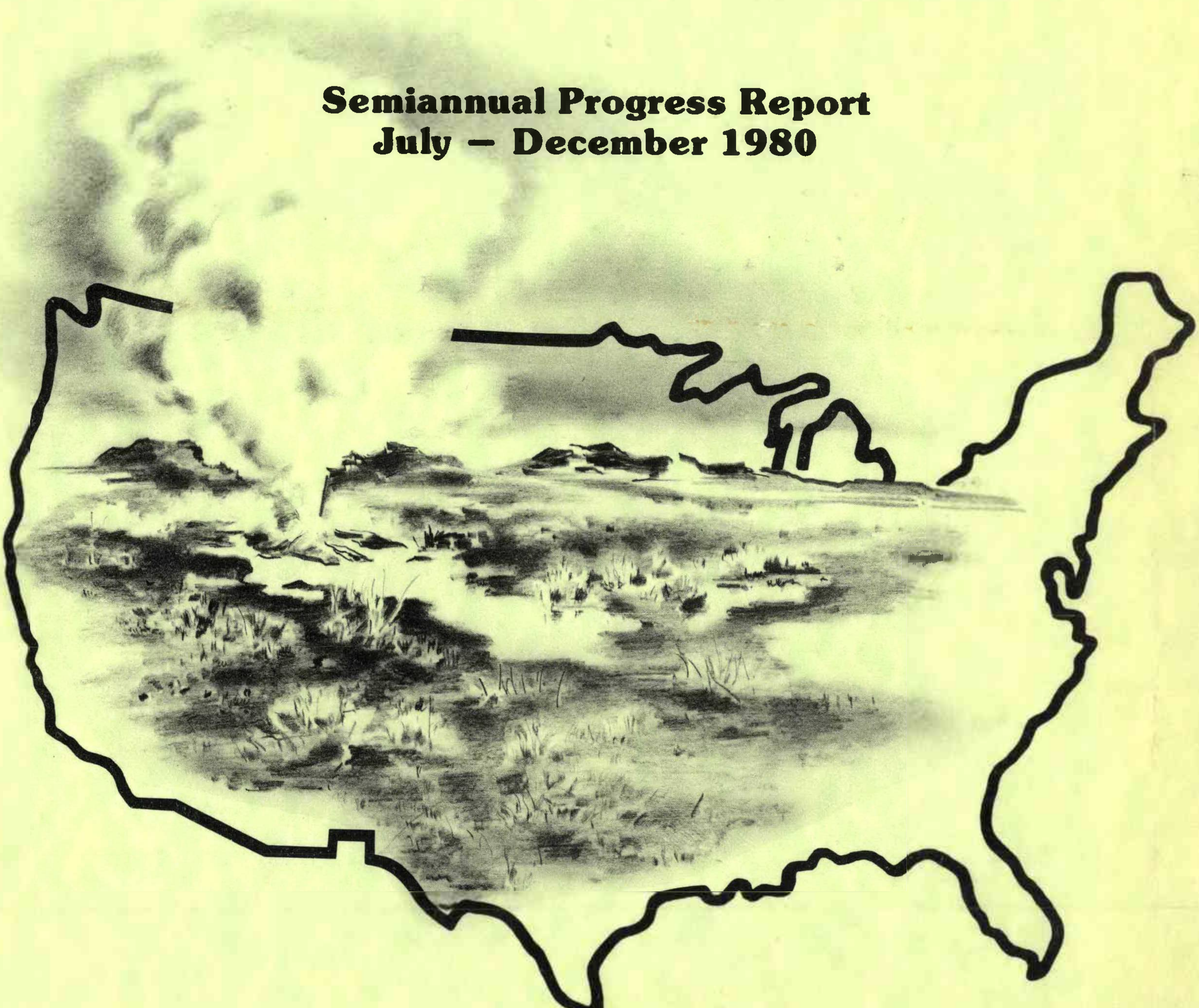
State Geothermal Commercialization Programs in Seven Rocky Mountain States

Semiannual Progress Report
July – December 1980



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Printed in the United States of America

Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161
NTIS Price Codes: Printed Copy A12
Microfiche A01

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DOE/ID/12101--3

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DOE/ID/12101-3

STATE GEOTHERMAL COMMERCIALIZATION PROGRAMS IN SEVEN ROCKY MOUNTAIN STATES

Semiannual Progress Report
July-December 1980

October 1981

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For the U. S. Department of Energy
Idaho Operations Office
Under Contract No. DE-AC07-76ID01570

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CONTENTS

PREFACE

The continuing efforts of the seven Rocky Mountain Basin and Range Commercialization teams in areas of public outreach, creative technical applications, innovative institutional arrangements, and positive encouragement in the use of geothermal energy is contributing to the awareness and development of this valuable alternative energy source. This document describes and attests to the accomplishments and findings of these seven commercialization teams during the last half of Calendar year 1980.

SUMMARY OF DEPARTMENT OF ENERGY STATE GEOTHERMAL COMMERCIALIZATION PROJECT IN THE ROCKY MOUNTAIN BASIN AND RANGE REGION

1.0 INTRODUCTION

This report chapter contains three sections that describe the activities and findings of the seven state commercialization teams participating in the Rocky Mountain Basin and Range commercialization program. The period covered is July through December, 1980. Section 1.0 provides background information, discusses program objectives and the technical approach that is used, and describes the benefits of the program. The summary of findings is found in Section 2.0. Prospect identification, area development plans, site specific development analyses, time-phased project plans, the aggregated prospective geothermal energy use, and institutional analyses are discussed. Section 3.0 covers public outreach activities and summarizes findings and recommendations.

Unless indicated otherwise, the information presented in this summary originates with the State Commercialization Team reports that make up subsequent chapters of the report. Those later chapters describe in similar format the commercialization activities carried out by the respective state teams.

1.1 Background

The Rocky Mountain Basin and Range Regional Hydrothermal Commercialization Project was initiated in 1977 to stimulate geothermal commercialization throughout the region. This program is a cooperative effort involving the U. S. Department of Energy (DOE) and seven states in the Rocky Mountain region. The Department of Energy is cooperating with other groups of states and local governments throughout the country in similar geothermal commercialization programs to ensure that the program elements reflect state and local as well as national goals.

DOE has provided support for state geothermal programs through cooperative agreements with state agencies that were selected by the respective governors' offices. The cooperative agreements support activities in planning, analysis, and marketing of geothermal energy and technical assistance to prospective users and developers. The state commercialization program is closely intertwined with the DOE-sponsored state-coupled geothermal resource assessment programs, which provide inventories and reservoir data about the geothermal resource areas in each state. Coordination of these two closely-related programs of resource assessment and commercialization helps assure that these efforts are all directed toward the single goal of stimulating the uses of geothermal energy. Now that the state commercialization programs are well-established, state and local governments have the expertise available to continue programs that provide both technical information and assistance to prospective developers and users.

The Idaho Operations Office of the Department of Energy (DOE-ID) has cooperative agreements with seven Rocky Mountain Basin and Range states (Colorado, Montana, New Mexico, North Dakota, South Dakota, Utah, and Wyoming) to conduct state geothermal commercialization programs. These seven states provide a portion of the funding and thus share the cost of this program with the Department of Energy.

The states are assisted in their efforts by additional contractors who provide technical support: The University of Utah Research Institute (UURI) provides resource assessment assistance; the New Mexico Energy Institute (NMEI) provides preliminary economic analyses; and EG&G Idaho, Inc. (EG&G) provides preliminary engineering assistance, coordination with other DOE programs, and other support services.

During this reporting period, the coordination of the state team efforts was turned over to EG&G Idaho, Inc. A new emphasis has been placed on these efforts. Rather than directing their efforts toward achieving long-range plans, the State teams have been solicited as to which efforts would be the most productive. As a result, a variation will be seen in the accomplishments of the various teams. In states where geothermal energy use is not large, the emphasis remains on long-range planning. In other states where geothermal resources are more pronounced and more available for immediate use, the emphasis of the teams has shifted toward outreach in order to allow interested parties access to data and information that is of more immediate use.

In order to assist in this latter effort, technical information and technical assistance, which previously had been handled more or less independently by the regional technical assistance center, EG&G Idaho, Inc., has been coordinating more closely with the state teams. Requesters of information and assistance are referred back to the state teams for initial assistance. Only when the state teams find their resources limited are requests forwarded to EG&G Idaho. This results in closer coordination between the state teams and the technical assistance center. As a result, the state teams have become more involved generally in direct outereach activities, thus reducing requests to EG&G Idaho. Conversely, the number of requests to the technical assistance center has been reduced markedly from its rapid growth; however, the nature of the requests has required more extensive involvement by EG&G engineering staff. This arrangement seems to more effectively involve both the state team and technical assistance center expertise in stimulating interest in geothermal energy use.

1.2 Objectives

Several major objectives are identified as means to effect the goal of increased geothermal commercialization through the activities of the state commercialization program. They include:

- Match geothermal sites with potential markets to identify and rank "targets of opportunity" where state commercialization efforts will be concentrated.

- Identify and describe the actions needed by both private and public participants for geothermal commercialization.

- Stimulate interest and cooperative action among participants in geothermal commercialization.

- Stimulate development of geothermal resources in the private sector by providing technical information, including permit requirements and financial, economic, engineering, and resource information.

- Help stimulate economic development through identification of geothermal energy potential for industrial and utility use and coordination with state economic development agencies.

- Identify the constraints to geothermal commercialization, and recommend ways to alleviate them where appropriate.

1.3 Technical Approach

The technical approach of the State Commercialization Projects has been to use existing information and data from available sources whenever possible. Interviews and discussions with a variety of state and local participants contribute data, direction, and ideas. Both quantitative and qualitative analyses are performed as necessary. Within these parameters and the objectives indicated in Section 1.2, a number of specific tasks were defined and performed. Although the specific tasks vary in scope and detail, all the states incorporated ten tasks into their contracts with DOE. The nature of each task is listed below; progress on each will be found in the respective State Sections.

1.3.1 Outreach

Outreach programs are conducted by each state to promote the use of geothermal energy by industry, utilities, private citizens, business, agriculture, government, and communities. A technical assistance program provides prospective geothermal users and developers with information about all aspects of development, including laws and regulatory processes, preliminary economic and engineering feasibility, and the geothermal resource.

1.3.2 Prospect Identification

Data about geothermal resources and sites are documented in order to identify the potential geothermal energy resources. These data include a classification of the resources as either electrical power generation or direct thermal application, and whether the resource is proven, potential, or inferred, on the basis of definitions for those terms that were established in previous studies (Meyer and Davidson, 1978).

1.3.3 Energy and Economic Analyses

Energy consumption and economic data are collected and analyzed to provide a basis for calculating current and future energy demand. This in turn is used to estimate the market demand for geothermal energy. Energy consumption is described or estimated by type of use and by commercial, residential, and industrial sectors. Industrial users are described by four-digit standard industrial classification (SIC) codes.

1.3.4 Area Development Plans (ADPs)

This task provides an assessment of the possible geothermal supply and demand over time. It covers a broad area, either a county or several counties in most cases, and includes the known resource sites and the identified prospective energy users within that area. It is a source of energy and economic data for the New Mexico Energy Institute analyses as well. The Area Development Plans generate the targets for the Site Specific Development Analyses.

1.3.5 Site-Specific Development Analyses (SSDAs)

Using targets identified by ADPs or other selection processes, the Site-Specific Development Analyses are written as tools for marketing geothermal energy. They identify specific applications of the energy for business, industry, government, and residential sectors. Analyses are prepared for major geothermal resource prospects and uses or users. They include examination of a variety of issues, including the technological, economic, environmental, institutional, developmental, and use considerations. Communication with the prospective users and developers is established and maintained to assure realism and implementation.

1.3.6 Time-Phased Commercialization Project Plan (TPPPs)

If additional detailed planning is required beyond the SSDA document, detailed project management plans showing specific activities and deadlines are prepared. These plans are completed for a limited number of sites that are in advanced stages of development or commercialization. They reveal actions by both private and government sectors needed to achieve commercial operation, and they stimulate cooperative interactions to accomplish the project milestones. Step-by-step procedures are described and shown on a time-line chart. Direct communication between the geothermal developer and the governmental entities is required and produced during the process.

1.3.7 Institutional Analyses and Handbooks

The local, state, and federal regulatory systems and practices for geothermal activity are documented and analyzed to understand the effects on the rate of commercialization

1.3.8 State and Regional Aggregations of Development Plans

The geothermal prospects included in all three types of plans are aggregated to obtain estimates of the amount of geothermal energy that can be developed and used between now and the year 2020.

1.3.9 Identification of Constraints and Recommended Actions

Technological, environmental, economic, and institutional constraints that might delay or preclude the development of geothermal energy are examined. Possible solutions are evaluated, leading to recommendations for action, to be taken by local, state, and federal governments and by the private sector.

1.3.10 Marketing

As this commercialization program progresses, the emphasis is changing from a planning activity to outreach and finally to marketing geothermal energy within the states.

1.4 Benefits

The benefits to be gained from geothermal commercialization projects are numerous. The ultimate goal is the replacement of energy from fossil fuels with energy from untapped domestic resources. Conserving natural gas and other fossil fuels can either directly or indirectly effect that goal. The value of the conventional energy saved, less the total project costs to put geothermal energy on line, gives a conservative estimate of benefits. However, when funds are spent within this country rather than being exported, they have a multiplier effect that should be considered. Taxes paid by the developer or user are an additional benefit to the governments.

For national planning, programming, and budgeting purposes, the information produced by State Commercialization Projects is essential. The projects provide realistic assessments of how much geothermal energy can and is likely to be produced within a specific time frame and by what consuming sectors. From this information, public and private expenditures congruent with the amount of energy can be appropriately allocated to stimulate geothermal production and use.

Indirect benefits include local values such as lower fuel bills for users and economic development stimulated by the lower cost of energy. Furthermore, the assurance that a supply of energy will be available at a comparatively stable price can help both the private and public sectors to plan for their futures.

During this report period, the actions of these State Geothermal Commercialization Teams and various public and private resources have heightened the awareness of officials and residents, and have stimulated many projects that may have a significant effect on the energy uses within the region.

2.0 SUMMARY OF ACCOMPLISHMENTS

Identification and stimulation of geothermal commercialization projects requires the synthesis of three elements. The geothermal resource must be of a suitable quality and magnitude. A user must be available who is either already located at the resource site or willing to locate at or near it. The site itself, including institutional, economic, demographic, environmental, and other facets, must be suitable for the proposed use. The tasks accomplished by the states were directed toward first revealing the opportunities to effect such three-way matches and then actively participating in implementaion.

2.1 Resource Identification

The identification and categorization of geothermal resource prospects is a continuing process in each state. The most current information regarding the number of prospects in the seven states is summarized in Table 1-1. This indicates that there are presently a total of 19 geothermal sites in the region that have electrical power generation potential. Two of these sites have been classified as proven, five as potential, and twelve as inferred. These numbers will continue to change as exploration and reservoir confirmation continues. On the basis of exploration results, some areas are added and others are reclassified into another category. In some states, little interest has been expressed in electrical power generation,

TABLE 1-1. NUMBER OF GEOTHERMAL RESOURCE SITES

State	High-Temperature Electric Prospects				Low-Temperature Direct Thermal Prospects				Grand Total
	Proven	Potential	Inferred	Total	Proven	Potential	Inferred	Total	
Colorado[a]	0	0	2	2	1	12	49	62	64
Montana	0	0	0	0	4	7	60	71	71
New Mexico	1	4	10	15	8	12	12	32	47
North Dakota[b]	0	0	0	0	0	71	0	71	71
South Dakota[c]	0	0	0	0	17	18	NA	35	35
Utah	1	1	0	2	6	8	35	49	51
Wyoming	0	0	0	0	5	7	2	14	14
Totals	2	5	12	19	41	135	158	334	353

a. This includes only those sites that have been inventoried by the Colorado Geological Survey.

b. The Madison, Dakota, Fox Hills, Hell Creek, and other less extensive aquifers are currently being surveyed for geothermal potential, and the list is continuously being revised.

c. The Madison Formation in the western part of South Dakota offers geothermal potential; this refers to those sites where towns are located.

but federal lease applications have been submitted. As Table 1-2 shows, as of October 1977, some 1402 federal geothermal lease applications had been submitted. By 1979, only 1,058 federal leases had been issued. The lease interest may indicate a large inferred potential for high-temperature resources. In any case, detailed investigations of leasing activity have indicated that the major part of that activity is directed toward the identification of sites for power generation. Too few leases have been issued and too few sites have been explored to conjecture how many sites will ultimately prove to be suitable for electrical power.

There are many locations where geothermal resources are a valuable source of energy for space and water heating and for commercial, agricultural, and industrial uses. Table 1-1 shows that as many as 272 sites are suitable for these uses, not counting the large but undefined Dakota and Madison aquifers that underlie much of the Northern Plains.

Additional details about the geothermal resource prospect development are discussed in the individual state summary reports. Further definition of resource prospects and leasing activity will be given in future reports.

2.2 Highlights of State Accomplishments

In the chapters that follow, each of the state teams has presented its activities and accomplishments for this reporting period. To accentuate

TABLE 1-2. GEOTHERMAL LEASING ON PUBLIC LANDS IN THE ROCKY MOUNTAIN BASIN AND RANGE REGION

	Acres Leased			Number of Leases Issued			Number of Federal Lease Applications[a]
	State	Federal	Total	State	Federal	Total	
Colorado	16,728	34,926	51,654	8	25	33	48
Montana	-0-	10,687	10,687	-0-	6	6	97
New Mexico	45,663	225,710	288,684	145	123	268	508
North Dakota[b]	-0-	-0-	-0-	-0-	-0-	-0-	-0-
South Dakota[b]	-0-	-0-	-0-	-0-	-0-	-0-	-0-
Utah[c]	234,268	459,138	693,406	238	275	513	657
Wyoming[c]	1,150	7,448	8,598	1	4	5	92
Totals	315,120	737,909	1,053,029	392	433	825	1,402

a. Noncompetitive and competitive Federal leases, as of October 1977 (Beeland, 1978), plus update report of Colorado

b. Not yet available.

c. Same values reported in last semiannual report

SOURCES: Uses and State Geothermal Commercialization Teams.

these accomplishments, some of the more important achievements are highlighted below. Please refer to the appropriate state section for more detail on these items.

2.2.1 Colorado

- A Site-Specific Development Analysis was completed for the Upper Arkansas Valley area.

- An institutional problem as to which state agency has jurisdiction over permitting ground water heat pump systems has been identified.

2.2.2 Montana

- A test well drilled at Camp Aqua proved to be unsuccessful in identifying a hot resource, but has proven a low-temperature resource that may be used by an alcohol plant.

- A well at Bozeman Hot Springs is producing 120°F at 1000 gpm of artesian flow. This appears to be the second best proven resource in the state.

2.2.3 New Mexico

- Carrie Tengley Hospital begins operation in September 1980.
- NMSO President's House completed in September 1980.
- Solar-assisted geothermal greenhouse in Taos dedicated in October.
- The State has made $600,000 available for geothermal drilling and demonstration projects.

2.2.4 North Dakota

- Site-specific development plans are being prepared for the Patterson Hotel in Bismarck, Maryvale Convent in Valley City, and St. Mary's School in New England.
- Ten percent income tax credit legislation is being drafted by the state commercialization team in conjunction with the North Dakota Legislative Council.
- A geothermal newsletter was published in September 1980.
- Billboards promoting geothermal energy were erected in Bismarck.

2.2.5 South Dakota

- The Geothermal Energy Handbook was released in November.

- Geothermal Energy Day was held in Pierre on October 21 to dedicate the St. Mary's, Philip, and Diamond Ring Ranch PON projects.

- Philip, S.D. is preparing a proposal in response to the HUD/DOE request for district heating system projects.

2.2.6 Utah

- Phillips Petroleum and Utah Power and Light signed a contract for the development of Roosevelt Hot Springs.

- A pump list was conducted on a well at Cove Fort and then signed over to Forminco, Inc. for use in an ethanol plant.

- Two exploratory wells were drilled at the Utah State Prison. Both had artesian production of 180°F water.

2.2.7 Wyoming

- A draft Site-Specific Development Analysis has been completed.

3.0 OBSERVATIONS AND CONCLUSIONS

3.1 Outreach Mechanisms

Public awareness created by the varied outreach activities of the state teams continues to increase favorably. The use of newsletters appears to be generating the greatest response. Personal contacts with individuals and groups is also contributing significantly to the interest in and the development of geothermal energy.

The distribution of heat pump literature, coupled with personal contacts, has caused a definite increase in the use of heat pumps, an area of application that is promising to become a significant segment of geothermal applications.

An upsurge in development is expected through technical assistance efforts, and more activity of this kind is planned by the state teams.

State research and development programs, state geothermal demonstration programs, and the Appropriate-Technology Small Grants program are continuing to elicit positive responses. Assistance being provided in preparing geothermal legislation will continue to encourage the use of geothermal energy.

Billboards promoting geothermal energy have generated a low response, and limited application of this medium is expected in the future.

3.2 Conclusions

Contacts with geothermal developers reveal that they are in much need of help, including general information and technical assistance. The state teams are shifting toward more technical assistance activities, and future efforts should include more of this type of outreach.

Significant contributors to the development of geothermal energy are the R&D program, and the demonstration program of New Mexico. Efforts should be directed to obtaining funding to increase this type of outreach activity.

The use of groundwater heat pumps is increasing, and this application could become a most significant use of geothermal resources. Groundwater heat pump literature that is now being used is proving to be very effective, and its use should be continued on an increasing scale.

Personal contacts are continuing to reap copious rewards, and the need for more interface is apparent.

The state team activities are gravitating to technical assistance activities and away from planning. It is expected that this should now produce greater results than heretofore experienced. This effort should be increased, and the services of especially qualified geothermal persons should be made available on a periodic basis, say 30 to 90 days, to the state teams to strengthen their position.

Interest is running high, but inadequate legislation, the risk associated with "first holes," funding limitations, the lack of financial incentives, and the need for technical assistance are limiting development. Therefore, removal or mitigation of these items should occur to accelerate geothermal energy development and use.

COLORADO GEOTHERMAL COMMERCIALIZATION PROJECT

Semiannual Progress Report
July-December 1980

Prepared by

Richard H. Pearl

Colorado Geological Survey

For the U.S. Department of Energy
Idaho Operations Office
Under Contract No. DE-FC07-79ID12018

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COLORADO GEOTHERMAL COMMERCIALIZATION PROJECT SEMIANNUAL PROGRESS REPORT, JULY-DECEMBER 1980

1.0 INTRODUCTION

1.1 Purpose of Project

The Colorado State Geothermal Commercialization project exists to promote the development of geothermal energy in Colorado.

1.2 Objectives

To assist and educate potential users of geothermal energy through the use of development analysis, outreach mechanisms, and technical assistance.

1.3 Team Members

Team members--Richard H. Pearl, Project Coordinator and Frank Healy, geologist (terminated 9/80). The following persons worked on the project part time: Ms. Becky Nelson, secretary and Mark Persichetti, draftsman.

1.4 Project Benefits to the State and DOE

Citizens of the State will become aware that the geothermal resources of Colorado can be put to beneficial use, and that the industrial base of

State will increase due to new industries using geothermal energy. DOE benefits: Geothermal energy use is increasing, which means that energy dependence of the nation is decreasing.

2.0 SPECIFIC DESCRIPTIONS AND PROJECTS

2.1 Geothermal Prospect Identification

2.1.1 Electrical Generation (over 150°C)

No sites in Colorado have been proven yet for electrical generation. At one of the three potential sites, Poncha Springs, the major energy company "farmed out" their lease to a geothermal direct applications developer, Chaffee Geothermal. As a result, this area has been downgraded from electrical potential to direct-use potential (Table 1). In Tables 1 through 4 the site numbers are used to refer to Figure 1.

TABLE 1. ELECTRICAL POWER GENERATION AREAS (>150°C)
(All areas classified as inferred)

Site	Highest Measured Surface Temp. (°C)	Estimated Probable Subsurface Temp. (°C)	Estimated Probable Heat Content (Btu's x 1015)	Depth
21 Mount Princeton	84	200	0.486	?
23 Poncha Hot Springs	Down graded to direct applications			
47 Cebolla Hot Springs	40	NA	0.48	?

TABLE 2. INFERRED DIRECT-USE THERMAL AREAS (>150°C)

Site	Highest Measured Surface Temp. (°C)	Estimated Probable Subsurface Temp. (°C)	Estimated Probable Heat Content (Btu's x 1015)	Depth
01 Juniper	38	50-75	0.016	?
02 Craig	39	40-60	0.033-0.340	?
03 Routt	64	125-175	0.111-0.166	?

TABLE 2. INFERRED DIRECT-USE THERMAL AREAS (>150°C) (Continued)

Site	Highest Measured Surface Temp. (°C)	Estimated Probable Subsurface Temp. (°C)	Estimated Probable Heat Content (Btu's x 1015)	Depth
04 Steamboat	39	125-130	0.049	?
05 Brand's Ranch	42	42-55	0.004-0.016	?
06 Hot Sulphur	44	75-150	0.070	?
07 Haystack Butte	28	50	0.006-0.017	?
08 Eldorado	26	26-40	0.015	?
09 Idaho	46	NA	0.171	?
10 Dotsero	32	32-45	0.005	?
12 South Canyon	49	100-130	0.002	?
13 Penny	56	60-90	0.166-0.486	?
14 Col. Chinn	42	NA	0.018	?
15 Conundrum	38	40-50	0.004	?
16 Cement Creek	25	30-60	0.013-0.066	?
17 Ranger	27	30-60	0.002-0.006	?
18 Rhodes	24	25-35	0.043-0.200	?
19 Hartsel	52	NA	0.047	?
22 Brown's Canyon	25	50-100	0.226-0.486	?
24 Wellsville	33	35-50	0.009-0.015	?
25 Swissvale	28	35-50	?	
29 Don K Ranch	28	NA	0.035	?
30 Clark	25	25-50	0.008	?
31 Mineral	60	70-90	0.949	?
32 Valley View	37	40-50	0.056	?

TABLE 2. INFERRED DIRECT-USE THERMAL AREAS (>150°C) (Continued)

Site	Highest Measured Surface Temp. (°C)	Estimated Probable Subsurface Temp. (°C)	Estimated Probable Heat Content (Btu's x 1015)	Depth
33 Shaws	30	30-60	0.015	?
34 Sand Dunes	44	NA	0.155	?
35 Splashland	40	40-100	0.155	?
36 Dexter	20	20-50	0.034	?
37 McIntyre	14	20-50	?	
38 Dutch Crowley	70	70-80	0.026-0.062	?
39 Stinking Springs	27	40-60	?	?
40 Eoff	39	40-60	0.017	?
42 Rainbow	40	40-50	0.047-0.094	?
43 Wagon Wheel Gap	57	NA	0.063-1.429	?
44 Antelope	32	35-52	0.011-0.088	?
45 Birdsie	30	35-52	?	
46 Waunita	80	175-225	0.061	?
47 Cebolla	40	NA	0.048	?
48 Orvis	52	NA	0.028-0.131	?
50 Lemon	33	NA	0.015	?
51 Dunton	42	50-70	0.007	?
52 Geyser	28	60-120	0.007	?
53 Paradise	46	NA	0.023	?
54 Rico	44	NA	0.174	?
55 Pinkerton	33	75-125	0.010-0.021	?
56 Tripp/Trimble	44	45-70	0.036	?

TABLE 2. INFERRED DIRECT-USE THERMAL AREAS (>150°C) (Continued)

Site	Highest Measured Surface Temp. (°C)	Estimated Probable Subsurface Temp. (°C)	Estimated Probable Heat Content (Btu's x 1015)	Depth
57 Stratton		?	?	?
58 Piedra River		?	?	?

TABLE 3. POTENTIAL DIRECT-USE THERMAL AREAS(<150°C)

Site	Highest Measured Surface Temp. (°C)	Estimated Probable Subsurface Temp. (°C)	Estimated Probable Heat Content (Btu's x 1015)	Depth
11 Glenwood	51	NA	0.38	0-610 m
20 Cottonwood	58	105-182	0.389-1.167	?
21 Chalk Creek		150-200	1.062-3.810	?
Mt. Princeton	56	150-200		?
Wright	72	150-200		?
Hortense	82	150-200		?
Woolmington	39	150-200		?
23 Poncha[a]	71	115-145	0.141-1.191	?
26 Canon City	40	NA	0.003	305 -
27 Fremont	35	35-50	0.010	1,524 m
38 Florence	28	34-50	0.008-0.043	
49 Ouray	69	70-90	0.226	?

a. Downgraded from an Electrical Power Generation area to a Potential Direct-Use Area.

TABLE 4. PROVEN DIRECT-USE THERMAL AREAS (>150°C)

Site	Highest Measured Surface Temp. (°C)	Estimated Probable Subsurface Temp. (°C)	Estimated Probable Heat Content (Btu's x 1015)	Depth
41 Pagosa Springs	58	80-150	0.023	90-200 m

Classification of the above systems is based on the following criteria:

- Inferred. Spring or thermal well has been located, field measurements of a pH, temperature, or discharge made, and in most instances geothermometer model analysis run.

- Potential. Some type of resource assessment work has been done by the Colorado Resource Assessment Team, or private companies have released their exploration data to the general public. From this information, an intelligent estimate can be made of the size and magnitude of the resource.

- Proven. Test wells have been drilled, and the production well may have been drilled.

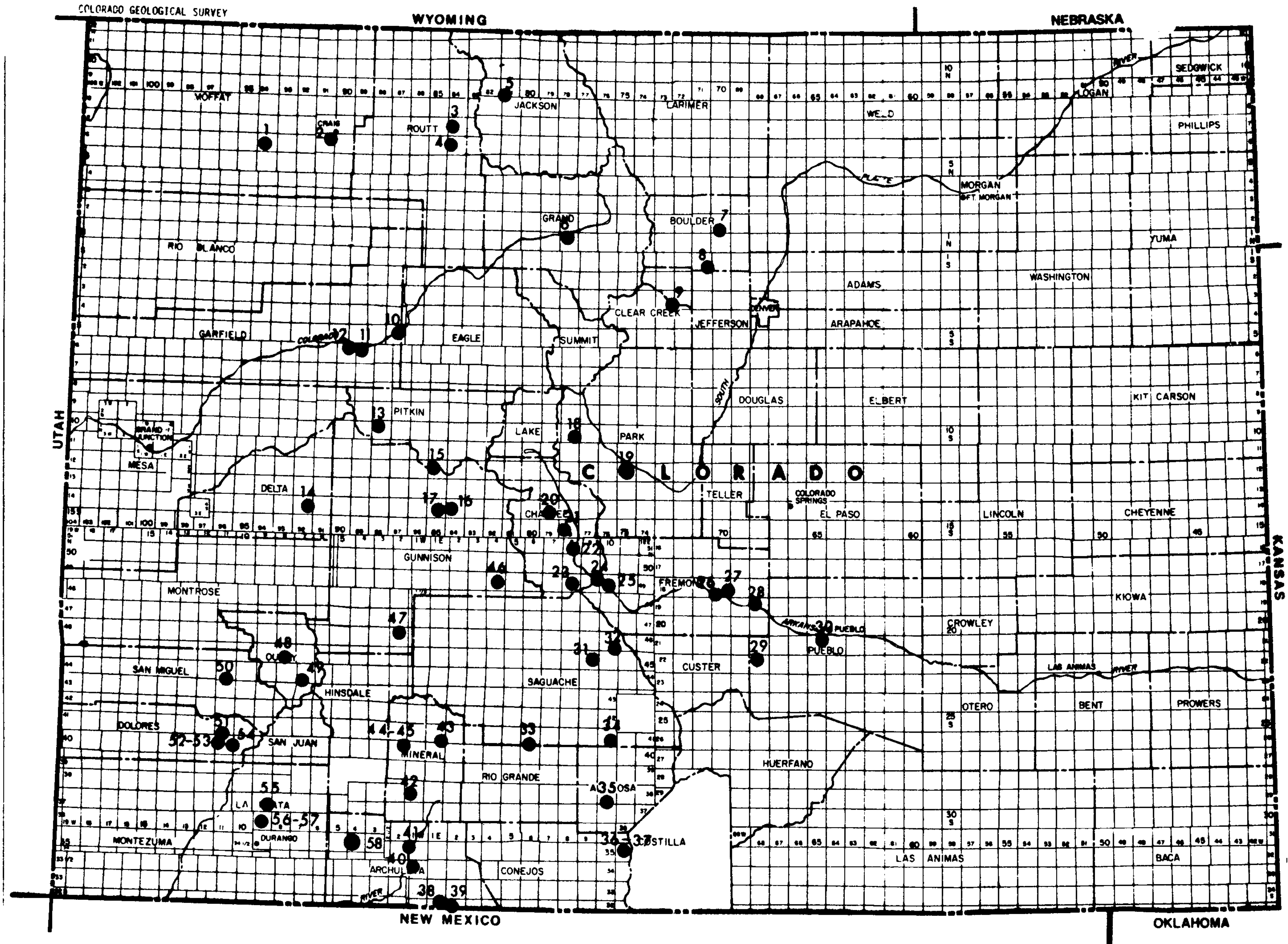

Fig. 1 Location of thermal springs and wells in Colorado.

2.1.2 Leasing

Table 5 lists current noncompetitive leases on Federally owned lands, Table 6 lists current competitive Federal leases [known geothermal resource areas (KGRAs)], and Table 7 lists current leases of Colorado State lands.

