OPEN FILE REPORT 81-02

GEOTHERMAL ENERGY OPPORTUNITIES AT FOUR COLORADO TOWNS

by

Barbara A. Coe and Judy Zimmerman

DOI: https://doi.org/10.58783/cgs.of8102.sitx5236

PREPARED FOR THE
U.S. DEPARTMENT OF ENERGY
DIVISION OF GEOTHERMAL ENERGY
UNDER CONTRACT DE-FC07-79ID12018

COLORADO GEOLOGICAL SURVEY
DEPARTMENT OF NATURAL RESOURCES
Room 715, 1313 Sherman Street
Denver, Colorado 80203

1981

TABLE OF CONTENTS

TABLES

FIGURES

NOTICE

ACKNOWLEDGMENTS

Many thanks to those residents, officials and business people of Durango, Glenwood Springs, Idaho Springs and Ouray, who so willingly provided information for this report. Although they were so numerous as to preclude naming them all here, their help is most appreciated. We hope that the report accurately reflects the conditions and goals at the four sites. If it does, it is primarily because of the assistance or the help of the people in those areas, who know it best.

INTRODUCTION

The State of Colorado seems to have significant geothermal energy potential. Geothermal energy use can help conserve other resources.

In order to more accurately define what the geothermal potential is, a detailed analysis of specific sites was considered to be necessary. Furthermore, such analyses can provide ideas and information to potential users, developers and others in the development process to help stimulate geothermal development. Additionally, geothermal energy offers opportunities for economic development, particularly as energy becomes an ever larger and more important part of businesses' operating costs. The analyses can also help identify constraints to geothermal energy development and subsequently suggest solutions. Finally, information about the potential and the limitations to development can help federal and state governments design and implement programs that help increase goethermal energy use.

Scope of Report

This study, conducted by the Colorado Geological Survey under contract with the U.S. Department of Energy, has analyzed the potential of four prospective geothermal development sites in Colorado and prepared hypothetical plans for their development. These plans are certainly not the only possible ones, but are meant to serve primarily as examples. Since these plans have, however, been prepared using information and ideas derived largely from residents and officials at those sites, as well as published reports, it is believed they are reasonably realistic and in tune with local conditions.

The study has included the investigation of several broad areas for each site. The first area of investigation was the site itself: its geographic, population, economic, energy demand characteristics and the attitudes of its residents relative to geothermal development potential. Secondly, the resource potential was described, to the extent it was known, along with information concerning any exploration or development that has been conducted. The third item investigated was the process required for development. There are financial, institutional, environmental, technological and economic criteria for development that must be known in order to realistically gauge the possible development. Using that information, the next concern, the geothermal energy potential, was then addressed. Planned, proposed and potential development are all described, along with a possible schedule for that development. An assessment of the development opportunities and constraints are included.

The summary section describes the findings of all four complete site analyses. Technical methodologies are described in the Appendix.

A. DURANGO SITE

Site Description.

The site for this study is located in La Plata County in Southwest Colorado (Fig. A-1). It includes the area from the Purgatory Ski area north of the City of Durango to just south of the Bodo Industrial Park. The Animas River, "River Of Souls," flows through the Valley and provides water for irrigation, industry and domestic use. The terrain varies from the rugged San Juan Mountains on the north to the mesas on the south. The elevation ranges ranges from 6400 to 9400 feet. About 20 miles south of the site is tne Southern Ute Indian Reservation and beyond that, the New Mexico State line.

Access to the north, east and west is obstructed by mountain passes that are prone to blizzards, slides and icy roads in winter (two-lane Highways 550 and 160 serve the area). To the south, where the terrain flattens, access is easier.

The City of Durango has an average 8214 annual degree days and an average low temperature of 11°F (Cuniff, et al, 1979). The growing season averages 117 days and is about 90 - 120 days for apple and pears and other fruit crops grown in the northern part of the study area and about 150 days for more frost-resistant crops such as alfalfa and potatoes (Cap Allen, pers. comm., 1979). The mean annual precipitation of the City of Durango is 19 inches and the mean annual temperature is 28°F in January, 67° in July (Division of Commerce and Development, 1974).

Land Use and Ownership - The fertile valley just north of the City of Durango was once primarily agricultural but is now low-density residential with a few scattered commercial establishments. Further north to the Purgatory Ski resort is some very low density residential development, a year-round luxury recreation resort and a few restaurants, lodges, a ski-rental shop and a private boarding school.

The City of Durango covers about 2,182 acres of land. South of the City, the Bodo Industrial Park contains about 240 acres. The valley north of the City has about 3500 acres of developable land (Dallas Reynolds, per. comm., 1979). Much of the land adjoining the study area at the north is National Forest Land, as shown in Figure A-2. County-wide, only about 40 percent of the land is privately owned (Table A-1.) Within the study area, much of the undeveloped land is undevelopable, either steep slopes or flood plain. The ownership restraints and geological conditions restrict the land available for expansion.

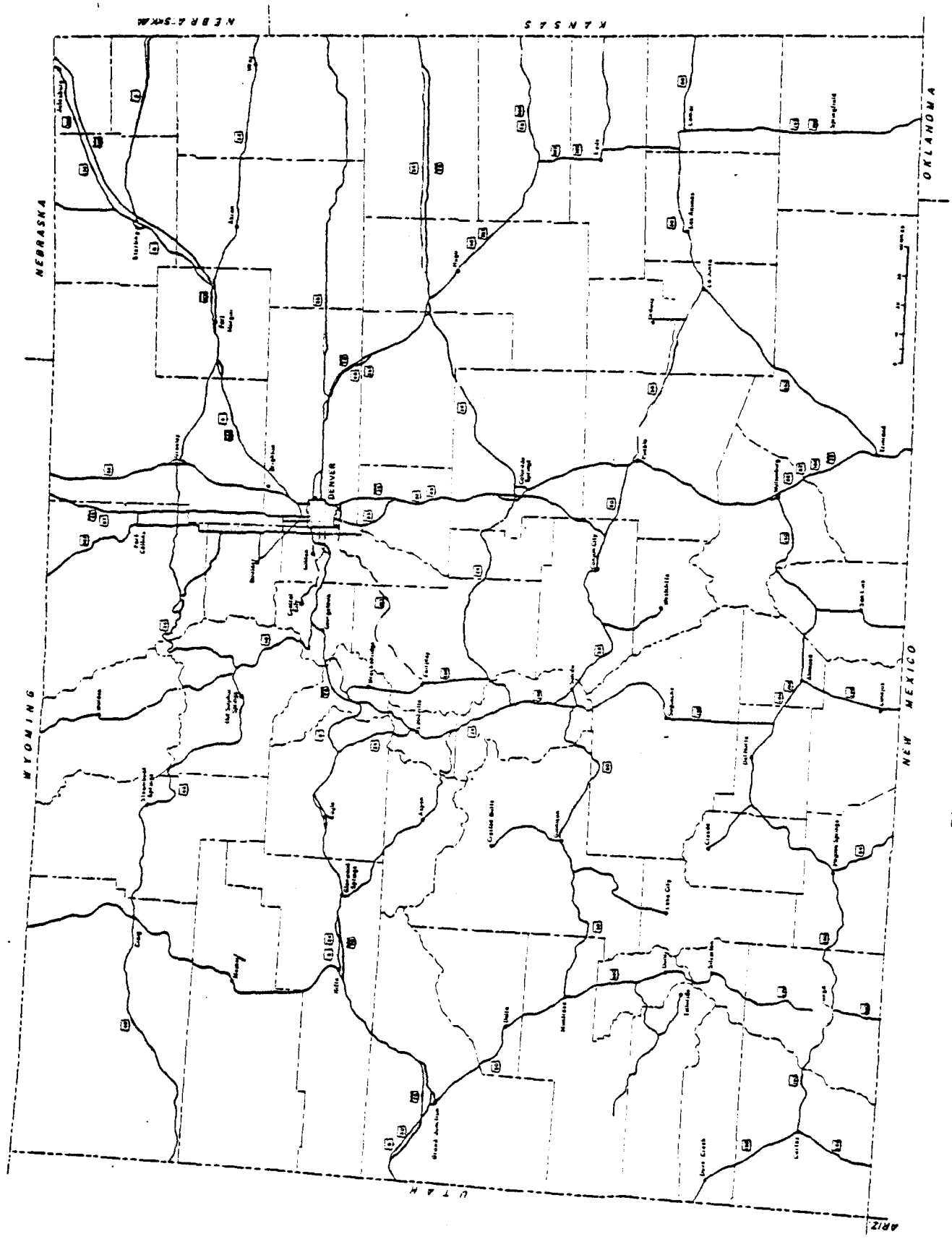
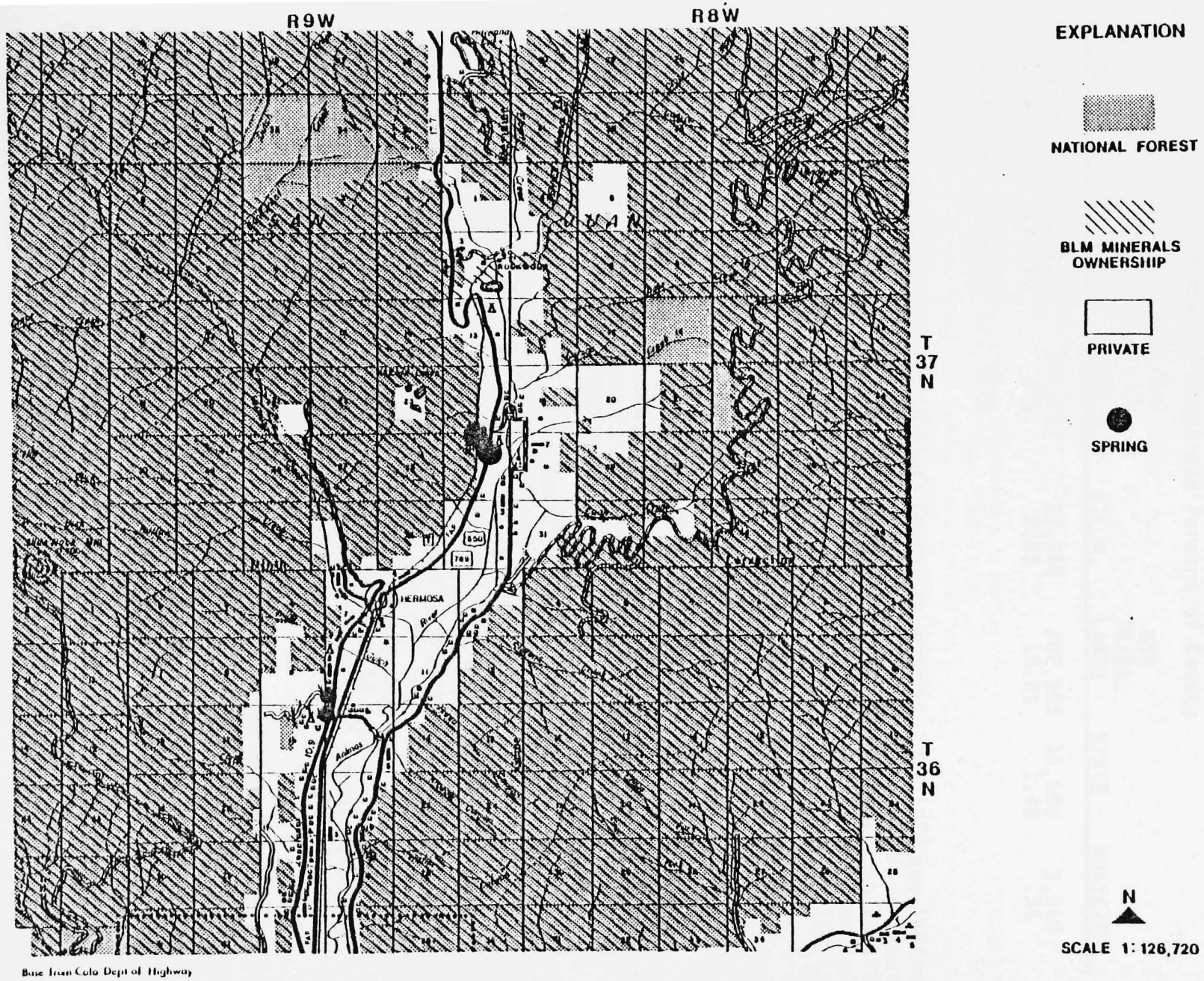


Figure A-1. Location of Durango Site



LAND AND MINERAL OWNERSHIP OF UPPER ANIMAS VALLEY AREA

Figure A-2.

TABLE A-1

LAND OWNERSHIP
LA PLATA COUNTY

Number of Acres and Percent of County

TOTAL	PRIVATE	U.S.F.S.	B.L.M.	UTE TRIBAL LANDS	STATE	MUNICIPAL
1,066,366	421,312	394,537	29,344	202,953	14,980	3,240
100%	39.5%	37%	2.8%	18.8%	1.4%	.3%

Source: Del Duca, et al, 1975

Population - The population of La Plata County is growing. The 1970 population of 19,199 grew to an estimated 27,500 in 1977, an increase of 43 perecent (Johnson, 1979). Within the City of Durango, the population grew from 10,333 to an estimated 12,240, an increase of 25.8 percent (Division of Commerce and Development, 1978). About 16,500 or 60 percent of the counties population is estimated to be located in Durango and the urbanizing (Johnson, 1979).

About 4447 dwelling units are estimated to be in the city, with 2829 of these single-family homes, 192 mobile homes, 806 apartments, and 620 rooms. About 850 units, nearly all single-family, are located in the northern part of the study area (Phillips, Brandt, Reddick, 1979). The population in Durango is expected to grow to 21,460 by the year 2000. The northern study area is forecast to ultimately support a total of 1,760 dwelling units (Phillips, Brandt, Reddick, 1979). Extrapolating to the year 2020 indicates a total of 41,410 persons within the study area.

Economy - The economy of La Plata County is diverse, including tourism and recreation, agriculture, wood products and other manufacturing, construction, government and mining (San Juan Regional Commission, 1978). The mining activity that brought the first permanent settlers into the area has, however, declined (Division of Business Research, Univ. of Colorado, 1978). Only two coal mines and no hard rock mines are currently producing (San Juan Regional Commission, 1978). An abundance of high quality coal in the county could encourage significant mining, but is constrained by the lack of a rail system and the high cost of trucking coal (Janet Schultz, pers. comm., 1979). Development of gold, silver, copper, natural gas, and coal resources primarily under Federal ownership offers potential but is determined by Federal leasing and permitting policies.

Light manufacturing is encouraged as a way to diversify the economy. Table A-2 shows the manufacturers currently in the area. The types and magnitude of manufacturing activities are limited by the remoteness of the area from large population centers and the lack of rail transportation. There is, however, a large rural market including four Indian reservations, five counties, and ten municipalities.

In La Plata County and surrounding counties, agriculture is a significant part of the economy, contributing about 10.9 percent of the regional income in 1970.

Dry beans, hay, wheat, and corn for grain and silage are the primary field crops. Small amounts of rye, beer barley, potatoes, oats, broomcorn, seeds, fruits, vegetables, and sugar beets are also grown (Division of Business Research, University of Colorado, 1975). Most crops are exported. Within the study area are cherry, pear, and apple orchards. A planned irrigation project, the Animas-La Plata project, would enhance the agricultural production, but is being met with significant opposition (Ron Short, pers. comm., 1979).

Livestock production in the region includes cattle, pigs, and sheep, with sales contributing about 5.5 percent of the Region's 1970 income (Division of Business Research, Univ. of Colorado, 1975). Most of the livestock is exported to feedlots or markets outside the region. Agriculture has been declining, presumably because of declining product prices and increasing land costs, with land in great demand for subdivisions (San Juan Regional Commission, 1978).

Timber has historically been a significant segment of the region's economy, with most of the timber on public land (Division of Business Research, Univ. of Colorado, 1975), but roadless area studies and wilderness designations have limited the availability of timber from these federal lands. Wood products manufactured in La Plata County are used mainly in the active local construction industry (San Juan Regional Commission, 1978).

Government, wholesale and retail trades and services are the largest sources of jobs in the Region. The City of Durango is the center of the Region's tourist activity, as well as its service center and La Plata County seat. Scenic and historical attractions such as the Mesa Verde Indian Ruins, the Narrow Gauge Railroad, old mining towns, the Purgatory ski resort, the Tamarron resort development and spectacular mountain vistas encourage some 1 million visitors to the area each year (Phillips, Brandt, Reddick, 1978). Conventions and skiers are attracted by scheduled jet service to La Plata airport. Ski buses bring skiers from all around the Southwest. About 658 commercial establishments were located in La Plata County in 1975, with 502 of those wholesale and retail trade and services as shown on Table A-3 (U.S. Bureau of the Census, 1977). In 1974, there were 47 hotels and motels in the City of Durango (Division of Business Research, Univ. of Colorado, 1975), along with numerous restaurants.

