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# GEOTHERMAL ENERGY POTENTIAL IN CHAFFEE COUNTY, COLORADO

by

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## INTRODUCTION

Chaffee County, located in central Colorado, has immense potential for geothermal development. This report has been prepared to assist residents and developers in and outside the area to develop the hydrothermal resources of the county. Data has been collected and interpreted from numerous sources in order to introduce a general description of the area, estimate energy requirements, describe the resources and postulate a development plan. This report describes electric power generation and direct heat application potential for the region and should be used in conjunction with the many excellent geothermal publications that are readily available.

## AREA DESCRIPTION

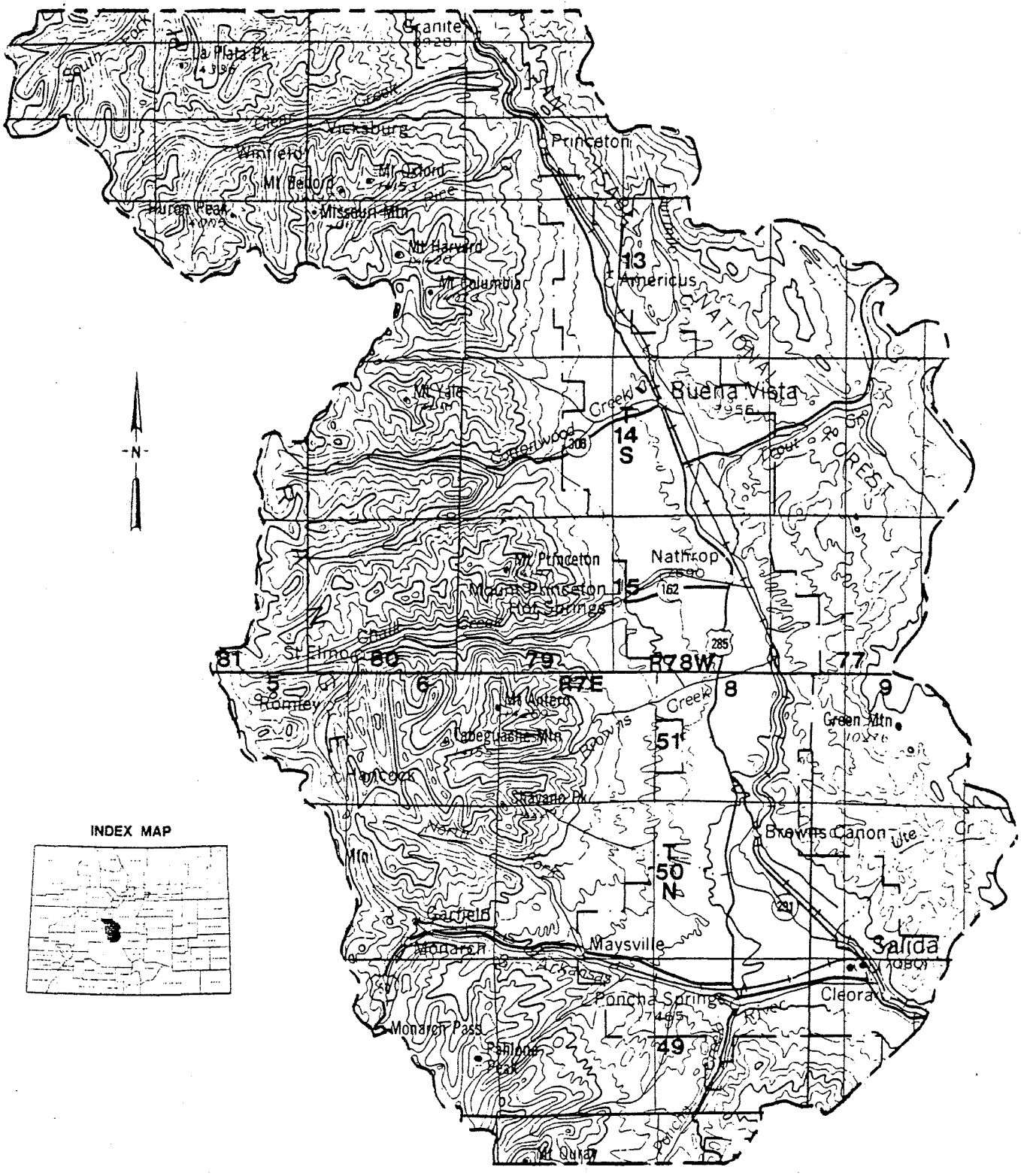
Chaffee County, located within Colorado Planning and Management Region Number 13, encompasses an area of approximately 1027 square miles. Located on the eastern slope of the Continental Divide, the county is nearly in the geographic center of the state (Fig. 1).