TABLE 5. FEDERAL NONCOMPETITIVE LEASES IN COLORADO, DECEMBER, 1980

Lessee	Acres	Township And Range	County	Date Issued
Phillips Petroleum Co.	329.50	49N, 11E	Fremont	11/75
Occidental Pet. Inc.	80.00	49N, 8E	Chaffee	11/75
Petrol-Lewis Corp. 50%, Petroleum Inc. 50%	1,549.66	49N, 9E	Chaffee	7/75
Petrol-Lewis Corp. 50%, Petroleum Inc. 50%	1,280.00	49N, 8E	Chaffee	11/75
Petrol-Lewis Corp. 50%, Petroleum Inc. 50%	2,113.30	49N, 7&8E	Chaffee	11/75
Petrol-Lewis Corp. 50%, Petroleum Inc. 50%	1,286.17	51N, 8E	Chaffee	7/75
Chevron Oil Co.	1,867.94	46&47N, 2&3W	Gunnison	1/75
Chevron Oil Co.	2,127.56	46&47N, 3W	Gunnison	1/77
Chevron Oil Co.	645.74	47N, 3W	Gunnison	1/77
Geothermal Kinetics	1,795.11	37N & 38N 12E & 13E	Alamosa	11/75

TABLE 5. FEDERAL NONCOMPETITIVE LEASES IN COLORADO, DECEMBER, 1980 (Continued)

Lessee	Acres	Township And Range	County	Date Issued
Geothermal Kinetics	1,203,15	29S, 73W	Alamosa	11/75
Geothermal Kinetics	320.00	38N, 12E	Alamosa	8/79
Geothermal Kinetics	642.88	37N, 12E	Alamosa	8/79
Geothermal Kinetics	827.31	38N &29S 1E&73W	Alamosa	11/75
Geothermal Kinetics	1,335.99	29S, 73W	Alamosa	11/75
Utah International	2,326.89	40&41N, 1E	Mineral	8/79
Utah International	2,335.22	40&41N, 1E	Mineral	8/79
Buttes Resource Co.	781.32	46N, 2W	Gunnison	1/77
Buttes Resource Co.	2,226.88	46N, 1&2W	Gunnison	1/77
Buttes Resource Co.	1,804.57	46N, 1 to 1-1/2W	Gunnison	1/77
Buttes Resource Co.	1,040.04	46&47, 2W	Gunnison	1/77
Buttes Resource Co.	1,970.30	46&47, 2W	Gunnison	1/77
Total	29,889.53 acres			

Source: U.S. Bureau of Land Management

TABLE 6. FEDERAL COMPETITIVE LEASES IN COLORADO, DECEMBER 1980

Lessee	Acres	Township And Range	County	Date Issued
Occidental Geothermal 50%, Petro-Lewis Corp. 50%	915.84	49N, 8E	Chaffee	1976
Phillips Petroleum	2,484.28	45N, 9E	Saguache	1975

TABLE 6. FEDERAL COMPETITIVE LEASES IN COLORADO, DECEMBER 1980 (Continued)

Lessee	Acres	Township And Range	County	Date Issued
Phillips Petroleum		46N, 9E		
Phillips Petroleum	1,636.42	45&46N, 10E	Saguache	1975
Total	5,036.54 acres			

Source: U.S. Bureau of Land Management

TABLE 7. COLORADO STATE GEOTHERMAL LEASES, DECEMBER, 1980

Lessee	Acres	Township And Range	County	Date Issued
Petro-Lewis Corp.[a]	640.00	14S, 79W	Chaffee	
Petro-Lewis Corp.[a]	2,004.85	14S, 78W	Chaffee	
Petro-Lewis Corp.[a]	4,332.31	15S, 78W	Chaffee	
General Geothermal	2,840.00	41N, 10E	Sauguache	
Occidental Geothermal	360.00	49N, 8E	Chaffee	
Petro-Lewis Corp.	3,226.61	50N, 8E	Chaffee	
Petro-Lewis Corp.	1,560.00	49N, 7E	Chaffee	
		50N, 8E		
		49N, 9E		
Phillips Petroleum	1,764.40	49N, 4&5E 48N, 4&5E	Gunnison and Sauguache	
Total	1,6728.17 acres			

Source: Colorado State Board of Land Commissioners

a. Acreage assigned from AMAX Exploration.

2.2 Area Development Plans

2.2.1 State Geothermal Planning Areas

There are no Geothermal Planning Areas in Colorado

2.2.2 Specific ADPs Completed or in Preparation

No ADPs were planned for 1980.

2.3 Site Specific Development Plans

2.3.1 Candidate Geothermal Sites/Applications

During CY-1980, site specific development analyses were to be made for the following areas:

- Upper Arkansas Valley
- Canon City-Pueblo Area
- Steamboat Springs
- Hot Sulphur Springs

2.3.2 Site-Specific Development Plans Completed or in Preparation

A Site-Specific Development Analysis was done for the Upper Arkansas Valley Area (see F. C. Healy 1980). In May and later in June 1980, before work could either begin or be completed for the other areas, DOE-ID redirected our activities away from these analyses. Therefore, the reports for the other three areas were not done.

2.4 Time-Phased Project Plans

No Time-phased projects plans were scheduled to be completed during 1980.

2.5 Site Aggregation of Prospective Geothermal Use

Table 8 lists the current uses of geothermal resources in Colorado.

TABLE 8. USES OF GEOTHERMAL ENERGY IN COLORADO

Use	Area
Recreation Swimming	Junipter Hot Springs
	Steamboat Hot Springs
	Hot Sulphur Springs
	Eldorado Warm Springs
	Idaho Hot Springs
	Glenwood Hot Springs
	Cement Creek Hot Springs
	Mt. Princeton Hot Springs
	Poncha Hot Springs
	Valley View Hot Springs
	Shaws Warm Spring
	Splashland Hot Water Well
	Pagosa Hot Springs
	Wagon Wheel Gap Hot Springs
	Waunita Hot Springs
	Ouray Hot Springs

TABLE 8. USES OF GEOTHERMAL ENERGY IN COLORADO (Continued)

Use	Area
Baths	Juniper Hot Springs
	Hot Sulphur Springs
	Idaho Hot Springs
	Glenwood Hot Springs
	Mt. Princeton Hot Springs
	Valley View Hot Springs
	Pagosa Hot Springs
	Cebolla Hot Springs
	Orvis Hot Springs
	Ouray Hot Springs
	Lemon Hot Springs
	Dunton Hot Springs
Space Heating	Cottonwood Creek Hot Springs
	Mt. Princeton Hot Springs
	Poncha Hot Springs
	Sand Dunes Hot Water Well
	Robert Owens Warm Water Well, south side of Alamosa
	Pagosa Springs
	Ouray
	Waunita Hot Springs
Other	
Laundry	Hot Sulphur Springs
Greenhouses	Penny Hot Springs
	Wright Hot Water Wells
Algae growing	Wellsville
Irrigation	Dutch Crowly
Bottled water	Clark Artesian Well
Fish Farming	Sand Dunes Hot Water Well
	Wellsville Warm Spring
Pig farms	Mineral Hot Springs
	Warm water wells south of Alamosa

2.6 Institutional Analysis

An analysis of the Colorado institutional framework was made by Coe and Forman (1980). Within the last year, an institutional problem regarding development of geothermal resources in Colorado has developed. This problem is related to the permitting of groundwater heat pump wells by the Colorado

Oil and Gas Conservation Commission and the Colorado Division of Water Resources. In Colorado, all water developments are permitted and regulated by the Colorado Divison of Water Resources. Geothermal development is permitted and regulated by the Oil and Gas Conservation Commission. Since there is no temperature definition in the Colorado Geothermal Act, it has been decided by the staff of the Oil and Gas Commission that groundwater heat pumps fall under their regulation. Therefore, a person wishing to install a groundwater heat pump is forced to pay $75.00 application fee, supply a performance bond, and meet other regulatory requirements. However, this is not the major problem. When a permit application is received by the Oil and Gas Conservation Commission, before any action is taken, the application is sent to the Division of Water Resources for review and comments. The Division of Water Resources has not yet made an internal decision regarding groundwater heat pump well applications; therefore the applications are idle and not being acted upon.

It is recognized by staff personnel from the Division of Water Resources, the Oil and Gas Commission, and the Colorado Geological Survey that the geothermal act was not intended to regulate groundwater heat pumps. However, the Commission staff is reluctant to initiate change in the rules. This problem will have to be solved in the very near future if groundwater heat pump applications in Colorado are to develop.

2.7 Public Outreach Program

2.7.1 Outreach Mechanisms

The outreach activities of the Colorado Commercialization Team during the last 6 months of 1980 consisted of issuing a newsletter, holding meetings with individuals, and answering letters and telephone calls of inquiry.

2.7.2 Summary of Contacts and Results

The following contacts were made during the period July through December 1980.

July:

- Jack Green, Mayors Office, City of Denver
- Walt Gorrod, City Councilman, Ouray
- Ouray Plain Dealer, newspaper, Ouray
- Con Cunningham, Center for Public Issues, consultant, from Glenwood Springs
- Colorado Highway Department Officials, regarding heating of bridge structures in Glenwood Canyon
- Denver Business World, newspaper

August:

- Russ Caldwell, Colorado Department of Commerce
- Coury and Associates, consulting firm, Denver

September: Dr. Jay F. Kunze, Energy Services, Inc. Rexburg, Idaho

Mr. Guy Miles, Alamosa, Colorado

Mr. Patrick O'Boyle, Telluride Ski Corporation

Chaffee County Times, Buena Vista

October: Alamosa newspapers article

Alamosa City officials

James Dorsey, Sunbelt Realty Assoc., Lousiville, Colorado

George Gault, Delta Colorado, working for City of Ouray

James Heriout, Battle Mountain High School, Minturn, Colorado,

U.S. Bureau of Reclamation officials, Grand Junction

November: Cap Allen, consulting engineer, Durango, Colorado

December: Ken Wright, Wright Water Engineers, Denver

Dick Johnson, Wright Water Engineers, Glenwood Springs

Ms. J. Andrikopoulos, Rocky Mountain High School, Ft. Collins

Paul Brown and Russell Kells, Mosca, Colorado

Green Mountain, Colorado Chapter of Kiwanis International

In addition to the above, contact was made almost daily with other State agencies such as the Oil and Gas Conservation Commission and the Division of Water Resources.

2.7.3 Overall Prospectus for Future Geothermal Commercialization

It is strongly believed by the Colorado Geothermal Commercialization Team that geothermal development in Colorado is on the edge of a breakthrough. Calls are being received frequently to request a wide range of information or assistance concerning geothermal resources and how they can be developed or used. In Colorado, there are several industries that have been critically impacted by the increased cost of conventional forms of energy. One of these is the greenhouse industry. This is an industry that could benefit by relocating and using a thermal water source, provided the location had good transportation and a labor force.

The State of Colorado has an economic development program to encourage industrial development in economically deprived areas. Fortunately, most of the thermal sources, especially the better ones, are located in or close to these areas. Two of these areas are the San Luis Valley and Pagosa Springs. In the San Luis Valley, especially in the Alamosa area, there is a strong movement to develop geothermal energy for a wide variety of uses. Pagosa Springs is developing their resource with a Department of Energy PON grant. Officials of Pagosa Springs are hopeful that they will be able to develop a geothermally heated industrial park in the near future. If these two areas are successful in developing their geothermal resources as planned, then the economic conditions of their areas will be greatly improved.

3.0 SUMMARY OF MAJOR FINDINGS AND RECOMMENDATIONS

Unfortunately, the Colorado Geothermal Commercialization Team was shorthanded during most of this reporting period, and was not able to accomplish everything that it desired. One of the major conclusions reached during the period relates to how much help and assistance the average developer of a geothermal resource needs. It is the feeling of the Colorado Team that if the use of geothermal resources for direct use applications is to develop, there will have to be direct governmental financial and technical assistance. This assistance will have to come in many forms. For example, someone should be available locally on the State level to provide general information and limited technical assistance when needed. Financial grant assistance should also be available. The two most useful grant programs are the Small Appropriate Technologies Program and the User Coupled Drilling Program. Both of these programs are being used extensively in Colorado

In Colorado, the direction the project took during the last part of 1980 away from planning work to more direct technical assistance work is seen as a major step. This has brought greater contact with the potential developers, and consequently we have been able to offer them a wide range of advice and assistance. It thus appears to us that this direct technical assistance effort will do more to bring geothermal energy online quickly than anything else we can do. We would urge that this type of effort be continued in the future.

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MONTANA GEOTHERMAL COMMERCIALIZATION PROJECT

SEMIANNUAL PROGRESS REPORT

September 1980-January 1981

Prepared by:
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Jeff Birkby

Energy Division

Montana Department of Natural Resources and Conservation

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Helena, Montana 59620

Work Performed under Contract No. DE-FC07-79ID12014
U.S. Department of Energy
Idaho Operations Office

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MONTANA GEOTHERMAL COMMERCIALIZATION PROJECT

SEMIANNUAL PROGRESS REPORT, JULY-DECEMBER 1980

1.0 PURPOSE OF PROJECT

Montanans' interest in developing geothermal energy ranges from total indifference and ignorance to rabid fanaticism. Unfortunately, there are too many potential users of geothermal energy in Montana who are unaware of geothermal's value in reducing heating costs. This lack of information is slowly being remedied by those directly involved in marketing geothermal products (heat pump dealers, well drillers, engineering firms), as well as by those involved in governmental programs, such as the Montana Geothermal Commercialization Project.

2.0 TASK DESCRIPTION AND PRODUCTS

This midterm report describes the activities of the Montana Geothermal Office during the period from September 1980 to January 1981, and is one in a series of midterm reports submitted to the Department of Energy over the last two years. The project's direction has changed since its inception, advancing from producing energy scenarios and development plans to its current tasks: providing direct technical aid to geothermal developers and increasing public awareness of the uses of geothermal energy. Most of our time is now spent in making presentations at energy fairs and conferences, matching geothermal developers with appropriate technical aid, and helping geothermal enterpreneurs obtain financial assistance.

The U.S. Department of Energy supplies approximately 88% of funding for the project, with the balance of funding coming from the Montana Department of Natural Resources and Conservation.

Michael Chapman served as Program Engineer until October 1980, when Jeff Birkby left the project to return to graduate school. At that time, Michael became Program Manager, and Gary Lippert was hired to work on financial problems.

2.1 Geothermal Prospect Identification

2.1.1 Resource Identification

Several new geothermal wells have been drilled since our last report--most notably the Bozeman Hot Springs and the Camp Aqua test wells. These new wells are described in the site-specific development section of this report. An updated version of the complete list of geothermal resources will be given in the next semiannual report. The locations of the sites mentioned in this report are shown in Figure 1. The present and planned uses of Montana's hydrothermal resources are listed in Table 1.

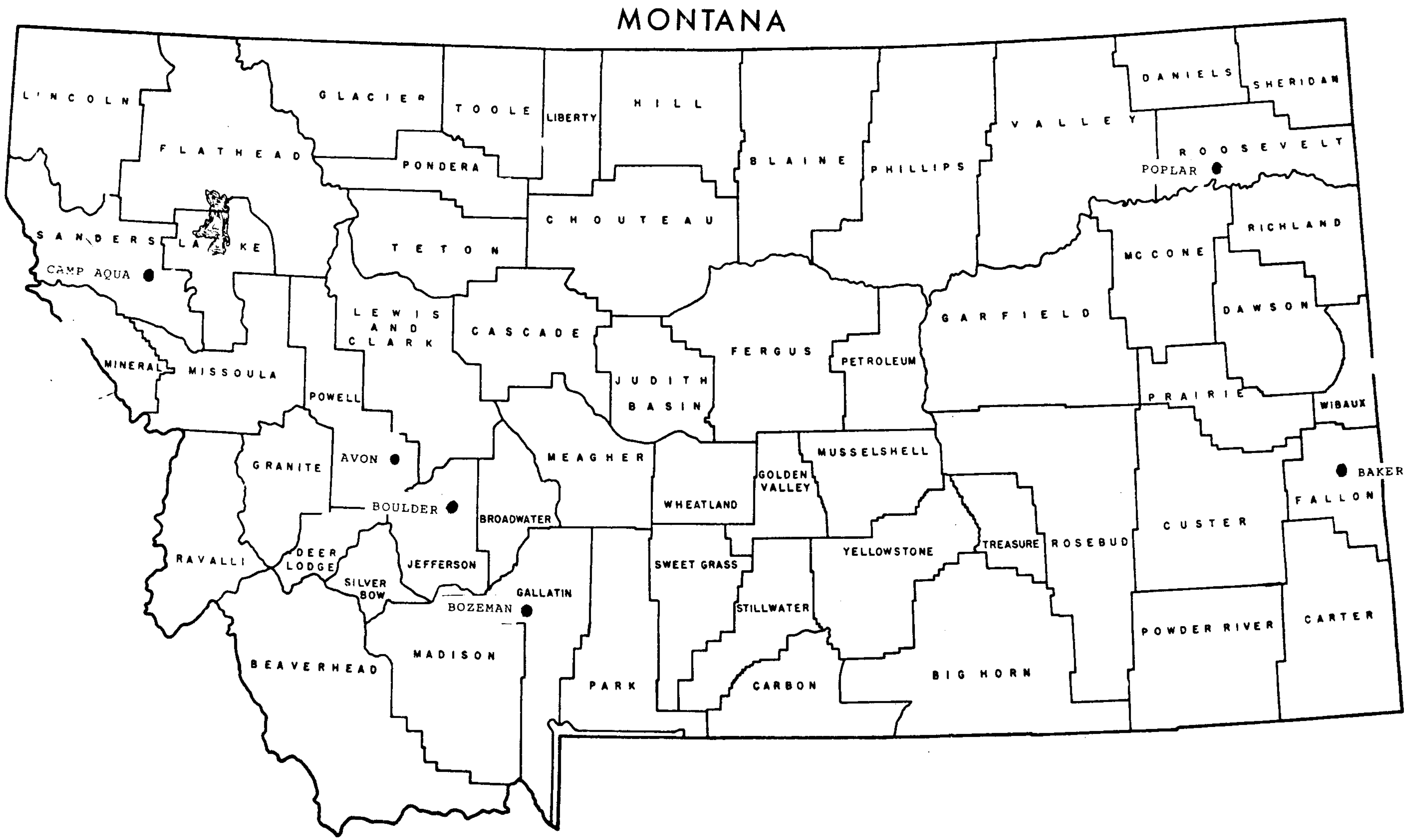

Fig. 1 Montana Geothermal Sites.

TABLE 1. PRESENT AND PLANNED USES OF MONTANA HYDROTHERMAL RESOURCES

Springs	Uses
Alhambra	Hydronic space heating of a nursing home--gravity feed-piping in concrete slab
Anaconda	Unused
Anderson's/McLeod	Pool and spa
Anderson's Pasture	Irrigation
Apex	Irrigation
Avon	Planned solar/geothermal greenhouse
Bear Creek	Unused
Bearmouth	Unused
Beaverhead Rock	Irrigation
Bedford	Irrigation
Blue Joint 1 and 2	Unused--elk wallow on Forest Service land
Boulder	Resort, pools, and plunges; prototype greenhouse; planned aquaculture facility [have raised mosquito fish (gambuzzia)]
Bozeman	Resort, pool, space heat in campground facility building, warehouse, shop
Bridger Canyon	Fish hatchery
Broadwater	Athletic club--pool, water-to-air space heating. One house on site heated, also another about 1/4 mile away. Expansion is planned.
Brooks	Irrigation
Brown's	Planned irrigation (information uncertain)
Camas	Pool and spa--planned space heating for school
Carter Bridge	Informal recreational use

TABLE 1. PRESENT AND PLANNED USES OF MONTANA HYDROTHERMAL RESOURCES (Continued)

Springs	Uses
Chico	Resort, pool--planned use with water source heat pump to heat lodge
Deer Lodge Prison	Unused
Durfee Creek	Irrigation and stock watering
Elkhorn	Pool and cabins
Ennis	Small natural flow but large potential; numerous hot water wells; planned space or district heating in town; planned ethanol facility
Gallogly	Pool
Garrison	Unused
Granite	Hotel, small pool
Green Springs	Unused
Gregson	Large resort, pools
Greyson	Irrigation(?)--other agricultural uses
Halvorson	Unknown
Hunsaker	Agricultural use(?)
Hunter's	Presently unused--old resort with great potential
Jackson	Pool--locally used for space heating
LaDuke	Unused
Landusky 1 and 2 and Plunge	Domestic use and stock watering
Little Warm Springs 1, 2, and 3	Domestic use, stock watering, irrigation
Lodgepole 1, 2, and 3	Irrigation
Lolo	Resort, pools--space heat in locker rooms

TABLE 1. PRESENT AND PLANNED USES OF MONTANA HYDROTHERMAL RESOURCES (Continued)

Springs	Uses
Lovell's	Irrigation
McMenomy Ranch	Some agricultural use
New Biltmore	Resort; pool and plunge; house heating
Nimrod	Informal recreation
Norris	Pool
Pipestone	Unused
Plunkett's	Irrigation
Potosi 1, 2, and 3	Space heating of house
Puller's	Unknown
Quinn's	Pool, whirlpool
Renova	Unused
Silver Star	Old resort--pool, water-to-air space heating, now closed; planned ethanol plant
Sleeping Child	Resort, pools
Sloan Cow Camp	Bathing, stock watering
Staudenmeyer Ranch	Irrigation
Sun River	Pool--hike in
Toston	Irrigation
Trudeau	Informal recreation
Vigilante	Unused
Warm Springs	Newly drilled well--planned space heat, domestic hot water
Warner	Irrigation
West Fork Swimming Hole	Informal recreation

TABLE 1. PRESENT AND PLANNED USES OF MONTANA HYDROTHERMAL RESOURCES (Continued)

Springs	Uses
While Sulphur Springs	Space heated bank; space heated motel; pool; planned water preheat for hospital laundry; planned four-building heating system for public buildings
Wells	**Uses**
Campaqua	Pools, baths, spa; planned ethanol facility
Lucas	Unknown
Marysville	Exploration well--now plugged
Ringling	Informal recreation
Symes	Showers and bath at hotel
Saco	Pool
Others	**Uses**
Hardin	Unused--one well plugged by gypsum, others plugged by oil companies
Baker	Planned district heating
Poplar	Planned district heating

3.0 SITE SPECIFIC DEVELOPMENT PLANS

3.1 Camp Aqua Test Well

Using money provided by the Montana Renewable Energy Grant Program, the Resource Assessment Team drilled a 4-in. test well in the Little Bitterroot Valley during the months of December and January. The test well was located near the Camp Aqua health resort about 6 miles from the town of Hot Springs in Sanders County. The resort was built on the site of a runaway well drilled in the 30's, one fed by an artesian geothermal aquifer that extends up and down the valley, and which is about 240 ft deep at the site. The aquifer is a gravel bed of tertiary age and of excellent permeability. Numerous local farmers use it for irrigation without pumping, and through their cooperative efforts guard it against depletion. The uniqueness of the resource makes it a potentially touchy subject.

The Little Bitterroot Valley is located to the west of Flathead Lake in Sanders County. Its population density is extremely low, even for Montana, and the local economy is based almost entirely on agriculture. The town of Hot Springs is the only population center within thirty miles of the drill site and is largely a retirement community, with a moderate component of tourism attracted to Camas Hot Springs. The hot springs resort, incidentally, was closed down by the Flathead Indian tribe on December 31, 1980, due to the high cost of heating the building with fuel oil. The heating bills in part reflected the rising cost of fuel, but also the dilapidated condition of the boiler and heating system at the resort. This closure seriously imperils the tourist trade in the area; several of the large businesses are now doubtful as to whether they can survive in the town.

The test well was scheduled to be drilled to examine the temperature characteristics of the bedrock system underlying the gravel bed. As it happened, the timing of the drilling coincided with later-stage feasibility studies being conducted by Energy Engineering of Kalispell, a corporation of local businessmen and engineers intent on building an 8 million gpy ethanol and food product processing plant in the same location. Thus the drilling could serve two purposes: extending the knowledge of the valley system and providing the ethanol people with information concerning the feasibility of using geothermal energy for process heat.

It was hoped that drilling through the gravel bed and into bedrock would reveal an increasing temperature that might indicate the presence of a major fault acting as a deep-strata conduit for the water. If the fault could be found, then a new resource might be developed that would number among the best in the state. As a side benefit, the food processing plant could then expect to derive most or all of its process heat from this resource, without disturbing the gravel bed. A tentative grant for $100,000 was awarded to the corporation for the development of a production well, if the test drilling should indicate a high likelihood of finding increased flow and temperature.

Unfortunately, the test well did not reveal such a resource. The gravel bed was penetrated and cased over, and drilling proceeded into bedrock. However, the temperature of the bedrock remained stable from its point of entry to its total depth of 1000 feet. Water temperature decreased from 120 degrees F. to 110 degrees F at the bottom of the hole, probably due to mixing with water migrating along bedding planes. This indicates that the well site was not close to the postulated fault, and also that drilling deeper would be unlikely to increase the temperature.

The test well is presently capped, and may some day provide a good source for a low-temperature direct-use facility, such as greenhouse heating. Meanwhile, Energy Engineering intends to make use of the gravel bed water and then to reinject it into the same stratum, in order not to disturb the artesian conditions that now exist.

From its start, the geothermal commercialization team has been involved in the Camp Aqua project on several levels. In October 1979, a meeting was held in Butte involving DOE, the University of Utah Research Institute (UURI), the Resource Assessment Team, and the Renewable Energy Bureau to discuss funding for expanded geophysical studies in selected Montana valleys, one of which was to be the Little Bitterroot. To fund the studies, the Resource Assessment Team was awarded $30,000 from the state. This amount was supplemented by $240,000 from DOE.

In September 1980, the geothermal team was contacted by the engineering staff of Energy Engineering of Kalispell concerning their plans for building a food processing plant to provide ethanol, chemicals, and animal feed, and using geothermal energy for process heat, as previously described. Pursuant to the contact, the corporation drafted the grant proposal to provide funds for production drilling.

Despite the failure to locate the hotter resource that had been hoped for, the ethanol facility with reinjection, and with careful attention to cascading energy flow and reclamation, will still be able to get from one-third to one-half of its heat from the geothermal water.

3.2 Bozeman Hot Springs

Bozeman Hot Springs is located ten miles west of the city of Bozeman on Highway 191, which leads south to Yellowstone National Park. The hot springs area has always been tourist oriented, although this may change in the near future as the city continues to grow towards the resort. The recent discovery of a large geothermal resource at the hot springs site may also prove decisive in shifting the past economic base. Both of these factors (the growth of the city and the discovery of a new resource) must therefore be considered in assessing the economic condition of the resort area.

The economic situation of Bozeman Hot Springs is closely tied to the city of Bozeman. The key attraction of the resort has always been the recreational use of the hot spring for both the city and the tourist trade. To date, the geothermal water is used to heat a swimming pool, to provide slab heating for two buildings and a warehouse, and to do laundry.

The economy of the city of Bozeman is heavily dependent on Montana State University, on tourism, and, increasingly, on industries serving both of these. Unlike much of the rest of Montana, agriculture in the area is not a major source of income; but like many other areas of the state, Bozeman, over the last few years, has seen considerable immigration of people leaving more heavily populated areas of the east and west for the relatively free and open country of the northwest. Thus, a combination of factors has led to a 16% growth rate in the Bozeman area over the last 10 years. A considerable portion of this growth has taken place at the west of town, near Bozeman Hot Springs. Several new housing tracts have sprung up in the immediate vicinity over the past three or four years, and new growth is continuing. Enrollment in Montana State University is also increasing, and surpassed the 11,000 mark for the spring quarter of 1981.

The future of tourism is in question due to the rise in gasoline prices and to the increase in interest rates, which affects the purchase price of recreation equipment. Whether this slump in tourism is temporary or permanent is unknown. Even if out-of-state tourism should decrease, however, there is the possibility that in-state tourism will increase, because Montanans travel within their own borders rather than going out of state.

With the discovery of a new resource at the site of the resort, a new factor has entered calculations regarding the local economy. While the old spring could supply the resort with hot water sufficient for heating the pool and buildings, this new resource is greater by a factor of ten, thus opening up new possibilities for direct application of geothermal energy in the area.

The well completed at Bozeman Hot Springs in October 1980 tapped water in Precambrian bedrock. The water's temperature was 120°F, and the artesian flow measured about 1000 gpm. This discovery advanced Bozeman hot springs into second place for the highest flow and temperature in the state, just behind Hunter's Hot Springs, which flows at about 1500 gpm at 140°F. The report submitted to the Renewable Energy Bureau by the spring owner is full of information on the project and its history.

The geothermal commercialization team has been involved in the drilling at the hot springs site since 1978, when the owner received a grant from the state Renewable Energy Grants program to drill a test well. The present well was drilled with remaining money from the original grant. Future involvement is planned in the analysis of appropriate end uses for the resource. Following the discovery of the new resource, the geothermal commercialization team made site visits and has put the owner in contact with a potential developer interested in geothermally heated commercial greenhouses.

To date, no action has been taken on end uses for the hot springs, and it is hoped that a statewide geothermal meeting planned for the fall of 1981 can clarify some of the considerations involved in decisions about end use, especially pricing the resource.

An awareness of the cost effectiveness of geothermal energy substantially increased the number of public contacts. Barriers to geothermal development still exist, however. The current staggering interest rates, high construction and drilling costs, and impending cuts in federal programs that aid in geothermal development have combined to slow the actual construction of geothermal projects. In spite of this pessimistic picture, it appears that geothermal energy will continue to be cost effective in selected Montana locations, and as coal, oil, and gas prices rocket, geothermal energy will become more and more important in reducing our state's dependence on fossil fuel.

A final report has been prepared for the prefeasibility drilling of the Bozeman Hot Springs. It was prepared by Charles Page, 133 Lower Rainbow Road, Bozeman, Montana 59715, telephone 406/587-3030.

NEW MEXICO GEOTHERMAL COMMERCIALIZATION PLANNING

SEMIANNUAL PROGRESS REPORT

July 1, 1980-December 31, 1980

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SANTA FE, NEW MEXICO 87501

Work performed under Contract No. DE-FC07-79ID12017

Mod. No. A001

U.S. Department of Energy

Idaho Operations Office

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1.0 INTRODUCTION

1.1 Purpose of Project

This project was developed as a mission-oriented program aimed at accelerating the commercial application of geothermal resources. It provides the Department of Energy, the State of New Mexico, and the private sector with a technical and economic guide for commercialization direction and actual implementation of development proposals. This was accomplished through the marketing strategies of public outreach, brokerage functions, and miniengineering evaluations of specific resources and appropriate direct-heat applications.

1.2 Objectives

In this market planning effort of the state geothermal energy commercialization, critical evaluation is made of the potential geothermal energy use, the availability of geothermal energy, and prospective user needs and applications.

In order to explore and assess all marketing possibilities for geothermal commercialization, the New Mexico state team, in conjunction with the New Mexico Energy Institute (NMEI), is investigating both onsite and offsite energy consumers, with special emphasis on colocated users and the appropriate site-specific direct-heat applications. This project mode has provided a basis for promotional marketing activities aimed at specific resource sites and potential users of geothermal energy and for concurrently supporting potential or current end-users of geothermal energy with technical assistance. This effort has inevitably provided good experience and greater insight into the marketing needs and demands of the end-users.

1.3 State Geothermal Commercialization Team Members

George Scudella, Principal Investigator and Project Manager; Resources Bureau Chief, Energy and Minerals Department, Santa Fe, NM

Roy Cunniff, State Geothermal Program Coordinator; Chief Engineer, NMSU Campus Project, Physical Science Laboratory, NMSU, Las Cruces, NM

Dr. Larry Icerman, NMEI Coordinator; Director of New Mexico Energy Institute, Las Cruces, NM

Dennis Fedor, EMD Coordinator; Energy Consultant, New Mexico Energy and Minerals Department, Geothermal Commercialization Office, NMSU, Las Cruces, NM

Kay Hatton, Mining and Minerals Division Coordinator; Geologist, M & M Division, Energy and Minerals Department, Santa Fe, NM

2.0 SPECIFIC TASK DESCRIPTIONS AND PRODUCTS

2.1 Geothermal Prospect Identification

The compilation and charting was made of the estimated geothermal energy potentially available from the prospect areas and sites as a function between now and the year 2020.

Figure 1 is a map showing the approximate outline of the geothermal resources of the state. Tables 1 through 3 list areas and sites of geothermal prospects for both electric and direct thermal uses in the state of New Mexico, as identified by various criteria.

In the first list, the prospective sites and areas are broken down to those that are (1) proven, (2) potential, and (3) inferred. The definitions used are those recommended by Meyer (December 1978):

- Proven sites are those (1) which are in an advanced stage of development or commercialization by a private company or by government for specific applications or demonstrations, or (2) those on which favorable quantitative data on the measured subsurface temperatures, volume, and water flows are available.

- Potential sites are those (1) on which there is exploraion or development activity, or (2) for which some favorable quantitative subsurface data have been estimated or measured.

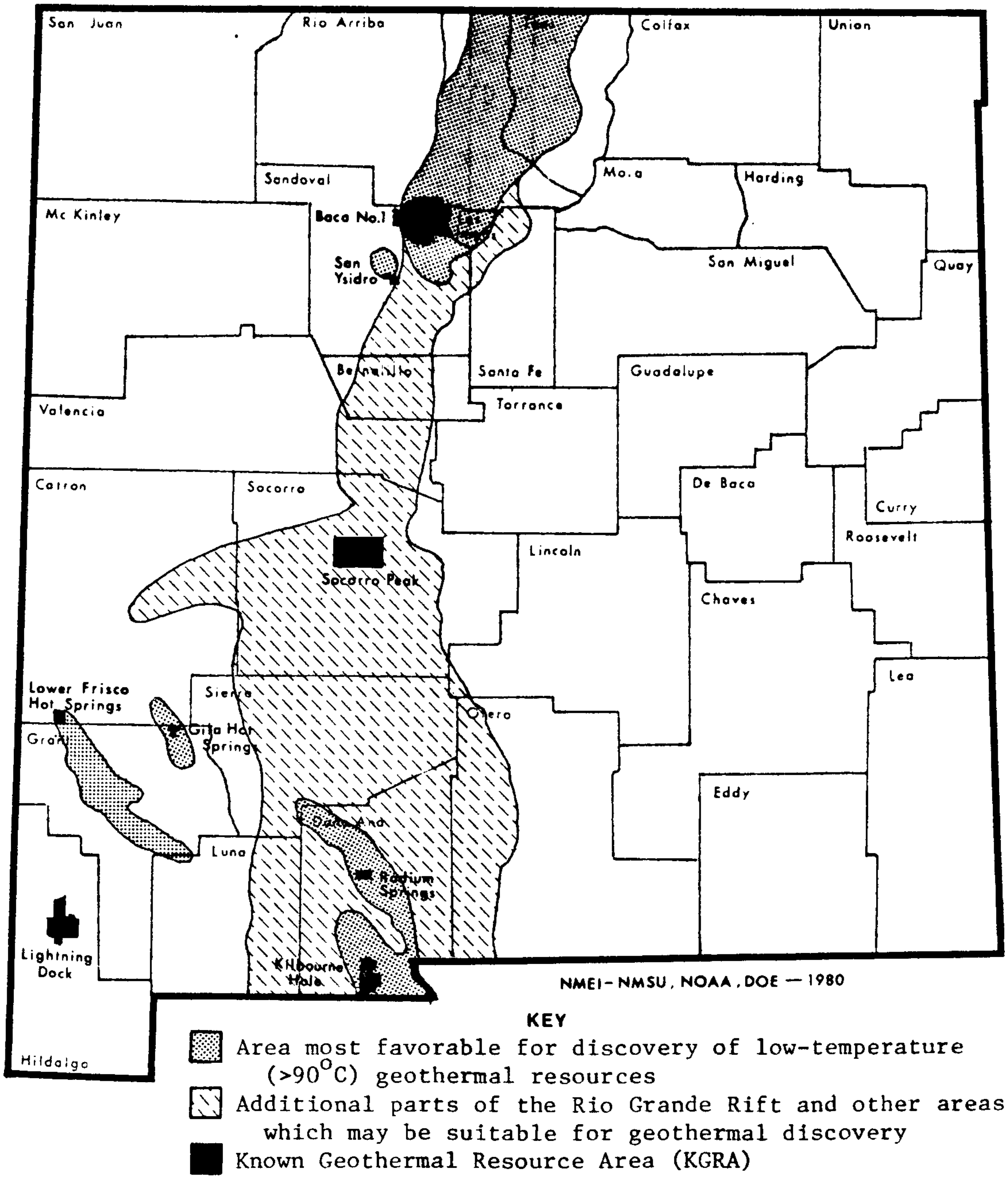

Fig. 1 Geothermal resources of New Mexico.