The Ft. Lewis College at Durango is another facility that is important to the economy of the area, with students contributing to the area's economy and increasing the attractiveness of the area by adding to the educational and cultural opportunities for residents. San Juan Basin Vo-Tech School, about 30 miles west of Durango, a vocational-technical school, attracts students from the study area and provides a trained labor force to the region in many tecnnical fields.

TABLE A-2

INDUSTRIES
DURANGO STUDY AREA
1977

Manufacturer	SIC Code	Temperature Required °C	No. of Employees
Basin Co-op Inc.	2048	274	15
Basin Packing Co.	2011	177	5
	2752	149	5
	2791	149	
Burnett Construction Co.	3273	66	35
Cabinets by Ralph Thomas	2434	0	5
City Market Bakery	2051	232	175
Coca-Cola Bottling Co.	2086	77	35
Cooper Publications Inc.	2721	149	5
Culhane Inc.	2099	150	5
Design III	2499	93	5
Double Eagle Ranch Inc.	3961	93	5
Durango Coca-Cola Bottling Co.	2086	77	35
Durango Herald Inc.	2711	149	35
	2751	149	
Durango Ornamental Iron Inc.	3446	0	5
	3444	93	
Durango U.S.A.	3949	93	5
Eagle Block Co.	3271	204	5
Graden Elevator & Feed	2048	274	5
	2047	121	
Jackson-David Bottling Co.	2086	77	35
Las Animas Wood Products	2431	93	5
Mesa Paving Co.	2951	260	35
Oliger Sheet Metals	3444	93	5
	3448	0	
	3449	93	
Print Shop The	2752	149	5
	2761	149	
Redfield Co. Durango Optics	3832	0	175
Rocky Mountain Doll House Co.	3944	0	5
Rocky Mountain Glassware	3231	649	5
	3229	1427	
San Juan Lumber Co.	2421	93	175
Telluride Iron Works	3532	0	35
Townsend Enterprises	3589	1371	5
Treasure Tunnel	3911	93	5
	3915	0	
	3999	93	

TABLE A-2 CONT.

Manufacturer	Sic Code	Temperature Required °C	No. of Employees
Tri-State Printing &	2751	149	5
& Basin Office Supply	2761	149	
Tritec Solar Industries Inc.	3433	93	5
	3564	0	
	3822	93	
United Stationery & Confectionery Co.	3065	93	5
Watts Jewelry Co.	3911	93	5

Source: Cuniff, et al, 1979

TABLE A-3

Number of Business Establishments by Industry in La Plata County 1975

Agricultural Services	6
Mining	8
Contract Construction	62
Manufacturing	20
Transportation and Other Public Utilities	22
Wholesale Trade	32
Retail Trade	192
Finance, Insurance and Real Estate Services	62
Nonclassifiable Establishments	206
	49
TOTALS	658

Source: U.S. Bureau of the Census
County Business Patterns, 1975, Colorado
Washington, D.C., 1977.

The construction industry is active, with housing construction at an all-time high. However, because seasonal or vacation homes are such a significant part of the homes being built, year-round housing shortages are a serious problem. Housing projects in process or proposed include 180 units on 90 acres in the northern Animas Valley being developed by Mennen Shaving Cream Corp., Rockwood Estates being developed adjacent to the Tamarron Resort and an 80-acre development in the northern Animas Valley. A new shopping center is planned to be located near the Industrial Park and intensive commercial development for the riverfront area within the City of Durango is being proposed by the City (Dallas Reynolds, pers. comm., 1979).

Within the commuting area, or all of La Plata County and that part of Montezuma County extending about 30 miles west, a total of 7,537 persons were in the labor force in 1970. Of those, 5.8 percent were unemployed. As shown in Table A-4, 20 percent were in retail trade and 13.3 percent were in services and miscellaneous (Colorado Division of Commerce and Development, 1978). The major employers in the commuting area, are all located within the study area.

Energy Demand - The natural gas consumption in the study area was investigated. As shown on Table A-5, the 3,417 Durango residential customers averaged about 150 MCF of natural gas for residential use per customer per year, or about 292 MCF of natural gas or 155 million Btu's per residence for both residential and commercial space and hot water heat. The total commercial energy consumed was about .93 of the total residential consumption. The average cost for residential consumption of natural gas is $2.80 per million Btu and about $10.00 per million Btu for electricity (Colorado Public Utilities Commission, 1979). The forecast demand, based on consumption, is 2.12×10^{12} Btu's by the year 2020 for residential and commercial uses.

The actual industrial energy consumption is more than the reported industrial natural gas sales because small industrial users are classified by the natural gas supplier as "commercial" and because industrial users may be using additional fuels.

In some parts of the study area, natural gas is not available. An example is the northern part of the valley where electricity or propane are used for heat. To account for the supplemental or alternative use of fuels other than natural gas, the thermal energy demand was calculated based on heating degree days and extreme low temperatures. These estimates indicate that about 1.67×10^{12} Btu's of thermal energy would be required by the year 1984 and about 2.55×10^{12} Btu's would be required by the year 2000, for all uses. The Tamarron Resort energy demand was assessed independently because it is a major energy market that is very near the geothermal resource area and is, furthermore, reliant upon electricity for heat. The energy demand for Tamaron was estimated to be $.037 \times 10^{12}$ Btu's by 1984 and $.108 \times 10^{12}$ Btu's by the year 2000 (Cuniff, et al, 1979)

Public Issues - The attitudes and goals of the residents of an area play a large part in the events that occur there. In this area, the northern part is the area most proximate to surface manifestations of hydrothermal activity. Although once an agricultural valley, the development now is predominantly low-density residential, with some scattered, but large, energy-consuming commercial establishments. The southern part of the study area, that part furthest removed from geothermal resources, is industrial. New industry is

TABLE A-4

LABOR DATA FOR COMMUTING AREA

Employment Category	1970		1977 Estimate	
	No.	Percent	No.	Percent
Agriculture	760	10.1	766	6.5
Mining	140	1.9	65	0.6
Contract Construction	518	6.9	594	5.0
Manufacturing	372	4.9	666	5.6
Transportation & Public Utilities	463	6.1	434	3.7
Wholesale Trade	157	2.1	282	2.4
Retail Trade	1,577	20.9	1,093	17.7
Financial, Insurance and Real Estate	258	3.4	336	2.9
Services and Miscellaneous	1,000	13.3	2,749	23.3
Government (Federal, State and Local)	1,189	15.8	1,768	15.0
TOTAL EMPLOYMENT	7,101	94.2	11,108	94.1
UNEMPLOYMENT	436	5.8	700	5.9
TOTAL LABOR FORCE	7,537	100.0	11,808	100.0

Source: Division of Commerce and Development, State of Colorado, Department of Local Affairs, 1978.

TABLE A-5

NATURAL GAS SALES
DURANGO
1977

Total Customers	Residential		Commercial		Industrial	
	Mcf	No. Customers	Mcf	No. Customers	Mcf	No. Customers
3,905	513,783	3,417	482,803	472	90,158	16

Source: People's Natural Gas Co., Durango, Colo., 1979

being encouraged to locate there in preference to other area. The middle portion is the City of Durango, with primarily commercial and residential uses.

No drastic changes are anticipated, since these patterns are deliberate. Light manufacturing is being encouraged in order to diversify the economy. A strong desire to preserve the quality of life in the area, without significant population growth, is apparent. This desire, combined with the previously-established economic patterns, seems likely to assure the continuation of the recreation and tourism focus. A continuation, therefore, of current development patterns and land use policies can be anticipated. This includes a sparse residential development and some new commercial facilities in the northern section, the limitation of industrial sites to the industrial park, and some increase density within Durango.

Geothermal Resource Evaluation

Pinkerton, Trimble and Tripp Hot Springs are the surface expressions of the geothermal resource for this development site. The characteristics of the springs that were identified by the Colorado Geological Survey in resource assessment work (Barrett and Pearl, 1976 and Pearl, 1979) are shown on Tables A-6, A-7 and A-8. Since that inventory was conducted, a highway cut has severed the spring conduit at Pinkerton Hot Springs, changing the location of the discharge. Analyses that were performed by the Colorado Geol. Survey indicated high enough temperatures for space heating and other uses requiring similar temperatures and about .04-.05 x 10^{12} Btu's of usable energy (Pearl, 1979). However, these estimates cannot be confirmed without additional information. Some additional exploration work was preformed by the Colorado Geol. Survey in the summer of 1980 and the data are being evaluated (R.H. Pearl, per. comm., 1980).

Current Uses of Geothermal Energy - There is apparently no geothermal energy currently in use in this area. At one time, Pinkerton Hot Springs and Trimble Hot Springs supplied water to swimming pools that were popular with residents and visitors in the area. A home heating system and a greenhouse were constructed at Tripp Hot Springs to use geothermal fluid but were not used. A system has been designed for Timberline Academy at Pinkerton Hot Springs to use geothermal heat. A grant was awarded by the U.S. Department of Energy for constructing such a system as soon as the State Highway Department restores the spring flow (Cap Allen, pers. comm., 1979). The owner of the Trimble Hot Springs has also indicated he will construct a geothermally-heated resort and is also well aware of the potential for extensive use of the geothermal energy throughout the area (Rudy Baer, pers. comm., 1979).

TABLE A-6

GEOTHERMAL RESOURCE CHARACTERISTICS
TRIPP/TRIMBLE/PINKERTON/MOUND

Spring or Wells	Location	Total Dissolved Solids mg/L	Surface Temperature C°	Total Current Discharge gpm
Trimble	36N,9W,Sec. 15	3340	36	<1
Tripp	36N,9W,Sec. 10	3240	44	NA
Pinkerton A	37N,9W,Sec. 25	3700-3980	32	54
B	37N,9W,Sec. 25	NA	33	20
Mound	37N,9W,Sec. 25	3800	32	54
Little Mound	37N,9W,Sec. 25	NA	26	2

Source: Barrett and Pearl, 1976

TABLE A-7

GEOTHERMAL RESERVOIR CHARACTERISTICS
TRIPP/TRIMBLE/PINKERTON/MOUND

Reservoir Type	Estimated Areal Extent mi^2	Estimated Thickness ft	Estimated Subsurface Temperature °C	Estimated Total Btu's 10^{15}
Tripp/Trimble				
Fracture	1	1000	58°C	.0357-.0357
Pinkerton				
Fracture	1.2	1000	50°C	.0099-.0209
				.0446-.0566

Source: Pearl, 1979

TABLE A-8

Dissolved Mineral Content of Thermal Waters in Study Area

	Pinkerton Hot Springs	Trimble Hot Springs	Tripp Hot Springs
Arsenic (ug/l)	120.0	17.0	17.0
Boron (ug/l)	3,000.0	1,400.0	1,500.0
Cadium (ug/l)	0.0	0.0	0.0
Calcium (mg/l)	510.0	510.0	470.0
Chloride (mg/l)	1,000.0	220.0	220.0
Fluoride (mg/l)	2.1	2.7	2.7
Iron (ug/l)	4,400.0	50.0	10.0
Lithium (ug/l)	2,500.0	1,600.0	1,600.0
Magnesium (mg/l)	79.0	42.0	41.0
Manganese (mg/l)	470.0	80.0	80.0
Mercury (ug/l)	0.0	0.0	0.0
Nitrogen (mg/l)	0.10	0.08	0.16
Phosphate (mg/l)	0.05	0.02	0.05
Potassium (mg/l)	120.0	47.0	47.0
Selenium (mg/l)	0	0	0
Silica (mg/l)	28.0	72.0	69.0
Sodium (mg/l)	750.0	510.0	500.0
Sulfate (mg/l)	690.0	1,400.0	1,400.0
Zinc (ug/l)	0	10.0	20.0
Alkalinity			
as Calcium Carbonate (mg/l)	1,340.0	894.0	810.0
as Bicarbonate (mg/l)	1,630.0	1,090.0	988.0
Hardness			
Noncarbonate (mg/l)	260.0	550.0	530.0
Total (mg/l)	1,600.0	1,400.0	1,300.0
Specific Conductance	5,600	4,400	3,900
Total Diss. Solids (mg/l)	3,990	3,340	3,240
Ph, Field	6.5	-	-
Discnarge (gpm)	54.0	1E	-
Temperature (C)	32	36	44
Date Sampled	9/75	9/75	9/75

Source: Barrett and Pearl, 1976

Geothermal Development Process

The manner in which geothermal energy can be developed is dependent upon conditions at the specific site. The most influential of these are described below.

Financial - To finance the federal geothermal projects, several avenues are possible. Some grants have been available such as the one Timberline Academy will receive to develop a simple geothermal heating system for the main school facilities. Since the Trimble project is not imminent, no financing arrangements have as yet been indicated, but presumably, the project will be financed with private funds. As another alternative, to develop and manage these and other projects in lieu of an interested private energy developer, a special district or cooperative could be established among potential users. Levies could be assessed, revenue bonds issued, or grant funds or loans, private or government, obtained.

Although U.S. Dept. of Energy grants for development are not currently widely available, other federal sources may be tapped, where their mandates coincide with the proposed geothermal energy development. For example, areas impacted by energy development as well as economically depressed areas are target areas for Federal agencies such as the U.S. Housing and Urban Development Department and the Farm Home Administration under the U.S. Department of Agriculture.

Leasing and Permitting - To establish the right to develop the energy, a prospective developer must either own or lease the geothermal rights and the land surface to be used and must have rights to the water containing the heat if the water is to be consumed. No leases on public land within the study area have been issued. To drill a well requires State permits (Coe and Forman, 1979).

Approval by La Plata County would also be required for a geothermal development outside Durango city limits and by the building department if within the City. Depending upon the size, magnitude of impacts and consistency of use, approval may require from a week to six months. A significant land development review begins with a sketch plan for preliminary review. It is submitted to certain State agencies and to the planning commission for their review, is discussed at a public hearing and then is considered by the Board of County Commissioners. In La Plata County, residents prepare their own land and resource management program. Thus, any new development would have to conform to the goals of the current residents in that region (Dallas Reynolds, pers. comm., 1979).

Technological Requirements - The procedure for exploring for geothermal energy is aimed toward learning more about the magnitude of heat, the size of the reservoir, possible reservoir depths, and suitable well locations. It would usually begin with a preliminary exploration program including geologic evaluation, seismic tests, possibly more geochemical analyses and drilling and analyzing gradient holes. A feasibility study is usually conducted to determine whether the investment seems to be warranted and finally a test well (or wells) is drilled and tested. Depending upon the magnitude of the energy demand and the production of the well, the test well may be used as a production well and/or additional wells may be drilled.

Too little is known about the geothermal resources in this area to conjecture

about specific technical requirements or engineering design. Since the dissolved solids content is not particularly high, no exotic treatment is indicated so far. The key question is whether the water is hot enough to use as an independent source of heat (about 60°C (140°F) is generally required). If the water produced is not near the 60°C temperature, it could still be a valuable resource by using heat pumps or boilers to boost the heat produced.

Disposal of the fluid in a manner to protect ground and surface water quality may be either by reinjection into another well, surface disposal or use of the geothermal fluid, depending upon the quality of the fluid, the standards of the stream or underground aquifer, as determined by the Water Quality Control Division. Or a downhole heat exhcanger that would extract the heat from inside the well might be suitable.

Environmental Considerations - Pending a detailed study, environmental effects of geothermal development are not definable. Reports do indicate that the existing spring discharge has damaged trees (Cap Allen, pers. comm., 1979). This implies that careful handling of the resource would be needed if the fluid recovered exhibited characteristics similar to those of the spring. This also implies that by properly controlling the fluid with a well, further environmental damage could be avoided. In any case, the State's permitting system is designed to assure that neither the groundwater sources or surface water sources will be degraded.

Other environmental concerns include soil, wildlife, wildlife habitat, plant life, land disturbance, damage to the ecosystem as a whole and socio-economic impacts. Air pollution is another matter of high concern for geothermal develoment. Noxious gases must be precluded from polluting tne air. The Colorado Air Quality Control Division is charged with assuring that standards are met and with issuing permits for discharging air pollutants, where appropriate. Development of geothermal energy, if properly done, is relatively environmentally benign. Most direct negative impacts can be avoided.

Indirectly, geothermal development could effect environmental damage by encouraging economic development and population growth in locations where the energy is available. So far, the availability of geothermal energy is not a primary determinant for industrial location decisions and should not attract massive and rapid growth in the foreseeable future. Further, the City and County have established the mechanism for prevention of development in hazardous areas and for review and control of new development.