Elevations within the county vary between 6,900 and 14,414 feet above mean sea level. The area is dominated topographically by the Arkansas River, which bisects the county flowing from north to south. Major tributaries of the Arkansas River include the South Arkansas River, Cottonwood Creek, Chalk Creek, Clear Creek and Trout Creek.

Nearly all of the urban development is concentrated along the Arkansas River. There are three incorporated municipalities in the county: Salida, the county seat, Buena Vista and Poncha Springs. Numerous smaller unincorporated "hamlets" and subdivisions located throughout the County area are mainly concentrated along the major highways and the Arkansas River (Fig. 1).

## GENERAL GEOLOGY

The Upper Arkansas Valley Basin, (known locally as the Collegiate Valley) within which Chaffee County is located, is part of the northern extension of the Rio Grande rift zone, extending from southern New Mexico northward to




# CHAFFEE COUNTY

## COLORADO

FIGURE 1

central Colorado. Faulting associated with the Rio Grande rift zone has generally resulted in local surface manifestations of hydrothermal springs in Chaffee County.

The area is bounded on the west by the Sawatch Range, the Arkansas Hills on the east and the Sangre de Cristo Range on the southeast. The Sawatch range, which reaches as much as 7000 feet above the valley floor, consists of predominantly Precambrian age metamorphic and igueous rocks and Tertiary intrusives. The Arkansas Hills, the southern limit of the Mosquito Range (Romero and Fawcett, 1978), consist of Precambrian metamorphic and igneous rocks capped in places by complexly folded and faulted Paleozoic sedimentary rocks and Tertiary age volcanics. The Arkansas Hills are a small mountain area in comparison to the towering peaks of the Sawatch Range to the west. Sedimentary deposits found along the interior portions of the county include both consolidated and unconsolidated sediments of Tertiary and Quaternary ages.

## CLIMATE

Climatic conditions in the county vary with elevation and location. The climate is mainly influenced by air movement over the surrounding mountain masses. Prevailing winds are from the southwest near Poncha Springs and Salida in the southern portion of the county and from the north, northwest in the northern portion. Precipitation from the west is mostly intercepted by the high mountains. Annual precipitation in the county ranges from over 30 inches in the western mountains to under 10 inches on the valley floor. Typical climatic conditions for the valley floor include low precipitation, low humidity, abundant sunshine, wide daily temperature range, and generally light winds. The average time between freezing temperatures during the summer months is approximately 107 days. Average monthly temperatures range from a low of appoximately 2°F in December to a high of approximately 85° F during July and August. The area around Buena Vista in the northern part of the county experiences slightly cooler temperatures throughout the year than the Salida and Poncha Springs area (UAACOG, 1976).

## LAND USE AND OWNERSHIP

Chaffee County includes approximately 657,150 acres. Land use patterns in the county follow a pattern according to the differing land types.

Major communities, most subdivisions, irrigated farming and ranching are located along the relativity flat river plains and adjoining terraces. Grazing, recreational activity and some lumber activity occurs above these flatter areas on the high terraces and forest lands. Isolated mining activity is also found in these areas. On the relatively steep slopes of the high mountains, recreation and open space is the primary land use.

As can be seen from Table 1, the United States Forest Service is the largest single land owner. The privately owned land is mainly along the west side of the Arkansas River and along its tributaries. Numerous small parcels of privately held land are found within the government land (Fig. 2.). In addition, it should be noted that certain portions of the county reflect this "checkerboard pattern" where federal, state, and privately owned lands alternate. A developer often must obtain federal, state or private leases to adequately secure a potential hydrothermal development.