TABLE 1. NEW MEXICO IDENTIFIED GEOTHERMAL PROSPECTS

Proven	Potential	Inferred
Electric (150°C)		
Baca Location	Animas	Closson
	Kilbourne Hole	Columbus Area
	Radium Springs	Guadalupe Area
	San Diego Mountain	Jemez Reservoir
		Lordsburg
		Lower Frisco Hot Spring
		Prewitt Area
		Socorro
		Southern Tularosa Basin
		White Sands (Town)
Direct Thermal (20°C to 150°C)		
Animas	Albuquerque	Closson
Faywood	Black Mtn.-W. Mesa	Crown Point
Gila Hot Spring	Cliff Area	E. San Augustin Plain
Jemez Springs	Derry H.S.	Fort Wingate
Los Alturas	Mesquite-Berino	Garton Well
Ponce De Leon	Mimbres H.S.	Jicarilla Apache Res.
Truth or Consequences	Ojo Caliente	Little Blue Mesa

TABLE 1. NEW MEXICO IDENTIFIED GEOTHERMAL PROSPECTS (Continued)

Proven	Potential	Inferred
Direct Thermal (20°C to 150°C) (Continued)		
Radium Springs	San Diego Mtn.	Mamby's H.S.
	San Ysidro	Mancisco Mesa
	Socorro	Montezuma H.S.
	Turkey Creek H.S.	Southern Tularosa Basin
	Upper Frisco H.S.	Tohatchi

Source: Swanburg, C., 1980
PSL/NMEI, 1980

- Inferred sites or areas are those identified by (1) surface manifestations such as wells or springs, (2) chemical thermometry, or (3) proximity to potential or proven sites.

2.2 Area Development Plans

2.2.1 State Geothermal Planning Areas

The New Mexico State Team has defined one substate geographical area in which the development and use of geothermal energy prospects are likely between now and the year 2020.

The first-priority target areas for area development planning are centered on the Rio Grande River Valley throughout its entire length within the state.

TABLE 2. STATE OF NEW MEXICO PROVEN AND POTENTIAL RESOURCES FOR DIRECT THERMAL APPLICATIONS

Site	Latitude & Longitude	Temperature (°C) Surface	Temperature (°C) Subsurface	Estimated Volume (km^3)	Estimated Power (MWe) Proven	Estimated Power (MWe) Potential	Estimated Power (MWe) Inferred
Albuquerque	35° 05' 106° 45'	27	30	3.0			0.0449
Faywood H.S.	32° 33' 108° 00'	54		1.0			
Gila H.S.	33° 12' 108° 12'	68	125				
Jemez Springs	35° 47' 106° 4'	73	103	3.0		0.0206	0.6150
Los Alturas	32° 16' 106° 42'	55	120	3.0			0.5635
Ojo Caliente	36° 18' 106° 58'	45	122-161	3.3			
Radium Springs	32° 30' 106° 58'	30-85	130-198	3.3			0.0368
San Diego	35° 37'		52				
San Ysidro	35° 30' 106° 40'	50	80	1.0			0.0206
Socorro	34° 2' 106° 56'	33	35	3.0			0.013
Truth or Consequences	33° 9' 107° 15'	36-46	100	1.0		0.0269	0.4563
Animas	32° 85'	102	144	3.0		.0359	0.4102
					0	0.0834	2.1508

Source: PSL/NMEI Data File, 1980

TABLE 3. STATE OF NEW MEXICO PROVEN AND POTENTIAL ELECTRIC APPLICATIONS

Site	Latitude & Longitude	Temperature (°C)		Estimated	Estimated Power (MWe)		
		Surface	Subsurface	Volume (km^3)	Proven	Potential	Inferred
Animas (Lightning Dock)	32° 85' 108° 50'	102	170	3.3		5	20
Baca Location	35° 54' 106° 32'		260-315	125.00	50	350	1942
Kilbourne Hole	31° 57' 106° 58'	45-83	155	3.50		5	25
Radium Springs	32° 30' 107° 58'	30-85	93-130	3.3		5	30
San Diego Mtn			125	1.00	—	5	20
					50	370	2037

Source: PSL/NMEI Data File, 1980

2.2.2 Specific Area Development Plan: Dona Ana County

Dona Ana County (see Figure 1) is one of the fastest growing areas in the state. The total county population is about 80,000, and the Las Cruces SMSA stands at about 51,000. Both the expanding industrial and governmental sectors are contributing to a robust economy in the county. Dona Ana County has the second largest geothermal heat potential in the state (the Baca location is largest), and therefore it is emerging as the first area of intense study and planning activity accomplished through private and government entities. The strong local interest and community leadership shown for the economic use of geothermal energy and the adjacent overflowing economic growth pattern of El Paso, Texas provided the basis of selection for the area development plan. A number of research investigations of the geothermal potential here have been conducted. There are two known geothermal resource area's (KGRAs) in the county: Radium Springs and Kilbourne Hole. The Kilbourne Hole KGRA, located next to the U.S.-Mexico border, has potential electrical generation capacity.

The Dona Ana Area Development Plan involves first the investigation of the area characteristics such as geography, population, economy, and the attitudes of the residents. Second, the energy demands of the area, both current and projected, are considered according to the Standard Industrial Code and fuel types. Third, the current and future geothermal energy development is described. A possible schedule of activites has been estimated. It should be kept in mind, however, that actual development is entirely dependent on the actions of the entrepreneurs.

In addition to the two KGRAs, the county has numerous hot water wells and hot springs. The geothermal potential, including all sites, is 0.9899 quad Btu's for 30 years for direct thermal use.

Most large-scale greenhouse operations can easily be converted to take advantage of heat from geothermal water, depending on the resource and its location.

2.3 Site-Specific Development Plans

2.3.1 Candidate Geothermal Sites

The specific resource sites and energy applications (residential, commercial, industrial, and agribusiness) that are candidates for site specific development plans (SSDPs) are identified and briefly described below.

Animas/Lightning Dock

Current application:	Space-heating of one house. Two geothermally heated greenhouses with a total of 130,000 ft^2. Geothermal irrigation and soil warming system for fruit orchard.

Anticipated application: Additional 500,000 square feet area of geothermally heated greenhouse. Site of DOE's 1979 AET grant in Region 6 of $20,000 to Tom McCants.

Resource data:

Surface temperature	102°C
Subsurface temperature	144°C

Estimated reservoir size: 3.3 km^3

Los Alturas

Current applications: Space-heating of home for the President of New Mexico State University (NMSU), and source of domestic water supply for Los Altras subdivision.

Anticipated application: Space-heating: Sandyland greenhouse, New Mexico State University campus, land development subdivision district heating.

Resource data:

Surface temperature	48°C
Subsurface temperaute	120°C

Estimated reservoir size: 6.0 km^3

Truth or Consequences

Current applications:	Several resort spas, bathhouses and pools, spaceheating of Yucca Lodge. Preheated boiler feedwater and hot water supply for Carrie Tingley Hospital, plus the geothermal therapeutic pools.
Anticipated application:	Spaceheating of senior citizens center, Yucca Gardens condominium building complex, and commercial buildings
Resource data:	Surface temperature 45°C Subsurface temperature 100°C
Estimated reservoir size:	1.0 km^3

Albuquerque

Current applications:	Heat pump spaceheating of nine-story office building (Sandia Savings)
Projected applications:	Large user spaceheating: West Mesa Airport, West Mesa High School, University of Albuquerque campus preheat boiler system, district heating of future subdivisions on the West Mesa

Resource data:	Surface temperature	27°C
	Subsurface temperature	N/A

Estimated reservoir size: 3.0 km^3

Jemez Springs

Current application: Bathhouse, greenhouse spaceheating

Projected application: Spaceheating of village municipal buildings

Resource data:	Surface temperature	73°C
	Subsurface temperature	103°C

Estimated reservoir size: 3.3 km^3

2.4 Time-Phased Project Plan

2.4.1 Active Demonstration/Commercialization Projects

There are nine geothermal developments in the state that are currently active demonstration and commercialization projects. All of these projects are considered to be candidates for the time-phased project plans.

Of those projects, six are demonstration projects that were initiated by the New Mexico Energy and Minerals Department and cost-shared with federal and private funding sources. These demonstration projects include the following:

1. Carrie Tingley Hospital at the City of Truth or Consequences. The geothermally preheated hot water system was designed and installed and is operated by the BDM Corp. The project uses an old active well system that provides natural hot water for the hospital's two therapeutic pools. The project started on March 1, 1980 and began operations with a ribbon-cutting ceremony on September 18, 1980. The system is being monitored and will be evaluated until June 1981. The system is equipped to handle 170,350 liters of continuously pumped well water (43°C) that contains a useful heat content of 12,000 Btu/min.

2. University President's House, University Center, NMSU, Las Cruces. This is a space-heating project for the residence. A well has been drilled into the Los Alturas Geothermal Anomaly, which underlies the residence. The space-heating system uses 50°C water from a depth of 137 meters (450 ft) at a flow rate of 64.3 l/min. The project started June 28, 1979; construction was completed in September 1980, and the residence was occupied in December, 1980. The monitoring and reporting will continue until June 1981.

3. Solar-Assisted Geothermal Greenhouse, Faywood Hot Springs. The resource is the Faywood Hot Springs, 48.3 km (30 miles) southeast of Bayard, New Mexico, the springs flow at 132.51 l/min and 57°C (125°F). The objective is to construct and operate the geothermal greenhouse using runoff water from the hot spring to produce native plants for waste tailings reclamation projects by Kennecott Copper Corporation. This development is being constructed and operated by handicapped labor from the Southwest Services for Handicapped Children and Adults. This service organization owns the greenhouse. This project was started on June 18, 1979 and is nearly completed (Summer 1981).

4. City of Truth or Consequences Senior Citizens Center. This is a retrofit space-heating project that will tap the underlying artesian thermal water basin under the city. The well water temperature in the area averages 43°C. The geothermal water will be pumped from a 154 meter (or less) well which is being drilled on city property. This well will be connected to the city's Senior Citizens Center to supply up to 100,000 Btu/hr during peak demand period. The complete design, installation, and monitoring of the spaceheating system was completed by February 1981. The project was started on June 28, 1979 and will terminate December 31, 1981.

5. Solar-Assisted Geothermal Greenhouse, Taos. The resource is the Ponce de Leon Hot Springs near Ranchos de Taos. The springs dis-

charge 1,305,977 l/day at 35°C at an elevation of about 2,256 m. The project will analyze and determine the use of a geothermal heat recovery system to provide thermal energy for greenhouse spaceheating (for 5,574 m^2) for growing cash crops and for other commercial processes. This project uses technology transfer from power plant waste heat recovery and is conducted by Solar America, Inc. of Albuquerque. The project began May 22, 1979 and was dedicated at a ribbon-cutting ceremony on October 28, 1980.

6. L'eggs Products, Inc., Mesilla Park. This project evaluated the resource potential and the engineering required for bringing geothermal energy on line for industrial process at the hosiery manufacturing plant. A 1,800 ft test well was drilled on the plant site on May 12, 1980. No appropriate resource was found, but a warm bottom hole temperature of 32°C was encountered. It was determined from a series of economic and engineering tests that the development of a deep resource would not be economically suitable for the company's requirement and needs.

With the exception of some aged hot spring resort spas, most private business enterprises using geothermal energy in the state started in the 1960's. The most significant developments are listed here:

1. Baca Location Geothermal Power Plant Demonstration Program, Jemez Mountains. The resources of the project area inside the Valles

Caldera include both a liquid and a vapor-dominated reservoir. The major, liquid-dominated reservoir is overpressured and contains a calculated 1.8 x 10^{12} kg of fluid in place. The average reservoir fluid temperature is in excess of 260°C. The main production and injection zone is the lower Bandelier Tuff; the upper Bandelier forms the caprock. Since the first geothermal well was acquired in 1963, Union Geothermal of New Mexico has drilled 23 wells, and probably 10 to 15 more wells may be needed for the proposed 50 MWe plant. Final approval of the environmental impact statement was made in May of 1980. Authorization for construction is still pending from the Public Service Commission, and additional water rights need to be granted from the State Engineer's Office before construction can begin.

2. <u>The Animas Valley Geothermal Greenhouses</u>. The operators are Tom McCants and Dale Burgett. Two hothouse operations are described together because of the same underlying resource and because of identical characteristics, energy-use applications, and geothermal energy-requirements.

The resource is the "Animas hotspot," a very shallow anomalous aquifer, where abundant water of 102°C (215°F) is obtained at depths of less than 29 meters. The thermal anomaly has no surface manifestations and it is very geophysically conspicious in a 1 square mile section. This apparently is a fault-controlled feature adjoining a sediment-filled basin.

The two greenhouse operations overlying the thermal anomaly use 3600 Btu/min and 1700 Btu/min with no thermal drawdown. The thermal capacity is used for the production of various high-priced floral plants, particularly roses.

3. Geothermal Heat Pump System of Sandia Savings Building, Albuquerque. Two aquifers, 90 ft and 270 ft deep, supply cool and warm waters according to seasonal demand. Two wells are involved in this operation: the shallow well supplies cool water with a temperature range from 17°C to 21°C (60° to 70°F); the deeper well supplies warm water at 26° to 27°C. The water is withdrawn from either the cool or warm well, depending on the season, and injected into the other well. A heat exchanger and three 100 horsepower compressors are used to boost or lower the water temperatures for winter heating or summer cooling. Heating requires 2,518,000 Btu/hr and cooling requires 3,467,182 Btu/hr.

2.5 State Aggregation of Prospective Geothermal Utilization

Table 4 shows the estimates of the total geothermal energy on-line for the planning area as a function of time.

TABLE 4. POSSIBLE ECONOMICAL GEOTHERMAL ENERGY ON LINE (10^{12} Btu)

Area Dev. Plan	1985	1990	2000	2020
#1	2.47	8.09	23.0	48.7
2	0	0	0.77	0.81
3	1.87	5.37	13.13	26.1
4	0.72	1.79	2.47	3.22
5	0	0.89	4.43	6.99
6	0	0	0	0
7	0.65	4.38	11.40	23.2
8	0	0	0	0

Area Dev. Plan	Area
1.	Dona Ana County
2.	Albuquerque Area--Bernalillo, Torrance, and Cibola
3.	Los Alamos, Rio Arriba, Sandoval, Santa Fe, and Taos
4.	Sierra and Socorro
5.	Catron, Grant, Hidalgo, and Luna
6.	Chaves, Eddy, Lea, Lincoln, and Otero
7.	McKinley, San Juan, and Valencia
8.	All northeastern counties

Source: PSL/NMEI

2.6 Institutional Analysis

2.6.1 Overview of State Legislation

Legislation regarding regulatory conflicts, geothermal leasing, and district heating authority was not feasible during the 1980 legislative session due to the administration's reluctance to put substantive issues on the call.

It is possible that some difficulties in the relationship between appropriative rights and correlative rights for geothermal resources may potentially be resolved through administrative action.

At any rate, district heating legislation and amendments to state geothermal leasing policies may not be examined any further until the 1982 session.

Through a review of state statutes, the assistance of the state engineer's office and the NUSL, and extensive discussions and correspondence with Steve Reynolds and D. E. Gray, who have been extremely receptive and helpful, the following findings resulted.

- In declared groundwater basins, conflicts between appropriative rights and correlative rights for geothermal resources may potentially be resolved administratively. In the State Engineer's view, this may be achieved through conditions placed on geothermal fluid appropriations for which prior rights protection vis-a-vis other geothermal appropriators is waived.

- The State Engineer's jurisdiction does not extend outside of declared groundwater basins. The appropriative rights/correlative rights conflict therefore cannot be resolved in these areas by means of conditions on geothermal appropriations. Legislation to resolve the conflict in these areas may be warranted.

- According to certain statutory provisions (72-12-25 NMSA (1978)), "nonpotable" water at depths of 2500 feet or more is exempt from declared basins. Although the State Engineer questions the force of this provision, it may remove most hindrances to development of deep sources. Geothermal development is clouded by this provision in the statute, and it deserves legislative review.

Only one legislative item was enacted in the 1981 session that is important in promoting geothermal energy in New Mexico. An appropriation called Chapter 134 of Laws 1980, Section 2, was enacted to provide $600,000 of state funds for the purpose of funding geothermal drilling and geothermal demonstration projects. The stipulation is made that awards be made only on the basis of equally matching funds from private or federal sources.

2.7 Public Outreach Program

The goal of this program is to increase awareness and acceptance of geothermal energy and to promote the use of geothermal resources by industry, commerce, agriculture, and government. This program is designed to expedite the direct applications of geothermal energy by (1) identifying geothermal application concepts; (2) identifying potential resource end-users; (3) identifying potential funding for end-users serving a broker function between end-users, government, and private developers; and (4) providing engineering and technical assistance to potential end-users.

2.7.1 Outreach Mechanisms

The New Mexico Outreach Program is oriented primarily to assisting selected potential end-users who were identified either in the early planning work of the state's O/R geothermal energy development or through the completed marketing analysis, referred to as the "New Mexico Assessment of the market potential of Geothermal Energy." These potential end-users were selected on the basis of their energy consumption, need for an alternative source of energy supply, energy-use planning attitude, and enthusiasm. More technical assistance requests were generated through this marketing survey project than through all of the other outreach mechanisms combined. Each case is handled with individual meetings to define the problems, goals, and needs, and then the meetings are usually followed up with small economic and engineering studies. A literature search of technical equipment is sometimes made, or information of various types on consultants may be supplied according to the requestor's needs.

The other outreach mechanisms are:

- o State EMD Research and Development Program
- o DOE Region 6 Appropriate Energy Technology Small-Grants Program
- o State Geothermal Demonstration Program
- o Energy Extension Service
- o New Mexico Energy Institute

The New Mexico R&D program has spent approximately $1.17 million for geothermal research and development. Geophysical and engineering projects have been funded by R&D funds, and this source of funding has generated numberous contacts and projects in New Mexico.

The geothermal team reviews geothermal proposals, makes staff recommendations to the R&D Review Board, monitors funded projects, and transfers the technology developed under R&D to the citizens of New Mexico.

The appropriate energy technology small-grants program is another area where the state team has provided help through information dissemination on the program and its application procedures. Critical review and recommendations were provided to the NM Energy and Mineral Department--the participating agency for DOE in this state.

In 1979, New Mexico awarded $200,000 to six contractors for geothermal space heating demonstrations. These demonstration projects are New Mexico's way of leading by example, and they are our announcement that New Mexico has viable geothermal resources that can be developed now.

Demonstration monitoring is continuing on the construction, operation, and evaluation of the six projects, and eventually the information and experience will be transferred to the public and to potential developers. The demonstrations also offer the monitor the opportunity to assist developers in administrative and permit procedures, thereby gaining practical experience that will be useful to future developers.

The geothermal team has worked with the Energy Extension Service to transfer to the public updated information and materials on goethermal energy relating to resource availability, space heating, agricultural applications, industrial uses, and commercial applications.

2.7.2 Summary of Contact and Results

All of the contacts made this past year are summarized and briefly described in Appendix A-5, "The Complete List of New Mexico Consultants, Resource Developers, Private Users and Suppliers."

2.7.3 Overall Prospectus for Future Geothermal Activity

The New Mexico Geothermal Demonstration Program has successfully raised the profile of the viability of geothermal energy as an alternative energy resource. New Mexico now finds itself in a position of not only having six active demonstrations but also having an intense interest in geothermal energy shown by a broad spectrum of our community.

Greatest interest in geothermal development is being shown in Dona Ana County in the southern part of the state. The county is the home of New Mexico State University, which has been actively drilling for geothermal energy on campus. The university has successfully completed several wells and obtained state and DOE financial assistance for campus domestic hot water heating.

EMD personnel have been working with community leders in Dona Ana County to identify potential users. Initial information has furnished prospects in the areas of space heating for a retirement center and greenhouse operations, process heat for a pet food processor, and geothermal application for a dairy.

Finally, the West Mesa area, Albuquerque, has become the focal point of geothermal exploration. The West Mesa area is the center of new growth in Albuquerque, and geothermal applications may have a viable future. Plans for further exploration in this area are being developed.

All in all, New Mexico's geothermal future continues to be bright and its activity is increasing. The EMD is taking a very active role in geothermal R&D, demonstration, outreach, and commercialization, and this effort should expedite development.

3.0 SUMMARY OF MAJOR FINDINGS AND RECOMMENDATIONS

The following are the State Team's findings and recommendations:

1. Outreach effort has increased substantially and has raised the geothermal profile.

2. New Mexico's Research and Development fund has had a substantial impact on geothermal development and outreach.

3. New Mexico's Geothermal Demonstration Program has provided the biggest boost to geothermal development, and the $200,000 appropriation has been developed into six projects valued at more than $500,000. The new $600,000 appropriation has generated one project, and more are expected in the near future.

4. Specially trained and experienced geothermal personnel should be made available to the states for 30 to 90 days to assist the states in organizing and fine tuning their operations. Examples: resource planning, well drilling, contracting, electrical generation, and space heating engineering.

5. State and Federal agencies have to realize that loan guarantees address a symptom, not the illness. Major technical efforts must

be made to reduce geothermal risks by improving the technology, especially technologies associated with exploration, well drilling, and reservoir identification. Prime emphasis must be placed on reducing or eliminating the huge risk associated with "first holes." This program must have provision for many initial wells, and have maximum access by small- and medium-size energy users.

APPENDICES

A-1 TOTAL ACREAGE OF GEOTHERMAL LEASES

A-2 FEDERAL ACTIVE COMPETITIVE LEASES

A-3 FEDERAL ACTIVE NON-COMPETITIVE LEASES

A-4 STATE LEASES

A-5 THE COMPLETE NEW MEXICO LIST OF CONSULTANTS, RESOURCE DEVELOPERS, PRIVATE USERS AND SUPPLIERS

TABLE A-1

TOTAL ACREAGES OF GEOTHERMAL LEASES - NEW MEXICO

Federal Leases	
Total Acreages of Competitive Lease in KGRA's: (51 Leases)	87,540
Total Acreages of Non-competitive Leases: (72 Leases)	138,170
State Leases	
Total Acreages of State Leases: (111 Leases)	45,663
TOTAL OF ALL ACREAGES LEASED	271,373

TABLE A-2

FEDERAL ACTIVE COMPETITIVE GEOTHERMAL LEASES - NEW MEXICO

COUNTY & LESSEE	SIZE, ACRES & (NO. OF LEASES)	KGRA/LOCATION	DATE ISSUED & (COST/ACRE)
DONA ANA			
Aminoil USA, Inc.	1,235.45 (1)	Radium Springs, KGRA, T21S, R1W	02/01/78 ($8.29)
Anadarko Production	18,476.45 (9)	Kilbourne Hole, KGRA, T27 & 28S, R1W	07/01/75 ($10.06- ($30.50 & $10.63)
Chevron USA	2,198.48 (3)	Radium Springs, KGRA, T21S, R1W	12/01/77 & 12/01/78 ($30.50 & $10.63)
N.K. Hunt	360.00 (2)	Radium Springs, KGRA, T21S, R1W	12/01/78 ($56.00)
HIDALGO			
Amax Exploration	6,580.43 (3)	Lightning Dock, KGRA, T25S, R19 & 20W	Various ($3.13, $8.11 and $13.07)
Aninoil USA, Inc.	1,271.64 (1)	Lightning Dock, KGRA, T25S, R19W	01/01/77 ($1.99)
J.E. Blakenship	1,235.72 (3)	Lightning Dock, KGRA, T25S, R19W	01/01/77 ($1.99)
Earth Power Corp.	5,060.12 (2)	Lightning Dock, KGRA T24 & 25S, R19 & 20W	10/01/76 & 12/01/78
Phillips Petroleum Co.	2,898.37 (2)	Lightning Dock, KGRA T25S, R19W	10/01/76 ($3.38 & $5.23)
RIO ARRIBA			
Amax Exploration	6,183.45 (4)	Baca Location No. 1 KGRA, T21N, R3 & 4E	08/01/77 & 12/01/77 ($5.67 & $5.31)
SANDOVAL			
Amax Exploration	3,870.84 (2)	Baca Location No. 1 KGRA, T18N, R3 & 4E	08/01/77 ($5.67)

Sources: Bureau of Land Management Hatton, Kay, 1980

TABLE A-3

FEDERAL ACTIVE NON-COMPETITIVE GEOTHERMAL LEASES - NEW MEXICO

COUNTY & LESSEE	SIZE, ACRES & (NO. OF LEASES)		LOCATION	DATE ISSUED
DONA ANA				
Mary Antweil	1,365.44	(1)	T19S, R2W	03/19/79
Chevron USA Inc.	2,522.17	(2)	T20 & 21S, R1E & 1W	06/29/79
J.F. Grimm	9,568.61	(5)	T25 & 26S, R1E	06/11/75
C.L. Hunt	13,730.68	(6)	T27S, R1 & 2W & T20S & 21S, R1W	05/29/75 & 06/26/79 & 01/25/80
Nancy B. Hunt	1,280.00	(1)	T28S, R2W	05/29/79
Nelson B. Hunt	15,536.00	(7)	T26S, R1 & 2W	05/29/79
N.K. Hunt	8,306.94	(4)	T29S, R1 & 2W	05/29/79
M.W. Sands	2,440.00	(1)	T20S R1W	04/27/79
Ramona Sands	4,307.79	(3)	T20 & 21S, R1W	04/27/79
H.W. Schoellkopf, Jr.	9,636.92	(3)	T17 & 28S, R2W	05/29/75
Southland Royalty Co.	14,263.29	(7)	T19, 20 & 21S, R1E,	06/15/79
HIDALGO				
Chevron USA, Inc.	5,814.13	(4)	T26S, R20W	09/11/79 & 11/01/79
Earth Power Corp.	533.68	(1)	T26S, R19W	12/28/76

TABLE A-3 (Cont'd)

FEDERAL ACTIVE NON-COMPETITIVE GEOTHERMAL LEASES - NEW MEXICO

COUNTY & LESSEE	SIZE, ACRES & (NO. OF LEASES)	LOCATION	DATE ISSUED
HIDALGO (cont'd)			
Sun Oil Company	1,280.00 (1)	T25S, R20W	10/24/79
Thermal Resources, Inc.	1,320.00 (2)	T25S, R19W	07/07/77
U.S. Geothermal Corp.	2,954.57 (2)	T25 & 26S, R19 & 20W	05/29/75
SANDOVAL			
Occidental Geothermal, Inc.	2,817.95 (4)	T15N, R1 & 2E	07/07/77 & 06/21/79
Sunoco Energy Dev. Co.	1,542.32 (2)	T15N, R3 & 4W	08/19/77
SIERRA			
Fluid Energy Corp.	12,182.93 (5)		

TABLE A-4

STATE LEASES - NEW MEXICO

COUNTY & LESSEE	SIZE, ACRES & (NO. OF LEASES)	DATE ISSUED
DONA ANA		
Chevron	639.36 (1)	08/14/79
Energetic Corp.	640.00 (1)	07/19/79
GRANT		
Aminoil USA	4,695.63 (18)	08/08/79 & 03/12/75
Supron Energy Corp.	3,868.90 (18)	03/12/75
HIDALGO		
Amax Exploration	8,176.00 (19)	07/10/79 & 07/19/79
Aminoil USA	11,078.55 (25)	08/03/79 & 03/12/75
SANDOVAL		
Cherokee & Pittsburg Mining	4,433.19 (7)	03/12/75
E.E. Fogelson	1,280.00 (2)	03/12/75
SOCORRO		
Arco	5,437.00 (10)	07/19/79
J.W. Covello	640.00 (1)	03/12/75
J.M. Kelly	2,624.27 (5)	03/12/75
Gulf Oil Corp.	2,150.56 (4)	03/12/75

Source: New Mexico State Land Office

(A-5)

THE COMPLETE NEW MEXICO LIST OF GEOTHERMAL ENERGY CONSULTANTS, RESOURCE DEVELOPERS, PRIVATE USERS AND SUPPLIERS

April, 1981

Prepared by:
Dennis Fedor

New Mexico Energy and Minerals Department
Santa Fe, NM

Geothermal Commercialization Office
Las Cruces, NM

Work performed under Contract No. DE-FC07-79ID12017
Mod. No. A001

U.S. Department of Energy
Idaho Operations Office

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CONSULTANTS/CONSULTING FIRMS

Name	Phone	Remarks/Expertise
Abernathy, George Director, Agricultural Engineering Department, NMSU P.O. Box 3268 Las Cruces, New Mexico 88003	(505) 646-2021	• Private Consultant on geothermal greenhouses
American Ground-water Hydrologists Contact: Dr. William Turner 2300 Candelaria Road, NW Albuquerque, NM 87107	(505) 345-9505	• Geothermal exploration & geothermal resource suitability surveys
G.A. Baca and Assoc., Ltd. 330 Garfield St. Suite 207 Santa Fe, New Mexico 87501	(505) 983-2594	• Complete system design
BDM Corporation Contact: Mr. Arthur J. Mansure 1801 Randolph S.E. Albuquerque, NM 87106	(505) 848-5302	• Project design engineering and management • Designed system for Carrie Tingley Hosp. • Engineers & scientific planning services.
Bridgers & Paxton Consulting Engineers, Inc. Contact: Mr. Frank H. Bridges 213 Truman Street, NE Albuquerque, NM 87108	(505) 265-8577	• Heat pump specialists • Designed systems for Albq. Sandia Savings Bldg and Salt Lake City LDS Bldg
Campbell, Mr. Doc Route 11 Gila Hot Springs Silver City, New Mexico 88061	(505) 534-9340	• A private user with 40 years experience in materials and system use of hot springs water at Gila H.S.
Chaturvedi, Dr. Lokesh P.O. Box 3CE NMSU Las Cruces, New Mexico 88003	(505) 646-3233	• Geothermal hydrologist
Chemical Engineer Associates Contact: Mr. Harold M. Belkin 221 W. Griggs Las Cruces, NM 88001	(505) 526-3221	

CONSULTANTS/CONSULTING FIRMS (Cont'd.)