Since according to the Colorado Division of Water Resources the water in the Animas River has not been completely allocated, some water is probably available for development. If the geothermal reservoir is a tributary to the river, obtaining some of these water rights would assure control of the geothermal fluid. If the geothermal reservoir is not tributary, only 1/100th of the estimated water underlying the land controlled by the developer could be extracted in any one year. Water rights might also be purchased, and a plan of augmentation filed to substitute water for the geothermal fluid, or the water could be reinjected in a reinjection well after removing the heat.

Economic Considerations - According to studies by the New Mexico Energy Institute, the cost to develop geothermal for the entire town of Durango would be competitive with natural gas in the very near future. When transmission costs are reduced, when retrofitting costs are eliminated (as in new structures) and when geothermal energy is compared with the cost of electricity or propane, the geothermal energy is considerably more economical. Analyses indicated that a large energy user such as the Tamarron Resort, which is only about 2 miles from the resource, could use geothermal energy at a much lower cost of electricity (Cuniff, et al, 1979).

Potential Uses of Geothermal Energy

The principal uses for geothermal energy in the Durango area are for space and water heating. Numerous opportunities are available for using geothermal energy. New residents and an active tourist business mean a large demand for hot water and space heat. In a resort area, space and water heating needs are large relative to the population. Those large facilities located nearest the resource areas would allow for use of the energy with a minimum of transmission costs. Among these are the Tamarron Resort, which has 320 condominium units plus restaurants, a lodge, sauna, indoor swimming pool, and conference facilities (Stan Wadsworth, pers. comm., 1979). The nearby Rockwood subdivision could also use the energy, the elimination of the need for retrofitting in new structures enhancing the economic viability of such a project. Since in both cases, geothermal energy is competing with expensive electrical heat, it could be considerably less expensive for building owners. Just how much money could be saved can be determined only through a detailed analysis.

There are other large facilities more distant from the resource areas that could use the energy. These include State-owned buildings such as the National Guard building, Highway Department buildings and Ft. Lewis College buildings, which could use the energy for space and water heat. The commercial, smaller public and residential buildings in Durango could eventually also convert to geothermal energy.

Industrial users could provide a market for the geothermal energy, as well, and in turn, low-cost energy could help attract new industry. The existing industries with temperature requirements commensurate with the estimated geothermal resources temperatures are listed on Table A-9. As industrial demands grow, more industrial uses of geothermal energy could be found. The total energy demand in Durango is forecast to be about 2.5×10^{12} Btu by the year 2000.

Developing the energy is dependent upon the various considerations that have been indicated. Steps required and a possible schedule for developing the geethermal energy are shown on Figure A- 3.

TABLE A-9

EXISTING POTENTIAL INDUSTRIAL PROCESS USERS OF GEOTHERMAL ENERGY

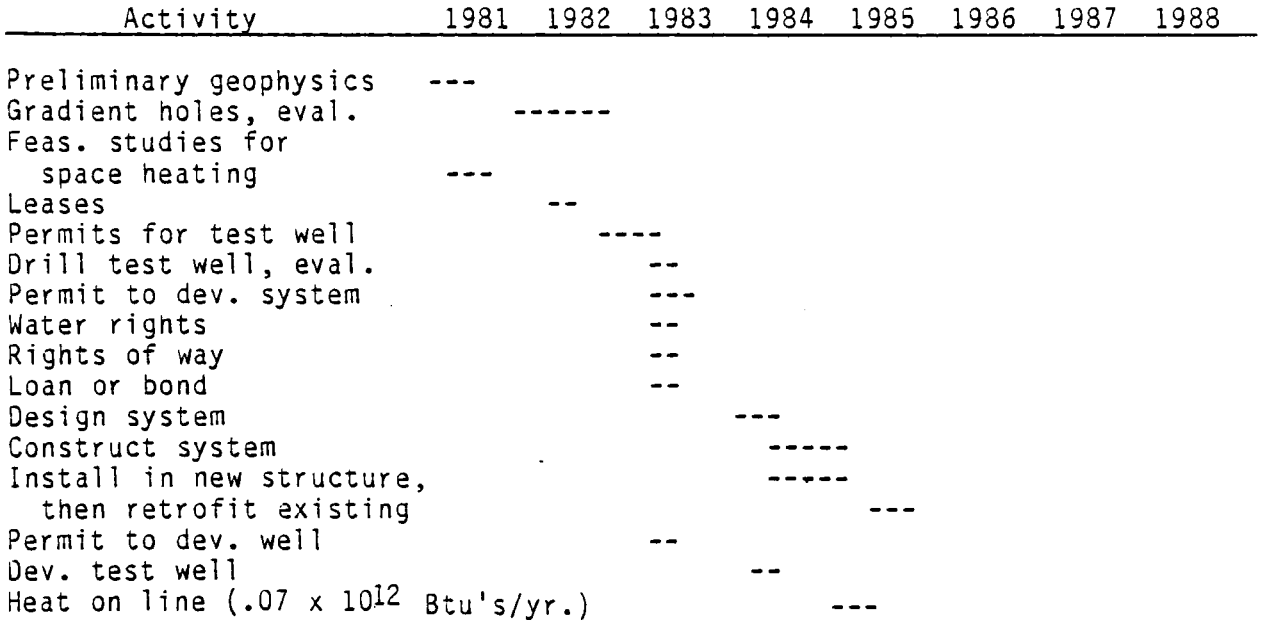
Durango, Colorado
1976

Industry	Standard Industrial Classification	Number of Plants	Low-grade Heat Required (10^{10} Btu's)*
Bottled and Canned Soft Drinks	2086	2	.44
Prepared Foods	2048	1	2.06
Confectionary Products	2065	1	.16
Food Preparations (honey)	2099	1	.28
Meat Packing	2011	1	.14
Sawmills and Planing Mills	2421	1	.14
			3.22

SOURCE: Coe and Solar Energy Research Institute

FIGURE A-3

DURANGO SITE
SCENARIO FOR DEVELOPMENT



*U.S. mean average plant size

Development Opportunities and Constraints- There are opportunities for development of geothermal energy in the Durango area. For the most part, they center around the tourist industry. The estimated one million visitors in the area each year use substantial amounts of heat and hot water. In addition some light industrial uses may be possible, including timber drying. Those structures nearest the known geothermal areas seem to afford the most economical means for development and, given the alternatives, seem to stand a good chance of incurring significant savings on fuel bills. There are, however, several conditions that have limited geothermal development.

The first constraint to such development is the lack of information about the resource and about the economic feasibility. Secondly, unless a private user or developer should become interested in developing the resource in the area, another major constraint will be the lack of front-end funds. Since Durango is not a target city for either economic development or for energy impact funds, potential federal grant programs or a federally-guaranteed loan seem the most plausible, were the community or a cooperative to initiate a project. The last constraint and the most difficult to overcome is the virtual lack of an intrepreneur, either private or government, who is aware of the energy and its value and willing to devote time and effort to see it developed. Until such a person takes on the task, either for personel benefit or the good of the community, or both, the energy will likely remain underground.

B. GLENWOOD SPRINGS SITE

Site Description

The City of Glenwood Springs is situated in a valley bordering the confluence of the Roaring Fork and the Colorado Rivers in Garfield County (Figure B-1). It covers an area of 1,490 acres and has an average elevation of 5,746 feet (Division of Commerce and Development, 1979). Rugged mountains bordering Glenwood Springs, along with the two rivers, limits the available, developable land. Within the City, steep slopes and areas subject to debris flows are hazardous areas on which to build (Gene Allen, pers. comm., 1979).

The average growing season is about 134 days, and the annual precipitation is 18 inches (Division of Commerce and Development, 1979). An average low temperature of 0 degrees and 7400 heating degree days are recorded for Glenwood Springs (Cuniff, et al, 1979).

Land Use and Ownership - Residential land makes up about 36 percent, commercial and industrial about 14 percent and public land 8 percent. Forty-two percent is vacant land, most of it not easily developable because of its rugged topography. National Forest surrounds the City, as shown on Figure B-2.

Population - A 1975 special census counted 5,351 residents in Glenwood Springs (U.S. Bureau of Census, 1976). Current population is estimated to be about 5,500 (John Fernandez, pers. comm., 1979). Population forecasts vary widely because of the uncertainty surrounding the area's energy development. By the year 2,000, a population of 8,749 to 9,152 persons is expected (Colorado West Council of Governments, 1977). Extrapolating the high forecast to the year 2020 results in a forecast population of 12,813.

About 1,784 dwelling units are estimated to be now in Glenwood Springs. Assuming the number of occupants per dwelling unit stays the same, between 2,916 amd 3,050 dwelling units are forecast by the year 2,000 and 4,271 by the year 2020. About 53 percent of the new homes between 1970 and 1974 were mobile homes. Townhouses and condominiums are becoming more common, as well (Division of Business Research, 1975). Because the area is served by the Rio Grande Railroad and by an Interstate Highway, I-70, access is somewhat easier than in many western Colorado towns.

Economy - Glenwood Springs is the retail trade, wholesale distribution and services center for eastern Garfield and northern Pitkin Counties. As shown on Table B-1, over 80 percent of the employed population worked in these sectors in 1970. This will be enhanced by the new shopping center that is scheduled to be built soon. Because of the "world's largest outdoor hot spring pool," (Chamber of Commerce, 1979), nearby ski and summer recreation areas, Glenwood Springs tourist trade is significant (McDowell-Smith, Assoc., 1975).

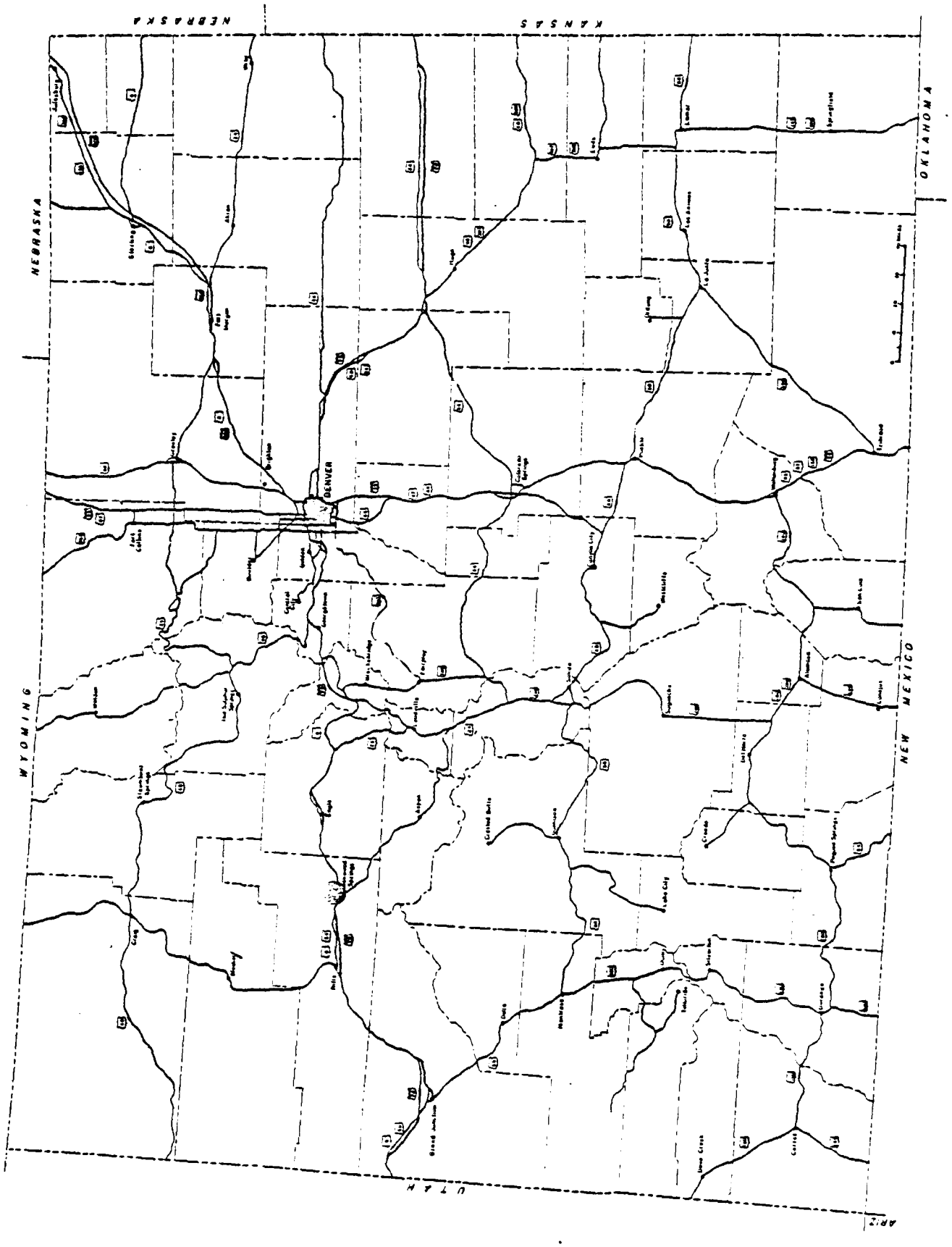
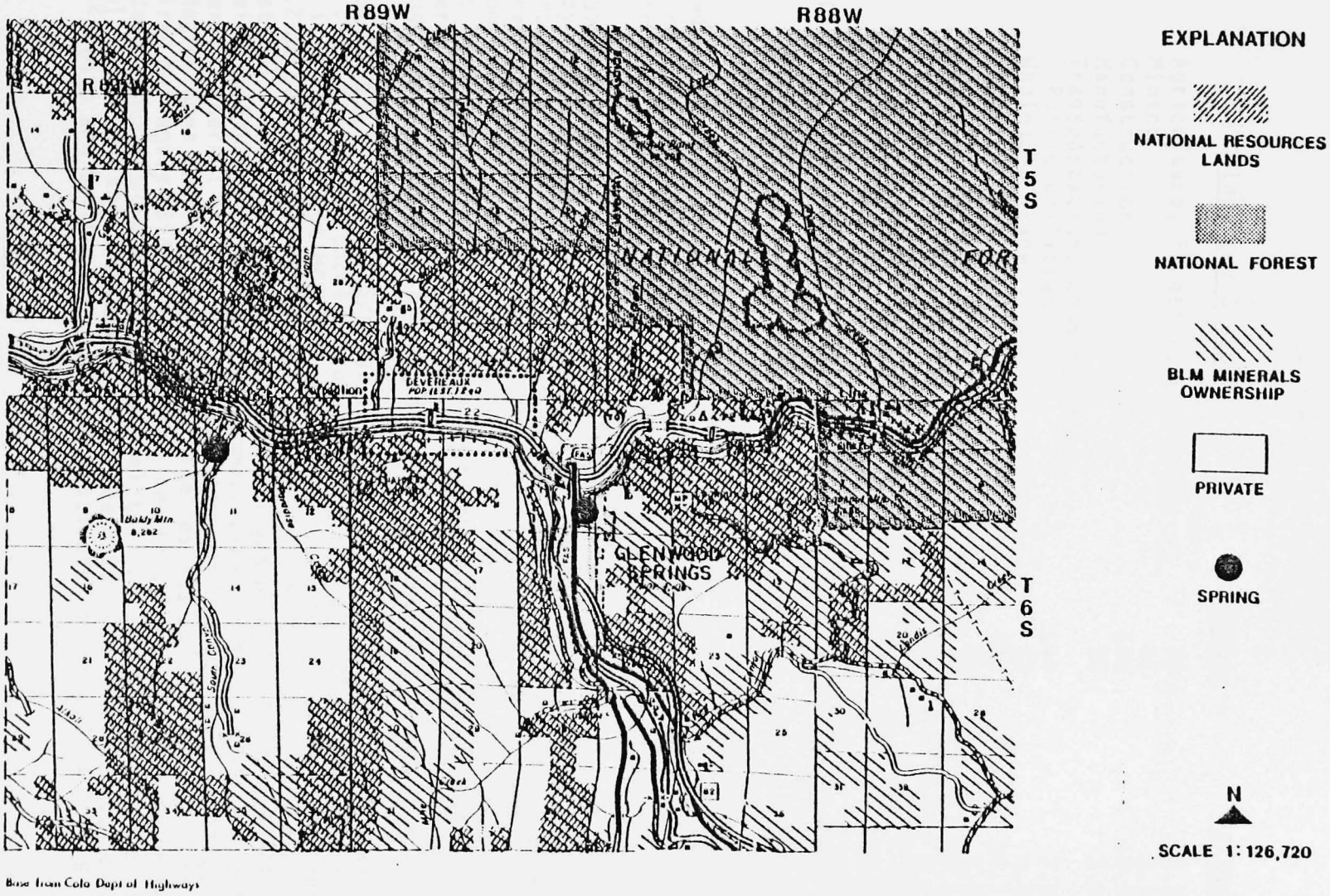


Figure B-1. Location of Glenwood Springs Site



Base from Colo Dept of Highways

LAND AND MINERAL OWNERSHIP OF GLENWOOD SPRINGS AREA

Figure B-2.