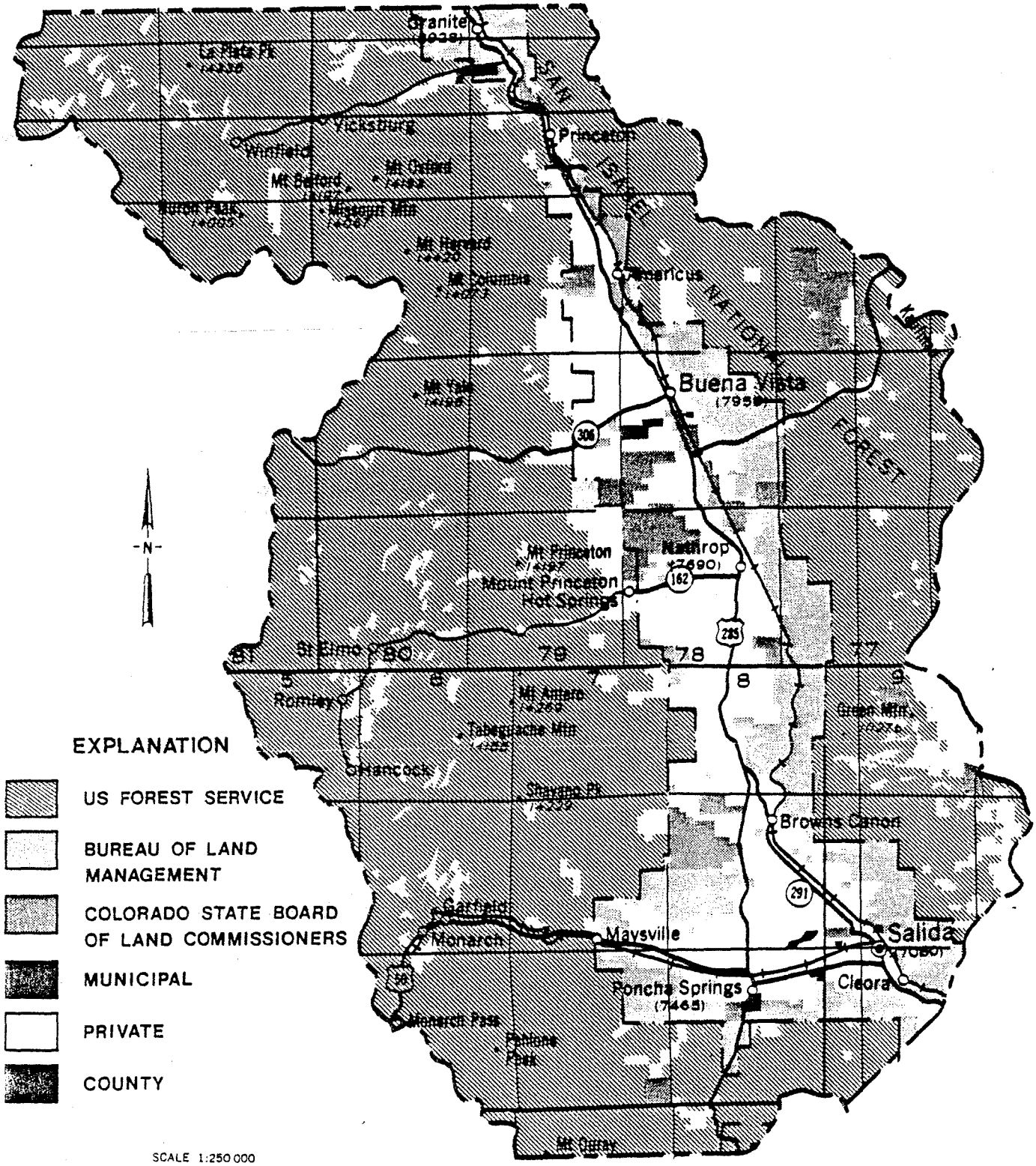
TABLE 1

APPROXIMATE LAND OWNERSHIP
IN CHAFFEE COUNTY

| | Acres | % of Total |
|---|---|---|
| U.S. Forest Service | 450,769 | 69 |
| Bureau of Land Management | 54,031 | 8 |
| State of Colorado | 20,103 | 3 |
| County and Municipal | 3,511 | 0.5 |
| Private | 128,736 | 19.5 |
| TOTAL | 657,150 | 100.0 |

SOURCE: UAACOG,1976

Salida and Buena Vista, the two major urban areas in Chaffee County, are the centers of the largest development pressure areas in the county (UAACOG, 1976). In addition, subdivision activity is present in the area, with over 45 subdivisions in the county as of 1976. (Latest year of record). Zoning plans for the county adopted in December of 1974 are set up to encourage growth and development on land adjacent to the existing growth centers (UAACOG, 1976).