Name	Phone	Remarks/Expertise
CH2M Hill Engineers o Mr. Bob Dart P.O. Box 22508 Denver, CO 80222	(303) 771-0900	• Engineers, planners, economists & scientists
o Mr. John Austin Box 8748 Boise, Idaho 83707	(208) 345-5310	• Consultant on Boise Idaho District Heating Project
o 3620 Wyoming Blvd NE Albuquerque, New Mexico	(505) 292-1262	
Coonce, C. A. & Associates Contact: Mr. Pat Coonce 12324 Pineridge, Ne Albuquerque, NM 87112	(505) 296-1089	• Water system engineers
Coupland and Moran Associates Contact: Mr. Dan Romero Electrical Engineer 200 Altez, SE Albuquerque, NM 87123	(505) 296-5573	• Electrical & mechanical engineering
Cunniff, Mr. Roy State Geothermal Prog. Coordinator Physical Science Laboratory Box 3-PSL NMSU Las Cruces, New Mexico 88003	(505) 522-9349	• Private Consultant • PI on NMSU campus space-heating project • Technical Advisor for all state demonstration projects
DuMars, Charles Dr. College of Law - UNM 1117 Stanford, N.E. Albuquerque, New Mexico 87131	(505) 877-7444	• Law practice in water and mineral resources
E G & G, Inc. 9733 Coors Blvd, NW Albuquerque, New Mexico	(505) 898-8000	
Energetics Corporation Contact: Mr. L. Dale Clark, Pres. 833 E. Arapaho Road, Suite 202 Richardson, Texas 75081	(214) 783-4731	
Energy Resources Exploration, Incorporated Contact: Mr. Bob Grant 9720 Candelaria, NE Suite D Albuquerque, NM 87112	(505) 2966226	• Geologist

Name	Phone	Remarks/Expertise
Gebhard Thomas Mr. Private Consulting Engineer 5819 Westmont Drive Austin, Texas 78731	(512) 4535577	• Planning & feasibility studies
GeoProducts Corporation Contact: Mr. Kenneth Boren, Pres Oakland, California 94612	(415) 893-8365	• A resource developer using hybrid concepts with biomass.
GeoThermal Services, Inc. Contact: Mr. Barry Williams, Project Supervisor 10072 Willow Creek Road San Diego, California 92131	(714) 566-4520	• Heatflow and gradient hole drilling • High temperature geophysical logging • Geothermal consulting
Goodrich, Mr. James L. Goodrich - Bartlett & Associates 1105 Gardner Las Cruces, New Mexico 88001	(505) 522-7633	• Long-range feasibility study • Advanced Planning-Feasibility-Coordination Consultant
Gruy Federal, Inc. Contact: Mr. Alan Lohse, Exec. VP Mr. Paul O'Connor, Tech. Mktg. Rep. 2001 Jefferson Davis Hwy, Suite 701 Arlington, Virginia 22202	(702) 892-2700	• Project management of drilling & testing of wells.
Intermountain Sciences Contact: Mr. Keith E. Brown Rt. 2 Box 210 Las Cruces, New Mexico 88001	(505) 524-0363	• Geothermal specialists Complete system design
Richard L. Lohse Geothermal Field Engineer New Mexico Energy Institute P.O. Box 3EI Las Cruces, New Mexico 88003	(505) 646-1745	• Private consultant • Geophysicist specializing in geothermal exploration and reservoir assessment
Los Alamos Technical Assoc., Inc. Contact: Mr. Phil Reinig P.O. Box 410 1650 Trinity Drive Los Alamos, New Mexico 87544	(505) 662-9080	

CONSULTANTS/CONSULTING FIRMS (Cont'd)

Name	Phone	Remarks/Expertise
Mancini, Dr. Thomas Mechanical Engr. Dept. P.O. Box 3450 NMSU Las Cruces, New Mexico 88003	(505) 646-2223	• Principal investigator for the T or C Senior Citizens' Center
R&D Associates 6400 Uptown Blvd., NE Suite 398-W Albuquerque, New Mexico 87110	(505) 881-0991	
Republic Geothermal, Inc. Contact: Mr. Gerald Huttrer, Mgr. Exploration P.O. Box 3388 Santa Fe Springs, CA 90670	(213) 945-3661	
Shain, Joe Engineers 1519 Pacheco Santa Fe, New Mexico 87501	(505) 983-1297	
Solar America, Inc. Contact: Mr. David Chavez 2620 San Mateo, NE Albuquerque, New Mexico 87110	(505) 883-0959	• Project design, engineering and management for geothermal greenhouses
Summers, W.K. & Associates, Inc. Contact: Mr. W.K. Summers President & Senior Geologist P.O. Box 684, 904 Cuba SE Socorro, New Mexico 87801	(505) 835-2095	• Conducted study on Gila geothermal energy potential • Hydrology & geology
Swanberg, Dr. Chandler A. Physics Department P.O. Box 3D New Mexico State University Las Cruces, New Mexico 88003	(505) 646-1920	
Application Center Contact: Mr. Jerry Yowell 2500 Central Avenue, SE Albuquerque, New Mexico 87131	(505) 277-3622	• Conducted state energy consumption study for New Mexico

CONSULTANTS/CONSULTING FIRMS (Cont'd)

Name	Phone	Remarks/Expertise
WESTEC Services, Inc. Contact: Mr. Peter Sherwood, Regional Manager 505 Marquette Avenue, NW Suite 1500 Albuquerque, New Mexico 87102	(505) 243-2835	• Contractor for Baca Geothermal Demonstration Project Data Management • Program management for El Centro, CA. District heating & cooling demonstration. • Feasibility studies for geothermal grain drying, tungsten ore processing, ethanol & ammonia production.
Western Energy Planners, Ltd. Contact: Mr. Jerry Tuttle 11000 Candelaria NE, Suite 112W Albuquerque, New Mexico 87112	(505) 296-4070	• Energy systems including economic & engineering systems

New Mexico Geothermal Commercialization Interest

RESOURCE DEVELOPERS (EXPLORATION AND LEASE-HOLDERS)

Name	Phone	Areas of Interest
AMAX Contact: Mr. Dean Pillsington or Mr. Harry Olson 7100 W. 44th Ave. Wheat Ridge, Colorado 80033	(303) 420-8100	• Rio Grande Rift • Animas Valley • Valles Caldera
American Drilling & Grouting Co. Clinton, Mississippi		• Dona Ana County
Aminoil USA, Inc. Contact: Mr. Claude Jenkins P.O. Box 11279 Santa Rosa, California 95406	(207) 527-5332	• Dona Ana County • Animas Valley
Bailey, Harry N. 25256 Terreno Drive Mission Viejo, California 92576	(505) 526-1404	• Drilled wells on land he owns at Radium Springs. Wants resource user.
Chaffee Geothermal, Ltd. Contact: Mr. Jay Dick, Mgr. 1776 S. Jackson, Suite 1000 Denver, Colorado 80210	(303) 692-9496	• Las Cruces/Las Alturas anomaly
Calvert Exploration Co. 1000 City Center Bldg. Oklahoma City, OK 73102	(405) 239-6251	
Chevron Resources Co. Contact: Mr. Eric Layman P.O. Box 3722, 595 Market St. San Francisco, California 94119	(415) 894-2889	• Radium Springs • Socorro • Lordsburg-Animas
Earth Power Corp. P.O. Box 1566 Tulsa, Oklahoma 74101	(918) 587-9704	• Lightning Dock KGRA
Exxon Company USA Contact: Mr. James H. Hafenbrack Geological Advisor P.O. Box 120 Denver, Colorado 80201	(303) 789-7792	• Hidalgo County • Animas Valley
Fluid Energy Corporation Contact: Mr. Hal Bemis Denver, Colorado 80210	(303) 756-5266	• T or C • Las Cruces

RESOURCE DEVELOPERS (EXPLORATION & LEASE-HOLDERS) (Cont'd.)

Name	Phone	Areas of Interest
Geoproducts Corporation Contact: Mr. Kenneth Boren, Pres. 1330 Broadway Oakland, Calif. 94612	(415) 893-8365	• Medium to low temperature resource developer • hybrid geothermal - wood residue electrical generation - ethanol production
Gulf Mineral Res. Co. Contact: Mr. Glen Campbell 1720 South Bellaire Denver, Colorado 80222	(303)758-1700	• Socorro
Hunt Energy Corporation Geothermal Division Contact: Mr. Roger Bowers 2500 1st Nat'l Bank Bldg. 1401 Elm Street. Dallas, Texas 75202	(214) 748-1300	• Radium Springs • Kilbourne Hole
McCulloch Geothermal Corp. Contact: Mr. H. R. Chantler 10880 Wilshire Blvd. Los Angeles, California 90024	(213) 879-5252	• Dona Ana County • Socorro
Occidental Geothermal, Inc. Contact: Dr. Robert Crewdson 5000 Stockdale Highway Bakersfield, California 93309	(805) 395-8000	• Sandoval County
Phillips Petroleum Co. Contact: Mr.Richard Lenzer P.O. Box 239 Salt Lake City, Utah 84110	(801) 364 2083	• Lightning Dock KGRA
Southland Royalty Co. Contact: Jere Denton 1000 Ft. Worth Club Tower Fort Worth, Texas 76102	(817) 390-9200	• Radium Springs • Las Cruces
Sunoco Energy Dev. Co. Contact: Mr.John Knox 12700 Park Central, P.O. Box 9, Suite 1500 Dallas, Texas 75251	(214) 233 2600	• Jemez Mtns.
Texaco, Inc. Coal & Energy Resources Contact: Mr. Russ Criswell P.O. Box 2100 Denver, Colorado 80201	(303) 861-4220	

RESOURCE DEVELOPERS (EXPLORATION & LEASE-HOLDERS) (cont'd)

Name	Phone	Areas of Interest
Thermal Power Co. Contact: Mr. Louis de Leon 601 California St. San Francisco, California 94108	(415) 981-5700	• Socorro Peak KGRA
Union Geothermal of New Mexico Contact: Mr. Richard O. Engebretsen P.O. Box 15225 Rio Rancho, New Mexico 87174	(505) 897-1776	• Developer of the Baca Geothermal Electric Power Generating Project

PRIVATE AND COMMERCIAL USERS (CURRENT OR POTENTIAL)

Name	Phone	Remarks/ Areas of Interest
AMDEC Corp. (formerly under Western Development Corp.) Las Cruces, New Mexico 88001		• Large home developer seeking potential district heating system for subdivision: High Range Home (atop the Las Alturas anomaly
American Linen Co. 550 N. Church Las Cruces, New Mexico 88001	(505) 526-6641	• Need industrial process heat
Aquaculture Products Contact: Mr. Michael Annison, Pres. 1754 Lafayette Street Denver, Colorado 80218	(303) 832-2144	• Seeking suitable locality & resource for shrimp production
Ashbough, Randy Inc. Building Contractor T or C, New Mexico	(505) 894-7215	• Potential residential space-heating
Bailey, Harry N. 25256 Terreno Drive Mission Viejo, California 92576	(505) 526-1404	• Drilled wells on land he owns at Radium Springs. Wants resource user.
Baker, Mr. Don 701 Mesa Pl. N.W. Socorro, New Mexico 87801	(505)835-3979	
Burgett Floral Co. Contact: Mr. Dale Burgett Star Route P.O. Box 265A Animas, New Mexico 88020	(505) 548-2353	• Operates 100,000 sq. ft. geothermally heated greenhouse
Campbell, Mr. Doc Rt. 11 - Box 80 Gila Hot Springs Silver City, New Mexico 88061	(505) 534-9340	• Developer of Gila Hot Springs district heating system and low temperature electrical generation • Seeking venture capital
Chaffee Geothermal, Ltd. Contact: Mr. Jay Dick, Mgr. 1776 S. Jackson, Suite 1000 Denver, Colorado 80210	(303) 692-9496	• Las Cruces/Las Alturas anomaly
Chino Greenhouses, Inc. Contact: Mr. Brian Fritz 1235 Urania Ave. Leucadia, California 92024	(714) 436-0194	• Seeking good resource and land for business

PRIVATE AND COMMERCIAL USERS (CURRENT OR POTENTIAL) (Cont'd.)

Name	Phone	Remarks/ Areas of Interest
Clemens, Mr. Clifford R. 221-25 Manor Road Queens Village, New York 11427		• Resident atop the Los Alturas anomaly
Geothermal Resources Internat'l Contact: Mr. Domenic Falcone 4676 Admiralty Way, Suite 503 Marina Del Rey, California 90291	(213) 821-8802	• In partnership with Mirador Corp. for a prospective fuel alcohol project
Good Samaritan Village Contact: Mr. Joe Pomplin, Adm. 3025 Terrace Drive Las Cruces, New Mexico 88001	(505) 522-1362	• Retirement center space-heating potential
Hildebrand Greenhouses Contact: Mr. Dick Hildebrand 2008 Edgehill Road Vista, California 92083	(714) 726-6351	• Seeking good resource and land for business
Jordan, Mr. Thomas 145-21 South Road Jamaica, New York 11435		• Los Alturas anomaly
Kilde, Dale Lang Corp. P.O. Box 2125 Gallup, New Mexico 87301		• Construction and development of industrial facilities
L'eggs Products, Inc. Contact: Mr. Stan Smith, Mgr. P.O. Box 788 Mesilla Park, New Mexico 88047	(505) 524-8541	• Industrial process heat requirement
McCants, Mr. Tom Star Route Box 265 Animas, New Mexico 88020	(505) 548-2260	• 1979 AET award recepient for greenhouse & space-heating systems
Mirador Corporation Contact: Mr. Mike or Mr. John Bright P.O. Box 1475 305 Black Street Silver City, New Mexico 88061	(505) 388-1701	• Seeking capital venture for fuel alcohol production concept in Animas Valley
Ojo Caliente Mineral Springs Co. Contact: Mr. George Mauro P.O. Box 468 Ojo Caliente, New Mexico 88054		• Seeking capital venture and technical assistance for retrofit space-heating

PRIVATE AND COMMERCIAL USERS (CURRENT OR POTENTIAL) (Cont'd.)

Name	Phone	Remarks/ Areas of Interest
Pajaro Valley Greenhouses, Inc. Contact: Mr. Arne Thirup P.O. Box 69 Watsonville, California 95077		
Prepared Foods, Inc. Contact: Mr. Russ Johns, Pres. El Paso, Texas		• Needs process heat for beef • To relocate in Dona Ana County
Roses, Incorporated Contact: Mr. James C. Krone Executive V.P. 1152 Haslett Road Haslett, MI 48840	(517) 339-9544	• National clearinghouse for rose growers • Researching geothermal energy option for its members
St. Ann's Hospital Contact: Ms. Dee Rush Administrator 800 E. Ninth Truth or Consequences, New Mexico 87901		• Prospect for retrofit space-heating
Sandyland Nurseries Contact: Mr. Frank Cobb, President P.O. Box 546 Mesilla Park, New Mexico 88047	(505) 523-8621	• Proposed major expansion to include drilling for production well
Headquarters: Sandyland Nurseries 3890 Bia Real Carpenteria, California 93013	(805) 684-5441	
Schaefer Wholesale Florists, Inc. Contact: Mr. Karl J. Schaefer R.D. 3 York, Pennsylvania 17402	(717) 741-3841	• Seeking suitable resource and land for business
Silver Mesa Greenhouses Contact: Mr. Jim Hutton P.O. Box 16301 Denver, Colorado 80216	(303) 573-9251	• Seeking good resource and land position for business preferably in Dona Ana County
Southwestern Services to Handicapped Children and Adults, Inc. Contact: Mrs. Jewell Burk 309 W. College Ave. Silver City, New Mexico 88061	(505) 388-1976	• Faywood Hot Springs greenhouse state demonstration proj.

PRIVATE AND COMMERCIAL USERS (CURRENT OR POTENTIAL) (Cont'd.)

Name	Phone	Remarks/ Areas of Interest
Tellyer Development Co., The Contact: H. B. Pardner Tellyer P.O. Box 1318 Las Cruces, New Mxico 88001	(505) 522-1964	• Subdivision development atop Los Alturas anomaly
Traylor, Mr. C. L. 1555 Candlelight Drive Las Cruces, New Mexiso 88001	(505) 522-4552	• Resident atop the Los Alturas anomaly
Yucca Lodge Contact: Mr. Karl Kortemeier 316 Austin Truth or Consequences, NM or	(505) 894-3556	• Seeking capital and technical assistance for the construction of geothermally heated condominiums
Yucca Lodge Contact: Mr. Karl Kortemeier S.R. 319 Placitas, New Mexico 87043		
Young, Tom Racquets & Health Club Contact: Mr. Tom Young 305 E. Foster Road Las Cruces, New Mexico 88001	(505) 526-4477	• Space-heating and hot water needs

SUPPLIERS (CURRENT AND PROSPECTIVE)

Heat Exchangers

Name	Phone	Remarks
APV Company, Inc. P.O. Box 11189 Palo Alto, California 94306	(415) 326-6875	
Agric Machinery Corp. 23 Main Street & Green Village Rd Madison, New Jersey 07940	(201) 377-7997	
Alpha-Laval Thermal American Heat Division P.O. Box 860 Sommerville, New Jersey 08076	(201) 685-1800	
Bell & Gossett - ITT 3200 N. Austin Ave. Morton Grove, Illinois 60053		• Heat exchangers for the Carrie Tingley Hospital Demo Project
Cherry - Burrell 2400 Sixth Street, S.W. Cedar Rapids, Iowa 52406	(319) 399-3200	
Graham Manufacturing Co. Inc. Department G 170 Great Neck Road Great Neck, New York 11021	(800) 645-3757	
Industrial Systems Corp. 1025 Lake Road Medina, Ohio 44256	(216) 725-8500	
Patterson Kelly Co. Divisions of HARSCO Corp. 115 Burson Street East Stroudsburg, Penn. 18301	(717) 421-7500	
Process Equip. Supply Salt Lake City, Utah	(801) 278-9944	
Skyline Sales Co. Salt Lake City, Utah	(801) 486-7114	
Trawter Inc. Texas Division P.O. Box 2289 Wichita Falls, Texas 76307	(817) 723-7125	

SUPPLIERS (CURRENT AND PROSPECTIVE)(Cont'd)

Instrumentation

Name	Phone	Remarks
Energy Control, Inc. Contact: Mr. A. Bruce Cantrell Box 6907 Albuquerque, New Mexico 87197		• Distributor for Higgins Energy Ass.
Higgins Energy Associates P.O. Box 7317 Newark, Delaware 19711	(301) 885-2172	• BTU meter for the Carrie Tingley Hospital Demo Proj
Tegal Scientific Inc. P.O. Box 5905 Concord, California (Local Rep. - Mr. Joe Weckerly 4200 Broadmore, NE Albuquerque, New Mexico 505 265-3381)		

Low Temperature Electrical Generation

Name	Phone	Remarks
Barber-Nichols Engineering Co. Contact: Mr. Ken Nichols, Pres. Denver, Colorado	(303) 421-8111	
Kinetics, Inc. Contact: Mr. Wally Brown Sarasota, Florida	(813) 366-3050	• Rankine-cycle engines
Wuilleumier & Associates Contact: Mr. Tim Wuilleumier, President 7714 Laurel Suite 2 Cincinnati, Ohio 45243	(513) 271-7001	

Pipe & Fittings

Name	Phone	Remarks
Albuquerque Heating & Plumbing Company Contact: Mr. Gene Stalen Albuquerque, New Mexico		

SUPPLIERS (CURRENT AND PROSPECTIVE) (Cont'd.)
Pipe & Fittings (Cont'd.)

Energy Materials, Inc. Contact: Mr. Dave Sibila, Mgr. 3300 South Tamarac Suite E105 Denver, Colorado 80231	(303) 750-4853	• High temperature plastic piping materials
Isco Inc. Commerce Plaza - Suite 8 2719 South Lemel Circle Salt Lake City, Utah 84115	(801) 487-9831	• Bondstrand Pipe
Mansville, John Sales Corp. P.O. Box 14624 Albuquerque, New Mexico 87111	(505) 294-1158	• Fittings - John Bell, Kernco Inc Albuquerque, NM
Perma Pipe (BHT Engineering Co. Inc) 1218 Wyoming El Paso, Texas 79902	(915) 533-1231	

Pumps

Name	Phone	Remarks
Alpha Southwest, Inc. 205 Rossmoor Road, SW Albuquerque, New Mexico 87102		
Berkeley Pumps Rodgers & Company, Inc. 2615 Isleta Blvd, SW Albuquerque, New Mexico 87105		
Centerlift, Inc. 5421 Argosy Avenue Huntington Beach, Calif. 92649	(213) 598-9711 or (714) 893-8511	
Cole Drilling Company 801 Delhi Street El Paso, Texas 79927	(915) 859-9889	
Farmers Pump Supplies 512 No. Copia El Paso, Texas 79927	(915) 562-3785	
Gould Water Systems Lucas Drilling Company 10058 Northloop El Paso, Texas 79927		

SUPPLIERS (CURRENT AND PROSPECTIVE) (Cont'd.)

Pumps (Cont'd.)

James, Cooke & Hobson Inc.
2817 E. Yandell
El Paso, Texas 7990

TP Pump & Pipe Company
1842 Two NW
Albuquerque, New Mexico 87102

TRW Reda Pumps Contact: Mr. Jim Rosser P.O. Box 131 Farmington, New Mexico 87401	(505) 325-4648	

Turbines & Power Systems

Name	Phone	Remarks
Barber-Nichols Engineering Co. Contact: Mr. Ken Nichols, Pres. Denver, Colorado	(303) 421-8111	
Hitachi America Ltd. Contact: Mr. Glenn Fedirko 100 California Street San Francisco, California 94111		• Pumps, turbines and power systems

5/81

NORTH DAKOTA GEOTHERMAL COMMERCIALIZATION PROJECT

SEMIANNUAL PROGRESS REPORT

July-December, 1980

Prepared by

Bruce A. Gaugler, Program Coordinator
Jill D. Ritz, Writer/Editor

Geothermal Energy Office
State of North Dakota

Work Performed Under Contract No. DE-FC07-79ID12011

U.S. Department of Energy

Idaho Operations Office

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NORTH DAKOTA GEOTHERMAL COMMERCIALIZATION PROJECT

SEMIANNUAL PROGRESS REPORT, JULY-DECEMBER 1980

1.0 INTRODUCTION

1.1 Purpose of Project

The North Dakota Geothermal Commercialization Project was established as a cooperative effort betweeh the United States Department of Energy (DOE) and the State of North Dakota to stimulate the commercialization of geothermal energy in the state.

1.2 Objectives

Several major objectives have been identified as means to accomplish the goal of geothermal commercialization in North Dakota. These are:

- Identify prospective geothermal users and developers in the state.
- Match geothermal sites with potential markets.
- Stimulate interest and cooperative action among participants in geothermal commercialization.
- Identify the constraints to geothermal commercialization, and recommend ways to alleviate them.

- Provide information to prospective users and developers, including permit requirements and financial, economic, engineering, and resource information.

- Conduct a state-wide outreach program to educate the public and to stimulate interest.

1.3 Technical Approach and Team Members

To evaluate the possibilities for geothermal commercialization, the state commercialization team investigates substate regions and specific sites in the state. The necessary data for incorporation into the reports are obtained from the assessment of available geothermal resources; current and projected residential growth and industrial development; institutional, technical, and environmental considerations; current and projected energy demand; and economic activity. This information provides the basis for the following specific tasks:

- Prospect identification
- Area development plans
- Site-specific development analyses
- Commercialization plans
- Institutional assessments
- Energy and economic assessments
- Outreach and marketing programs

The Geothermal Energy Office is conducting the North Dakota Geothermal Commercialization Project. Team members are : Bruce A. Gaugler, Program Coordinator; Jolene Wetch, Graphics and Statistics Analyst and Secretary; and Jill D. Ritz, Technical Writer.

1.4 Project Benefits to North Dakota and DOE

The North Dakota Geothermal Commercialization Project provides the state with a planning and assistance program to impart information and advice to state agencies, local governments, industries, small businesses, and individuals. Increasing the level of understanding regarding the nature and advantages of geothermal energy will encourage its use and lessen reliance on fossil fuel energy sources.

North Dakota's project provides DOE with an assessment of environmental, economic, institutional, and resource conditions that affect the timing and extent of geothermal commercialization in North Dakota. This information is essential for long-range national energy development planning and will indicate the contribution that North Dakota's geothermal resources can make to satisfying the national energy demand.

2.0 SPECIFIC TASK DESCRIPTIONS AND PRODUCTS

2.1 Geothermal Prospect Identification

North Dakota has a tremendous store of geothermal energy. Most of the aquifer systems that underlie the state are good sources of low- to moderate-temperature geothermal fluids suitable for space heating and cooling, agricultural uses, and low-temperature industrial processes. The temperatures of North Dakota's geothermal fluids are not presently considered adequate for electrical generation.

Both the United States Geological Survey and the North Dakota Resource Assessment Team are compiling hydrothermal data for the state. The United States Geological Survey is mapping depths, qualities, and temperatures for the Madison, Dakota Group, and Fox Hills/Basal Hell Creek aquifer systems. The data are not expected to be published until late 1981, but information is currently available to the state commercialization team on a site-specific basis.

The North Dakota Resource Assessment Team has completed temperature logging on approximately 240 wells and has constructed preliminary shallow geothermal gradient maps for portions of the state. The results of these studies are summarized in the Resource Assessment Team's semiannual report entitled, "An Evaluation of Hydrothermal Resources in North Dakota, Phase II." The report is available from the University of North Dakota, Engineering Experiment Station (Bulletin #80-10-EES-01).

The Resource Assessment Team expects to continue shallow well logging during 1981, with emphasis on mapping the shallower Cretaceous and Tertiary aquifers. Data from aquifers in glacial drift and alluvial deposits are currently available from county groundwater studies. Although water temperatures are relatively low (45°F to 65°F), the shallow aquifers generally provide sufficient quantities and qualities of groundwater suitable for groundwater heat pump applications.

Depth, thickness, temperature, and chemical data for the Mississipian Madison Formation, which underlies the western three fourths of North Dakota, have been compiled by the Resource Assessment Team and are presented in Figures 1 through 4. Although the Madison contains water in a useful temperature range, the poor water quality and excessive depth will probably prevent its development as a significant hydrothermal aquifer.

To date, no geothermal leasing activity has occurred in North Dakota. Because the state's reservoirs are so extensive, leasing of federal or state lands is not economically practical at this time.

2.2 Area Development Plans

2.2.1 State Geothermal Planning Areas

The state commercialization team has identified eight substate regions for area development analysis. These eight geographic regions, which coincide with the boundaries of North Dakota State Planning Regions, are shown in Figure 5.

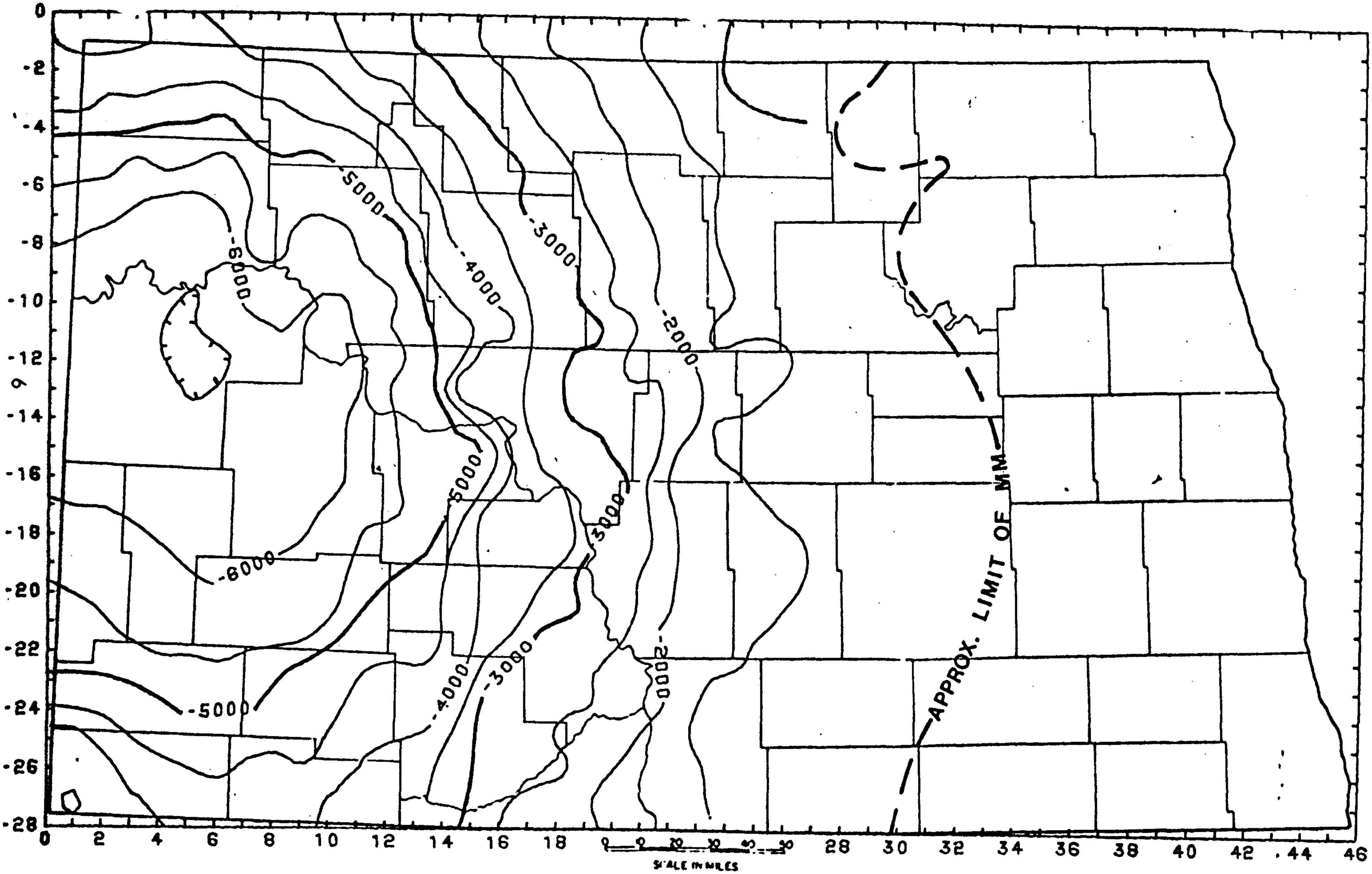

Fig. 1 Structure map on the top of the Mississippian Madison Formation.

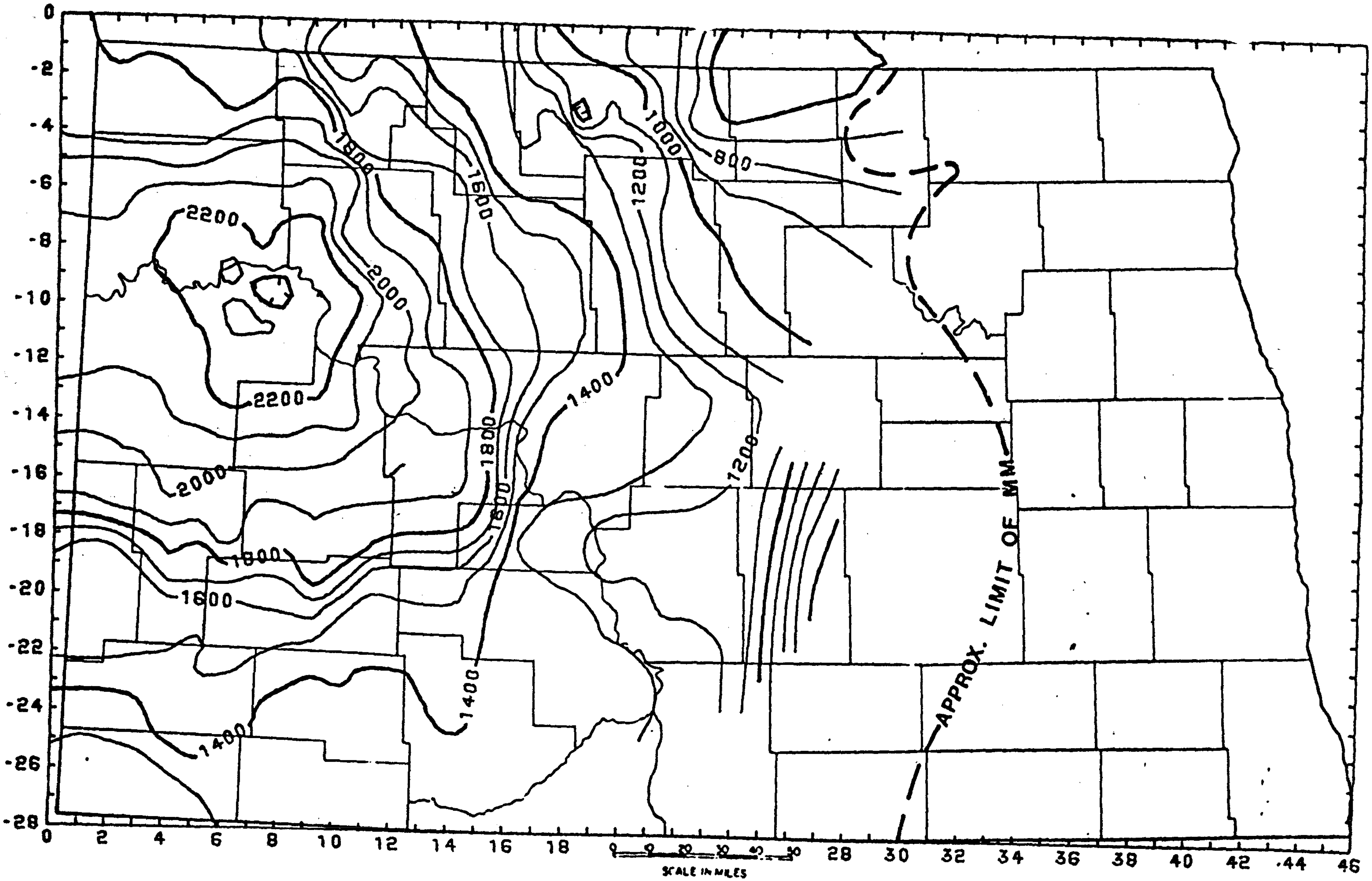

Fig. 2 Isopach map, thickness of the Mississippian Madison Formation.

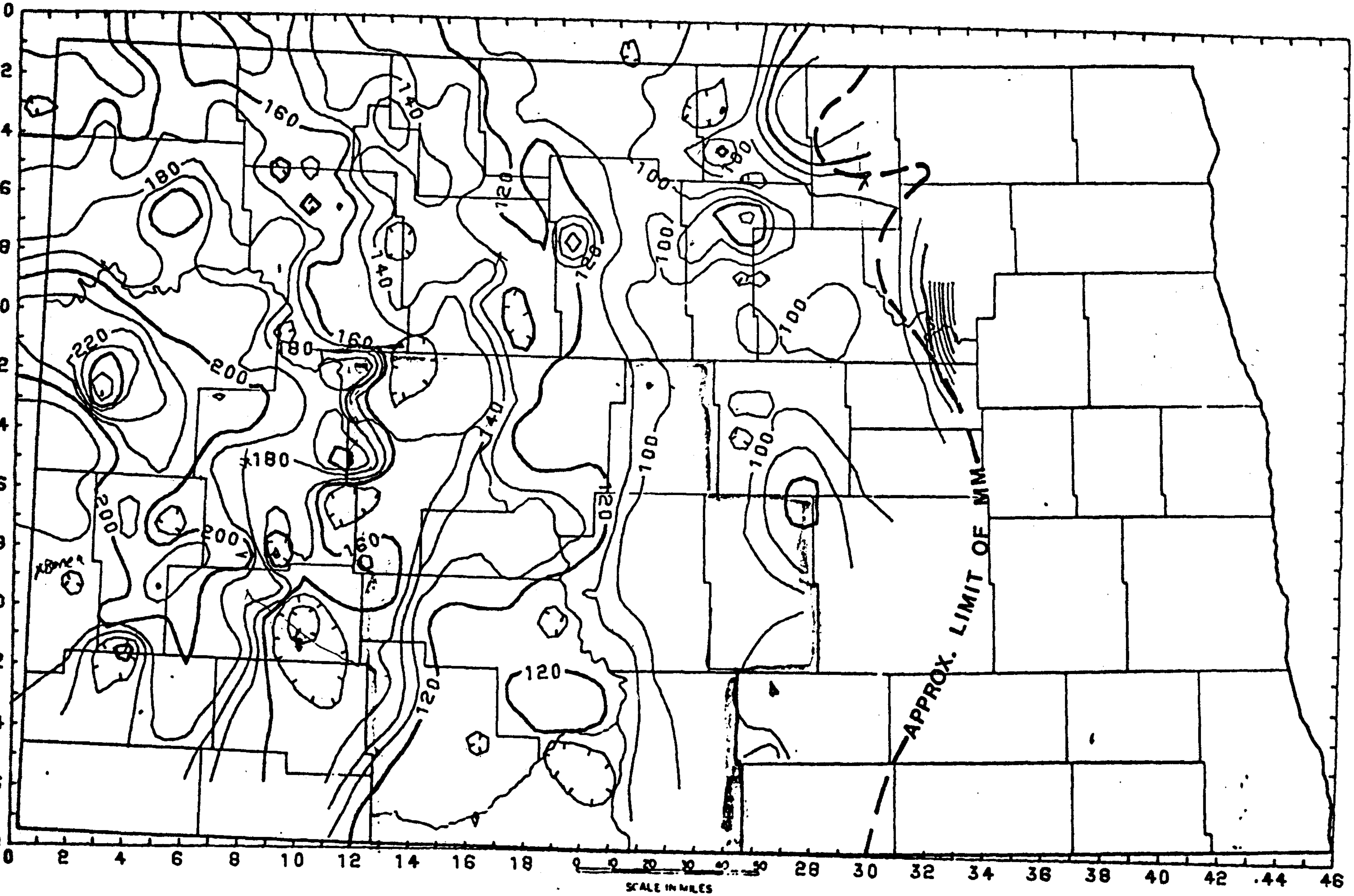

Fig. 3 Isotherm map, temperature of the water in the Mississippian Madison formation.