TABLE B-1

EMPLOYED POPULATION 16 YEARS OLD AND OVER BY MAJOR INDUSTRY GROUP

Glenwood Springs
1970

Industry Group	Number	Percent
Agriculture, Forestry, Fisheries	59	3.3
Mining	42	2.3
Construction	190	10.5
Manufacturing	50	2.8
Transportation, Communication, Public Utilities	144	7.9
Wholesale Trade	82	4.5
Retail Trade	438	24.1
Finance, Trade, Real Estate	90	5.0
Services	552	30.4
Government	168	9.3
Total Employed	1,815	100.0

SOURCE: Business Research Division, University of Colorado, 1975.

Glenwood Springs has 11 manufacturers, as shown on Table B-2, including wood working and newspapers. Although only about 2.8 percent of the employed force was in that sector in 1970, it can represent a significant energy demand.

Energy development could stimulate economic growth. The City owns coal land nearby that could be mined (Bob West, pers. comm., 1979). Most significantly, if intense oil shale development should begin, sub-regional energy company offices may locate in Glenwood Springs (Gene Allen, pers. comm., 1979). The economy of the city seems to be healthy. Where city revenue is concerned, about $5 million of their general obligation bond limit is available. Although property tax is the principle source of revenue, some 48 percent is generated through the 2 percent sales tax (Gary Schmueser, pers. comm., 1979).

Energy Demand - Glenwood Springs is served by natural gas. As shown on Table B-3, there were 2,187 total customers using a total of 521,086 MCF during 1977. This is a total of 131 MCF per residential customer or commercial consumption of 1.2 percent of the residential consumption. No customers were classified as industrial. The current estimated natural gas price is $3.00 per MCF or $3.57 per million Btu (Lee Heines, pers. comm., 1979). The current residential and commercial thermal energy required for Glenwood Springs was estimated, based on the degree days and low temperature. The results show about 38×10^{10} Btu's required currently. Since no particular new industries are planned or proposed, forecast industrial use is proportional to forecast growth in other sectors. For all uses, the thermal demand by the year 1983 was estimated to be about $.71 \times 10^{12}$ Btu's and by the year 2,000 was estimated to be 1.01×10^{12} Btu's.

TABLE B-2

MANUFACTURERS
GLENWOOD SPRINGS
1977 and 2020

Manufacturer	SIC Code	Temperature Required	No. of Employees
Arbaney Timber Co., Inc.	2584	0	35
	2411	0	
	2421	93	
Coca Cola Bottling Co.	2086	77	5
Eitzen, Louis C. Co., Inc.	3829	0	5
Gazette Press	2752	149	5
Glenwood Post Publishing Co.	2711	149	35
Glenwood Spgs. Creamery Co.	2021	77	5
	2024	77	
	2026	77	
Modern Cabinet Co.	2541	93	5
	2431	93	
	2511	66	
Quick Print	2752	149	5
Raymond's Printing & Office Machines	2751	149	5
	2752		
Valley Printing	2752	149	5
Western Editorial Services	2721	149	15
	2731	149	

TABLE B-3

NATURAL GAS CONSUMPTION
GLENWOOD SPRINGS, COLORADO
1977

Residential		Commercial		Total	
MCF	Customers	MCF	Customers	MCF	Customers
236,250	1803	284,386	384	521,085	2187

SOURCE: Colorado Public Utilities Commission

Public Issues - Both private developers and the City are interested in using geothermal energy, if it is found to be economically feasible. Rapid or extreme growth is not sought by residents of this City, although some light industry would be acceptable. Retaining single family residential areas as they are seems quite desirable. It is advocated, too, that new growth should pay for itself (McDowell-Smith, Assoc., 1975).

Geothermal Resource Evaluation

Much can be learned about a geothermal energy reservoir from preliminary exploration techniques. Among these are obtaining and testing water samples (geochemistry), geophysics and drilling and testing shallow holes. Table B-4 shows the temperature and other characteristics of the geothermal resources at Glenwood Springs. As shown, surface temperatures are within the range of temperatures suitable for space heating and flow rates are high. The dissolved minerals content is quite high, as much as 20,000 milligrams per liter. Subsurface temperatures and energy content have been estimated, as shown on Table B-5. Table B-6 shows the chemical composition of the Glenwood Springs thermal waters. Some resource definition geophysical work was done by the Colorado Geological Survey in 1978 but was considered inconclusive (Richard Pearl, pers. comm, 1980).

Current Geothermal Energy Uses - The geothermal fluid at Glenwood Springs is currently used in the large and extremely popular swimming pool, as well as in therapeutic baths. New uses are being investigated and planned. Currently being analyzed is the use of geothermal heating in the City's maintenance garage and for sewage treatment (Ralph Williams, pers. comm, 1979).

Geothermal Development Process

Financial Considerations - For several years, the City of Glenwood Springs and several private developers have discussed their desire to use their geothermal energy. But in order to initiate a project, funding is needed. Too little is known, so far, about either the resource or the economic feasibility to warrant or attract loan funds to pay for development. The Four Corners Regional Commission had allocated funds for one geothermal well to be used to heat a senior citizens' apartment house (Steve Colby, pers. comm., 1979). Unfortunately, the apartment house funding was not obtained, so the well was never drilled. Local banks might be reluctant to loan funds on structures

TABLE B-4

GEOTHERMAL RESOURCE CHARACTERISTICS
GLENWOOD SPRINGS

Spring or Well	Location	Total Dissolved Solids (mg/L)	Surface Temperature (C°)	Current Discharge (gpm)
Railroad Spring	6S,89W,Sec. 9	18,400	51	75
Spring D		18,000	50	74
Spring C	6S,89W,Sec. 10	--	46	2-3
Spring B	" " "	17,700-18,400	49	75-110
Spring A	6S,89W,Sec. 9	17,600	44	2-3
River	" " "	--	50	10-50
Vapor Caves	" " "	18,000	50	5
Big Spring	" " "	20,200	50	2,263
Drinking Spring	" " "	18,800-20,500	50-51	140-160
Graves Spring	" " "	21,500	46	5

SOURCE: Barrett and Pearl, 1978.

TABLE B-5

GEOTHERMAL RESERVOIR CHARACTERISTICS
GLENWOOD SPRINGS

Reservoir Type	Estimated Areal Extent (mi^2)	Estimated Thickness Thickness (ft)	Estimated Subsurface Temperature (°C)	Estimated Energy Content ($Btu's X 10^{15}$)
Stratigraphic	.5-1.32	250	65	.0106-.0279

SOURCE: Pearl, 1979.

using geothermal energy until the effects are better tested (Gene Allen, pers. comm., 1979).

Leasing and Permitting - Any geothermal developer would be required to own or lease the geothermal rights and the land surface to be used, as well as having rights to water that would be consumed (Coe and Forman, 1979). State permits are also required for drilling wells (Coe and Forman, 1979).

Additionally, Garfield County requires permits for pipelines in certain types of areas. Although Glenwood Springs currently has no regulations that specifically address geothermal development, they would probably initiate them were activity to begin (Gene Allen, pers. comm., 1979). Zoning, subdivision, and building regulations are applicable to structures that might be built.

TABLE B-6

Dissolved Mineral Content of Glenwood Springs Thermal Waters

	Yampa Hot Springs
Arsenic (ug/l)	0.0
Boron (ug/l)	890.0
Cadium (ug/l)	0.0
Calcium (mg/l)	510.0
Chloride (mg/l)	11,000.0
Fluoride (mg/l)	2.3
Iron (ug/l)	60.0
Lithium (ug/l)	800.0
Magnesium (mg/l)	91.0
Manganese (mg/l)	80.0
Mercury (ug/l)	0
Nitrogen (mg/l)	0.01
Phosphate (mg/l)	0.04
Potassium (mg/l)	180.0
Selenium (mg/l)	0
Silica (mg/l)	32.0
Sodium (mg/l)	690.0
Sulfate (mg/l)	1,100.0
Zinc (ug/l)	30.0
Alkalinity	
as Calcium Carbonate (mg/l)	634.0
as Bicarbonate (mg/l)	773.0
Hardness	
Noncarbonate (mg/l)	1,000.0
Total (mg/l)	1,600.0
Specific Conductance	36,800
Total Diss. Solids (mg/l)	20,200
Ph, Field	6.3
Discharge (gpm)	2,263
Temperature (C)	50
Date Sampled	7/75

Source: Barrett and Pearl, 1976

Whether geothermal leases would be required can be determined only by a detailed ownership inventory. There is concern among some of the potential developers about legal questions. When the land in the City was sold by the original owner, deed restrictions stipulated that no actions could be taken by the purchasers or subsequent owners that would adversely affect the hot springs (Ralph Williams, pers. comm., 1979). Recently, the owner of the hot spring is reported to have acquired mineral rights on property across the street from his property (John Fernandez, pers. comm., 1979). Both the legal and the technical consequences of drilling geothermal wells in Glenwood Springs bear investigation.

Technological Requirements - As mentioned in the resource evaluation section, the geothermal fluid contains a high concentration of dissolved minerals. Without an engineering analysis, the specific techniques required to avoid

corrosion and/or scaling are not defined. Some possibilities are a pressurized system that will exclude oxygen if oxidization is a problem, chemical treatment or a heat exchanger, which could be of a variety of designs. Although the dissolved solids content is likely to require precautions, the hardware and techniques are probably readily available.

Environmental Considerations - Those hazards mentioned previously, namely unstable and steep slopes, require that development in certain areas be limited to avoid environmental and property damage. Too little is known about the conditions at this site to assess the environmental concerns specific to geothermal development. Water and air pollution must be controlled as required by the Colorado Health Department. Impacts on vegetation, wildlife, soil, water availability, land use and social and economic conditions are all issues that will usually be addressed prior to any extensive geothermal development. As mentioned above, the large volume of dissolved minerals in the geothermal fluid will require measures to control water pollution that would not be required in an area of purer fluid.

Economic Considerations - Preliminary economic analyses conducted by the New Mexico Energy Institute indicate that the cost of providing geothermal energy could be competitive with natural gas. Continuing increases in natural gas prices will most likely make geothermal even more attractive. Although these are preliminary data, they do indicate the value of conducting a more detailed analysis (Cuniff, et al, 1979).

Potential Uses of Geothermal Energy

Although there seems to be some potential for industrial use of geothermal energy in Glenwood Springs, the primary potential is for space and water heat in residential, commercial and public buildings. No specific projects are planned, as yet. However, numerous ones have been proposed and are being investigated. Under investigation currently is the feasibility of heating the municipal maintenance garage and treating sewage with geothermal heat.

Figure B-3 shows the necessary steps to develop the geothermal energy and a possible time-frame. The residential and commercial thermal energy demand and selected industrial energy demands are included. The project could be conducted in phases, beginning with installations in new structures and conversion of public buildings, then commercial ones, and finally, conversion of residences. Each phase would act as a demonstration to the next; each would begin as time, cost of alternative fuels, availability of funds, and attitudes permitted. As such, this is but one possible time-frame. A speeding up or slowing down of increases in natural gas cost could result in a dramatically different schedule. The availability or lack of other alternative sources could have an equally profound effect. The 1.10×10^{12} Btu of energy estimated to be on line by the year 2000 (Cuniff, et al, 1979) assumes industrial demand growth proportional to the residential and commercial energy demand.

Development Opportunities and Constraints-In Glenwood Springs as in the Durango area, there is an apparent market for geothermal energy. It too, consists primarily of residential and commercial space and water heating. Again, a strong tourist economy results in high commercial energy consumption.

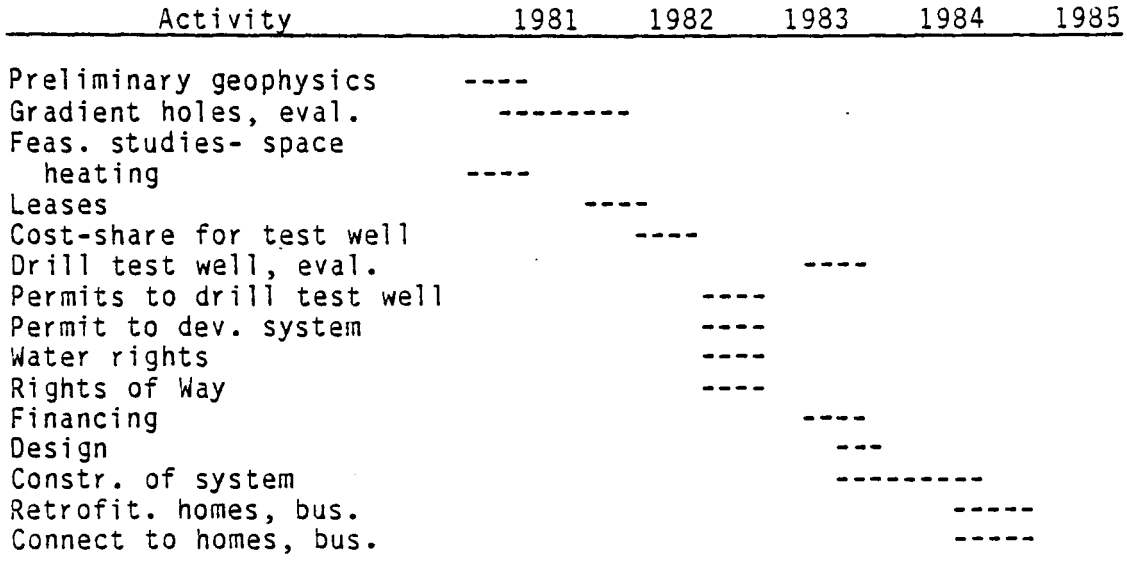
The certainty regarding the adequacy of the resource temperature is greater at this site and the current flow rate is quite high. Quite probably, the high

minerals content would necessitate the use of heat exchangers. Even so, the proximity of the resource to potential users helps to keep the system cost low.

There are two primary constraints to development in Glenwood Springs. One of them is, as in the Durango area, the lack of funds. The second is the uncertainty regarding resource ownership. Current investigations may help clarify the ownership questions.

FIGURE B-3

GLENWOOD SPRINGS
SITE DEVELOPMENT SCHEDULE



C. IDAHO SPRINGS

Site Description

Idaho Springs is a part of the greater Denver Metropolitan Region, as shown on Figure C-1. It is located 35 miles west of Denver at the junction of two transporation corridors, Clear Creek and Chicago Creek Canyons. It follows the banks of Clear Creek and is bisected by Soda Creek. The narrow mountain valley has an elevation of 7,542 feet with canyon walls that climb to 8,500 and 9,300 feet (Taylor and Scanlon, 1973).

Land Use and Ownership - National Forest bounds the Idaho Springs area on the south, as shown on Figure C-2. The location of Idaho Springs limits its ability to expand, however, with its carrying capacity limited to about 7,000 persons (Thomas Johnson, pers. comm., 1979). Chicago Creek Canyon at the south has some land suitable for low density development and Soda Creek, also at the south, has good development potential. Some land at the west is also developable (Taylor and Scanlon, 1973).

Population - The current population of Idaho Springs is about 2,900 (T. Johnson, pers. comm., 1979). It has grown from 1,480 residents in 1960, and 2,003 in 1970, largely because of its proximity to employment in Metro Denver employment centers. This is a growth rate from 1970 to 1979 of 24 percent and a higher total population than that forecast by the State Division of Planning for the year 2000 (Colorado Division of Planning, 1979).

Seven hundred eighteen residential structures were identified in 1973. About 20 percent of these were mobile homes (Taylor and Scanlon, 1973). Most of the permanent structures are estimated to be between 50 and 80 years old, many of them Victorian frame style construction. About 91 percent seem to be sufficiently sound for continued occupancy. The historic low density is increasing slightly with the construction of townhouse condominiums (Taylor and Scanlon, 1973).

Economy - The economic base of the city is tourism. County employment by Sector data shown on Table C-1 indicate that the largest percent of workers in 1970 were employed in the services sector, the next largest in trade and the next in construction (Taylor and Scanlon, 1973). and 11 motels in Idaho Springs. Table C-3 shows the 2 manufacturers located in Idaho Springs.

Primary city income is from the 7 percent sales tax. The general obligation bond capacity of $640,520.70 will be fully available next year, once an existing bond is paid (Thomas Johnson, pers. comm., 1979). Industry is not encouraged. Rather, continuation of the predominantly suburban residential character is considered to be desirable for the future (Thomas Johnson, pers. comm., 1979).