# LAND OWNERSHIP
# CHAFFEE COUNTY
# COLORADO

FIGURE 2

## POPULATION

Population increases have occurred steadily in Chaffee County since 1960. This increase has taken place primarily in the unincorporated areas of the county with the incorporated cities increasing also, but at a slower rate. The growth in the rural areas is mainly attributed to subdivision activity from the early 1960s to the present. Table 2 lists the population history and projections for the area.

### TABLE 2

CHAFFEE COUNTY POPULATION

| | 1960[1] | 1970[1] | 1980[2] Est. | 1990[2] Est. | 2000 Est. | 2020 Est. |
|---|---|---|---|---|---|---|
| CHAFFEE COUNTY | 8,298 | 10,162 | 12,600 | 15,700 | 19,106[3] | 28,390[5] |
| BUENA VISTA | 1,806 | 1,962 | 2,979 | 4,139 | 5,037[4] | 7,484[4] |
| PONCHA SPRINGS | 201 | 198 | 428 | 676 | 823[4] | 1,223[4] |
| SALIDA | 4,560 | 4,355 | 5,455 | 6,839 | 8,323[4] | 12,368[4] |
| UNINCOR-PORATED | 1,731 | 3,647 | 3,738 | 4,045 | 4,923[4] | 7,315[4] |

SOURCE:
1. U.S. Dept. of Commerce, Bureau of the Census, 1960 and 1970
2. Population Estimates and Projections, Colorado Division of Planning, Series CP-25, Number 79 (c)-1, October 1979
3. Colorado Population Trends, Colorado Division of Planning, Vo. 5, Number 1, Winter 1976
4. Colorado Geological Survey Estimates
5. New Mexico Energy Institute Estimates

## ECONOMIC ACTIVITY AND CONDITIONS

Historically, agriculture, the railroad industry and mining were the principal enconomic activities in Chaffee County. With the decline of the mining era and the passing of Salida as a major railhead in 1975, the county's economy now is predominantly dependent on tourism and agriculture within the county, major mining projects outside the county and the Colorado State Reformatory near Buena Vista.

Chaffee County's present economy can be considered as "healthy". Major employers for persons residing in the county are listed on Table 3. It should be noted that some of the major employers are located outside the county boundaries, but within commuting distances. Examples of this include the AMAX Molybdenum mine at Climax, near Leadville and Homestake Mining Company's facility near Sargents.

A listing of county businesses is shown on Table 4. The area is well endowed with a full range of retail and wholesale services. Between 1973 and 1978, 256 new businesses were started in Chaffee County. Approximately 160 of these businesses do not predict expansion, 93 plan to expand, 33 that are planning expansion do not expect to increase their labor force and 63 plan to expand and add employees as necessary (Economic Overview, Region 13, 1978). These small businesses normally would not be considered as important to growth and human settlement as the larger employers. However, when relating these statistics to the population of the county, these small enterprises become an important factor to the area's economic base.

According to the Chaffee County Comprehensive Plan compiled in 1976, the constraints affecting continued economic development are water availability, mountain freight rates, natural resource availability and energy fuels. If geothermal exploration proves successful and productive, some of these constraints will be diminished (UAACOG, 1976).