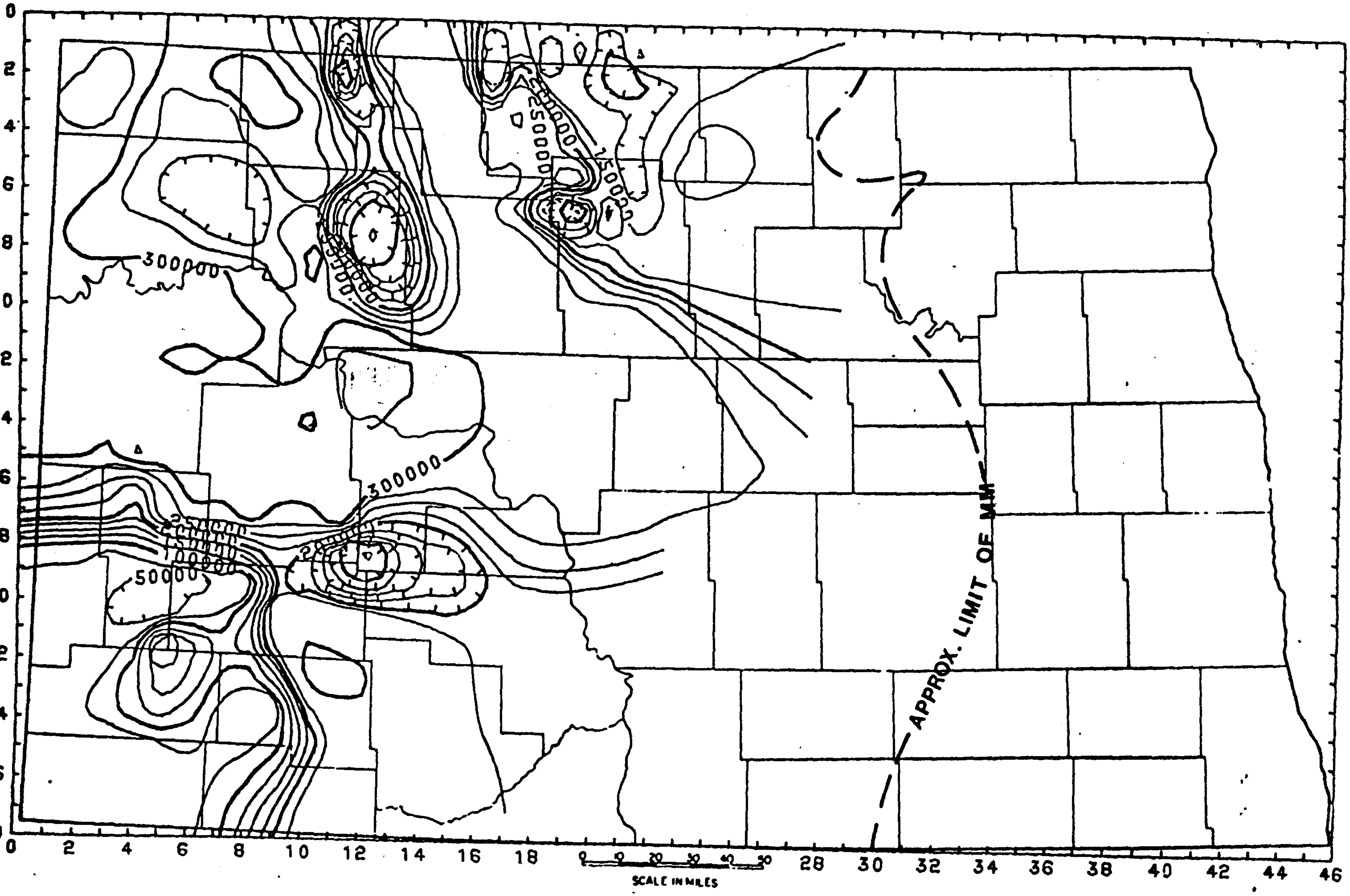

Fig. 4 Concentration of total dissolved solids (TDS), Mississippian Madison formation.

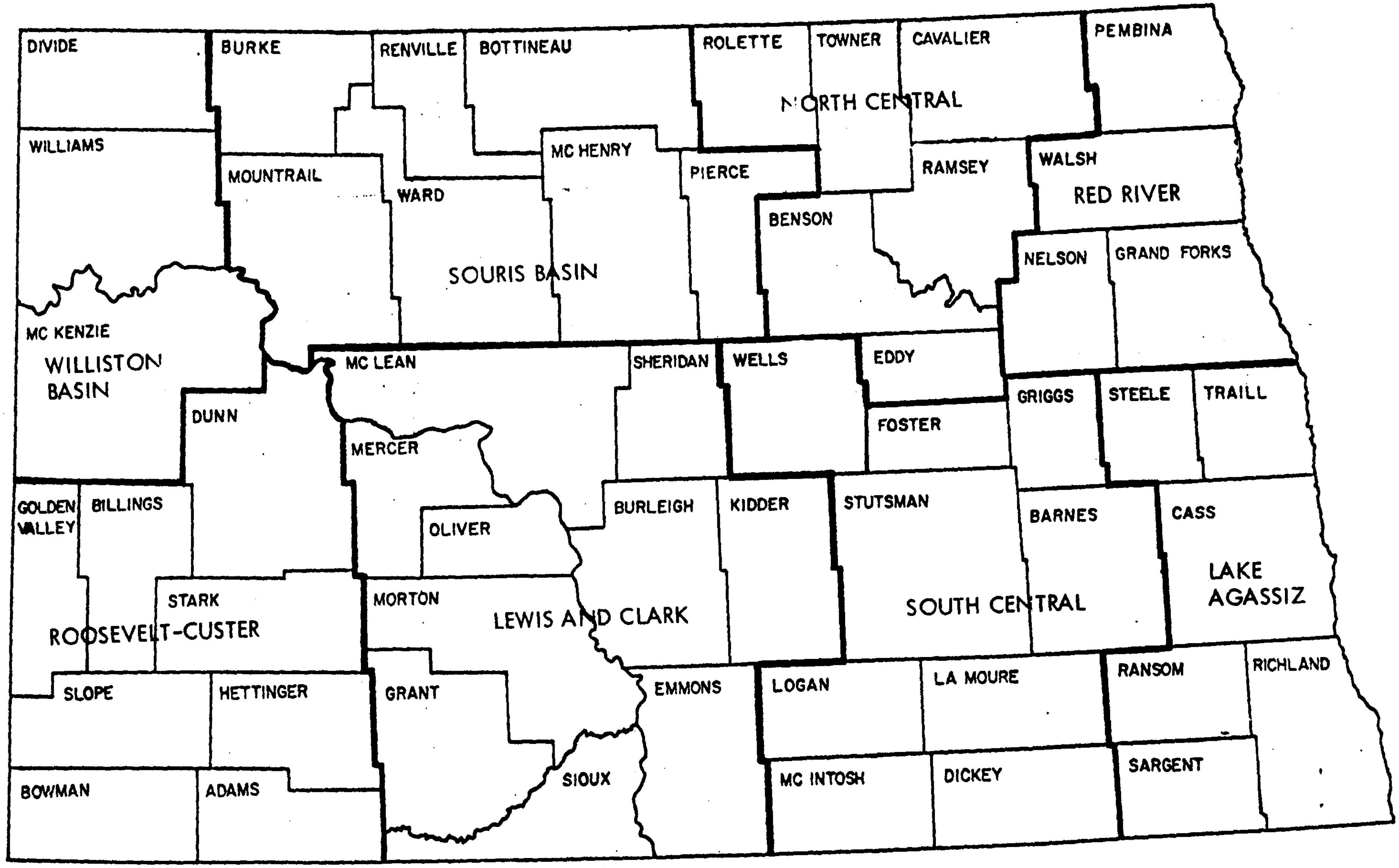

Fig. 5 North Dakota geothermal planning areas.

The area development plan for the Roosevelt-Custer Region has been published, and the Lewis and Clark 1805 area development plan is nearing completion. Since geothermal resources occur in abundance throughout the state and their characteristics are similar, no additional area development plans are anticipated for the contract year. However, in conjunction with the North Dakota Geothermal Resource Assessment Team, the commercialization team plans to develop a comprehensive handbook outlining the state's geothermal resources and applications, and the institutional, technical, economic, and environmental considerations associated with geothermal development in the state.

2.2.2 Specific ADPs--Completed or in Preparation

The Lewis and Clark 1805 Region encompasses ten counties in southcentral North Dakota. The groundwater resources of the region offer an excellent source of geothermal energy. The areal extent of the potential geothermal resources varies from 0.5 square mile (Glencoe Channel) to 140,000 square miles (Dakota and Madison aquifers). Water temperatures in the alluvial and glacial drift aquifers range from 44°F to 51°F; temperatures in the bedrock aquifers range from 45°F to 200°F. These low- to moderate-temperature geothermal resources are suitable for a variety of uses, including groundwater heat pump applications, some industrial processes, and agricultural uses.

Since 1975 the population of the Lewis and Clark 1805 Region has increased 11.6 percent and is expected to continue to grow, in large part because of intensified energy development in western North Dakota. As the population increases, so will demands on fossil fuel sources for industrial processes and space heating and cooling. These limited fuels can, in many cases, be replaced by geothermal energy resulting in considerable energy and dollar savings.

Several homeowners in the region have installed groundwater heat pumps for residential heating and cooling. A groundwater heat pump is generally more economical to operate than conventional heating systems, with the possible exception of natural gas. However, many rural areas and small communities in the region do not have natual gas service and must rely on the more expensive energy sources, such as electricity and fuel oil.

2.3 Site-Specific Development Plans

2.3.1 Candidate Geothermal Sites/Applications

The specific resource sites that are candidates for site-specific development plans are identified in Table 1.

2.3.2 Site-Specific Development Plans--Completed or In Preparation

Site-specific development plans are currently being prepared for the following projects:

TABLE 1. CANDIDATES FOR SITE SPECIFIC DEVELOPMENT PLANS

	Applications		Resource Data		
Location	Current	Proposed	Representative Depth (ft)	Representative Temperature (°F)	Formation
Badlands	Warm water used to prevent frost damage to gardens	Residential space heating	250	55	Cannonball (?)
			1100	66	Hell Creek/Fox Hills
			3800-5600	140-150	Dakota
			9085	191	Madison
Harvey	None	Residential and commercial space heating	150	52	Glacial till
			2100	76	Dakota
			3850	≈105	Madison
Bismarck	Residential space heating	Residential and commercial space heating; district heating systems	180	≈49	Cannonball (?)
			3057	100	Dakota
			4730	109	Madison
Jamestown	None	District heating system	100	51	Buried stream channel
			≈1500	73	Dakota
			2010	95	Madison
Fargo	None	District heating system	154	47	Glacial till

Patterson Hotel, Bismark

Plans are to convert the upper nine levels of the historic Patterson Hotel into housing units for the elderly, while retaining the main floor for commercial enterprises. A feasibility study indicates that a geothermal system can satisfy all of the building's heating requirements. The project developers are seeking funding assistance from a federal rent subsidy program and the User Coupled Drilling Program.

Maryvale Convent, Valley City

Maryvale Convent, originally designed as a geothermal building in 1964, has plans to convert from fuel oil heat to geothermal energy for space heating. Application has been made to the North Dakota State Water Commission for a water-use permit.

St. Mary's School, New England

An engineering study was undertaken by a Bismarck firm to determine the feasibility of using geothermal energy to heat the 95,000 square foot school. Preliminary results of the study indicate that a nearby State Water Commission monitoring well, which was offered to the school as a possible water supply source, is unable to provide a sufficient quantity of water to meet the school's geothermal heating requirements. A second supply well, as well as a reinjection well, would probably be necessary.

2.4 Time-Phased Project Plans

2.4.1 Active Demonstration/Commercialization Projects

Groundwater heat pumps, used in conjunction with low-temperature geothermal resources (40°F to 72°F), currently provide space heating and cooling at 20 (19 residential and 1 commercial) sites in the state. All of the projects are small-scale applications and have been accomplished by individuals.

The University of North Dakota, Engineering Experiment Station, began monitoring ten of the heat pump installations in November 1980. The monitoring program will provide valuable data on actual energy savings, operational or maintenance problems, net energy extracted from the groundwater, and variations in system performance.

2.4.2 Time-Phased Project Plans--Completed or in Preparation

No time-phased project plans have been completed by the state commercialization team.

2.5 Institutional Analysis

Geothermal development in North Dakota has, so far, been on a relatively small scale by individuals. All of these applications have involved the use of groundwater from moderately shallow wells as the medium of thermal transfer. Since no state laws currently regulate geothermal energy development, laws pertaining to water appropriation, development, and disposal have been applied to geothermal applications.

The increased development of the state's geothermal resources has stimulated interest in appropriate legislation. The state commercialization team has been working with the North Dakota Legislative Council in drafting legislation that would provide a 10% income tax credit on the actual cost of acquisiton and installation of geothermal energy devices. The North Dakota Industrial Commission is formulating legislation to present to the 1981 state legislature dealing with regulatory powers over the exploration, development, and use of the state's geothermal resources.

2.6 Public Outreach Program

2.6.1 Outreach Mechanisms

The state's outreach program is designed to inform the public about the potential and the advantages of geothermal energy in North Dakota. In addition to providing information to interested individuals and organizations upon request, the state commercialization team also actively seeks opportunities to promote the development of geothermal energy.

Existing outreach mechanisms include the following:

- Newsletter. In September, the state commercialization team began printing a monthly newsletter for distribution to state legislators, local officials, building contractors, and other interested individuals. The first issues dealt primarily with an overview of geothermal energy resources and applications in the state, geothermal regulations, and proposed legislation.

- Billboards. Two billboards have been erected in Bismarck for the months of December 1980 and January 1981. Bismarck was chosen the most practical site because of its importance as the state capitol, its drawing potential as a major shopping area, and its apparent colocation with a geothermal resource. Although the billboards are attractive and have been placed on two well-traveled thoroughfares in the city, public response has been relatively low.

- Talks. Formal talks concerning geothermal resource potential in the state and its effect on the housing industry were presented at the Bismarck-Mandan Home Builders Association monthly meeting and the North Dakota Home Builders Association annual convention.

Proposed outreach mechanisms for the contract year include:

- <u>Newsletter</u>. The monthly newsletter has generated a considerable amount of positive feedback, and the mailing list is being expanded. Future editions will emphasize current and proposed geothermal projects in the state, technical and economic assistance programs, and other subjects of special interest to North Dakota developers.

- <u>Brochures</u>. A brochure entitled "Geothermal Groundwater Heat Pump: An Efficient Way to Heat and Cool Your Home" is in the final stages of preparation and will be published in early 1981. The brochure, which explains the use of groundwater heat pumps for residential heating and cooling in North Dakota, was written as a joint venture between the University of North Dakota Engineering Experiment Station and the North Dakota Geothermal Energy Office.

  A groundwater heat pump brochure written especially for architects, designers, and contractors is in the initial stages of development. Publication is expected in mid-1981.

- <u>Talks</u>. A slide-tape show on geothermal energy in North Dakota, which is being produced by EG&G Idaho, will be made available for presentations at fairs, meetings, and conventions.

2.6.2 Summary of Contacts and Results

Many individuals, businesses, and government agencies have contacted the state commercialization team with inquiries on geothermal resources, applications, regulations, and funding sources. As a result of these preliminary contacts, a number of homeowners are proceeding with plans to install groundwater heat pump systems and several private developers and local officials are investigating the feasibility of establishing district heating and cooling systems in their communities.

A more detailed account of the state commercialization team's contacts is presented in the appendix.

2.6.3 Overall Prospectus for Future Geothermal Commercialization

Interest in geothermal use is growing rapidly in North Dakota. Opportunities for geothermal commercialization in the state exist in the agricultural and industrial sectors, but the major emphasis continues to be on applications for residential and commercial space heating and cooling and for district heating systems.

Development in all sectors should continue to accelerate as developers become increasingly aware of the economic benefits of geothermal energy utilization and as the state legislature enacts incentives for geothermal development.

3.0 SUMMARY OF MAJOR FINDINGS AND RECOMMENDATIONS

North Dakota has a tremendous store of geothermal energy. Most of the aquifer systems that underlie the state are good sources of low to moderate temperature geothermal fluids, suitable for direct thermal applications. The greatest potential for geothermal commercialization in the state continues to be the use of groundwater heat pump systems for residential and commercial space heating and cooling, although opportunities for industrial and agricultural uses of geothermal energy are also apparent.

During 1980, the state commercialization team has concentrated on the identification of the state's geothermal resources and potential markets and an overall assessment of economic, technical, and institutional considerations. The next contract year will realize a transition in emphasis from planning activities to project stimulation and implementation.

Individuals, small businesses, and communities are interested in developing North Dakota's geothermal resources, but several constraints limit the extent of geothermal development actually taking place:

- Lack of Funding. Individuals, small businesses, and communities often lack the front-end capital necessary to implement large-scale projects, such as district heating systems. Although interest in grant funds is high, these sources of funding are limited.

- Lack of Economic Incentives. North Dakotans are becoming increasingly aware of the economic advantages of geothermal energy. Operating costs for groundwater heat pumps are lower than those for most conventional heating systems, but the initial outlay for a groundwater heat pump system is comparatively high.

  Legislation has been drafted on the state level to allow a 10% income tax credit on the actual cost of acquisition and installation of a geothermal energy device. However, most geothermal energy applications in North Dakota are ineligible for federal tax credits. Revising federal guidelines for geothermal tax credits would be a tremendous stimulus to geothermal commercialization in the state.

- Technical Assistance. Because of the increased interest in geothermal energy in the state, requests for technical assistance to the state commercialization team from developers have, out of necessity, been referred to consultants unfamiliar with North Dakota's unique geothermal resource characteristics and the special requirements of geothermal projects. Future geothermal programs should emphasize technical assistance to developers with increased funding provided to allow the individual states to retain additional technically-oriented personnel.

4.0 APPENDIX

SUMMARY OF MAJOR CONTACTS AND RESULTS

Federal Government:

Internal Revenue Service Fargo	Federal geothermal tax credit legislation
Ken Sayers Community Services Bureau of Indian Affairs Belcourt	General

State Government:

Sheila Kuhn State Health Department	Disposal permit regulations
Francis Schwindt State Health Department	Water well regulations and pollution control
Roger Koski Dist. 32 State Representative	Geothermal tax credit legislation
Don Mathsen Engineering Experiment Station University of North Dakota	Groundwater heat pump brochure
Kent Conrad State Tax Commission	Geothermal tax credits
Nancy Jamison Legislative Council	Geothermal tax credit legislation
Joe Schmidt State Water Commission	Water well permit requirements

Barry Zvibleman State Water Commission	Water well permit requirements
Chuck Fine Business and Industrial Development Dept.	Geothermal tax credits

Local Government:

Russ Staiger Downtown Development Assoc. Bismarck	District heating project solicitation
Claudy Nelson Area II Concerned Low Income People, Inc. Minot	General
Patricia McCleary Community Action Program Fargo	Proposed district heating project for Fargo
Mayor Eugene Leary Fargo	Proposed district heating project for Fargo

Commercial/Industrial:

Jim Christianson Patterson Tower Partnership Bismarck	Seeking funding for proposed project through federal rent subsidy and User Coupled Drilling programs
North Dakota Home Builders Assoc.	Speech
Reuben Meland Meland Plumbing and Heating Northwood	Groundwater heat pump distributor and installer
Mr. Paulson Montana-Dakota Utilities Bismarck	Gas and electric rates
Loren Kopseng Carlson Homes, Inc. Bismarck	Proposed district heating demonstration project in Bismarck

Jamestown Refrigeration Jamestown	Installing heat pumps in nine town house units in Jamestown
Maryvale Convent Valley City	Proceeding with plans for geothermal space heating
K.H. Hoenen Geo-resources Inc. Williston	General
Mike Robb Globe Development Bismarck	Has installed a direct cooling air conditioning system in a chiropractic clinic in Bismarck
James Collins T.P.I. Inc Bismarck	General
Bill Davis T.P.I. Inc.	Proposed Renewable Energy Institute at Minot
Toman Engineering Mandan	District heating system
Allen Thomas Al's Plumbing & Heating Bismarck	Groundwater heat pump distributor and installer
Kohl and Schwartz Eng. Bismarck	Performing engineering study for St. Mary's School, New England
Ralph Nelson Bismarck Plumbing & Heating Bismarck	Groundwater heat pump distributor and installer
Russell Drilling Harvey	Proceeding with plans to geothermally heat the workshop
John Piasecki Trout Wells Jamestown	Reinjection regulation information
Warren Saterlie Montana-Dakota Utilities Bismarck	Proposed warehouse in south Bismarck may incorporate geothermal energy for space heating and cooling

Julie Clairmont Country West Development Bismarck	Information on geothermally heated greenhouses
Rick Nelson Mandan	Groundwater heat pump distributor

Individuals:

Ron Landenberger Mandan	Proposed district heating project for south Mandan
Bill Mills Bismarck	Installing groundwater heat pump in his home
Don Haverland	Heat pump information
Bruce Bell	Heat pump information
Hugh Sanders Bismarck	Heat pump information
Joe Lafave Bismarck	Installing groundwater heat pump in his home
John Hanson Amidon	Heat pump information for residential and agricultural uses
Roger Schmidt Hankinson	Information for proposed corn alcohol production facility in Hankinson
Eileen Severson Bismarck	Heat pump information
Loren Dewitz Tappen	General
Cody Bahmiller Bismarck	Planning to install a groundwater heat pump in her home
Lynn Mader Bismarck	Heat pump information
Bill McCullough Bismarck	Planning to use geothermal for hot tub, swimming pool, and home heating and cooling

SOUTH DAKOTA GEOTHERMAL COMMERCIALIZATION PROGRAM

SEMIANNUAL PROGRESS REPORT

July-December 1980

Prepared by

Phil Lidel

SOUTH DAKOTA OFFICE OF ENERGY POLICY
Pierre, SD 56501

Work Performed Under Contract No. DE-FC07-79ID12012
U.S. Department of Energy
Idaho Operations Office

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CONTENTS

SOUTH DAKOTA GEOTHERMAL COMMERCIALIZATION PROGRAM

SEMIANNUAL PROGRESS REPORT, JULY-DECEMBER 1980

1.0 INTRODUCTION

Geothermal activities the last 6 months of 1980 followed the trend of previous months. The major portion of the state teams efforts were directed toward outreach and marketing.

Communities, schools, and individual homeowners are interested in space heating. Unfortunately, funding is a problem because of a prolonged drought and high interest rates.

Some of the more significant highlights of the past 6 months are as follows:

- The South Dakota Geothermal Energy Handbook became available to the public in November.

- Geothermal Energy Day was held in Pierre on October 21. South Dakota politicians, federal and state officials, and private citizens participated in ribbon cutting ceremonies for the PON projects at Pierre, Philip, and Diamond Ring Ranch.

- The town of Philip is preparing a response to a DOE/HUD request for district heating and cooling systems in a CDBG eligible community.

- Dunham Associates, Inc. submitted an unsolicited proposal to DOE entitled a "Multi-Use Demonstration of Madison Formation Geothermal Water at Lemmon, South Dakota."

- The towns of Wessington, Faulkton, and Dupree are preparing requests for Technical Assistance.

2.0 SPECIFIC TASK DESCRIPTIONS AND PRODUCTS

2.1 Geothermal Prospect Identification

The South Dakota Department of Water and Natural Resources submitted a budget to DOE for a resource assessment.

Data from the survey of artesian wells in a five-county area surrounding Pierre include:

- 57 wells were surveyed

- 24 wells are capable of direct-use space heating

- 14 wells are being used to directly heat garages, sheds, and swimming pools

- 4 wells are used in conjunction with groundwater heat pumps to heat homes.

2.2 Area Development Plans

2.2.1 State Geothermal Planning Areas

The planning areas, which are shown in Appendix A, have been modified to conform with the Planning and Development Districts, (COGS). This modification will improve the flow of data from the districts to the energy office.

2.2.2 Specific ADPs Completed or in Preparation

Area development plans for Districts 5 and 6 should be developed for the upcoming contract year.

2.3 Site-Specific Development Plans

These have not changed since the last report.

2.4 Time-Phased Project Plans

2.4.1 Active Demonstration/Commercialization Projects

The three demonstration projects in South Dakota went on-line in November. The project descriptions of the systems construction and operation are presented in Appendix B. They were taken from the Geothermal

Direct Heat Applications Program Summary presented at the semiannual review meeting at Las Vegas, Nevada November 20-21, 1980 by the Geothermal Energy Division of the U.S. Department of Energy.

2.5 State Aggregation of Prospective Geothermal Use

This list has not yet been compiled.

2.6 Institutional Analysis

One thousand copies of the South Dakota Geothermal Energy Handbook were published in October, 1980. The handbook includes sections on permits, regulations, assistance, and resource use and is distributed free to any interested persons.

2.7 Public Outreach Program

2.7.1 Outreach Mechanisms

The objective of the marketing and outreach program has not changed. Information dissemination and technical assistance to the private sector are the main goals of the South Dakota geothermal program. These goals are being achieved through the use of a variety of outreach mechanisms.

- <u>The Energy Newsleter</u> published monthly by the Office of Energy policy has a circulation of 3,200, including financial institutions, engineers, architects, rural electric cooperatives, chambers of commerce, and educational institutions. Geothermal energy articles published the last 6 months include (1) User-Coupled Drilling Program, (2) Technical Assistance Program, (3) Geothermal Energy Day, (4) HUD/DOE District Space Heating RFP, (5) The South Dakota Geothermal Energy Handbook, and (6) availability of the direct-use geothermal and groundwater heat pump slide shows to the general public.

- <u>The South Dakota Highliner</u>, a monthly publication of the South Dakot Rural Electric Association with a circulation of 72,000 featured geothermal energy in the November, 1980 issue. The article included information and pictures of the three PON projects, a description of a groundwater heat pump, and an in-depth interview with Phil Lidel, Geothermal Program Director.

- <u>Television</u>. It was planned to saturate the state with geothermal energy public service announcements during October, which is energy month in South Dakota. However, because of the congressional political campaigns in South Dakota, viewing time was unavailable until November. The Midamerica Communications, Inc., TV company provided 20 statewide prime slots for the announcement during November and December, 1980 (see Appendix C). The announcement featured users of the PON projects explaining their programs.

- *Talks*. (1) October 21, 1980 was proclaimed Geothermal Energy Day in South Dakota. Dedication of the three PON projects was held in Pierre at the Legion Cabin. A 10:00 a.m. overview meeting featured opening remarks by Congressman Jim Abdnor; a description of the projects by the principal investigators, and a summation by Dr. Clay Nichols, DOE/ID. Dr. Charles Metzger, DOE Regional Representative, was the principal speaker at the noon luncheon. Ribbon cutting ceremonies were held at the three locations in the afternoon. (2) A public meeting was held at Edgemont in August to inform the local people of the geothermal energy opportunity in South Dakota. Participants in the program were the South Dakota Commercialization Team and the three principal investigators from Diamond Ring Ranch, St. Mary's Hospital, and the Haakon County School. (3) The audiovisual slide show of geothermal energy use in South Dakota was received from EG&G the last day of September. The slide has been a valuable visual aid for presentations given at Lemmon, Gregory, and Rapid City.

- *Brochures*. The South Dakota Geothermal Energy Handbook was published in October. The ten sections of the handbook cover a wide range of geothermal subjects including source, resource use, materials selection, corrosion, environmental concerns, permits, regulations, and assistance. One thousand issues are available to South Dakota citizens.

A 10-page brochure entitled "Water Use From Groundwater Heat Pump Wells" was developed by the Office of Water Quality for South Dakotans. The pamphlet has been distributed to many people in eastern South Dakota that have wells with water temperatures below 100°F.

The future thrust of the outreach effort will be technical assistance to South Dakotans that have a geothermal resource. An analysis of the data from the well logs of a five-county area in central South Dakota (see Appendix A of the South Dakota Commercialization Program January-June 1980) reveals that only 16 of 57 wells are being used for space heating. The remaining 41 are being used primarily for livestock water. The town of Dupree has a well with 150°F that is not being used for space heating. It is imperative in these times of escalating conventional fuel costs that people having such a resource develop its full potential.

2.7.2 Summary of Contacts and Results

Contact has continued with the Council of Governments, state agencies, and educational institutions in the exchange of geothermal energy information. In addition, private consultants, community action programs, and private citizens have been given information about direct geothermal use and groundwater use for heat pump assisted space heating.

Major areas of interest that have developed in the past 6 months are: (1) district space heating, (2) groundwater heat pump use for schools and private residences, and (3) the use of existing wells for space heating and agricultural purposes.

Appendix D contains a detailed list of contacts.

2.7.3 Overall Prospectus for Future Geothermal Commercializations

The future of geothermal energy depends on the ability and the willingness of the private sector to develop the potential that is in the state.

The five-county inventory of wells in central South Dakota indicates the agricultural sector needs to develop the existing source of multiple use.

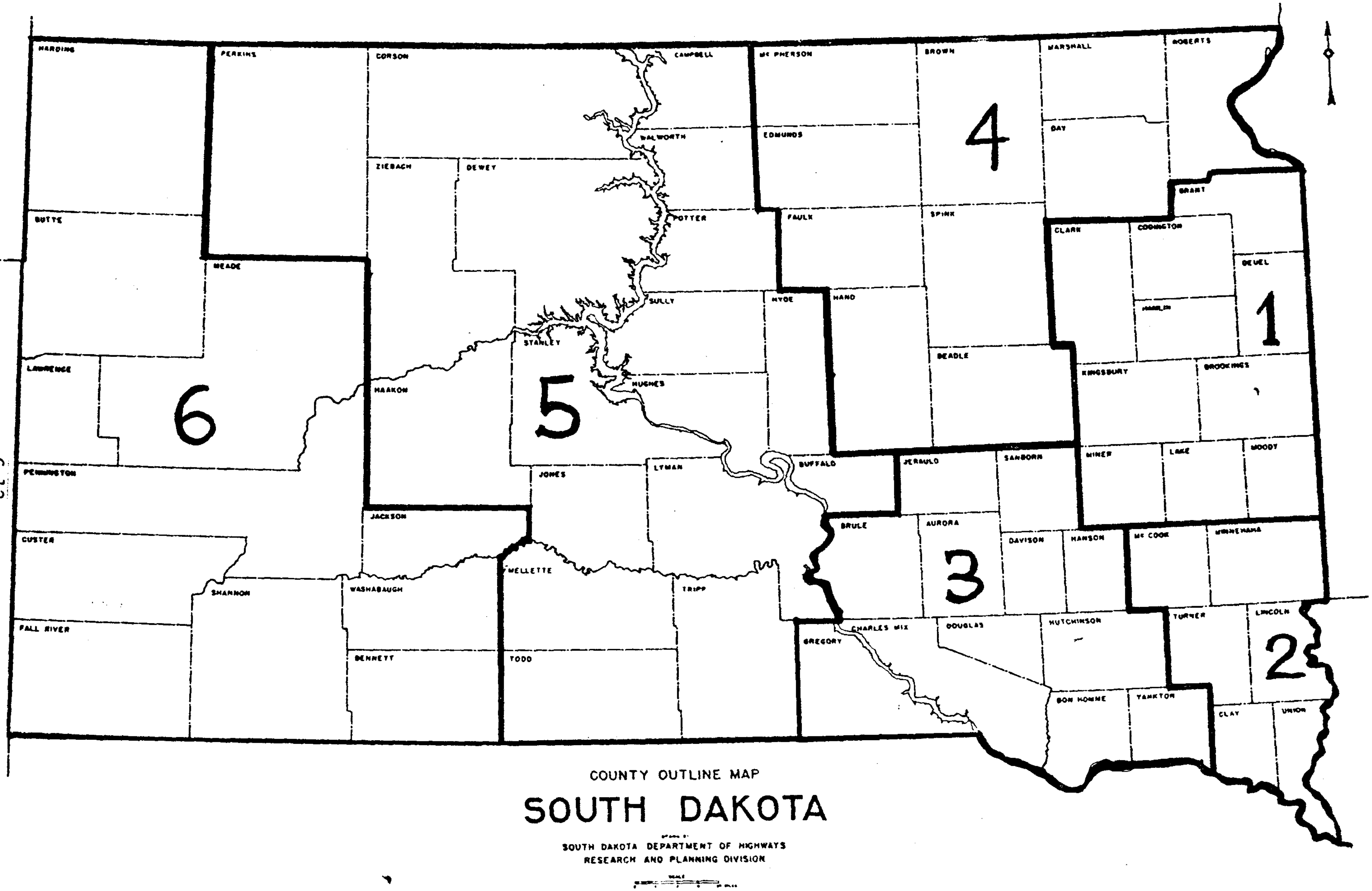
Two communities, Wessington and Faulkton, have existing flowing wells with temperatures below 90°F. The two communities have asked for advice in using the water for space heating. There are undoubtedly other East River communities that have the same resource. The potential source in conjunction with groundwater heat pumps must be studied. The City of Dupree has a municipal well with a temperature of 150° that could possibly be used for heating the school and city buildings. Technical assistance and the encouragement of private funding would advance the use of geothermal energy greatly.

3.0 FINDINGS AND RECOMMENDATIONS

The public must be made aware of the potential that lies beneath their feet. Technical assistance and self help programs must be publicized to help viable projects become a reality. The state commercialization team will accomplish these goals by (1) promoting the use of EG&G's Technical Assistance Program, (2) distributing the direct use handbook and the groundwater heat pump brochure throughout the state, and (3) matching the use with a developer that has the proper expertise to economically put BTU's on-line.