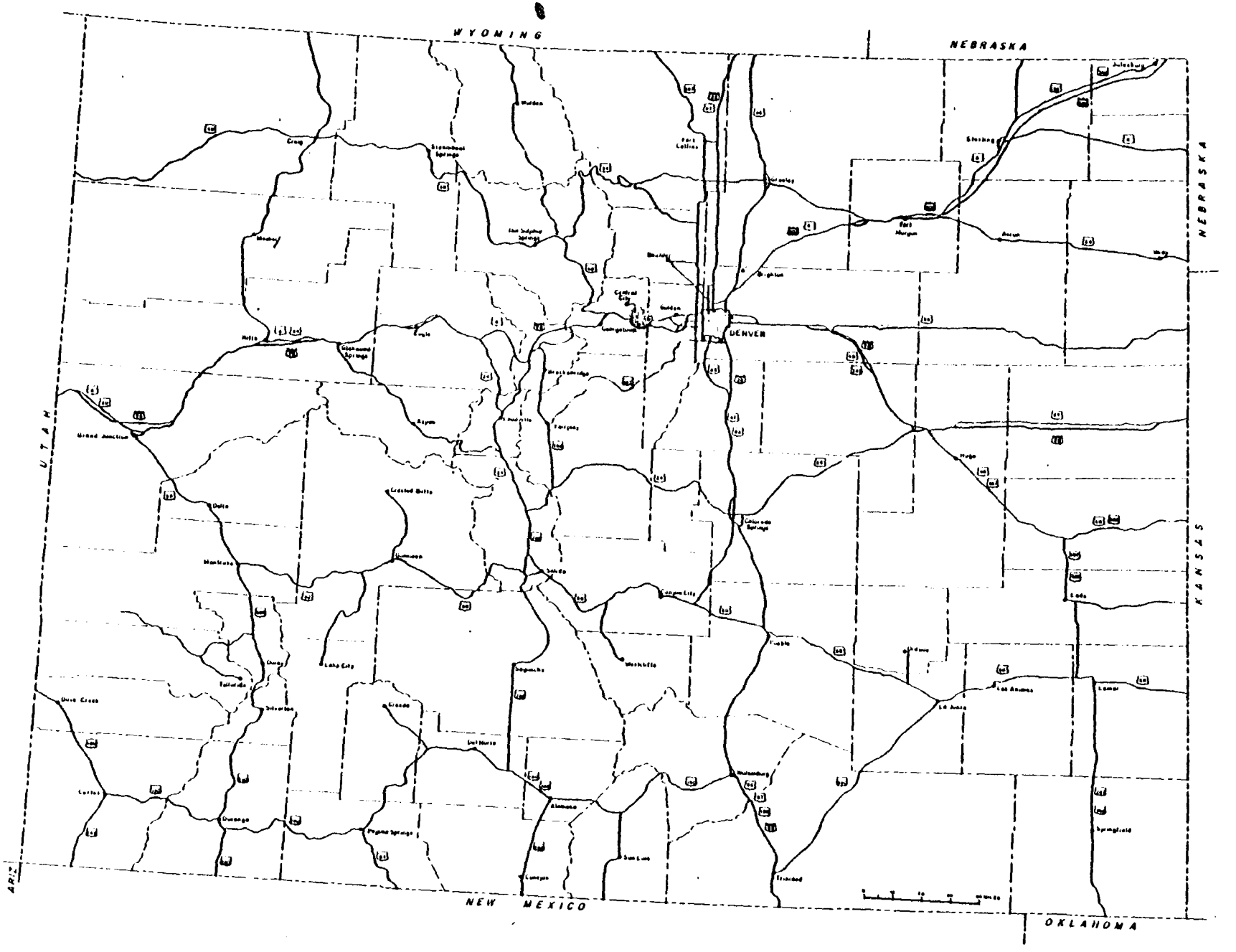
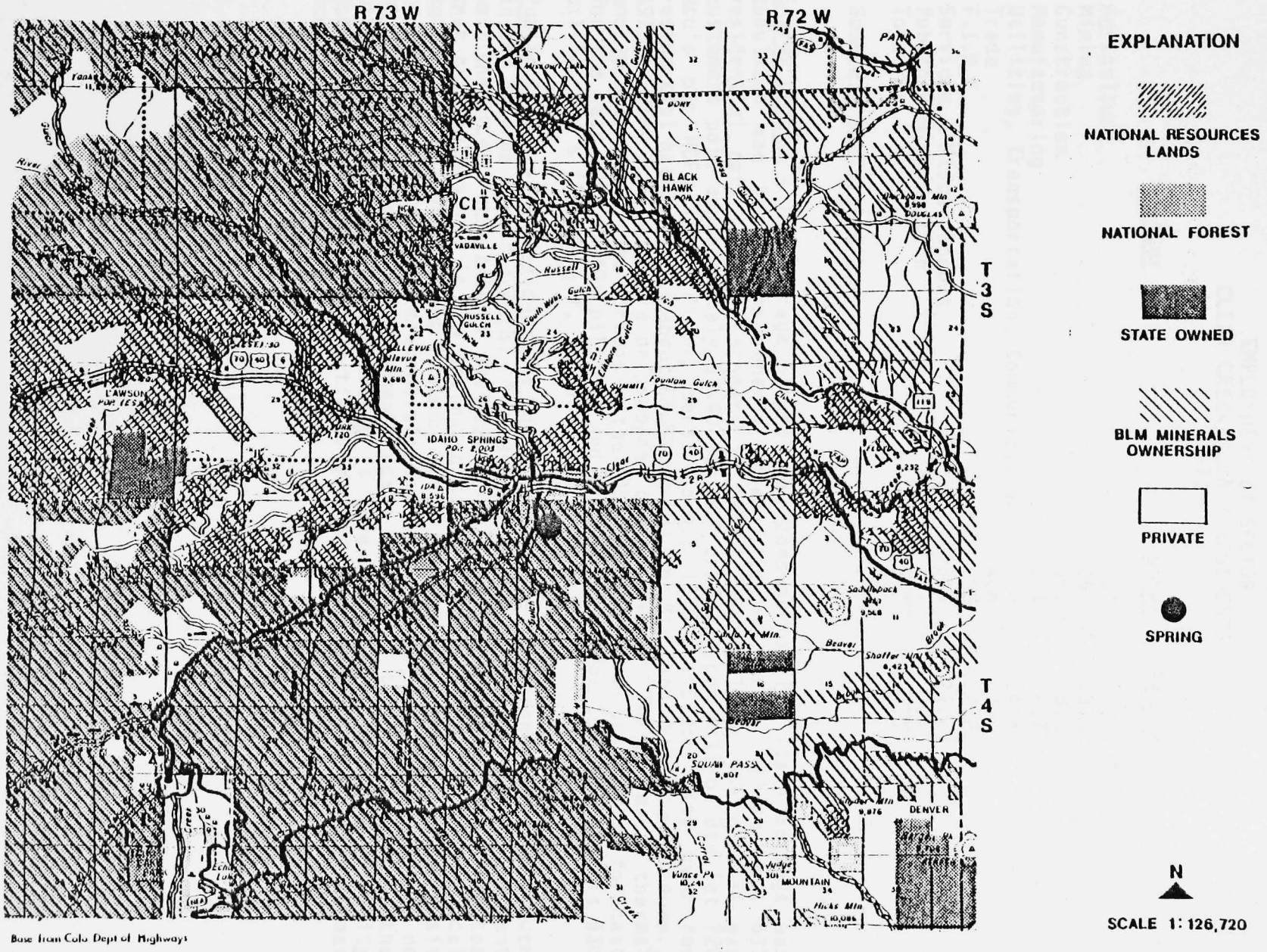


Figure C-1. Location of Idaho Springs Site



LAND AND MINERAL OWNERSHIP OF IDAHO SPRINGS AREA

Figure C-2.

TABLE C-1

EMPLOYMENT BY SECTOR
CLEAR CREEK COUNTY RESIDENTS
1970

Sector	Number	Percent
Agriculture	20	1.0
Mining	268	13.5
Construction	361	18.2
Manufacturing	134	6.7
Utilities, Transportation, Communication	90	4.5
Trade	406	20.4
F.I.R.E.	55	2.8
Services & Miscellaneous	506	25.5
Public Administration	147	7.4
Total	1,987	100.0

Source: Scales, 1972.

Energy Demand - The average natural gas consumption for Idaho Springs was tabulated and the thermal energy demand was estimated. There were 633 residential natural gas customers in 1979. During 1978, the natural gas customers paid approximately $2.40 per MCF or $3.38 per million Btu (at 720 Btu's per MCF) (John Nixon, pers. comm., 1979). Electricity used for residential heating costs about $8.80 per million Btu (John Nixon, pers. comm., 1979). Some residents are on propane, coal and wood. The estimated thermal energy demand for Idaho Springs in the 1983 is 373 billion Btu's, that forecast for the year 2000 is 439 billion, and that forecast for the year 2020 is 530 billion Btu's (Roy Cuniff, and others, 1979).

Public Issues - The residents of Idaho Springs are quite concerned that growth in the city be "good" growth. A recent survey indicated that over 90 percent want the City to stay under 7,000 population. The City administrator indicates that that population is the estimated carrying capacity, given the physical setting limitations (Thomas Johnson, pers. comm., 1979). The current emphasis on residential and commercial development will most likely continue, with no significant industrial development, again because of the limitations of the site. The use of geothermal energy is appealing, as reflected in the City Council's unanimous vote to actively pursue its possible development (Thomas Johnson, pers. comm., 1979).

TABLE C-2

BUSINESS IN IDAHO SPRINGS

Accountants
1. Connie Kenward
2. John Sammons

Advertising--Directory
1. Mountain Bell

Aluminum Products
1. R & S Sales and Welding Services

Antiques
1. Dandy Lions Gallery

Antique Repair
1. The Silver Bell

Appliances
1. Montgomery Ward & Co.

Appliance Repair
1. Public Service Co. of Colorado

Appraisers
1. Eureka Realty Co.

Art Galleries
1. Artisan

Automobile Repairing (Body & Paint)
1. Cullen Auto Body Shop

Automobile Parts
1. Clear Creek Supply Co.
2. Idaho Springs Auto Supply
3. Roy's Standard Service

Automobile Repairing & Service
1. A OK Auto Clinic
2. A & B Garage
3. Blue Ribbon Tire Co.
4. Clear Creek Standard & Care
5. Mt. Evans 66
6. Warren's Auto Service

Banks
1. First State Bank

Barbers
1. The Barber Shop
2. Genuine Hare Barber & Beauty Shop
3. Toadstool Haire

Bars
1. Buffalo Bar
2. Cross Roads Inn
3. Sultan's Lounge and Restaurant

Beads
1. Clear Creek Trading Co.
2. Mountain Records and Gifts

Baths
1. Indian Springs Resort

Beauty Salons
1. Beauty Nook
2. Betty J Beauty Salone
3. Charisma Beauty Salon

Beer & Ale
1. County Store & Standard Gas
2. J & J Pioneer Liquors

Book Dealers
1. Hawkeye Bookstore

Boots
1. Ferd's Sporting Goods
2. Ponderosa Sports Inc.

Bowling
1. Placer Inn & Lanes

Building Contractors
1. Wheelock Construction

Building Materials
1. Idaho Springs Lumber Co.

Bus Lines
1. Trailways Bus System

Table C-2 continued

Cabinets
1. Thiessen Const. & Insulation

Carpet Layers
1. Vista Carpet Co.

Chiropractors
1. Dr. Joel McKee

Clinics
1. Idaho Springs Medical Clinic
2. Mountain Community Med. Center

Dentists
1. Robert Hickam
2. Boyd Tomasetti
3. Paul Rocke
4. Neal Wilsted

Educational Consultants
1. Mark Harrington

Engineers--Consulting
1. Colorado Cadastral Mapping Co.

Fireplaces
1. Clear Creek Stove Co.

Fishing Bait
1. Original R & D Bait

Funeral Directors
1. Tomford Mortuary

Gasoline-Wholesale
1. Blackwell Oil Co., Inc.
2. Cass's Texaco

Gift Shops
1. Chicago Creek Traders
2. The Dogsled
3. High Country Crafts
4. This N That Shops
5. Wells Curio Shop
6. Wells Fargo II

Camping Equipment
1. Cook's Liquor & Sporting Goods

Ceramic Products
1. Hi Country Ceramics
2. House of Unique Gifts

Cleaners
1. Wardrobe Cleaners

Clocks
1. The Cuckoo Clock

Department Stores
1. McDonalds Clothing

Drilling & Boring Contractors
1. Prickett & Sons

Electric Contractors
1. Mountain Electric Co.

Feed Dealers
1. General Hardware Stores

Firewood
1. Heritage Wood Co.

Fraternal Organizations
1. Elks BPO Lodge
2. Masonic Temple

Gas Companies
1. Williams Energy Co.

Geologists
1. Irvin Nielson

Grocers
1. Idaho Springs Husky Station
2. Safeway
3. Seven-Eleven Stores
4. West End Market

Table C-2 continued

Heating Contractors
1. A & N Plumbing and Heating

Heating Equipment
1. Kincannon Heating & Sheet Metal

Ice Cream Dealers
1. The Sugar Plum

Industrial Equipment
1. Marv's Manufacturing & Repair

Insulation Contractors
1. Alpine Energy

Insurance
1. Bank Insurance Agency
2. Chas Crabill Agency
3. Bob Gilbertson
4. Alfred Maclay Insurance

Landscape Contractors
1. James Greene

Laundries
1. Snow-White Laundromat
2. B & J Restaurant

Lawn Mowers
1. Snapper Lawn & Garden Products

Lawyers
1. Kathy Beilstein
2. Walter Cass
3. David Drucker
4. Richard Garnett
5. David Goodman
6. David Kanigel
7. Sadler & Owen
8. Edward Shindel
9. Richard Weinberg

Leather Goods--Wholesale
1. Mountain Mama Products

Liquor Stores
1. Clear Creek Pharmacy
2. Pick Liquor

Mental Health Services
1. Mental Health Services for Clear Creek County

Mining Companies
1. Petro Nuclear Mineral Explorations

Mining Equipment
1. R F S Inc.

Motels
1. Argo Motor Inn
2. Blair Motel
3. Krenzel Motel
4. Columbine Motel
5. H & H Motel
6. Miners Trailer Court
7. Peoriana Motel
8. Rest Haven Motel
9. Six & Forty Motel
10. Top's Court

Museums
1. Argo Gold Mill

Newspapers
1. The Clear Creek Courant
2. Front Range Journal

Table C-2 continued

Optometrists
1. Patrick Fowler

Physicians - M.D.
1. Morgan Durham
2. Steward Williams

Real Estate
1. Blue Spruce Realty
2. Eureka Realty Co.
3. Red Carpet Credence Realty
4. Stanbro Real Estate Co.
5. George Sumpter

Restaurants
1. A & W Drive Inn
2. Beau Jo's Pizza Parlor
3. Big Bob's Valley Cafe
4. Canyon's Claim
5. Chief Idaho Restaurant
6. Eric's Deli & Restaurant
7. Fifty-Niner Restaurant
8. Jiggies Cafe
9. King's Derby Restaurant & Lounge
10. Las Dos Mujeres
11. Original Eat Shop
12. Roy's Restaurant
13. Six & Forty Restaurant

Road Service
1. Berthoud Falls Service & Towing

Sandwiches
1. The Lunch Box

Senior Citizen Service
1. Senior Nutritional Program
2

Shoes
1. The Shoe Place

Sportswear
1. Belle Fashions

Variety Shops
1. Ben Franklin

Physicians - D.O.
1. Robert Bichon
2. Roger Bichon

Printers
1. Mountain Graphics
2. Sander Graphics

Refrigerating Equipment
1. M & A Sales & Service

Road Service
1. Berthoud Falls Service & Towing

Rubbish Removal
1. Clear Creek Disposal

Savings & Loand
1. Golden Savings & Loan

Service Stations
1. Idaho Springs Conoco Service
2. Roy's Standard Service

Skiing Equipment
1. Maison de Ski

Theatres
1. Mines Theatre

Veterinarians
1. Clear Creek Veterinary Clinic

SOURCE: Mountain Bell Telephone Directory, 1979

TABLE C-3

MANUFACTURERS LOCATED
IN IDAHO SPRINGS
1977

	SIC CODE	REQUIRED TEMPERATURE °C	NUMBER OF EMPLOYEES
Dogsico, The	3961 3911	93 93	5
Johnson Newspapers Incorporated	2711 2752	149 149	5

Geothermal Resource Evaluation

The characteristics of the geothermal resource in Idaho Springs are shown on Table C-4. As indicated, the surface temperature is near that required for economical space heating (60°C). Shown on Table C-5 are estimated subsurface temperatures and the estimated energy content. There are estimated to be 171 X 10^{12} Btu's of energy available. Table C-6 shows the chemical content of the geothermal water from this resource site. During the summer of 1980 the Colorado Geological Survey did some preliminary resource exploration work in the vicinity of the hot springs (R. H. Pearl, pers. comm., 1980). According Pearl (pers. comm., 1980) data collected during this work is currently being analyzed. A report detailing the results of their findings will be prepared during 1981.

Current Development - Water from the well is currently used in baths and a swimming pool at the Indian Springs Resort. The resort management is, however, most interested in converting his building to geothermal heat. He indicated he would drill a new well in the near future (Jim Maxwell, pers. comm., 1979).

Development Process

Financial Considerations - Financing geothermal development, beginning with detailed feasibility studies and reservoir confirmation is, so far, a difficulty for Idaho Springs. No private energy developers are known to be interested in investing in such development. The uncertainty associated with exploration for the resource is, on the other hand, not the sort of financial risk to which a local government is prepared to commit financial resources, were such resources available. The uncertainty of the total project cost and benefits adds to the difficulty of obtaining financing.

For structures that would use geothermal heat, the local bank is not yet familiar enough with geothermal energy to have confidence in it. Given the state of knowledge, back-up systems might be required or loans might be difficult to obtain. Bank representatives did, however, indicate that financing a subdivision would probably be more attractive to the bank than would financing a single unit. More knowledge about the Idaho Springs resource could change the perception of the bank's representatives.

TABLE C-4

GEOTHERMAL RESOURCE CHARACTERISTICS
IDAHO SPRINGS

Spring or Well	Location	TDS mg/L	Surface Temperature (°C)	Current Discharge (gpm)
Spring A	4S,73W, Sec. 1	1940-2110	40-45	21
B	"	1070	24	<1
C	"	1070	20	1
Lodge Hot Water W Well		2070	46	30

Barrett and Pearl, 1976

*These springs and wells have altered since this survey was conducted, according to owners.

TABLE C-5

GEOTHERMAL RESERVOIR CHARACTERISTICS
IDAHO SPRINGS

Reservoir Type	Estimated Areal Extent mi^2	Estimated Thickness ft	Estimated Subsurface Temperature °C	Estimated Total Btu's 10^{15}
Fracture	1.52	1,000	80°C	.1714

Pearl, 1979

TABLE C-6

Dissolved Mineral Content of Idaho Springs Thermal Waters

	Lodge Hot Water Well
Arsenic (ug/l)	46.0
Boron (ug/l)	360.0
Cadium (ug/l)	0
Calcium (mg/l)	150.0
Chloride (mg/l)	66.0
Fluoride (mg/l)	3.5
Iron (ug/l)	1,000.00
Lithium (ug/l)	870.0
Magnesium (mg/l)	38.0
Manganese (mg/l)	7.0
Mercury (ug/l)	0
Nitrogen (mg/l)	0
Phosphate (mg/l)	0.05
Potassium (mg/l)	82.0
Selenium (mg/l)	0
Silica (mg/l)	58.0
Sodium (mg/l)	520.0
Sulfate (mg/l)	420.0
Zinc (ug/l)	10.0
Alkalinity	
as Calcium Carbonate (mg/l)	1,220.0
as Bicarbonate (mg/l)	1,490.0
Hardness	
Noncarbonate (mg/l)	0
Total (mg/l)	530.0
Specific Conductance	2,920
Total Diss. Solids (mg/l)	2,070
Ph, Field	6.9
Discharge (gpm)	30
Temperature (C)	46
Date Sampled	10/75

Source: Barrett and Pearl, 1976

If funds were available to aid the City with conducting the feasibility study and assessing the reservoir, the actual construction of a geothermal heating district could readily be financed through general obligation or revenue bonds.

Leasing and Permitting - For any geothermal development certain legal requirements must be met. To establish the right to develop the energy, a prospective developer must either own or lease the geothermal rights and the land surface to be used and must have rights to the water containing the heat if the water is to be consumed (Coe and Forman, 1979).

Geothermal rights, surface rights and water rights may all be necessary for development. Whether geothermal or surface leases are required depends upon the well location which cannot yet be decided. If the location is on City

property, leases would be unnecessary. Water rights should be no problem, since the City has extensive unused water rights on Soda, Chicago and Clear Creeks (Thomas Johnson, pers. comm., 1979).

In Idaho Springs, no City ordinance specifically regulates geothermal development. A developer must comply with zoning and subdivision regulations. Since the regulations permit greenhouses in residential districts, some additional energy benefit could be obtained from small private geothermally-heated greenhouses.

Technological Considerations - The technological considerations cannot be accurately assessed from available information. The existing and previous wells are known to have become plugged from mineral scale. This scaling may be caused, however, by simple oxidization resulting from an open piping system. If this is the problem, it can be easily controlled with proper system design and construction.

Environmental Considerations - Again, too little information is available to indicate what specific environmental problems, if any, might be encountered in developing this system. Dissolved solids of the geothermal fluid range from 1,070 to 2,111 mg/L, a moderate amount. Disposal of waste fluid and air pollution would be controlled by the State as in any case, to preclude significant environmental degradation. Slope instability and flood plains are hazardous conditions for structures if handled improperly. Such potential hazards should be considered when an application for development is reviewed. Indirectly, these hazards can affect geothermal development, mandating the restriction of the building of structures, or by making environmental degradation possible if structures are allowed. Sites for both geothermal wells themselves and development to use the energy should be carefully investigated prior to development.

Economic Considerations - A preliminary economic evaluation of geothermal development at this site was conducted by the New Mexico Energy Institute. The results indicated that the geothermal energy could be provided at a cost competitive with natural gas, even considering retrofitting costs (Cuniff, et al, 1979).

The front-end cost of such a project is sizable, however, perhaps as much as $8 million or more. Given the uncertainties about the resources and about the cost, funds are extremely difficult to obtain. Prospective lenders are reluctant and further, the uncertainties constrain the ability of a potential developer, especially a local government, to obtain a loan. Federal research and development programs to delineate the resources and to do site-specific feasibility studies may be necessary if community development is to occur.

Potential Uses of Geothermal Energy

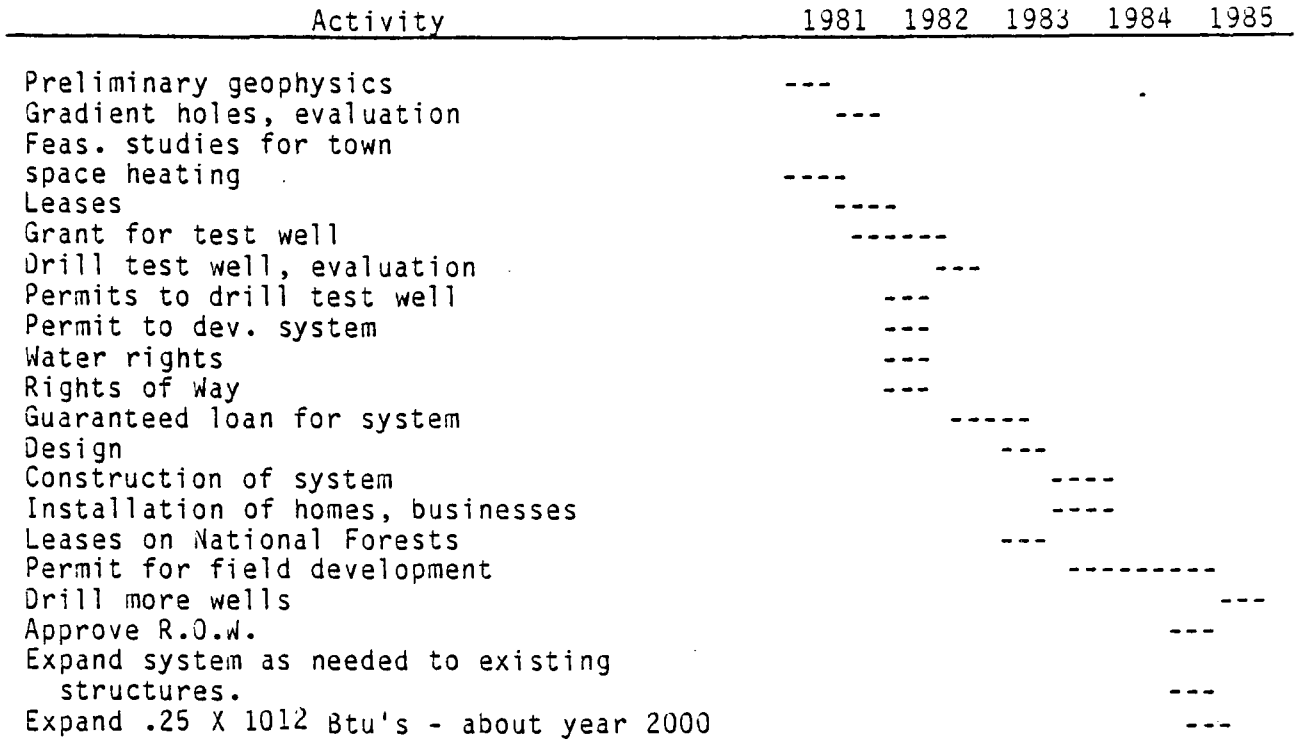
There is little doubt that unless some very substantial and unforseen changes occur in the economy, the primary potential for geothermal energy development in Idaho Springs is for residential and commercial space and water heating. In addition to the aforementioned resort space heating, a more significant proposal in terms of the amount of energy supplied is to supply geothermal space and water heat to the entire town. As mentioned, residential and commercial buildings have the primary demand. If the entire town were converted, about 373 billion Btu's of geothermal energy could be on line by

1983. Over the long term, the market should expand, with a forecast 530 billion Btu's on line by the year 2020. The schedule on Figure C-3, shows a possible development time-frame. As shown, funds are needed in order to learn more about the feasibility and the capability of the resource.

Development Opportunities and Constraints-The geothermal energy at Idaho Springs does have potential for development for residential and commercial use. There are financial barriers to geothermal development by this small community. Whereas housing or commercial structure developers could develop geothermal energy for new structures, they may be reluctant to do so by a lack of sufficient profitability to warrant the effort. Idaho Springs is not a depressed area, nor is it an energy-impacted one, so is ineligible for Federal programs directed to these needs. Communities like Idaho Springs are often limited from investing further, and are reluctant to do so because of the lack of sufficient financial and engineering data. Were the reservoir and feasibility data available, such that the uncertainty was minimized, guaranteed loans, general obligation bonds or revenue bonds could be a much more acceptable way to finance the actual construction. The lack of front-end financing for preliminary studies is the key to the lack of development thus far.

FIGURE C-3

IDAHO HOT SPRINGS
SITE DEVELOPMENT SCHEDULE



D. OURAY SITE

Site Description

The City of Ouray is located in the heart of the Uncompahgre Valley, in the San Juan Mountains of Ouray County in southwestern Colorado, as shown on Figure D-1. It is located in a natural ampitheatre and is confined by towering cliffs that rise as high as 5,000 feet above street level (Ouray Chamber of Commerce). The elevation of Ouray is 7,800 feet. The Uncompahgre River that flows through Ouray originates just above the city. With an annual growing season of only 129 days (Region 10 Planning Commission, 1976), 9,000 degree days and an average low temperature of 20°F, agriculture in the area is obviously very limited, but the need for heating fuel quite high.

Land Use and Ownership-Generally, commercial establishments border the highway through Ouray and residences are located along the hillside behind. U.S. Highway 550 provides Ouray with good access which is relatively easy from the north, but hindered by the rugged terrain and severe winter storms to the south. National Forest land surrounds the City as shown on Figure D-2.

Population - The estimated 1975 population of the city of Ouray is 844. The population grew at about 4 percent a year since 1970 (Ryan, 1976). The forecast of 2074 for the 2020 assumes 3 percent annual growth until the year 2,000 and 2 percent thereafter. In 1970, the County median age was 34.2, as contrasted with 26.0 for Colorado as a whole. Retired persons migrate into Ouray, whereas younger persons migrate outward to obtain employment (Ryan, 1976).

Economy - In Ouray, the major source of employment has historically been mining. Since the recent closing of two mines, unemployment has been high and tourism has become the predominant economic sector. Not only is tourism very seasonal (May through October) because of severe winters, but it declined in 1979 previously because of the gasoline shortage (George Gault, pers. comm., 1979). Government, in 1970, was the third largest employment sector as shown on Table D-1. Even when the mines were open, making available relatively well-paid employment, county per capita income was lower than that for the State, although higher than that for nearby counties, as shown on Table D-2.

Of the seventy-one commercial and professional services establishments listed in the 1979 Ouray telephone directory, 15 of these were motels and hotels and 9 of them were restaurants, reflecting the strong tourist economy. Table D-3 shows the businesses in Ouray.

City revenue has been short, because of the mine closures (George Gault, pers. comm., 1979). The sales tax will be increased from 2 percent to 3 percent in January, 1980 (John Brennan, pers. comm., 1979).