APPENDIX A

STATE GEOTHERMAL PLANNING AREAS



COUNTY OUTLINE MAP

SOUTH DAKOTA

APPENDIX A

APPENDIX B

ACTIVE DEMONSTRATION PROJECTS

PROJECT TITLE: Direct Utilization of Geothermal Energy for Philip Schools

PRINCIPAL INVESTIGATOR: Charles A. Maxon, Superintendent of Schools
(605) 859-2679

PROJECT TEAM: Haakon School District 27-1
Hengel, Berg & Associates

LOCATION DESCRIPTION: Philip, South Dakota
80 miles (128 km) east of Rapid City, SD
Population: 1000
Area Activities: Agriculture, light industry, and trade center

RESOURCE DATA:

Well Depth: 4266 ft (1300 m)
Date Complete: 2/23/79
Completion Technique: Open hole
Wellhead Temperature: 157 degrees F. (69 degrees C)
Flowrate: 300 gpm (18.9 l/s) artesian
Summary: The Madison Formation extends under the western half of South Dakota and into the bordering states of Wyoming, Montana and North Dakota. Most Madison wells in South Dakota are naturally flowing with temperatures ranging from 110 degrees F (43 degrees C) to 170 degrees F (77 degrees C).

SYSTEM FEATURES:

Application: Space, water and district heating
Heatload (Design): 5.5×10^6 BTU/hr (1.61 MW)
Yearly utilization (Maximum): 9.53×10^9 BTU/yr (.32 MW-yr)
Energy Replaced: Electricity - 122,989 kWh
Fuel Oil - 54,729 gals.
Propane - 23,858 gals.

Facility Description: 5 school and 8 business district buildings

Disposal Method: Surface discharge to the Bad River after treatment to remove Radium 226.

Summary: The school heating project has stimulated the development of a business district heating system, Philip Geothermal, Inc. In addition, Little Scotchman Industries, the city water plant and county maintenance building use geothermal fluids from other wells for space heating.

STATUS:

Construction complete. Adjustment of the flow through the system and monitoring to start.

CURRENT ESTIMATED PROJECT COST:

Total:	$1,205,804		
DEO Share:	$ 936,199 78%	Participant Share:	$269,605* 22%

LESSONS LEARNED:

The initial phase of this project was the development of the geothermal resource. A well was drilled into the Madison Formation. The total depth of the well is approximately 4,266 feet. During the drilling operations we had a full time drilling consultant at the well site during drilling operations. He was to be available in the event that drilling problems would shift the drilling operation from a footage basis to a day rate. We would recommend that on a future well that the drilling consultant be placed on a retainer so that he would be available to come to the well site with 24 hours notice. This would reduce the cost of the drilling consultant by eliminating that expense when the drilling operation is proceduring without any problems.

After setting the main casing the open hole completion of the well was drilled. Problems developed during the open hole drilling which included shale lenses and sand pockets in the limestone. This condition could create future problems during operation of the well such as sloughing of the sands and shale into the open hole. A 5" O.D. flush joint casing was suspended inside of the 7 5/8" casing previously installed. On any future wells drilled into the Madison Formation we would recommend that the open hole completion be completed before setting the main casing. If shale lenses or sand pockets that are drilled through they can be cased out with the main casing at a considerable savings in cost.

Samples of the geothermal fluid were tested by the Federal Environmental Protection Agency. Their tests indicate the presents of Radium 226 in the geothermal waters. The level of Radium 226 is approximately 99 pico curies per liter. This exceeds the EPA standards for drinking water 5 pico curies per liter or less. To obtain a discharge permit to discharge the geothermal fluid into the Bad River, the Radium 226 level had to be reduced to less than the 5 pico curies per liter.

Among the various methods investigated for removal of Radium 226, was the method used by the Uranium Mining and Milling Companys. The method they used involved adding a 10% aqueous solution of Barium Chloride to the water. The resulting chemical reaction provides a Barium Sulfate to which the Radium 226 adheres. The result is a floculation that will settle out of the water. This process has a 99% efficiency. The Barium Chloride Treatment facility consists of a building to house the mixing tanks, a short section of discharge line, and an in-line static mixer. The Barium Chloride solution is added by metering pumps to the in-line static mixer. The barium chloride solution is mixed into the geothermal fluid and piped to the holding pond. The holding pond was designed for a three day retention time. The retention pond was divided into two cells so that maintenance could be preformed on one cell while operating would be the one remaining cell.

The heating system in the High School-Armory building and in the Elementary School building were low pressure steam systems. During the planning for the modification of these sytems to a low temperature hot water it was anticipated that the control valves could be reused. However, as the modification contract proceeded it became apparent that the seals in many of the control valves had deteriorated. This showed up when the contractor pressurized the system during standard test procedures.

Another problem that became apparent during the testing of the system was that a few of the baseboard radiation units had developed pin holes at their connections from the years of use. When the pressure test was applied, these areas started to leak water and had to be repaired. On future conversion projects, consideration should be given to pressure testing sections of the system prior to design to determine if that portion of the system could be used or if would have to be replaced. This would add additional cost to the preliminary engineering phase of the project. However, under certain circumstances this may be money well spent.

The contractual arrangement between the Owner and Contractor on this project has been very good. Changes to the construction contract have been kept to a minimum. The negotiated Change Orders with the contractor have been reasonable.

In some of the classrooms the existing steam fin tube radiation and the baseboard radiation units were replaced with hot water fin tube radiation units. The hot water fin tube radiation units were sized based on using water at approximately 140 degrees F. Engineering calculations show that in some instances it was more economical to add a cabinet unit heater along with the baseboard radiation units to provide the required heat for the room. The cabinet unit heaters were installed at the end of the baseboard radiation units were possible, however, in several instances the cabinet unit heater was placed in the middle of a baseboard radiation run. This created a problem because the baseboard radiation covers had to be cut. To make a neat joint between the baseboard radiation cover and the cover on the cabinet unit heater, the contractor provided a PVC window glazing gasket with a profile that covered the raw edge of the baseboard radiation cover.

The piping the boiler room of both the High School and the Elementary School is designed to vary the flow to the space heat exchanger. During periods of maximum heat demand, all of the geothermal fluid is directed to the space heat exchanger. From the space heat exchanger, the geothermal fluid flows to the domestic hot water heat exchanger. During periods of moderate to low space heating demand, the geothermal fluid is diverted around the space heat exchanger to the domestic hot water heat exchanger. The flow is controlled by a pneumatic actuated three way valve. The pneumatic actuated three way valves normally used in commerical installations would not operated against the artesian flow of this project. We were directed by the manufacturer to their industrial division. All of the three way valves on the geothermal side of the system are of the industrial type.

Pipeline

The geothermal fluid is piped to the school buildings, the business district buildings, and to the Barium Chloride Treatment plant using a filiment wound fiberglass expoxy resin pipe. This pipe is designed for applications up to 210 degrees F (99 degrees C).

This pipe is assembled in a bell and spigot method. Whenever the pipe has to be cut in the field the cut end has to be shaved to provide a new spigot. This shaving is done with a specilized pipe shaver provided by the manufacturer.

All of the fittings, sockets, pipe ends and pipe sockets must be clean and dry and must be sanded within 2 hours of assmebly. The sanding was accomplished using a flapper type sander on a drill.

If there is just the least bit of moisture or grease from the hands of the individuals handling the pipe, a perfect bond is not obtained. During the construction of this project we had only two joint failures. The contractor was exceptionally careful butting the pipe together because of the high cost of repairing the pipe failure. The joints if made properly are as strong or stronger than the pipe itself.

To repair a joint failure requires that a section of the pipe be cut out and new bell and spigots be cut on each then sanded and the pieces put back together.

The pipe was bedded in a layer of sand. The sand all passing a 3/8" screen was obtained locally. Approximately 6" of sand was placed under the pipe and another 6" was placed over the pipe. The soil in which the trench was excavated is composed primarily of the pier shale. This soil will expand and contract with changes in moisture. The sand was placed to provide a cushion to the pipe during these periods when the soil around it is moving.

The discharge line from the school is the supply line for the business heating district. The heating district was designed to provide a geothermal fluid at the same relative elevation to all of the eight building to be heated.

The construction of the system was recently completed. We have entered the adjustment and monitoring phase. All of the building in the heating district have not been connected to the system as of this date. As each building is added to the system a readjustment of the valves in the fire-hall and the various businesses will have to be made.

PROJECT TITLE: Diamond Ring Ranch Geothermal Demonstration Heating Project

PRINCIPAL INVESTIGATOR: Dr. S. M. Howard, Professor of Metallurgical Engineering, (605) 394-2341

PROJECT TEAM: South Dakota School of Mines and Technology
Re/Spec, Inc.
Diamond Ring Ranch

PROJECT OBJECTIVE: Utilize existing Madison well to provide grain drying, and space heating for homes.

LOCATION DESCRIPTION: Haakon County, Central South Dakota
50 miles (80 km) west of Pierre, SD
Population: 2900 (Haakon County)
Area Activities: Agriculture

RESOURCE DATA:

Well Depth: 4112 ft (1253 m)

Date Complete: 1959

Completion Technique: Open hole

Wellhead Temperature: 152°F (67°C)

Flowrate: 170 gpm (10.7 ℓ/s) artesian

Summary: The Madison Formation extends under the western half of South Dakota and into the bordering states of Wyoming, Montana, and North Dakota. Most Madison wells in South Dakota are naturally flowing with temperatures varying from 110°F (43°C) to 170°F (77°C).

SYSTEM FEATURES:

Application: Space heating and grain drying

Heatload (Design): 3.35×10^6 Btu/hr (.98 MW)

Yearly Utilization (Maximum): 7.87×10^9 Btu/yr (.26 MW-Yr)

Energy Replaced: Electricity - 185,288 kWh
Propane - 49,415 gal.

Facility Description: Six structures and a 700 bushel/hr grain dryer are served by geothermal water.

Disposal Method: Surface discharge to ranch reservoirs

Summary: Two heating loops circulate water through water-to-air heat exchangers and fan coil units to provide space heating for the hospital barn, mobile homes, shop, employee's home and owner's home. An additional loop provides hot water to the 700 bushel/hr commercial grain dryer.

STATUS:

The system is operating. Monitoring equipment is being installed.

CURRENT ESTIMATED
PROJECT COST:

Total:	$403,098		
DOE Share:	$250,725	Participant Share:	$152,373
	62%		38%

LESSONS LEARNED:

1. The 4,000-ft. long pipeline carrying geothermal water to the isolation heat exchangers has three high spots along its length which could have been avoided only at greatly increased pipeline expense. A degasser at the wellhead proved insufficient to prevent gas pockets from forming in the line's high spots. This problem was eventually overcome by installing PVC air vent valves at the first two of the high spots.

2. The space heating system is comprised of a plate-type isolation heat exchanger used to heat recirculating water to six structures: four homes, a hospital barn, and a shop building. These structures are supplied by two loops with the return water mixing as it re-enters the isolation exchanger. The problem of freezing arises in the event of a power failure. Freezing is most likely in the barn and shop since these structures have low thermal mass unlike the homes. To prevent freezing, the recirculating system will be charged with antifreeze. The cost of the antifreeze would have been substantially reduced by use of smaller recirculating lines (2 inch rather than 3 inch) and by dividing the isolation exchange into two units so as to put the structures subject to freezing all on one loop. It should be noted that this would have increased the capital cost but lowered operating cost assuming the antifreeze is lost several times during the system's life.

3. Dividing the exchangers as described above would also have allowed subjugating the heating demands of the barn and shop to the other space heating demands. This would be a distinct advantage since the ambient temperatures of those structures are lower.

PROJECT TITLE: Geothermal Application of the Madison Aquifer for St. Mary's Hospital

PRINCIPAL INVESTIGATOR: James Russell, Hospital Administrator
(605) 224-5941

PROJECT TEAM: St. Mary's Hospital
Kirkham, Michael and Associates
Sherwin Artus, Reservoir Consultant
Dr. J. P. Gries, Geologist

PROJECT OBJECTIVE: To demonstrate that 106°F (41°C) water can be used for preheating domestic hot water and space heating.

LOCATION DESCRIPTION: Pierre, South Dakota
Population: 14,500
Area Activities: Government (Pierre is the state capitol) and agriculture.

RESOURCE DATA:

Well Depth: 2176 ft (663 m)

Date Complete: 4/21/79

Completion Technique: Perforated casing

Wellhead Temperature: 106°F (41°C)

Flowrate: 375 gpm (23.7 ℓ/s) artesian

Summary: The Madison Formation extends under the western half of South Dakota and into the bordering states of Wyoming, Montana and North Dakota. Pierre is located on the eastern edge of this formation.

SYSTEM FEATURES:

Application: Domestic water preheating and space heating

Heatload (Design): 5.55×10^6 Btu/hr (1.63 MW)

Yearly Utilization (Maximum): 11.44×10^9 Btu/yr (.38 MW-Yr)

Energy Replaced: Fuel oil - 115,000 gals.

Facility Description: The existing 83,000 ft^2 (7710 m^2) hospital and a new 65,000 ft^2 (6038 m^2) addition will be served.

Disposal Method: Surface discharge to the Missouri River.

Summary: Three plate-type heat exchangers provide make-up air heating, space heating via fan coil units and domestic water preheating. The new addition heating system is designed to utilize the geothermally heated water in the hot deck coil of the air handling units and the heat pump.

St. Mary's Hospital (cont'd)

STATUS:

The well was completed in April of 1979. The original flow rate was approximately 250 gpm. After further perforations of the well casing and by pumping 8,000 gallons of 20 percent HCL solution into the well, the flow rate was increased to the present level of 375 gpm.

The construction work for the application of the geothermal resource to the existing hospital and the new addition is completed. The systems were put into operation in mid-October of 1980 and balancing and final adjustments of control systems are now under way. System performance to date have exceeded the anticipated capability as follows:

Completed Well	System Operation
Well Supply Temp. = 106°F	108°F
Closed Loop Supply Temp. = 100°F	104° to 105°F
Domestic Hot Water Supply = 100°F	106°F

CURRENT ESTIMATED
PROJECT COST:

Total: $718,000

DOE Share: $538,500
75%

Participant Share: $179,500
25%

LESSONS LEARNED:

1. There is great difficulty in estimating the cost of a producing geothermal well. Our original estimated cost for the well was $125,000. The final well cost was $316,000 which exceeded our original estimate by 150%.

2. Resource and discharge permits can be a problem. We were not familiar with all that was required when we began and, had we been, it could have speeded up the process. Cooperation of the reviewing agency was excellent.

3. Perseverance pays off. In proposing the project, we originally hoped to find 117°F water. When our well came in producing 106°F water there was considerable skepticism even among ourselves that we could accomplish much of what we had set out to do. With the support of DOE, our project continued and is now complete and operational. It appears that our annual fuel savings may be even greater than originally projected. In addition, the temperature of the geothermal fluid increased 2°F in production.

APPENDIX C

GEOTHERMAL ENERGY ANNOUNCEMENTS

midamerica communications, inc.
box 25 sioux falls, south dakota 57101
phone 605/336-0775

December 16, 1980

Ms Carol Srstka
Office of Energy Policy
Capitol Lake Plaza
Pierre, SD 57501

Dear Carol:

Pursuant to your phone conversation with Gypsy Hines of our staff Monday moring, this is to advise you thqt the geothermal energy announcement was purchased as air time according to the following schedule. Any showings of the spot in addition to the times listed below are being done at the stations without charge to OEP.

KELO/KDLO/KPLO	
Sunday 11/23	10:00-10:30 PM
Thursday 11/27	10:00-10:30 PM
Wednesday 12/3	6:00-6:30 PM
Monday 12/8	6:00-6:30 PM
KSFY/KABY/KPRY	
Monday 11/24	6:00-6:30 PM
Thursday 11/27	10:00-10:30 PM
Sunday 11/30	10:00-10:30 PM
Thursday 12/4	6:00-6:30 PM
Wednesday 12/10	6:00-6:30 PM
Sunday 12/14	10:00-10:30 PM
KOTA	
Thursday 11/27	10:00-10:30 PM
Sunday 11/30	10:00-10:30 PM
Wesnesday 12/3	5:30-6:00 PM (local news block)
Sunday 12/7	10:00-10:30 PM
KEVN	
Saturday 12/13	4 times during championship games of girls' "A" basketball
Sunday 12/14	1 time during Sunday Night Movie
Wesnesday 12/17	1 time during "Eight Is Enough"

Sincerely yours,

Larry B. Eliason
Vice President

APPENDIX D

Representative Sample of Contacts: July-December 1980

1. Marlo Audiss
   Gregory, SD 57533
   Subject: Requested and received information on groundwater heat pumps.

2. Dick Berg
   Hengel, Berg, and Associates
   Rapid City, SD 57701
   Subject:

3. John Biegler
   Polo School District
   Orient, SD 57467
   Subject: School superintendent requested and received technical assistance for space heating.

4. Barbara Boggs
   National Water Well Association
   500 W. Wilson Bridge Road
   Worthington, OH 43085
   Subject: Coordinator of the one day heat pump road show conducted by NWWA in Sioux Falls in August 1980.

5. John Bonaiuto
   601 4th Street
   Brookings, SD 57006
   Subject: Requested and received groundwater heat pump information for Brookings school system.

6. Todd Boyd
   Box 276
   Clear Lake, SD 57226
   Subject: Requested and received groundwater heat pump information for his home.

7. Al Bender
   Water Resources Institute
   Brookings, SD 57006
   Subject: Requested and received geothermal energy information for City of Eureka.

8. Dan Carda
S.D. Experiment Station
S.D. School of Mines & Technology
Rapid City, SD 57701
Subject: Chemist and geologist, strong advocate of geothermal energy use in South Dakota, assisted Stan Howard with Diamond Ring Ranch project. He has given freely of his time in promoting geothermal energy serving as speaker at informational meetings of Edgemont, Rapid City, and Pierre.

9. Gerald Cerfoss
Wessington, SD
Subject: Requested and received information about funding sources to develop geothermal energy for City of Wessington.

10. Mickey Daly
Star Rt. 61, Box 26
Midland, SD 57552
Subject: Requested and received the South Dakota Geothermal Energy Handbook.

11. Art deWit
DeWild, Grant, Reckert & Associates
1113 E. 14th Street
Sioux Falls, SD 57104
Subject: Consulting engineer interested in the use of groundwater heat pumps for commercial applications. He is interested in using the "flaming fountain" for heating the capitol mall complex.

12. Paul Goudreault
Water Quality Specialist
Rosebud Sioux Tribe
Rosebud, SD 57570
Subject: Requested and received information about geothermal resource in Todd County.

13. Dan Hanson
Grand Electric Association
Bison, SD 57620
Subject: Requested and received South Dakota Geothermal Energy Handbook.

14. Roy Hauck
Box 995
Pierre, SD 57501
Subject: Stanley County rancher interested in agricultural use of geothermal energy. He requested and received information on direct and heat pump assisted use of geothermal energy.

15. Virgil Herriott
    P.O. Box 216
    Colman, SD 57017
    Subject: Strong advocate of heat pump assisted geothermal energy also a TETCO heat pump distributor.

16. John Hussman
    OST Water Development
    P.O. Box 562
    Pine Ridge, SD 57770
    Subject: Requested and received information about geothermal resource on Pine Ridge Reservation.

17. Renee Jesness
    McIntosh Independent School District
    McIntosh, SD 57641
    Subject: Requested and received information about geothermal space heating.

18. Ed Lacey
    Trent, SD 57065
    Subject: Groundwater heat pump distributor.

19. Marty McGrane
    Box 1138
    Pierre, SD 57501
    Subject: Editor of South Dakota Highliner; featured geothermal energy in November 1980 issue.

20. Betty McNulty
    Executive Vice President
    Watertown Chamber of Commerce
    1 South Broadway
    Watertown, SD 57201
    Subject: Chaired a November 5, 1980 meeting about district heating with Dr. Michael Karnitz of the Oak Ridge National Laboratories as principle speaker.

21. David Miller
    P.O. Box 105
    Mitchell, Sd 57301
    Subject: Requested and received groundwater heat pump information.

22. Stephen Miller
    5th District C.O.G.
    Box 640
    Pierre, SD 57501
    Subject: Coordinator of federal funds for local area.

23. Reuben Pastians
Midwest Geothermal Energy Inc.
P.O. Box 1422
Huron, SD 57350
Subject: President of groundwater heat pump company that is a division of the Huron Drilling Company. He was one of the speakers at the Geothermal Energy Day held in Pierre October 21, 1980.

24. Albert Rahm
RR 2, Box 53
Turton, SD 57477
Subject: Requested and received information about groundwater heat pumps.

25. Steve Vamosi
356 Thrall St.
Cincinatti, OH 45220
Subject: Made a preliminary feasibility study of the capitol mall complex.

26. Van Heuvelen
R.R. 1 Box 73
St. Lawrence, SD 57373
Subject: Requested and received information about groundwater heat pumps.

27. Bob Waterman
South Central CAP
P.O. Box 6
Lake Andes, SD 57356
Subject: Requested and received information about the geothermal resource in Charles Mix County.

28. Monica Westerland
St. Paul District Heating Development Co.
Phone: 612-297-8955
Subject: Requested and received information about district heating projects in South Dakota.

UTAH GEOTHERMAL COMMERCIALIZATION PROJECT
SEMIANNUAL PROGRESS REPORT
July-December 1980

Prepared by

Standley Green

L. Ward Wagstaff

Douglas Nielsen

UTAH DIVISION OF WATER RIGHTS

Work Performed Under Contract No. DE-FC07-791012

U. S. Department of Energy

Idaho Operations Office

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UTAH GEOTHERMAL COMMERCIALIZATION PROJECT

SEMIANNUAL PROGRESS REPORT, JULY-DECEMBER 1980

1.0 INTRODUCTION

The Utah Geothermal Commercialization Project is part of a regional program funded primarily by the U.S. Department of Energy to provide support and planning information about geothermal development, and to perform outreach or marketing activities for geothermal use. In 1977, the Utah Division of Water Rights contracted with the DOE to perform these functions for Utah. Personnel working on the Utah project are Stanley Green, Project Supervisor; L. Ward Wagstaff, Planning and Technical Analyst; and Douglas Nielsen, Information and Marketing Specialist.

2.0 SPECIFIC TASK DESCRIPTIONS AND PRODUCTS

2.1 Geothermal Prospect Identification

No new deep geothermal wells were drilled in Utah for electrical exploration during the period of July-December 1980. A number of temperature gradient surveys were conducted within the state by major exploration companies. Several projects, including Utah Roses at Bluffdale and Christensen Brothers at Newcastle, began using hydrothermal energy during the 1980-81 heating season. Most recent data on electrical prospects are given in Table 1, and data for direct-use (moderate-temperature) resources are given in Tables 2, 3, and 4. Areas of hot and warm water in Utah are shown in Figure 1.

TABLE 1. GEOTHERMAL ELECTRICAL PROSPECTS

Prospect	Measured Temp. (°C)	Well Depth [m (ft)]	Estimated Power Capacity (MWe)	Notes
Roosevelt Hot Springs (proven)	265	365 to 2130 (1200 to 7000)	300 to 500	20 MWe planned for about 1983, followed by 55-MWe plants. Phillips and UP&L in exclusive negotiations.
Thermo (potential)	177 to 205	2225 (7300)	-	Well drilled by Republic in 1977. May be suitable for binary power system.

TABLE 2. PROVEN DIRECT-USE GEOTHERMAL PROSPECTS

Prospect	Location	Temp. (°C)	Well Depth (m)	TDS (ppm)	Notes
Monroe Hot Springs	Sec. 15, T25S, R3E; Sevier Co.	74	457	2,800	Well drilled; project not commercial
Crystal Hot Springs	Sec. 11, T4S, R1W; Salt Lake Co.	90[a]	125[b]	1,665[t]	Production well drilled by Utah Roses; geological investigations planned by the State of Utah
Sandy City	Sec. 1, T3S, R1W; Salt Lake Co.		1527[d]	1,120	Work proceeding to increase temperature and flow
Newcastle	Sec. 20, T36S, R15W, Iron Co.	96[e]	153[e]		Two production wells drilled; in use this year
Beryl	Sec. 18, T34S, R15W, Iron Co.	149[f]	2134	low	Deep well reportedly producible, but it is not currently in use
Cove Fort	Sec. 7, T25S, R6W; Sec. 33, T25S, R6W; Beaver & Millard Co.	173[g] 130[g]	2358 1691	9,405[h] 10,000[h]	Two wells, planned for use with alcohol plant

a. Reported temperature in Utah Roses production well.

b. Depth of production well drilled by Utah Roses.

c. TDS in spring (surface discharge).

d. Deep well drilled by Utah Roses to 1527 in (5009 ft).

e. Temperature, depth of first well, and TDS from Goode, 1978.

f. Temperature and depth of Beryl well from Goode, 1978. TDS reportedly low.

g. Data on Union Wells #42-7 and #31-33 released through UURI.

h. TDS data for Cove Fort Well shows wide variation range. Well #42-7: 4774 to 9405 ppm; Well #31-32: 1320 to 10,000 ppm,

TABLE 3. POTENTIAL PROSPECTS FOR DIRECT USE OF GEOTHERMAL RESOURCES[a]

Prospect	Location	Maximum Measured Temperature (°C)
Wasatch Hot Springs	Sec. 25, T1N, R1W; Salt Lake County	40[b]
Beck's Hot Springs	Sec. 14, T1N, R1W; Salt Lake County	55[b]
Midway	T3S, R4E; Wasatch County	46[c]
Udy (Belmont Hot Springs)	Sec. 23, T13N, R3W; Box Elder County	45[b]
Crystal (Madsen's) Hot Springs	Sec. 29, T11N, R2W; Box Elder County	60[b]
Utah Hot Springs	Sec. 17, T7N, R2W; Weber County	59[b]
Ogden Hot Springs	Sec. 23, T6N, R1W; Weber County	57[b]
Abraham (Baker) Hot Springs	Sec. 23, T6N, R1W; Juab County	82[b]

a. Sites investigaed by UGMS, including temperature gradient surveys.

b. Peter J. Murphy, UGMS

c. Kohler, 1979

d. Goode, 1978

TABLE 4. AREAS OF INFERRED DIRECT THERMAL RESOURCES

Prospect	Maximum Recorded Water Temperature (°C)
Lower Bear River Area	105
Bonneville Salt Flats	88
Cove Fort - Sulphurdale	165
Curlew Valley	43
East Shore Area	62
Escalante Desert	149
Escalante Valley	85
Fish Springs	61
Grouse Creek	42
Heber Valley	44
Jordan Valley	89
Pavant Valley/Black Rock Desert	67
Sevier Desert	82
Sevier Valley	77
Utah Valley	46
Central Virgin River Basin	42
Uintah Basin	55
Beaver Valley	24
Blue Creek Valley	28
Cache Valley	49
Canyonlands	28
Cedar City and Parowan Valley	21
Cedar Valley	27
Northern Juab Valley	20
Park Valley	23
Promontory Mountains Area	25
Rush Valley	27
Skull Valley	24
Snake Valley	27
Tooele Valley	32
Tule Valley	28
Wah Wah Valley	29
Castilla Hot Springs	40
Como Warm Springs	25
Diamond Fork Warm Springs	20

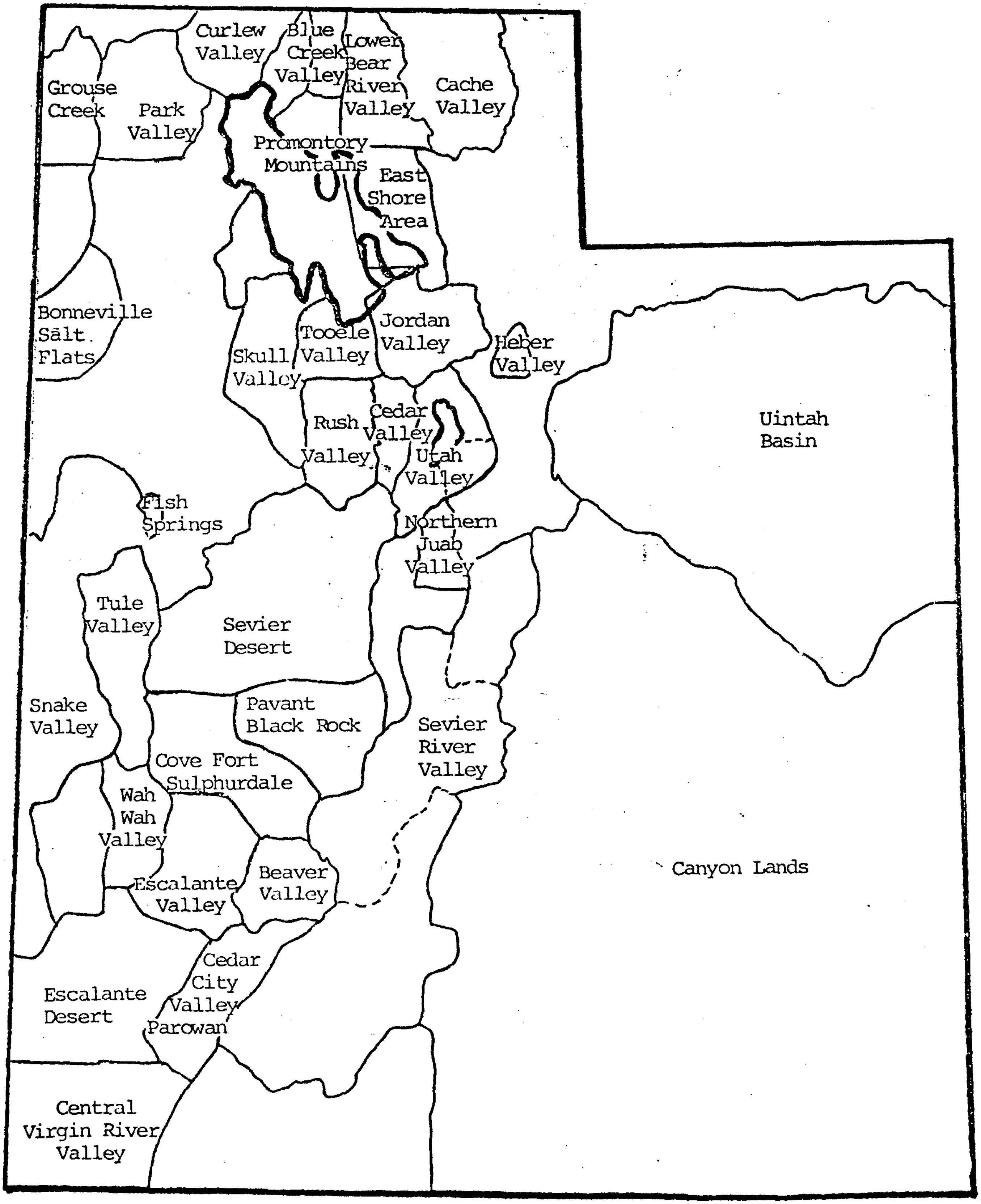

Fig. 1 Areas of hot and warm water in Utah.

A major step in development of the Roosevelt Hot Springs Geothermal Prospect occurred in the fall of 1980 when Phillips Petroleum Company and Utah Power and Light signed a contract for development of the resource. The contract included plans for an initial 20-MWe plant, to be followed several years later by full scale 55-MWe plants. Further testing and development drilling is scheduled for later in 1981.

A pump test was conducted on a well at Cove Fort which had been drilled by Union Oil Company. When Union abandoned the prospect, the well was signed over to the Forminco, Inc. Forminco entered into a preliminary agreement with R & R Energies, Inc., to develop the resource for direct heat use in an ethanol plant. No firm data on the well test have been published, but reports indicate that the resource tested out very well. The project thereafter went into a planning stage.

The Utah Geological and Mineral Survey (UGMS) drilled two exploratory wells at the Utah State Prison in conjunction with the U.S. DOE sponsored Utah State Prison PON project. An existing well, originally drilled for the Utah Division of Forestry and Fire Control, was deepened from 280 ft (85 m) to about 500 ft (152 m). A second exploratory well nearby was drilled to 1,000 ft (304 m). Both wells bottomed in the fractured quartzite bedrock which apparently forms the matrix for the hydrothermal reservoir. Both wells had a slight artesian flow, and the water's temperature was about 82°C (180°F). A flow test of the wells was scheduled for early in 1981. Because the 410 ft (125 m) well at Utah Roses, adjacent to the prison property, was used for heating during the 1980-1981 winter, it was not possible to make accurate reservoir measurements.

The UGMS, as part of the State-coupled resource assessment program, gathered information about wells along the Wasatch Front in an effort to locate possible hydrothermal anomalies. Members of the UGMS staff used available well logs and other records to determine likely targets for further investigation. They then made extensive field measurements of temperature gradients and water chemistry to determine which areas along the front have abnormally high temperatures. This work will continue into 1981. No data from the study are yet available for publication.

Several new state geothermal leases were issued during the last half of 1980; these are listed in Table 5.

TABLE 5. NEW STATE GEOTHERMAL LEASES, JULY-DECEMBER 1980

County/ Leaseholder	Size (acres)	No. of Leases	Location	Date Issued
Beaver				
Atlantic Richfield Co.	640	1	T28S, R9W	7/14/80
Jefferson & Wiseman	1315	5	T29S R13W	7/21/80
Juab and Millard				
M. A. Rhodes	5924	5	T14, 15, 16S R11, 12W	11/03/80
Phillips Petroleum	1298	1	T14, 15S R13W	11/10/80

2.2 Area Development Plans

2.2.1 State Geothermal Planning Areas

Area Development Plans (ADPs) were intended to provide an indication of the opportunity for hydrothermal development within a specific substate ,feed area. An area development plan includes a match of projected energy demand for the area with the estimated energy potential of the geothermal resource. One result is an estimate of the portion of future energy demand that could be supplied by hydrothermal resources within the area. This information could then be used for planning agencies, and for the targeting of the most likely sites for geothermal development within the state.

The first step in the ADP process was to divide the state into suitable analysis areas. County groupings were based on geographic and social characteristics, the size and nature of the economic base, and the nature of the hydrothermal resources within each area. The planning areas are shown in Figure 2 and listed in Table 6.