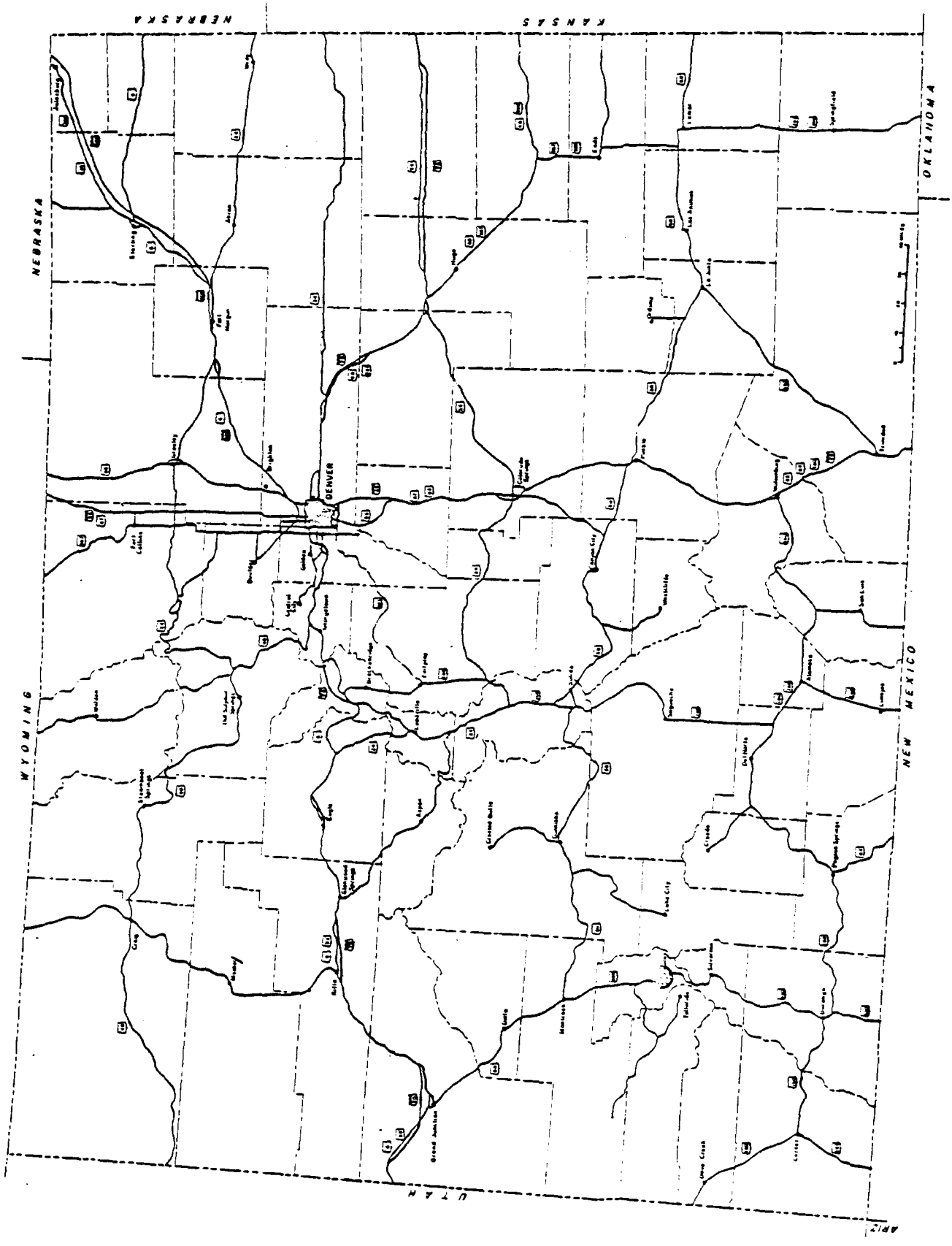
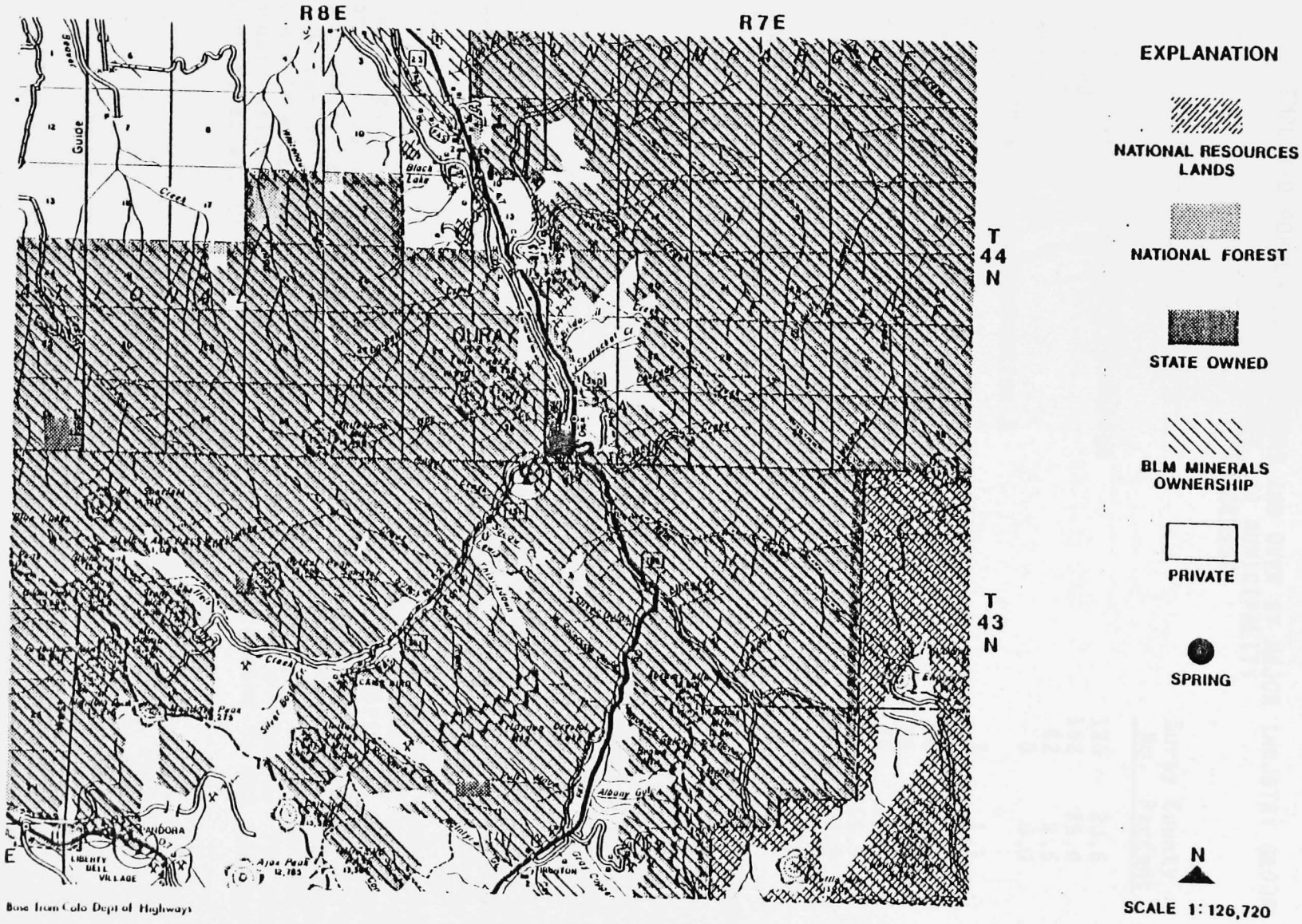


Figure D-1. Location of Ouray Site



LAND AND MINERAL OWNERSHIP OF OURAY AREA

Figure D-2.

TABLE D-1

OURAY

EMPLOYED POPULATION 16 YEARS AND OVER BY MAJOR INDUSTRY GROUP
BY COUNTY AND MUNICIPALITY
1970 CENSUS

Industry Group	Ouray County No.	Ouray County Percent
Agriculture, Forestry & Fisheries	126	20.6
Mining	162	25.6
Construction	52	8.5
Manufacturing	0	0.0
Transportation, Communication & Public Utilities	7	1.1
Wholesale Trade	10	1.6
Retail Trade	58	9.5
Finance, Insurance & Real Estate	26	4.2
Services	76	12.4
Government	95	15.5
Total Employed	612	100.0

Source: 1970 Census of Population, Colorado, U.S. Department of Commerce, Bureau of the Census, Washington D.C.

To provide solutions, an economic development project is underway. For increasing revenue and employment, both additional manufacturing (George Gault, pers. comm., 1979) and a convention center have been suggested (John Brennan, pers. comm., 1979). Because of its relative isolation and lack of a rail system, new development must be amenable to highway transportation.

Public Issues - The citizens of Ouray are quite supportive of economic development efforts (George Gault, pers. comm., 1979). They also express great interest in geothermal development if it is feasible (public meeting, 1978).

Energy Demand - The City of Ouray is not served by natural gas. As such, current actual energy consumption figures for the City of Ouray are not available. Propane, coal and fuel oil, along with electricity, are widely used for heat (John Brennan, pers. comm., 1979). The cost of propane was reported to be $4.26 per million Btu, while electricity for residential use was about 10.00 per million Btu. Based on other similar cities, the commercial energy demand is expected to be 100 percent of the residential demand. The estimated annual residential and commercial thermal heat demand is 112 billion Btu's (Cuniff, et al, 1979).

TABLE D-2

COLORADO PLANNING AND MANAGEMENT REGION NO. 10
TOTAL AND PER CAPITA PERSONAL INCOME BY REGION, COUNTY AND COMMUNITY
1970[a] AND 1973[b]

Place of Residence	Total Personal Income			Per Capita Personal Income		
	1970	1973[c]	Percent Increase	1970	1973	Percent Increase
Black Canyon Region	$105,872,216	$144,783,522	36.8	$2,356	$3,046	29.3
Delta County	33,613,914	45,335,498	34.9	2,199	2,834	28.9
Orchard City	2,899,359	4,011,829	38.4	2,493	3,259	30.7
Cedaredge	1,400,210	1,907,043	36.2	2,410	3,111	29.1
Crawford	336,870	514,583	52.8	1,970	2,843	44.3
Delta	8,222,844	10,189,000	23.9	2,226	2,875	29.2
Hotchkiss	1,034,787	1,414,458	36.7	2,041	2,634	29.1
Paonia	3,015,117	3,819,3609	26.7	2,597	3,270	25.9
Gunnison County	19,392,102	25,652,682	32.3	2,559	3,013	17.7
Crested Butted	953,064	1,157,496	21.5	2,562	2,837	10.7
Gunnison	10,328,507	13,806,720	33.7	2,239	2,720	21.5
Marbled	33,267	44,940	35.1	2,559	2,996	17.1
Mount Crested Butted	33,267	323,568	872.6	2,559	2,996	17.1
Pitkind	64,020	144,687	126.0	1,455	2,837	95.0
Hinsdale County	991,416	1,428,840	44.1	4,908	5,880	19.8
Lake Cityd	425,789	646,800	51.9	4,679	5,880	25.7
Montrose County	43,619,250	59,078,631	35.4	2,375	3,147	32.5
Montrose	17,246,880	24,081,720	39.6	2,655	3,590	35.2
Naturita	1,515,360	1,966,640	29.8	1,848	2,440	32.0
Nucla	2,036,554	2,648,855	30.1	2,146	2,833	32.0
Olathe	1,425,816	1,855,050	30.1	1,886	2,490	32.0
Ouray County	3,702,670	5,890,635	59.1	2,395	3,555	48.4
Ouray	1,662,804	2,674,192	60.8	2,244	3,368	50.1
Ridgeway	661,550	1,008,509	52.4	2,525	3,589	42.1
San Miguel County	4,552,864	7,397,236	62.5	2,336	3,431	46.9
Norwoodd	922,080	1,538,361	66.8	2,260	3,411	50.9
Ophird	N.A.	23,884	N.A.	N.A.	3,412	N.A.
Sawpitd	N.A.	92,097	N.A.	N.A.	3,411	N.A.
Telluride	1,816,605	2,814,588	54.9	3,285	4,599	40.0

a1970 equals 1970 Census, which equals 1969 Annual Personal Income
b1973 equals 1973 "Census," which equals 1972 Annual Personal Income.
c1973 Total Personal Income equals July 1, 1973 population times 1973 "Census per capita personal income.
d1973 Personel income estimate based on state and county estimates
SOURCE: Division of Business Research, University of Colorado, 1975.

TABLE D-3

BUSINESSES IN OURAY
1979

Accountants
1. Robert Ellis
2. Lawrence Stevens

Ambulance
1. Ouray County Ambulance

Antiques
1. Relics of the Past

Art Galleries
1. Westside Gallery

Bakery
1. Down-Under Bakery

Banks
1. Citizens State Bank

Beauty Shops
1. Ilenes Beauty Den

Bus
1. Continental Trailways

Coal & Coke Dealers
1. Paul Boyd Coal Co.

Florist
1. Ouray Florist & Gift

Fraternal Organizations
1. Elks Club

Gift Shops
1. Benham's Bear Creek Store
2. The Hogan
3. Ore Car Gift Shop
4. The Viking
5. Wilderness Hut

Insurance
Navaho Traders

Jewelry
Navaho Traders

Lawyers
1. David Smith
2. Richard Tisdel

Liquor
1. Ouray Liquor

Lounge
1. 550 Inn

Lumber
1. Rice Lumber Co.

Markets
1. Duckett's AG Market

Medical
1. Ouray Medical Center

Medical
1. Ouray Medical Center

Mining Companies
1. Baumgartner Co.
2. Ranchers Exploration & Dev. Corp.
3. Idarado Mining Co.
4. Camp Byrd Inc.

Table D-3 continued

Motels
1. Alpine Motel
2. Antlers Motel
3. The Barn Motel
4. Box Canyon Motel
5. Bright Diamond Motel
6. Circle M Motel
7. Elkhorn Motel
8. Ouray Chalet Motel
9. Ouray Cottage Motel
10. St. Elmo Hotel & Art Gallery
11. Twin Peaks Motel
12. Weisbaden Chalet Motel & Spa
13. House of Yesteryears
14. Mountain View Inns
15. Red Mountain Lodge

Newspapers
1. Ouray County Plaindealer

Pharmacy
1. Apteka Pharmacy

Physician - M.C.
1. Robert Maisil

Real Estate
1. John Lesnefskyrant

Restaurants
1. Alpine Cafe
2. The Bonton Restaurant
3. 1876 Gourmet Restaurant
4. Nugget Restaurant
5. Coachlight
6. The Depot
7. Old Trapper Inn
8. The Outlaw

Rocks
1. Columbine Mineral Shop

Service Stations
1. Al's Service Station
2. Lunday's Automotive
   Gas & Towing

Solar Energy Equipment
1. Willow Divide Design
   Design & Construction

Sporting Goods
1. Mainstreet General Store

Theatre
1. Chipeta Theatre

Tours
1. San Juan Scenic Jeep Tours
2. Switzerland of America
   Jeep Rentals

Trading Post
1. Chief Ouray Trading Post

Utilities
1. San Miguel Power Assoc.

Variety Stores
1. Ouray Variety

SOURCE: Mountain Bell Telephone Directory, 1979

Table D-3 continued

Not Listed in Directory
1. Alpenglow - Rental Condominiums
2. Barney's Plumbing and Heating - Hardware
3. Four J Trailer Court - Campground
4. Four J Table Construction
5. Georgie's Place - Boutique
6. The Longbranch - Restaurant
7. Bob Williams - Contractor

Resource Evaluation, Springs

Table D-4 shows the temperature and other characteristics of the geothermal resources located at Ouray. Estimates have been made of the reservoir characteristics and of the enrgy in the ground, as shown on Table D-5. Table D-6 shows the chemical content of these springs. If a .06 factor for efficiency and a 30-year life with 1/30 withdrawal per year, the amount of energy available would still be 45×10^{12} Btu's. Table D-6 shows the chemical content of these springs. In order to more fully define the extent of the thermal resources the Colorado Geological Survey during the summer of 1980 sampled the soil for contained mercury content and ran eletrical resistivity surveys in Ouray. The data collected during these surveys is currently being analyzed and a report will be prepared during the winter of 1980-81 (R. Pearl, pers. comm., 1980). Thermal gradient holes, followed by a test well would provide valuable information.

The existing surface temperatures are sufficiently hot to use for space and water heating, as well as for some lower-temperature processes.

Current Uses - The city swimming pool and municipal maintenance garage use waters from the Pool Spring. The Weisbaden Motel uses natural hot water for mineral baths, a swimming pool and for space and water heating (Barrett and Pearl, 1978) and another motel uses it for space and water heating.

Development Process

Financial Considerations - A mode of financing a geothermal development, especially at the front end, is necessary in order for development to occur. A small town such as Ouray has very limited revenues in the most lucrative times, but when the major source of revenue closes its doors, the situation is critical. Because of its current economic depression, however, some federal funding, such as U.S. Housing and Urban Development (HUD) and U.S. Farm Home Administration (FmHA) grant and loan programs may be open to Ouray.

TABLE D-4

GEOTHERMAL RESOURCE CHARACTERISTICS

OURAY

SPRING OR WELL	LOCATION	TDS	SURFACE TEMPERATURE	CURRENT DISCHARGE (gpm)
Pool	T44N,R7W, Sec. 31	1,650	67-69	200
Uncompahgre	T44N,R7W, Sec. 31	1,570	49	5
Weisbaden				
Spring A	T44N,R7W, Sec. 31	910	53	--
Spring B	T44N,R7W, Sec. 31	410	--	2 (est)
Spring C	T44N,R7W, Sec. 31	300	--	1-30

Source: Barrett and Pearl, 1978

TABLE D-5

GEOTHERMAL RESERVOIR CHARACTERISTICS
OURAY

RESERVOIR TYPE	ESTIMATED AREA EXTENT mi^2	ESTIMATED THICKNESS ft.	ESTIMATED SUBSURFACE TEMPERATURE °C	ESTIMATED TOTAL BTU's 10^{15}
Fracture	2	1,000	70-90	.2256

Source: Pearl, 1979

TABLE D-6

Dissolved Mineral Content of Ouray Thermal Waters

	Pool Hot Springs
Arsenic (ug/l)	13.0
Boron (ug/l)	200.0
Cadium (ug/l)	0
Calcium (mg/l)	370.0
Chloride (mg/l)	41.0
Fluoride (mg/l)	3.0
Iron (ug/l)	10.0
Lithium (ug/l)	2,800.0
Magnesium (mg/l)	8.9
Manganese (mg/l)	670.0
Mercury (ug/l)	0
Nitrogen (mg/l)	0.01
Phosphate (mg/l)	0.06
Potassium (mg/l)	9.2
Selenium (mg/l)	0
Silica (mg/l)	47.0
Sodium (mg/l)	110.0
Sulfate (mg/l)	990.0
Zinc (ug/l)	10.0
Alkalinity	
as Calcium Carbonate (mg/l)	106.0
as Bicarbonate (mg/l)	129.0
Hardness	
Noncarbonate (mg/l)	850.0
Total (mg/l)	960.0
Specific Conductance	2,000
Total Diss. Solids (mg/l)	1,650
Ph, Field	6.7
Discharge (gpm)	125
Temperature (C)	67
Date Sampled	9/75

Source: Barrett and Pearl, 1976

While construction of a geothermal system is expensive, the riskiest part of a project is the well drilling and may, therefore, be the most critical. A reservoir confirmation program and also an economic feasibility study were indicated by the local officials and residents in Ouray to be needed (public meeting, 1978). Financing of structures using geothermal energy could be difficult until the financial institutions are better acquainted with the resource resource (George Gault, pers. comm., 1979).

Institutional Requirements - Any geothermal development in the State is subject to certain State requirements. To establish the right to develop the energy, a prospective developer must either own or lease the geothermal rights and the land surface to be used and must have the rights to the water containing the heat if the water is to be consumed. To drill a well requires State permits

(Coe and Forman, 1979). No City ordinances would directly restrict geothermal development; the City has, in fact, historically promoted it (John Brennan, 1979). Zoning and County flood plain, wildlife and geologic hazard regulations require the choice of a suitable location for structures (Susan Rahm, pers. comm., 1979).