2.2.2 Specific ADPs

No new work was done on the ADPs during the second half of 1980. The results of the analysis of projected residential and industrial energy demand, based on data presented in the Utah Semiannual Progress Reports of January 1980 and July 1980, are shown in Table 7. More complete data are

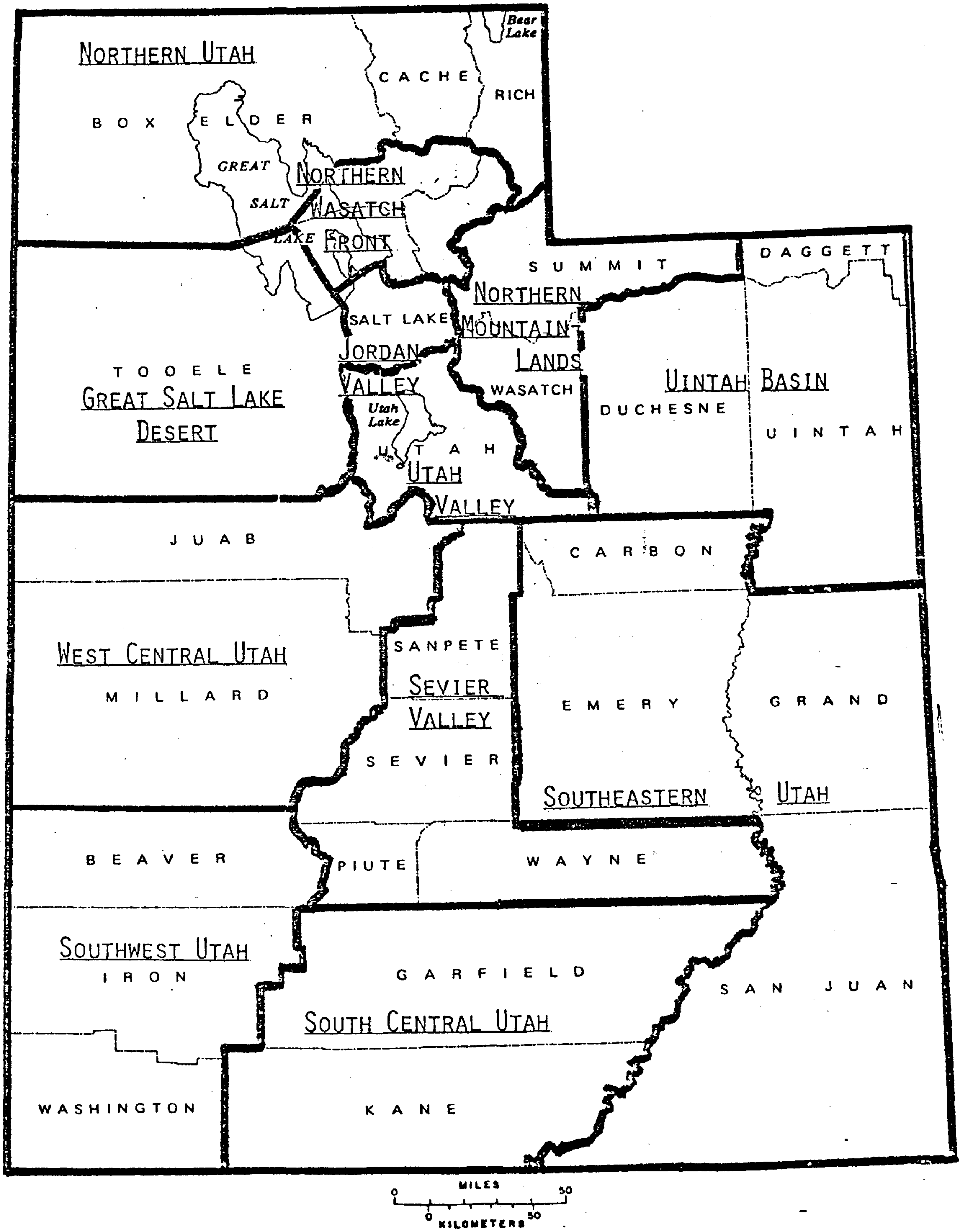

Fig. 2 Substate areas to be considered in area development plans in Utah.

TABLE 6. AREA DEVELOPMENT PLANS BY COUNTY

Area	Counties
Jordan Valley	Salt Lake
Southwest Utah	Beaver, Iron, Washington
Sevier Valley	Piute, Sanpete, Sevier, Wayne
Northern Wasatch Front	Davis, Morgan, Weber
Utah Valley	Utah
West Central Utah	Juab, Millard
Northern Utah	Box Elder, Cache, Rich
Northern Mountainlands	Summit, Wasatch
Great Salt Lake Desert	Tooele

TABLE 7. RESULTS OF AREA DEVELOPMENT PLANS--PROJECTED ENERGY USE[a]

Area	Residential Equivalent Natural Gas (10^6 scf)			Residential Electricity (10^3 kwh)			Industrial Energy Demand (10^{10} Btu/yr)	
	1980	2000	2020	1980	2000	2020	1979	2020
Jordan Valley	30,700	53,700	78,000	123,000	216,000	313,000	1,107	1,560
Southwest Utah	2,190	3,960	6,630	12,300	24,070	40,790	10.8	16.6
Sevier Valley	1,760	2,800	3,870	9,560	16,400	22,620	123.2	189.0
Northern Wasatch Front	13,900	24,300	35,300	45,300	80,000	116,300	407.8	625.6
Utah Valley	9,100	15,800	24,000	33,100	58,300	88,000	169.1	259.4
West Central Utah	800	1,300	1,800	4,100	7,000	9,600	39.9	61.3
Northern Utah	4,600	7,600	10,300	16,400	27,600	37,900	181.1	283.2
Northern Mountainlands	900	1,600	2,400	3,200	3,400	5,200	2.4	3.5
Great Salt Lake Desert	1,100	1,900	2,700	5,000	8,700	12,000	357.5	548.4

a. Natural gas and electricity data from utility records and population projections; industrial energy from NMEI.

found in these earlier reports; they are summarized here for convenience. These projections are based on available population and industry information, and could be greatly modified by developments such as the MX missle system.

2.3 Site-Specific Development Analysis

Site-Specific Development Analyses (SSDAs) are intended to portray various aspects of the development of a particular application at a specific geothermal resource site. In general, an analysis would consist of a step-by-step outline of development procedures, time frame estimates for expedient development, a preliminary analysis of the technical and economic feasibility of the project, and the identification of specific factors that might hinder or prohibit the successful completion of the project. SSDAs are more detailed and technical in nature than the Area Development Plans, and offer more insight into the real development potential and problems at a given site.

2.3.1 Candidate Geothermal Sites and Applications

Proven or potential resource sites may be candidates for SSDAs. These are sites where test drilling to confirm the resource has taken place ("proven" sites), or where some subsurface data are available ("potential" sites). Candidate sites for SSDAs are listed in Table 8. Two categories

TABLE 8. CANDIDATES FOR SITE-SPECIFIC DEVELOPMENT ANALYSES

Planned Development	Planned Use
Crystal Springs	Space heating
Crystal Springs	Greenhouses
Udy Hot Springs	District heating
Cove Fort	Alcohol plant
Newcastle	Greenhouses
Abraham Hot Springs	Recreation and Agriculture
Other Promising Sites	
Beck's Hot Springs	
Wasatch Hot Springs	
Utah Hot Springs	
Ogden Hot Springs	
Hooper Hot Springs	
Midway	
Beryl	
Thermo	

are listed--sites where specific projects are already underway, and sites that appear to be good prospects for development but for which no specific plans have been announced.

2.3.2 Site-Specific Development Plans: Completed and in Preparation

During the period of July-December 1980, no new site-specific analyses were run; however, the data and assumptions used for the Salt Lake City analysis of heat pump district heating were reevaluated, and the projected costs and savings were recalculated.

Block 53 Redevelopment: Heat Pump District Heating. Block 53 is located in downtown Salt Lake City near the south end of the main business district. It is bounded on the west by State Street (100 East) and on the south by 400 South. The block was purchased by the Salt Lake City Redevelopment Agency for the purpose of providing space for several state, city, and private office buildings, and possibly for constructing high-rise condominium buildings. At the request of the Redevelopment Agency, the State Commercialization Team performed a preliminary economic analysis of a district heating system using ground water heat pumps.

The approach used in the study was to analyze proposed buildings to estimate heating and cooling loads; to estimate the cost of a heat pump system, including wells, heat pump equipment, and operating costs; to estimate the cost of a conventional natural gas/chiller system, including boilers, chillers, and the associated natural gas and electricity; to use these costs plus historical energy cost escalation rates to estimate future costs through the projected life of the project; and to discount these future costs back to present value.

Table 9 summarizes the basic input assumptions for the analysis. The energy cost escalation rates and the bond rates used were taken relative to inflation. An inflation rate of 10% was assumed for the energy escalation rates. For the bond rates, which were used to discount the future values back to present values, a number of discount rates relative to the inflation rate were used, i.e., the bond rate equal to the inflation rate (0%), the inflation rate plus 2% (+2%), the inflation rate minus 2% (-2%), etc. The present value of the basic system at different discount rates is shown in Table 10, and present values for the project at the various rates are plotted in Figure 3.

It is evident from Table 10 and Figure 3 that the heat pump system is definitely economically feasible under the assumptions used. It should be noted that, using the present value analysis, a positive present value indicates the economic advantage of the project. Although this value varies according to the relative bond rate, it is positive for all cases.

Unfortunately, circumstances have precluded the use of heat pumps for the redevelopment project. The State office building, which was to be built first, was planned under strict budget restrictions, which limited the amount of capital available for construction. In effect this precluded the consideration of any projects which involved capital outlay and future savings. The State office building is now in the advanced stages of construction.

TABLE 9. BASIC ASSUMPTIONS, BLOCK 53 HEAT PUMP ANALYSIS

Conditions		
Total flow space		732,000 ft^2
Design heating load		8.90 x 10^6 Btu/hr
Design cooling load		14.94 x 10^6 Btu/hr
Annual heating load		14.52 x 19^9 Btu/hr
Annual cooling load		19.4 x 10^9 Btu
Design temperatures:	summer, inside	78°F
	summer, outside	95°F
	winter, inside	65°F
	winter outside	5°F
Costs		
Heat pumps		$376,200
Heat pumps, annual operation (cooling)		78,700
Heat pumps, annual operation (heating)		49,100
Wells and piping plus 30%		396,300
Annual pumping cost		17,400
Boilers		72,200
Chillers		311,400
Cooling towers		41,400
Annual cooling cost (electricity)		104,200
Annual heating cost (natural gas)		42,400
Summary		
Heat pump system, capital cost		$772,800
Heat pump system, operating cost		145,200
Conventional system, capital cost		424,900
Conventional system, operating cost		146,600
Wells		
4 wells, 700 ft deep, 20 in. diam.		$ 90/ft

TABLE 10. PRESENT VALVE, BLOCK 53 HEAT PUMP DISTRICT HEATING SYSTEM

Discount Rate (relative to inflation)	Present Value at 20 years
-4%	1,092,208
-2%	757,543
0%	527,750
+2%	368,471
+4%	257,084
+6%	178,540

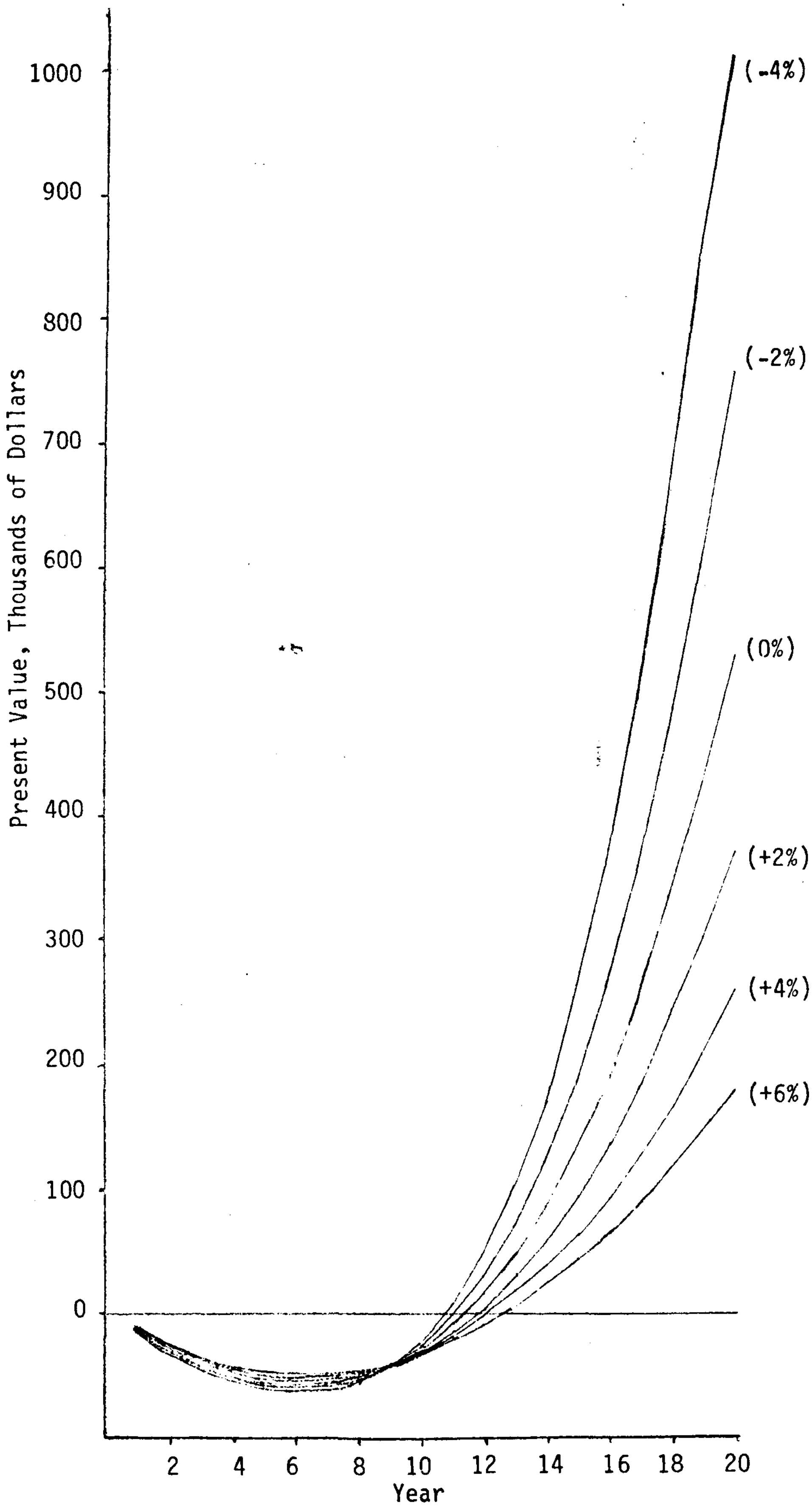

Fig. 3 Present value of the Block 53 heat pump district heating system at various bond rates.

The Redevelopment Agency had intended to pursue the heat pump alternative, but was also operating under capital limitations. The Agency applied for a HUD District Heating System grant but was turned down. It now appears unlikely that any parts of the development will utilize ground water heat pumps.

2.4 Time-Phased Project Plans

Time-Phased Project Plans (TPPPs) are intended to be detailed analyses of specific developments at given sites, with emphasis on the specific development steps, the sequence in which they occur, and an estimate of when each step will begin and end. The project is analyzed at all stages of development, including prelease activities, leasing, exploration, reservoir verification and development, developer and market negotiations, permitting from state and federal agencies, plant construction, and contribution system construction. The TPPP should demonstrate potential trouble spots in the development process and allow for actions to mitigate problems.

2.4.1 Active Demonstration/Commercialization Projects

Active or firmly planned geothermal projects are candidates for TPPPs. Candidate projects in Utah are listed and described in Table 11. During the latter half of 1980, no new projects were actually initiated, but several projects achieved substantial progress. The signing of a marketing agreement between Phillips Petroleum and Utah Power & Light was a major

TABLE 11. ACTIVE GEOTHERMAL PROJECTS

Site (Developer)	Application	Resource Characteristics	Geothermal Energy Requirements	Status of Project
Crystal Hot Springs (Utah Roses)	Greenhouses	Reported artesian flow at 90°C in 125-m well.	Development as supported by resource, up to about 234 x 10^9 Btu/yr.	The initial set of greenhouses, 70,000 ft^2, is being heated geothermally, with an additional 65,000 ft^2 planned for construction early in 1981.
Crystal Hot Springs (State of Utah)	Space Heating	Probably similar to Utah Roses well	Initial phase, minimum security building, 10.9 x 10^9 Btu/yr. Possible eventual development to 55.7 x 10^9 Btu/yr.	An existing 288-ft well was deepened to 500 ft and a 1,000-ft exploratory well was drilled. Both had artesian flows at temperatures close to 90°C.
Sandy City (Utah Roses)	Greenhouses	1,527-m well with slight flow; bottom hole temp. 75°C, temp. at surface around 50°C.	Greenhouse conversion from natural gas, about 70.0 x 10^9 Btu/yr.	The well has not produced flows or temperatures hoped for. Utah Roses is seeking a permit to discharge to the Jordan River.
Newcastle (Christensen Bros.)	Greenhouses	Two wells: 152-m well producing at 96°C, other well similar. Water quality good.	Development expected to grow as supported by the resource.	First set of greenhouses in operation; additional greenhouses planned by Christensen Bros. and also by major hydroponics firm.
Monroe Hot Springs (Monroe City)	Space Heating	Slight flow from 457-m well at about 74°C.	Intial phase, South Sevier High School, 4.5 x 10^9 Btu/yr.	Flow and temperatures were much lower than expected; project has been suspended.
Crystal (Madsen's) Hot Springs	Resort	Hot Springs, 56°C Flow about 100 lps.	Multiple use for recreation and space heating are planned.	The resort is undergoing major renovations; work is scheduled to continue several years.

TABLE 11. ACTIVE GEOTHERMAL PROJECTS (Continued)

Site (Developer)	Application	Resource Characteristics	Geothermal Energy Requirements	Status of Project
Midway (Several Individuals)	Space Heating (Homes)	Maximum measured temp. 46°C. Generalized hot groundwater system.	Water from springs now used for several resorts and homes.	A number of resorts and private homes currently use water from the springs for space heating and recreation. Several individuals plan to drill in order to heat homes.
Utah Valley (Arrowhead Greenhouses)	Greenhouses	Warm well supplies water at about 35°C.	Small greenhouse operation.	A small, family-run greenhouse operation uses warm water from a shallow well, has been in operation for about 5 years.
Cove Fort (R & R Energy)	Alcohol	Well drilled by Union-about 173°C	Planned initial development of 7 $\times 10^6$ gal alcohol production.	A well test was reported to yield flow and temperature results that were better than expected.

step toward development of the high-grade geothermal resource at Roosevelt Hot Springs. The contract calls for the drilling of at least two additional production wells and the construction of a 10-MWe pilot plant at the resource site. The pilot plant will be followed by full size 55-MWe plants at intervals of a few years.

The Utah Roses greenhouse at Bluffdale was heated with water from a geothermal well during the 1980-81 heating season. The owners estimated an operating cost of approximately $1.00 per hour to heat the 70,000 ft^2 greenhouse. The well is considered to be adequate to heat another 65,000 ft^2 of greenhouse under construction adjacent to the original greenhouse.

The Crystal Hot Springs Resort at Honeyville is in the process of renovating existing pools. The Christensen Brothers greenhouse at Newcastle used hot water from a geothermal well to heat a set of hydroponic greenhouses. The Monroe City Project, as reported in the previous semiannual report, has been suspended indefinitely while city officials investigate alternative uses for the geothermal well there. An existing geothermal well at Cove Fort was flow-tested for possible use in an ethanol plant; data from the test were not released, but the well was reportedly more productive than previously expected.

2.4.2 Time-Phased Project Plans

A Time-Phased Project Plan for the Roosevelt Hot Springs Geothermal Prospect was completed in the summer of 1979. After the plan had been completed, a unit agreement was signed between Phillips Petrolium Company and the ATO Consortium (AMAX Exploration, Inc., Thermal Power Company, and O'Brien Resources Corporation). Negotiations between Phillips, as Unit Operator, and Utah Power and Light, the preferred customer, resulted in a contract agreement in the fall of 1980. These two contracts have been major milestones for development of the resource, and their conclusion clears the way for the development of the resource at Roosevelt Hot Springs.

Plans for the development of the resource include an initial plant of 20 MWe, to come on line about 1983. The operation of this pilot plant will provide information about the reservoir which can be used in the planning and design of the subsequent plants. The full size 55-MWe plants would follow the initial plant after two or three years, and would come on line every few years as the reservoir is proven capable of supporting them.

2.5 State Aggregations of Prospective Geothermal Applications

Using information supplied by the Utah team, the Physical Science Lab at New Mexico State University made projections to the year 2020 of the amount of geothermal energy that would be economical each year. This information was reported in the Semiannual Report of the Utah team for July 1980. The reader is referred to that report for the tabulated and plotted results of the aggregation process.

2.6 Institutional Analysis

During the latter half of 1980, the Utah State team again worked to prepare legislation for resubmittal to the Utah Legislature. The team has cooperated with the drafting committee, composed mainly of representatives from geothermal companies that are active in Utah, and their legal representatives. The proposed legislation is essentially the same as that rejected by the legislature early in 1980. However, because Utah Power and Light has signed the agreement with Phillips Petroleum to develop the resource at Roosevelt Hot Springs, it is expected to drop its opposition to the legislation. If that occurs, it is expected that the legislation will pass without great resistance.

The proposed legislation addresses the problems involved in the development of high-temperature resources used for electrical production. The legislation, like its predecessor bills, would define geothermal resources as those with temperatures in excess of 120°C (248°F); these resources would be placed under correlative rights, and lower temperature resources would be governed by Utah Water Law, which follows the appropriative doctrine. The legislation would delegate to the State Engineer (in the Division of Water Rights) the authority and responsibility to regulate geothermal resources. He would have the authority to unitize a resource. The Legislation defines the relationship between geothermal rights and water rights, and provides for a judicial appeal process.

Rights to resources at temperatures below 120°C would be obtained through the filing, approval, and perfection of a water right. This means that the approval process, including advertisement of the application and hearings, would apply.

Several issues still need legislative attention, but no bills have yet been prepared to deal with them. Among the remaining issues are tax incentives for geothermal developers, particularly direct users; exemption of small district heating systems from public utility regulations; and the authority of municipalities and other governmental or quasi-governmental entities to form district heating or energy systems.

One regulatory problem which has continued to arise is that of disposal of spent geothermal fluids. It has been assumed that reinjection is, for hydrologic, geologic, or water quality reasons, the best method for disposing of these fluids. In some cases, this may not be true. However, the process of obtaining permission for the use of alternative methods from the U.S. EPA, Utah Water Pollution Control Board, and from the Division of Water Rights can be a difficult one.

2.7 Public Outreach Program

2.7.1 Outreach Mechanisms

The Outreach Program consists of several component activities:

- o Basic public education
- o More specific information service in response to requests from individuals, government agencies, researchers, geothermal companies, and government contractors
- o Technical assistance to prospective users
- o Marketing--an active effort to reach prospective industrial, private, and public users, both directly and through appropriate state and local agencies
- o Assistance in preparing proposed geothermal legislation.

The Utah Outreach Program has been directed and coordinated by Douglas Nielsen. Sopme of the specific outreach activities during the second part of 1980 are described below.

- Legislation. Stanley Green, the state team leader, has worked with the drafting committee to give advice and to help coordinate the preparation of geothermal legislation.

- Newsletter. The "Utah Water/Geothermal Report," under the direction of Douglas Nielsen, has been continued. The newsletter has received very favorable response.

- County Fairs. The state team traveled to several county fairs throughout Utah, where the Utah Geothermal Display, slide shows, and printed information were presented. Sevier, Beaver, and Iron Counties were visited.

- Energy Fairs. The Utah Geothermal Display was taken to several energy fairs during this period, and was used in conjunction with slide presentations and pamphlets.

- Local and Industrial Contacts. The state team initiated contact with the Utah Industrial Promotion Division and the Central and Southwestern Utah Association of Governments.

Plans for upcoming activities include the following:

- Continued Presentations. The state team plans to continue using the geothermal display and other outreach material at county fairs, energy fairs, and other public events.

- Geothermal/Industrial Packet. Plans include the preparation of a Utah Geothermal Information Packet, which could be used by industrial commissions or multicounty agencies to inform new industry of the potential for geothermal development and use.

- Utah Geothermal Pamphlet. Work is proceeding on a pamphlet that would deal specifically with the use of geothermal energy in Utah.

- Use of Site-Specific and Generic Studies. The state team plans to use both site-specific and generic feasibility studies to demonstrate the viability of geothermal energy use in Utah.

2.7.2 Summary of Contacts and Results

A detailed description of all of the contacts of the state team is far beyond the scope of this report. Contacts listed in previous reports will not be repeated here. A few contacts, however, will be summarized.

The state team has continued to work with ongoing projects, including the Utah State Prison Project, the Utah Roses projects, the alcohol plant at Cove Fort, and with other users such as the greenhouse operators at Newcastle and Benjamin and resorts at Plymouth, Honeyville, Monroe, Veyo, and La Verkin. The state team members have also assisted numerous individuals or companies who made inquiries about regulatory process, resource availability, or development problems.

2.7.3 Overall Prospectus for Future Geothermal Commercializatin

Geothermal projects in Utah that were already underway have made substantial progress, but new projects have experienced difficulty in getting under way. Also, few new projects have been seriously proposed.

Probably the most significant progress for any project was the signing of the development agreement between Phillips Petroleum Company and Utah Power and Light. The agreement was the product of several years of difficult negotiations, and marks the point at which development can actually begin. The two companies have also begun the various permitting processes, some of which will inevitably be tedious and drawn out.

As mentioned in Section 2.4.1, the Utah Roses greenhouse at Crystal Hot Springs used hot water from a geothermal well during the 1980-81 heating season. The success of the Utah Roses project has sparked much interest in the resource at Crystal Hot Springs, and the problem of resource capacity has become a major issue. A number of applications have been filed for the use of the resource, but the recharge to the system and hence the resource capacity are still unknown. This lack of knowledge could seriously retard development at the site. Late in 1980, the Utah Energy Office requested funding assistance for a reservoir test at the site. This request was turned down by DOE.

In addition, problems have been encountered in water rights and resource availability, disposal, and funding.

In general, geothermal development is progressing in Utah but not at a swift pace.

3.0 SUMMARY OF MAJOR FINDING AND RECOMMENDATIONS

Summaries of some of the more important recommendations for the project are included here. Most of these have been presented in earlier reports.

- The state needs to pass adequate geothermal legislation.

  The legislation should accomplish the following:

  - define geothermal resources in terms compatible with nature and with other standard definitions (such as the federal definition) and so that electrical and direct-use development will be facilitated
  - Clarify ownership of the resource
  - Clarify the regulatory authority of the State Engineer, and provide guidelines where necessary
  - Clarify the relationship between geothermal resources and water in a way that facilitates development of both high- and low-temperature resources
  - Define and clarify the relationship between geothermal rights, water rights, and correlative (property) rights

- Clarify and specify the authority of the State Engineer to unitize

- Specifically authorize local governments to establish geothermal or other district heating systems

- Remove small distributors of direct heat resources from regulation by the Public Service Commission

- Provide proper tax incentives for direct users.

o <u>Guidelines and rules for disposal should be clarified</u>. Areas requiring clarification include the circumstances under which reinjection will or will not be required, the effect that various disposal alternatives may have on the water right applications, and the ways in which alternative methods of disposal will or will not satisfy water quality and water availabilty requirements.

WYOMING GEOTHERMAL COMMERCIALIZATION PROJECT

SEMIANNUAL PROGRESS REPORT

July-December 1980

Prepared by

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Work Performed Under Contract No. DE-FC07-79ID12013

U.S. Department of Energy

Idaho Operations Office

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WYOMING GEOTHERMAL COMMERCIALIZATION PROJECT

SEMIANNUAL PROGRESS REPORT, JULY-DECEMBER 1980

1.0 INTRODUCTION

1.1 Purpose of Project

The purpose of the Wyoming Geothermal Commercialization Program is to match geothermal resources with potential users and applications. The program also is a clearing house of geothermal development information and a link to Wyoming geothermal resource data.

1.2 Objectives

The objectives of the Wyoming Geothermal Commercialization Office (GCO) are as follows: To bring about a general understanding and use of geothermal energy in Wyoming

- o To create a working relationship with both state and federal agencies involved in geothermal development, and contribute to the accomplishment of national geothermal energy goals of the United States Department of Energy

- o To develop usable plans for predicting and encouraging geothermal development over the next 40 years

- To maintain regional ties with other states

- To assess the institutional barriers to and intentions for the development of geothermal energy.

1.3 Technical Approach and Team Members

The GCO approach is primarily a planning and advocacy effort. The office, in cooperation with state agencies, businesses, and concerned citizen groups, uses a variety of publications and information sources to develop an awareness of geothermal energy. In addition, the specific development plans provide a general view of the future for geothermal energy in Wyoming.

The team members are:

Richard W. James	Program Director
Dr. E.G. Meyer	Co-Principal Investigator
Karen Marcotte	Research Associate
Patti Burgess-Lyon	Graduate Research Assistant
Mary Weber	Secretary
Keith Bray	Work-Study Student

1.4 Project Benefits to the State and DOE

Specific benefits to the state have been the development of an overall awareness of geothermal energy, the description of a major resource (Salt Creek Oil Field), and the enumeration of the substantial conflicts between state and federal water rights and Salt Creek Oil Field. Also, the continuing contributions, both informational and educational, to communities and individuals interested in geothermal energy are of great benefit to the state. DOE benefits from the GCO by the continuing input of data to the overall aggregation of geothermal resources in the United States. In addition, a sizable portion of the DOE direct heat goal has been accomplished by existing enhanced oil recovery operations in Wyoming.

2.0 SPECIFIC TASK DESCRIPTIONS AND PRODUCTS

2.1 Geothermal Prospect Identification

The proven direct-use thermal prospects in the state are listed in Table 1. Table 2 identifies the potential prospects, and Table 3 lists the inferred prospects.

TABLE 1. PROVEN DIRECT-USE THERMAL PROSPECTS

Resource	Temperature (°C)	Depth (m)
Midwest	49 to 77	300 to 1,400
Casper area		
Emmigrant Gap	32 to 47	410 to 470
Airport	95	885
Thermopolis	32 to 70	600
Cody	38 to 48	185 to 500

TABLE 2. POTENTIAL DIRECT-USE THERMAL PROSPECTS

Resource	Temperature (°C)	Depth (m)
Thermopolis	60	1,150
Countryman Well	50	1,500
Saratoga Hot Spring	85	910
Auburn Hot Spring	130	1,500
Little Sheep	85	1,200
Fort Washakie	100	760
Astoria Spring	70	600

TABLE 3. INFERRED DIRECT-USE THERMAL PROSPECTS

Resource	Temperature (°C)	Depth (m)
Red Springs Anticline	60	1,200 to 1,300
Rattlesnake Anticline	60	300

2.2 Area Development Plans (ADPs)

2.2.1 State Geothermal Planning Areas

Figure 1 outlines the geothermal planning areas.

2.2.2 Specific ADPs Completed or in Preparation

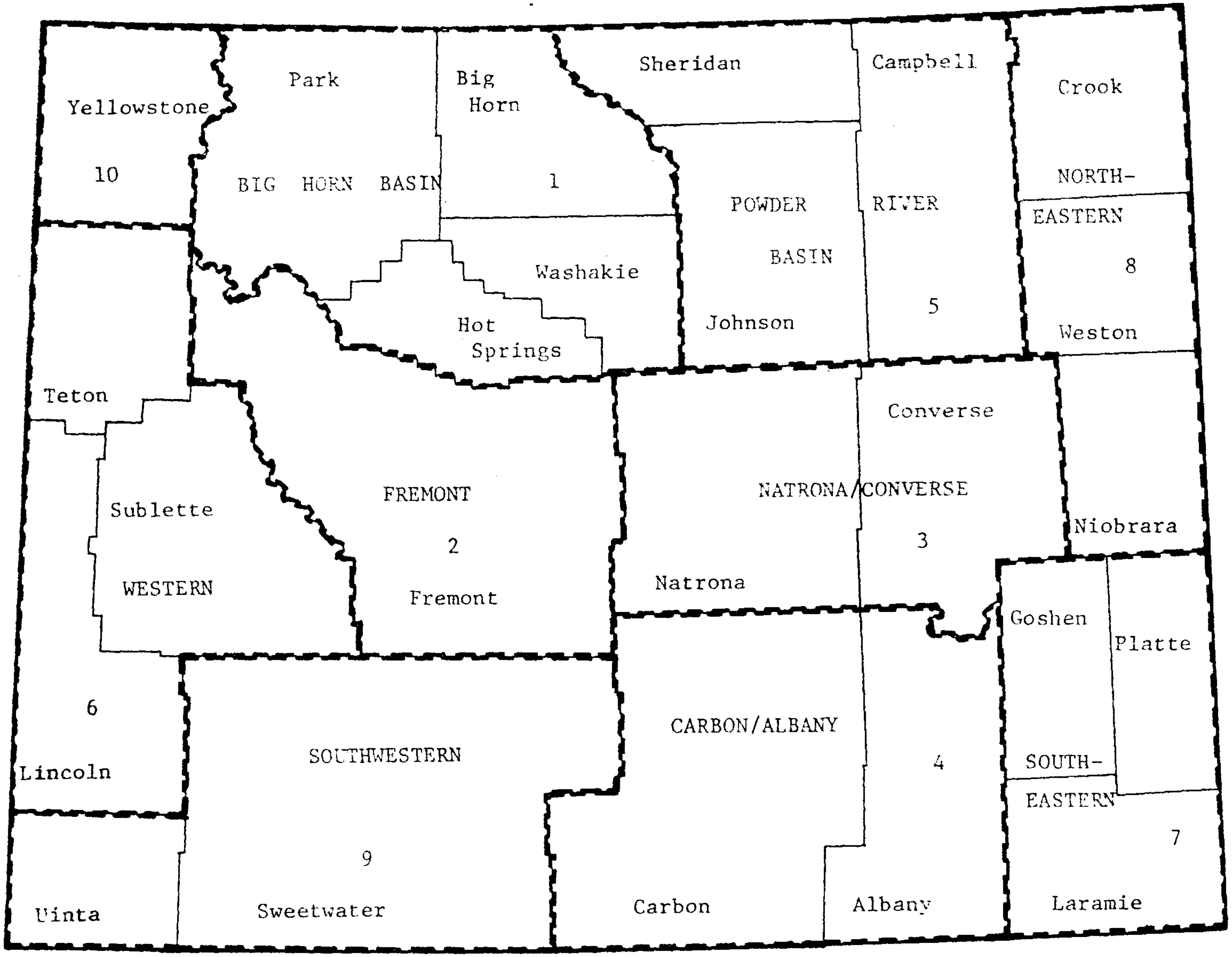
The shaded area of Figure 2 identifies the location of specific area development plans, which are:

- Big Horn Basin
- Fremont County
- Converse/Natrona

2.3 Site-Specific Development Analyses (SSDAs)

2.3.1 Candidate Geothermal Sites and Applications

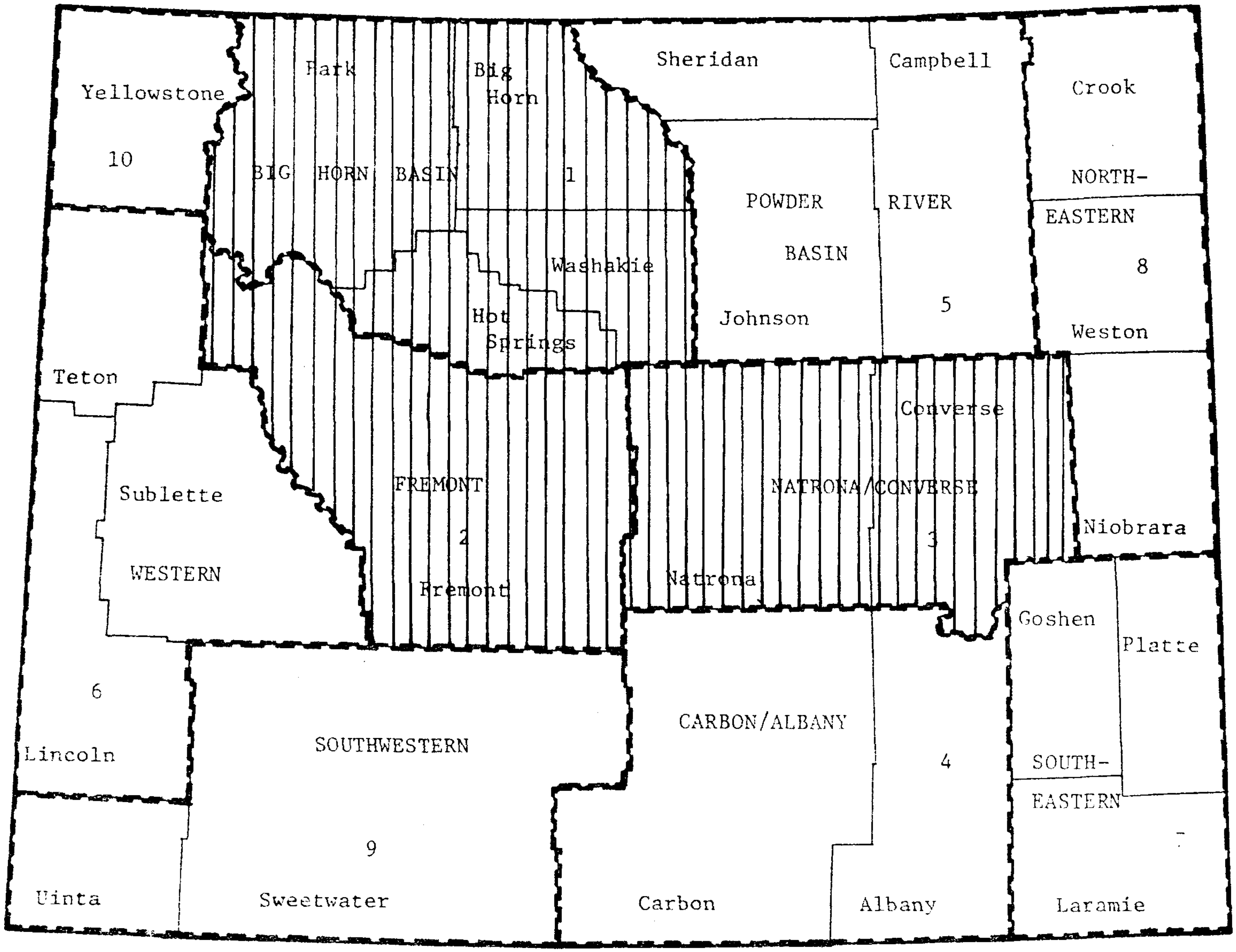
Table 4 lists candidate geothermal sites and their proposed applications.



Scale: 1 in. = 50 mi.
1 cm. = 31.69 km.

Note: Numbers in regions indicate ADP priorities.

Fig. 1 Wyoming geothermal planning regions.



Scale: 1 in. = 50 mi.
1 cm. = 31.69 km.

Note: Numbers in regions indicate ADP priorities.

Fig. 2 Wyoming area development plan locations.

TABLE 4. CANDIDATE GEOTHERMAL SITES AND APPLICATIONS

Site	Applications
Midwest/Edgerton	District heating
Midwest/Edgerton	Agricultural Industrial park
Auburn Hot Spring	Agricultural Business park

2.3.2 SSDAs Completed or in Preparation

Thermopolis/East Thermopolis SSDA. The temperatures of the thermal waters in the Thermopolis area are not sufficiently high for use in generating electricity. Direct use would therefore be a more realistic use of that resource. The Thermopolis geothermal resource is considered to be a low-temperature resource (maximum surface temperature of approximately 150°F), and has many potential applications.

Thermopolis is an agriculturally oriented community. Geothermal uses best suited to Thermopolis and its low-temperature resource are agribusinesses such as vegetable drying, greenhousing, soil warming, mushroom culture, and pickling. Other uses compatible to Thermopolis are space heating, concrete curing, bentonite drying, and carcass wash and cleanup.

One must calculate the temperature loss that occurs with the flow rate to determine the delivered net energy content.

Figures 3 and 4 indicate the potential of the Thermopolis resource. Basically, one should consider temperatures at or below 140°F on Figure 3 and at or below 60°C on Figure 4. Figure 5 is a geologic map of the Thermopolis area, and Figure 6 shows a generalized cross section of the hydrothermal system. A draft Thermopolis/East Thermopolis, Wyoming SSDA has been prepared by the Wyoming GCO.

Proposed uses of geothermal waters in the Thermopolis area include the following:

- A commercial greenhouse for one of the private wells; tomatoes would be the major crop; an Appropriate Technology Small Grant has been applied for to pay for developmental investment costs.

- A small-scale ethanol production plant for an existing well; an Appropriate Technology Grant has been applied for; this plant would use geothermal water, heat pumps, and passive solar energy as the energy sources; river moss from the bottom of the Big Horn River is the proposed raw material; a water-powered paddlewheel would be used to acquire the moss.

- A geothermally heated fish farm for the region is in the early stages of the planning process.

- A district heating system. The major factor preventing the development of this project is the uncertainties remaining in

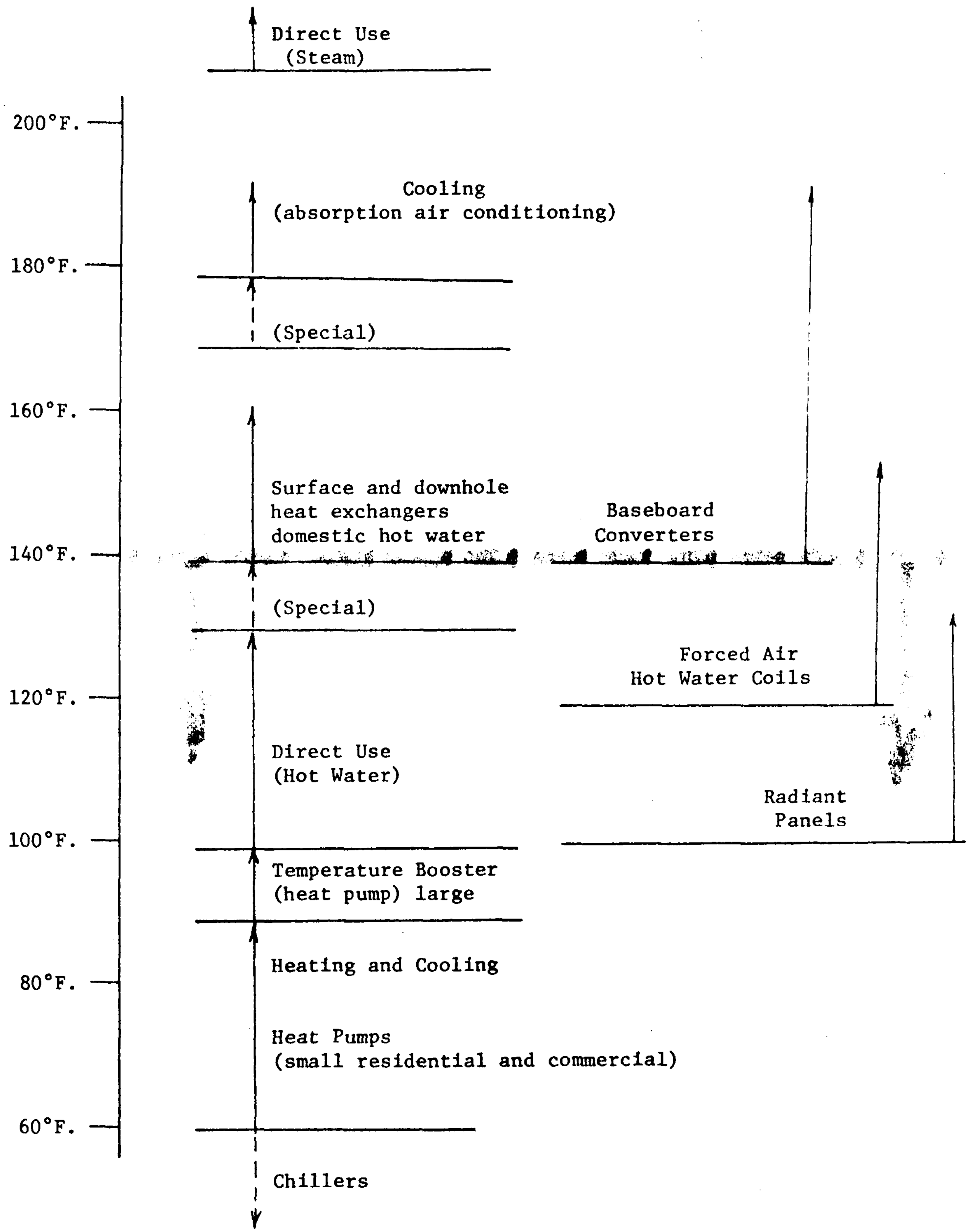


Fig. 3 Thermopolis resource temperature systems.

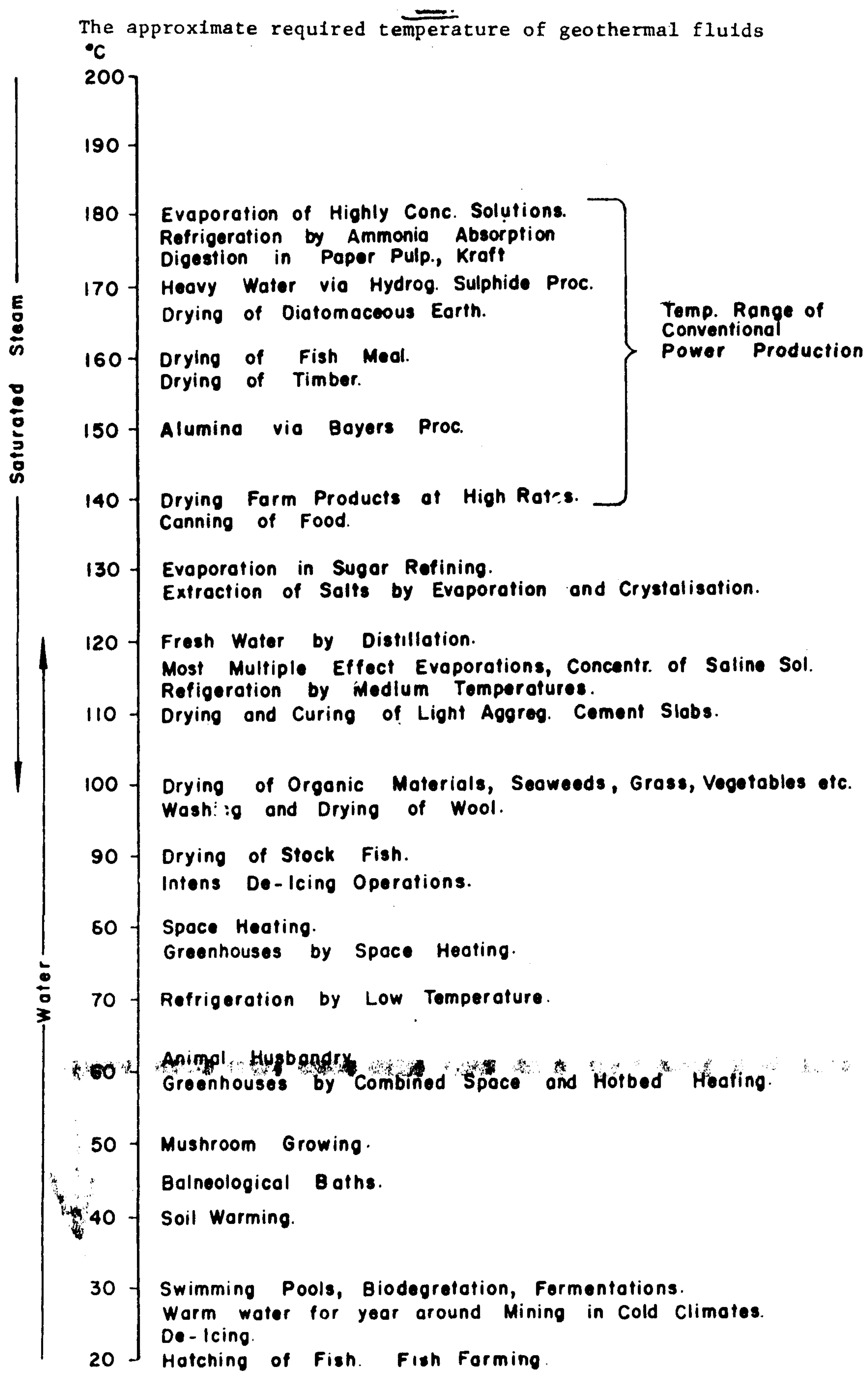
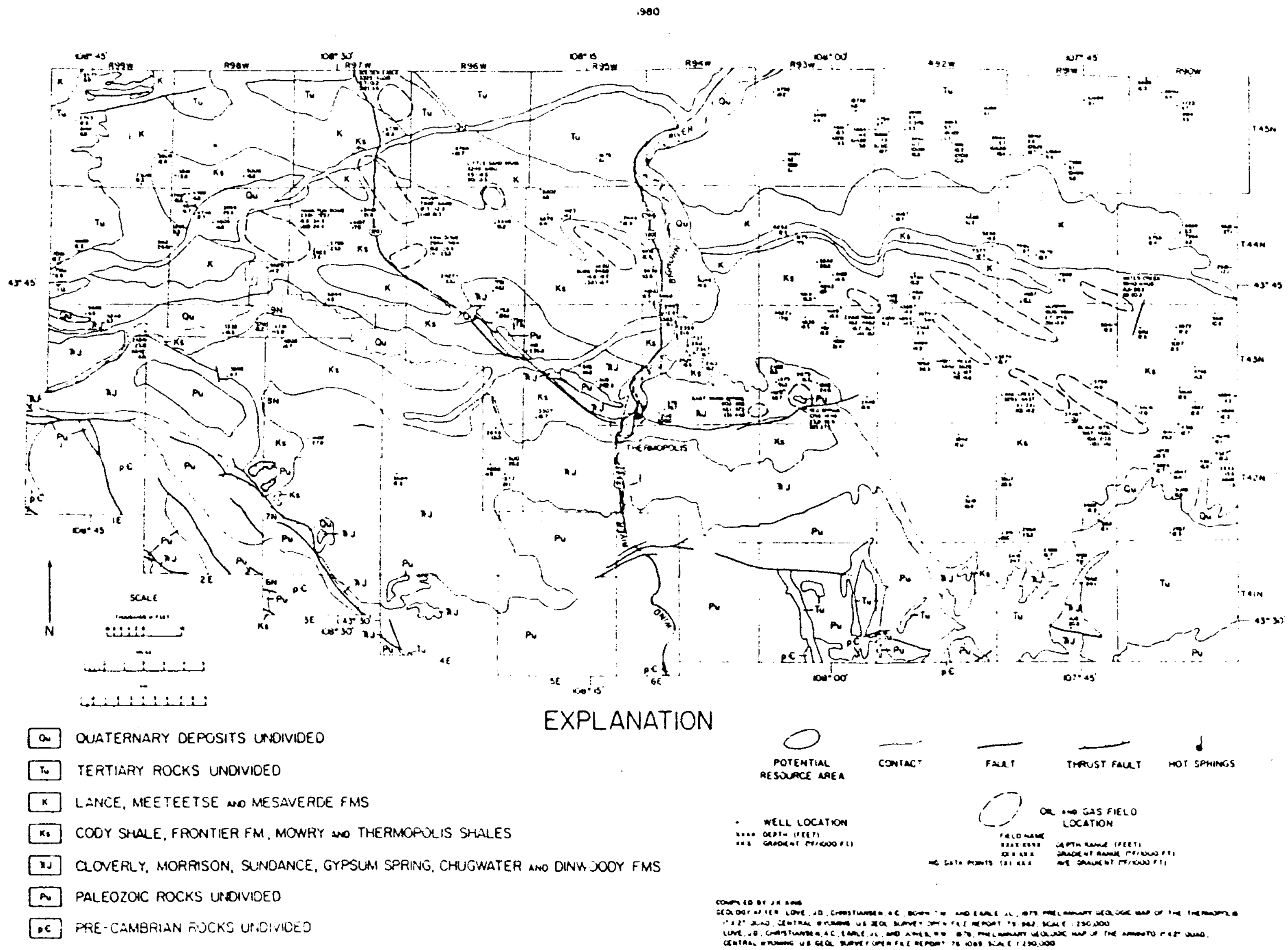
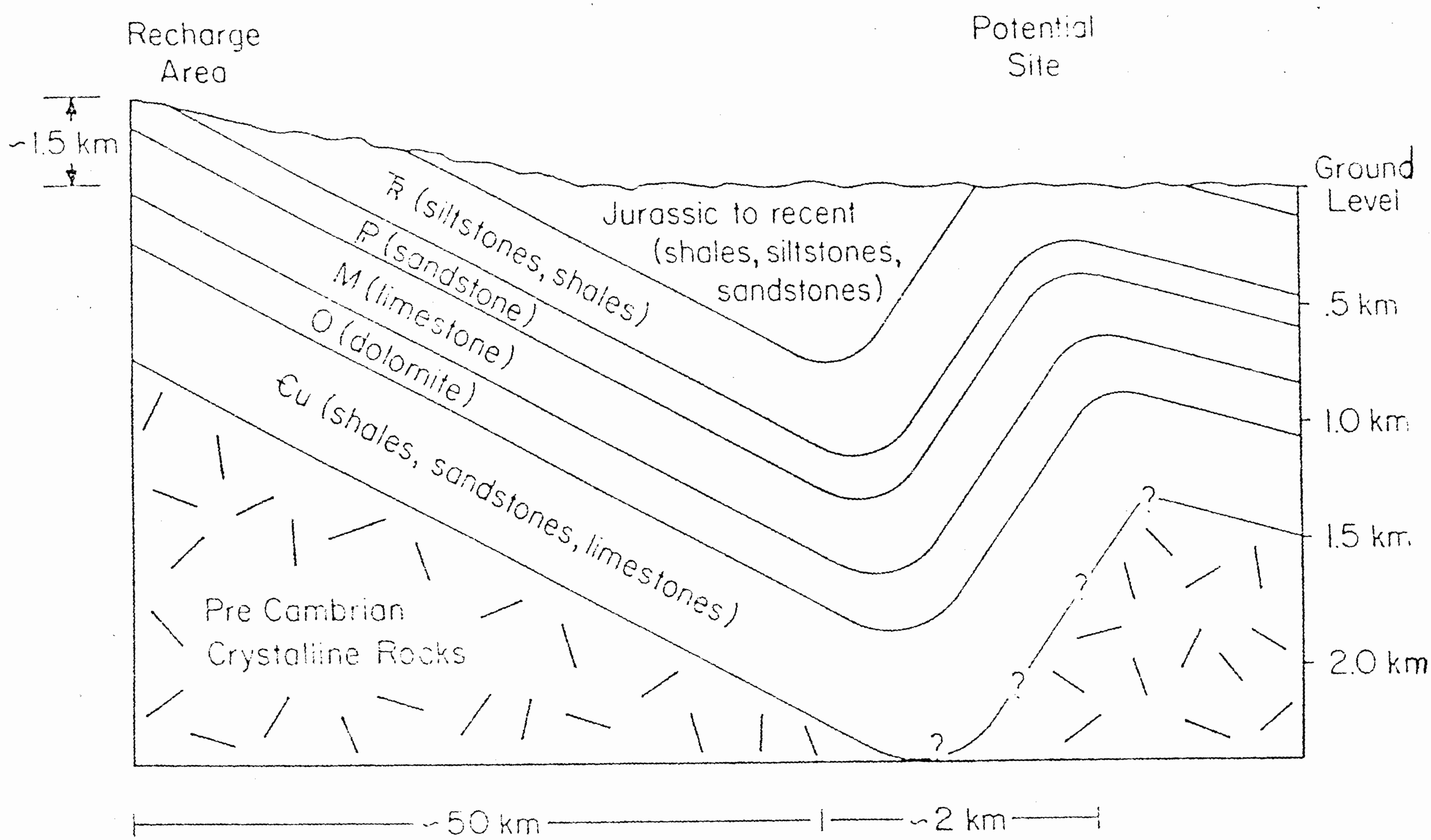


Fig. 4 Thermopolis resource temperature applications.



Source: King, et.al., 1980.

Fig. 5 Thermopolis geologic and thermal data.



Source: King, et.al. 1980.

Fig. 6 Generalized cross section for the Thermopolis hydrothermal system.

regard to the reservoir characteristics; thus far, no one has been able to predict with any certainty what effect well drilling and large-scale developement would have on the temperature and flow rates of the springs in the State Park; preliminary marketing estimates by the NMEI indicate that geothermal energy would be cost effective in this region by 1983.

Cody SSDA. This SSDA will be written in the early part of 1981. Recent data published by the Wyoming Resource Assessment team indicate a sizable, usable resource in the Cody area. An abridged version of that report is included as Appendix A.

2.4 Time-Phased Project Plans

None.

2.5 State Aggregation of Prospective Geothermal Use

A summary of the projected energy use for ADPs and SSDPs is given in Table 5.

2.6 Institutional Analysis

The GCO, in cooperation with the National Conference of State Legislatures, has been working for nearly a year with the Joint Mines, Minerals,

TABLE 5. ENERGY USE SUMMARY

Project	Energy Use (10^9 Btu/yr) 1980	1985	2000	2020
ADPs				
Big Horn Basin	10	50	100	165
Fremont County	20	35	60	100
Converse/Natrona	0	2,250	3,000	5,000
Carbon Albany	0	15	45	60
Powder River Basin	15	25	60	88
Western	15	25	50	75
Southeastern	0	5	10	10
Northeastern	10	25	40	60
Southwestern	0	0	5	10
Total ADPs	70	2,430	3,420	5,568
SSDPs				
Thermpolis District Heat	0	25	45	75
Midwest District Heat	0	50	70	100
Midwest Industrial Park	0	1,300	2,930	4,900
Countryman Well	0	20	40	40
Saratoga District Heat	0	15	45	60
Auburn Agribusiness	0	10	60	75
Total SSDPs	0	1,420	3,190	5,250

and Industrial Development Interim Committee of the Wyoming State Legislature to develop and enact clarifying geothermal legislation. Several hearings have been conducted, and testimony has been given by interested parties, including the State Engineer, State Geologist, State Land Commissioner, State Geothermal Resource Assessment Team, and the GCO. The outcome of these hearings was the introduction of two bills, House Bills 282 and 283, both sponsored by the Joint Interim Committee.

House Bill 282 is a simple bill that gives the State Board of Land Commissioners the authority to lease state lands or school lands for geothermal development. The bill gives leasing and rule-making authority to the Board, enabling it to lease geothermal resources in the same manner as it leases lands for oil and gas development, without it being "...construed to alter the definition of underground water under Wyoming Statute 41-3-901(a)(ii)," where geothermal resources are defined. It is apparent that this bill will clear up many potential problems that could arise from the Board conducting geothermal leasing procedures without the authority to do so.

House Bill 283 states that it is "...an act to amend Wyoming Statute 41-3-101 relating to water rights and benefical use; specifying that the extraction of heat is a beneficial use of water". Geothermal resources are defined as groundwater and thus fall under the regulatory authority of the State Engineer as far as exploration, development, and use are concerned. The bill states that "...the use of water for the purpose of extracting heat therefrom is considered a beneficial use subject to prior rights." It appears that this bill would direct regulatory issues to the State Engineer. It also clearly states that the State of Wyoming considers heat extraction from water to be a beneficial use of that water.

2.7 Public Outreach Program

2.7.1 Outreach Mechanisms

- o Distribution of published information of the GCO and the Wyoming Resource Assessment Program
- o Information request responses that come to the GCO both by mail and phone
- o Newsletter, a monthly item with a circulation of nearly 500
- o Toll-free incoming telephone line
- o Speeches to groups and city councils, etc.
- o Radio programs and newspaper stories.

2.7.2 Summary of Contacts and Results

Four formal presentations were made to the County Planning Commission, Town Planning Commission, Chamber of Commerce, and the public in a one week trip to Thermopolis.

- o A 20-minute radio talk on geothermal potential was given on KTHE in Thermopolis.

- An advance news release was printed in Thermopolis, Casper, and Laramie papers just before the trip.

- An interview was given to Dennis Davis of the Casper Star-Tribune, the state's largest paper. Resulting articles appeared in Cody and Casper newspapers.

- An editorial favorable to geothermal energy appeared in the Thermopolis paper one week after the formal presentations.

- The net result of the trip was that the Thermopolis Town Planning Commission passed a resolution to apply for a HUD District Heating feasibility grant.

- The same resolution was approved by the City Council

- A task force was set up for the purposes of choosing consultants and preparing the proposal.

It appears that additional geothermal use will occur in Thermopolis. Perhaps with the help of a good proposal, the city will receive a grant to determine the true potential of the resource.

3.0 SUMMARY OF MAJOR FINDINGS AND RECOMMENDATIONS

Awareness of geothermal energy and its potential has increased dramatically in Wyoming, as evidenced by the increase in inquiries received by this office. State support is continuing from the Mineral Division of the Department of Economic Planning and Development and from the State Planning Coordinator.

Geothermal development presents good opportunities in some areas of Wyoming, especially in Thermopolis and Midwest where proven resources have been identified. Exploitation of the Madison Formation in the Powder River Basin offers possibilities, but because of the depth involved, will require larger investment capital than the above areas. Wyoming will probably never use geothermal waters as a sole energy source extensively since other sources of alternative energy are so abundant in the forms of solar or wind power. However, with the continued dissemination efforts of this office, more small-scale uses of the low-temperature resource are likely, particularly for space heating. There is also a good possibility in Wyoming for joint use of geothermal and solar/wind sources in combination.

APPENDIX A

CODY, WYOMING SITE-SPECIFIC DEVELOPMENT ANALYSIS--

ABRIDGED VERSION OF PRELIMINARY DATA

Prepared By:

Wyoming Geothermal Commercialization Office

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FIGURE

APPENDIX A

CODY, WYOMING SITE-SPECIFIC DEVELOPMENT ANALYSIS--ABRIDGED VERSION OF PRELIMINARY DATA

1. INTRODUCTION

Six holes were drilled near Cody in northwest Wyoming in an effort to define a low- to moderate-temperature hydrothermal resource. The holes were drilled during January, February, and March of 1980. The total depths of the holes ranged from 116.0 m (380.5 ft) to 56.4 m (185.0 ft). The project was financially supported by Cooperative Agreement DE-FC07-791-D12026 between the U.S. Department of Energy and the University of Wyoming.

2. EVIDENCE OF A HYDROTHERMAL SYSTEM

The DeMaris Hot Springs, a group of at least seven vents ranging in temperature from 24° to 37°C are one mile west of Cody in northwest Wyoming.

The springs occur on the southeastern flank of a large anticline, the Rattlesnake anticline, where the impermeable Chugwater Formation has been eroded through by the Shoshone River. Within 1,000 feet of the hot springs a well that passes through the Chugwater Formation yields 208 gpm of water at 34°C. This well and the hot springs appear to define the northern boundary of the hydrothermal system.

A series of travertine and sulfur deposits crop out along the eastern flank of the Rattlesnake anticline. The deposits are near the contact of the Chugwater Formation and the underlying rock units. The travertine deposits extend approximately 2 miles south of the DeMaris Hot Springs. In this area, the Rattlesnake anticline merges into a smaller structure known as the Horse Center anticline.

The thermal data for the Horse Center anticline suggest that the regional hydrothermal system extends as much as 7 miles south of Cody. The most convincing data, on the basis of bottom hole temperatures in 11 oil wells, are the thermal gradients of 49 to 205°C/km in the anticline.

3. PRELIMINARY INTERPRETATION

The Cody Horse Center hydrothermal system is believed to extend on a line south-southeast from the DeMaris Hot Springs to well Letha C-4 (see Figure 1). The width of this zone varies from 1 to about 2 miles.

The area of greatest potential use is in T52N, R102W, S1/2 of Section 2, and W1/2 of Section 11 (see Figure 1). In this area, warm waters [34°C (93°F)] can be reached at shallow depths [51 to 300m (168 to 1,000 ft)]. The maximum temperature of this system may approach 55 to 65°C (131 to 149°F) at depths of 260 to 500 m (853 to 1,640 ft). Warm waters will be found at the shallower depths in the more western portions of this potential use area.

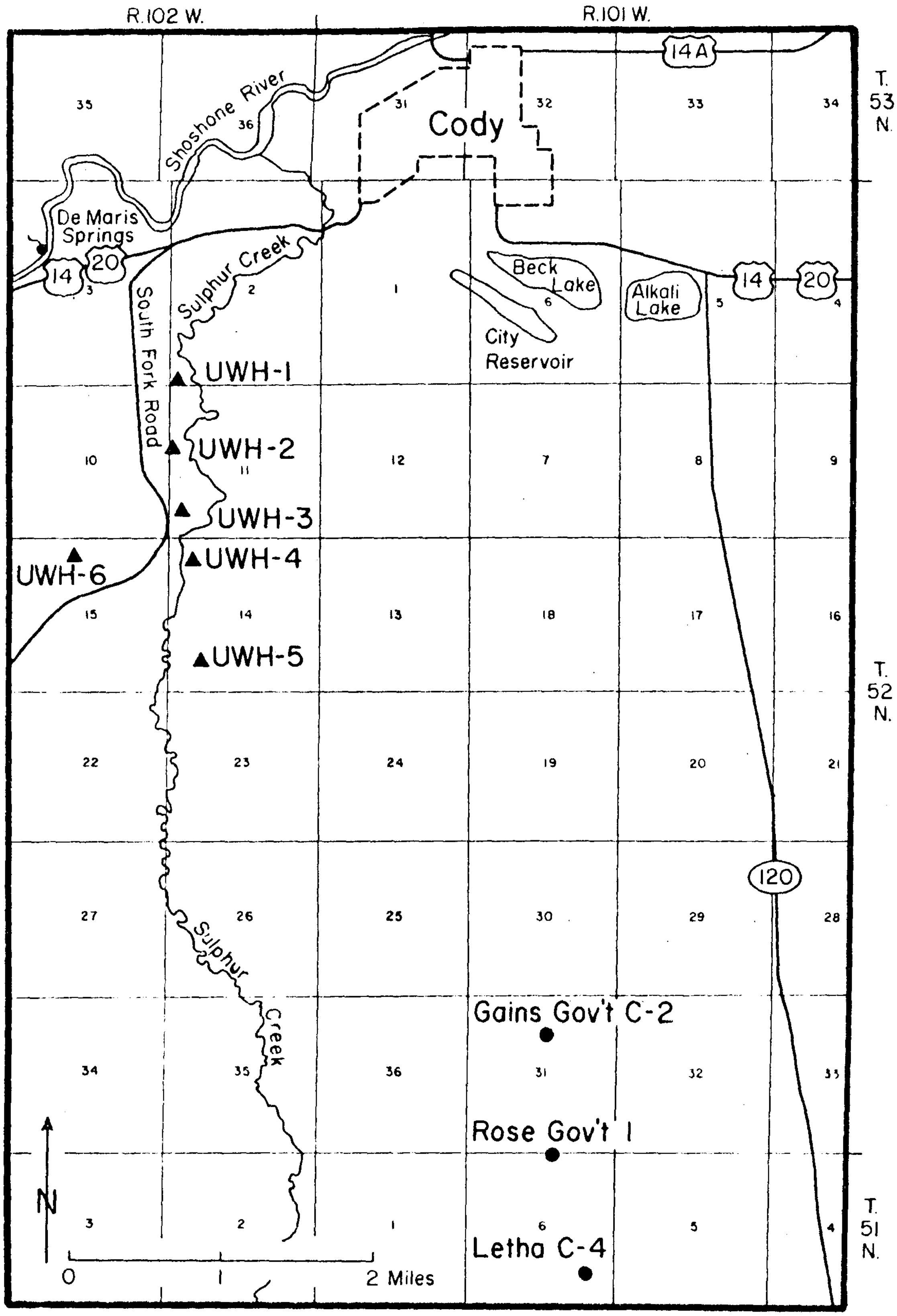

Fig. 1 Cody area drilled holes (triangles) and thermally logged oil wells (circles).

The main aquifers for Cody Horse Center hydrothermal system are the Tensleep Sandstone, Madison Limestone, and Bighorn Dolomite. These formations are reported to have good porosities and permeabilities, with flows in the Madison Limestone and the Bighorn Dolomite sometimes exceeding 1,000 gpm (Lowry, 1976). However, the water flow of wells drilled into these aquifers may vary greatly between wells due to secondary fracture permeability, secondary silica cementation of the Tensleep Sandstone, and the cavernous nature of the Madison Limestone and Bighorn Dolomite.