Technological Considerations - The procedure for exploring for geothermal energy is aimed toward learning more about the magnitude of the heat, the size of the reservoir, possible reservoir depths, and suitable well locations. It would usually begin with a preliminary exploration program including a geologic evaluation, seismic tests, possibly more geochemical analyses and drilling and gradient holes. A feasibility study is usually conducted to determine whether the investment seems to be warranted and finally a test well (or wells) is drilled and tested. Depending upon the magnitude of the energy demand and the production of the well, the test well may be used as a production well and/or additional wells may be drilled. No analyses are yet available to indicate the technical requirements of this geothermal resource. The water has been piped to the swimming pool and seems not to have caused any undue corrosion or scaling.

Environmental Considerations - Pending a detailed study, the probable environmental effects of geothermal development are not clearly definable. Geologic hazards, abundant wildlife and flood plains will limit development in certain areas of Ouray and Ouray County. In the geothermal water, concentrations of radiochemical elements preclude its potability (Barrett and Pearl, 1979). Sufficient information is not available concerning the effect that the current discharge of the Pool Spring has upon surface water. Water standards and pollution control regulations would indicate the procedures necessary to prevent contamination.

Economic Considerations - Preliminary economic analyses conducted by the New Mexico Energy Institute indicate that the development of geothermal energy would be quite economical per million Btu, as low as $2.47 per million Btu. This is extremely low compared to the current cost of alternative energy resources. The front end cost of developing a system, including retrofitting, could run as high as $2.5 million (Cuniff, et al, 1979).

Potential Uses of Geothermal Energy

The existing energy demand in the City of Ouray is primarily for residential and commercial uses. This analysis will not attempt to predict new industrial consumption. Whether new industry is encouraged to locate in Ouray will depend largely upon the relative value of the various locational criteria such as energy, site availability, transportation and labor market and upon specific incentives that might be provided to industry to locate in the area. A new convention center and/or a large wholistic health spa, which have been suggested, would seem to take good advantage of the truly spectacular and unusual site. Manufacturing of easily-transportable items could, on the other hand, provide higher-paying jobs. Figure D-3 shows the major steps required for development of the geothermal energy. Ouray is currently seeking ways to accomplish the first step of their development process, the feasibility study. As shown, it seems likely that the public buildings, then commercial ones and finally, residences, would be retrofitted. No growth and hence, no increase in energy demand is forecast until some new economic development is accomplished. About 112 billion Btu's of thermal energy could be demanded, given the forecast

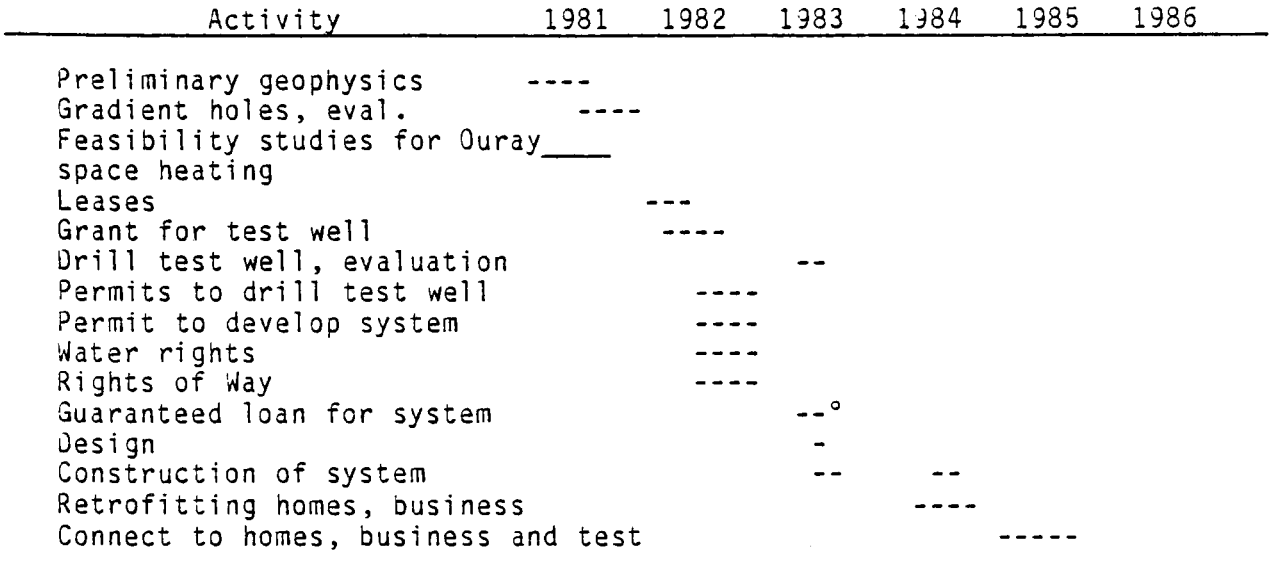
population.

Development Opportunities and Constraints - In Ouray, if estimates are correct, the geothermal energy supply is much in excess of the demand. The commercial buildings in this popular tourist stop, as well as the residences, offer a prime opportunity for geothermal use.

Given the temperature of this resource along with the amount of flow, it may seem surprising that the resource has not been more extensively used. Several conditions seem to have restrained the development. The first of these is the lack of information - about both the resource and about the economic feasibility. The second of the constraints is the lack of funds to obtain such information. There is some concern, too, that drilling a well might result in the loss of the resource into a permiable lower formation or a fault. Until funds are available to help the City do the necessary research, it seems highly unlikely that this energy will be developed, especially in light of its current economic situation.

FIGURE D-3

OURAY HOT SPRINGS
SITE DEVELOPMENT SCHEDULE



SUMMARY

The four sites chosen for these analyses were selected for several reasons. First, they are all located at town sites. Second, the estimated subsurface temperatures are all sufficiently high for space and water heating. Finally strong expressions of interest among residents and potential users were indicated in those areas. They are not considered to necessarily represent the other sites in the State, although many characteristics will certainly be shared because of the commonality of laws, historical development and the similarity of geographic characteristics.

In the case of these four sites, several similarities are apparent, along with some differences. All are located in mountain valleys where space to expand is limited. All are at fairly high elevations. The strongest industrial sector in all of them is trade and services with tourism and recreation stimulating much of the activity. They largely currently lack extensive manufacturing or agricultural processing, although Ouray's historically-important mining industry could revive, depending largely upon the national economy and federal government policy. The Ouray site is economically depressed and could benefit from assistance. All four sites have a large commercial energy demand relative to the residential energy demand, presumably because of the large amounts of heat and hot water necessary for motels and restaurants.

In each case, the development process seems reasonably straightforward, especially since federal leases are not seen to be necessary for direct thermal development of the magnitude discussed. In each case, too, the constraints to development were similar. They included the lack of energy developer interest and the lack of funds and/or development expertise as well as resource information. Among those potential users who were interested, none have so far been able to go beyond the initial conceptual, planning and analyses stages of development. By obtaining a U.S. Department of Energy cost-share contract, the Timberline Academy near Durango will, it is hoped, soon lead to develop a district heating system.

These areas do have potential for geothermal energy development. Geothermal energy also seems to have the potential for aiding the economies of these areas as well as for helping to conserve other energy resources. While their development is likely to be economically feasible, and most beneficial to users, it is not generally perceived by energy developers to be sufficiently profitable to warrant their investment. Community cooperative or user-development therefore seems necessary. If information can be provided to potential users/developers about the resources and about their development feasibility, extensive near-term development will seem more probable. At this point, it seems likely that government cost-shared programs will be necessary to provide that information at these four sites. So far, the focus of federal funding programs for geothermal development has been upon agricultural and industrial processing and on demonstrations of new uses. The demand for commercial and residential energy is not only substantial but is intimately tied to Colorado's economy. Geothermal energy could help supply that demand.

APPENDIX

METHODOLOGY

For the most part, this analysis and possible development scenario used information from secondary sources. Both a variety of publications and numerous individuals were surveyed, as shown in the Sources of Information Section. It was necessary, however, to tailor and choose among these data in many instances. Where these instances are not self-explanatory in the text, they are described below:

Population - Where population estimates and forecasts had been prepared by local organizations, those figures were used in preference to those prepared at another governmental level. Since forecasts were not available for the year 2020, forecasts for 2000 were extropolated to that year, unless there were capacity limits that were lower, such as in Idaho Springs and the northern Animas Valley (Durango area).

Economy - To identify those industrial sectors that could use geothermal energy requires a knowledge of the application and facilities for using geothermal energy.

Energy Demand - The estimates of energy demand were calculated by the New Mexico Energy Institute personnel from a formula, using heating degree days, average low temperature (for peak needs) and estimated square footage. That formula may be found in Rules of Thumb for Geothermal Direct Applications, published by EG&G, Inc., Idaho Falls, Idaho.

The analyses also required some judgment about the future of the economy. Changes based upon acts of God and governmental policy changes, either U.S. or foreign, in particular, are impossible to predict. The scenarios, therefore assume no drastic changes in government policy, in societal values of in natural events. They also assume no drastic changes in available raw materials. As such, for lack of more authoritative knowledge, they assume that the future will be largely like the past and present. Given these and other uncertainties, at least several economic scenarios are possible. As such, the only claim to be made for the scenarios in this report is that they are reasonable, based upon the information provided.

SOURCE OF DATA

Allen, Cap, 1979, Personal communication: Durango, Colorado.

Allen, Gene, 1979, Director, Community Development, Glenwood Springs.

Animas Regional Planning Commission, 1972, Comprehensive plan for the Durango urban area: Durango, Colorado.

Baer, Rudy, 1979, Personal communication.

Barrett, J.K. and Pearl, R.H., 1976, Hydrogeological data of thermal springs and wells in Colorado: Colorado Geol. Survey Info. Series 6, 124 p.

Brennan, John, 1979, Personal communication: San Miguel Power Association, Ouray, Colorado.

Chamber of Commerce, 1979, Pamphlets: Glenwood Springs, Colorado.

Chastain, Hugh, 1979, Personal communication-Durango, Colorado: LaPlata Electric, Durango, Colorado.

City of Idaho Springs, Zoning ordinance.

Coe, B.A., and Forman, N. A., 1980, Regulation of geothermal energy in Colorado: Colorado Geol. Survey, Info. Series 15, 27.

Colby, Steve, 1979, Personnel communciation.

Colorado Dept. of Local Affairs & Reg. Planning Comm., 1976, An analysis of opportunities for devlopment, Colorado Planning and management region 10: Colorado Dept. of Local Affairs, Denver, Colorado.

Colorado Division of Housing, 1978, Housing in Colorado: Estimates of housing inventory and household characteristics for January 1, 1977, and projections of household growth to January 1, 1982: Colorado Dept. of Local Affairs, Denver, Colorado.

Colorado Divison of Commerce and Development, 1978, Durango community profile: Colorado Dept. of Local Affairs, Denver, Colorado.

Colorado Public Utilities Commission, 1977, unpublished data.

Colorado State Planning Office, 1968, General plan, Garfield County, Colorado: State of Colorado, Denver, Colorado.

Colorado West Council of Governments, 1977, Growth monitoring system.

Cuniff, Roy, et al, 1979, unpublished economic analysis data: Physical Science Lab, New Mexico State University, Las Cruces, New Mexico.

SOURCE OF DATA

Del Duca, Edward, and others, 1975, Land use, where do we go from here?: San Juan Basin Regional Planning Commission, Durango, Colorado.

Division of Business Research, 1975, Colorado regional development profile, Plateau Region: Graduate School of Business Adm., Univ. of Colorado, Boulder, Colorado.

Division of Commerce and Development, 1974, Durango community profile: Colorado Dept. of Local Affairs,, Denver, Colorado.

Divison of Business Research, 1978, San Juan Basin Colorado Planning and management region 9, Colorado regional development profile: Graduate School of Business Administration, Univ. of Colorado, Boulder, Colorado.

E.G.&G., 1978, Rules of thumb for geothermal direct applications: E.G.&G., Idaho Falls, Idaho.

Fernandez, John, 1979, List of Glenwood Springs facilities, ordinances, boards and tax base information (unpub): Glenwood Springs Planning Commission.

___1979, Personal communication: Glenwood Springs Planning Office, Glenwood Springs, Colorado.

Garfield County, 1972, Subdivision regulations: Garfield County, Glenwood Springs, Colorado.

Gault, George, 1979, Personal communication: Ouray, Colorado.

Harmon, O'Donnell and Henninger Assoc., Inc., 1979, "Summary of findings" for proposed Glenwood shopping center: Denver, Colorado.

Heines, Lee, 1979, Pesonal communication--Glenwood Springs, Colorado: Rocky Mountain Natural Gas Co., Glenwood Springs, Colorado.

Idaho Springs, "Siftings-News": Idaho Springs Chamber of Commerce, v. 14, Idaho Springs, Colorado.

James M. Hunter and Assoc., 1969, Planning report: Community cultural complex, Durango, Colorado: Boulder, Colorado.

Johnson's City Directory, 1978, Durango city directory.

Johnson, Thomas, 1979, Personal communication: City administrator, Idaho Springs, Colorado.

Kyner, Wynn, 1979, Personal communication--Glenwood Springs: Glenwood Springs building inspector.

SOURCE OF DATA

Maxwell, James, 1979, Personal communication--Idaho Springs: Indian Springs Resort, Idaho Springs, Colorado.

McDowell-Smith, Assoc., 1975, Evaluation of selected community needs, Rifle, Colorado.

Mountain Bell, 1979, Yellow pages: Idaho Springs Telephone Directory.

Murdock, Robert, 1979, Personal communication--Durango, Colorado: United Bank of Denver, Denver, Colorado.

Nixon, John, 1979, Personal communication--Idaho Springs: Public Service Co. of Colorado, Idaho Springs, Colorado.

Oblinger-Smith Corp., 1972, Ouray County, Colorado, water and sewer facility plan: Denver, Colorado.

Ouray Chamber of Commerce, Unpublished data.

Ouray County, 1976, Housing report, city of Ouray, Colorado.

Ouray geothermal energy advisory committee minutes, 1978, unpublished: Ouray, Colorado.

Parsons, Don, 1979, Personal communication--Glenwood Springs: Rocky Mountain Natural Gas Co., Glenwood Springs, Colorado.

Pearl, R.H., 1979, Colorado's hydrothermal resource base--An assessment: Colorado Geol. Survey, Resource Series 6, Denver, Colorado, 144 p.

Phillips, Brandt, Reddick, 1978, The City of Durango land and resource management program (draft copy): Durango, Colorado.

Planning and Zoning Office, 1973, Zoning regulations of Garfield County, Colorado: Garfield County, Glenwood Springs, Colorado.

Rahm, Susan, 1979, Personal communication--Ouray: Ouray city council, committee on economic studies, Ouray, Colorado.

Reynolds, Dallas, 1979, Personal communication--Durango: Phillips, Brandt, Reddick, Durango, Colorado.

Ryan, Charles, 1976, Population and economy, Ouray County, Colorado (Draft Copy): Dist. 10 Planning Comm., Montrose, Colorado.

___1977, Overall economic development program, Region 10: Regional Planning Commission, Montrose, Colorado.

San Juan Regional Commission, 1978, Southwest Coloado regional overall economic development program: Durango, Colorado.

SOURCE OF DATA

Scales, K. E., 1972, Idaho Springs community profile: Colorado Division of Commerce and Development.

Scales, Kathy, 1972, Idaho Springs community profile: Colorado Div. of Commerce and Development.

Schmueser, Larry, 1979, Personal communication: City Manager, Glenwood Springs, Colorado, Glenwood Springs, Colorado.

Schultz, Janet, 1979, Personal communication: Colorado Geological Survey, Denver, Colorado.

Shaw, Andy, 1979, Personal communication--Idaho Springs: Golden Savings and Loan Assoc, Idaho Springs, Colorado.

Short, Ronald, 1979, Personal communication--Durango: San Juan Regional Commission, Durano, Colorado.

Sisson, William, 1979, Personal communication--Glenwood Springs: Bank of Glenwood Springs, Glenwood Springs, Colorado.

Soil Conservation Service, 1971, General soil map, LaPlata County, Colorado: U.S. Dept. of Agriculture.

Taylor and Scanlon and Assoc., 1973, Comprehensive plan for Idaho Springs.

U.S. Bureau of the Census, 1977, County business patterns, 1975, Colorado: Washington, D.C.

___1979, Personnel communication: Denver, Colorado.

Wadsworth, Stanley, 1979, Personal communication: Tamarron Resort, Durango, Colorado.

Walters, Marvin, 1979, Personal communication--Durango: Peoples Natural Gas Co,, Durango, Colorado.

West, Robert, 1979, Personal communication: Becvaric/Wright, Glenwood Springs, Colorado.

Williams, Ralph, 1979, Personal communication: Univ. of Denver Research Institute, Denver, Colorado.