TABLE 3

MAJOR EMPLOYERS
CHAFFEE COUNTY REGION

| | EMPLOYEES | | |
|---|---|---|---|
| | Present 1978 | 1983 | Proposed 1990 |
| Public Service Company | 19 | 20 | 25 |
| Rio Grande Railroad | 20 | 15-20 | 15-20 |
| Safeway Stores, Inc. | 42 | 80 | 110 |
| First National Bank | 32 | 37 | 42 |
| U.S. Post Office - Salida | 35 | 35 | 40-45 |
| City of Salida | 33 | 38 | 50-60 |
| Chaffee County | 105 | -- | -- |
| School District R-32-J | 124 | -- | -- |
| City of Buena Vista | 12 | -- | -- |
| Calco, Inc. | 14 | 42 | 60 |
| Sangre de Cristo | 24 | -- | -- |
| Gibson's | 25 | 28 | 32 |
| Salida Transfer | 5 | -- | -- |
| Mountain Bell | 22 | 25 | 25 |
| Hascall & Haines Chevrolet | 20 | 25 | 40 |
| Butala Construction | 25 | -- | -- |
| Avery Construction | 30-40 | -- | -- |
| Picknee Construction | 6 | -- | -- |
| Salida Hospital | 101 | -- | -- |
| Columbine Manor | 40-45 | 50 | 50 |
| Chaffee County Bank | 17 | 25 | 25 |
| Climax Mine-AMAX | 771 | -- | -- |
| Buena Vista School District | 112 | -- | -- |
| U.S. Soil | 40 | 85 | 100 |
| Colorado State Reformatory | 196 | -- | -- |
| Cozinco | 25 | -- | -- |
| CF&I Steel | 35 | -- | -- |
| Monarch Recreation | 100 | -- | -- |
| Homestake Mining | 45 | Increase to 171 for life of project (estimated 40% Chaffee County residents) | |

SOURCE: Economic Overview, Region 13, December 1978

TABLE 4

CHAFFEE COUNTY BUSINESS SUMMARY

ACCOUNTANTS

Abramczyk, J.D.
Lindbloom & Co., Inc.
Marshall, Robert R.
Provenza, Stanley
Touber, Edward

AGRICULTURAL EQUIPMENT & SUPPLY

Fairplay Western Store
Hughes Oil and Implement
Johnson Village Feed and Coal
Salida Feed and Farm Supply
Vista Feed and Coal

AUTOMOBILE DEALERS, SERVICE STATIONS, ETC.

Argy's Motor Company
Acme Brake Company
Boesch Motors, Inc.
Bob's Conoco
Bob's Standard
Bradbury Conoco
Buena Vista Auto Clinic
Buena Vista Standard Station
Blackwell's Rocky Mtn. Oil Co.
Downtown Auto Body Shop
Exxon Oil Products
Foreman Sales and Service
Gately Motor Company
Gunsmoke Trading Post
Hascall and Haines Chevrolet
Hertz Rent-a-Car
High Country Automotive
Hi-Way Auto & Mobile Home Sales
Hughes Oil & Implement Co.
Husky Oil
Jim's Transmission and Gear
Kelley Motor Service
Kolbeck Service
Lewis Petroleum Products Co.
Monarch Motors, Inc

AUTOMOBILE DEALERS SERVICE STATIONS, ETC. CONT.

Morrison Repair
Pete's Auto Repair
Pitney and Son Auto Sales
Pond M. Auto Parts
Riley's Auto
Sak's Auto, Inc.
Salerno Service
Salida Automotive Parts
Salida Auto Salvage
Salida Ford
Smitty's Garage
Spa Standard Service Station
Stallsworth Motor Co.
Ted's Auto Sales
Texaco Products
Vista Auto Supply
Western Auto Store

BUILDING MATERIALS, SUPPLIES, HARDWARE

Coast to Coast
Cody Hardware
Hart Rok Redi Mix Concrete, Inc.
Hobbs Linoleum Tile & Carpet
Hylton Lumber Co.
JM Floor Covering
Knotty Pine Lumber & Hardware
Nick's Lumber Co.
Midland Home Center
Patterson Hardware Co.
Salida True Value Hardware
Salida Floor Covering
S. and M. Specialties
Scott's Ace Home Center

CAMPGROUNDS

Brown's Campground
Buena Vista KOA
Crazyhorse Camping Resort
Fessler's Trailer Park
Four Seasons Mobile Home Park

TABLE 4 CONTINUED

CAMPGROUNDS, CONT.

Gingerbread Ranch
KOA Campground

CHAMBERS OF COMMERCE

Buena Vista
Salida

CHURCHES

Assembly of God
Buena Vista Church of Christ
Christian Science Soc. of Salida
Church of the Ascension
Church of Christ
Church of Jesus Christ of Latter Day Saints
Church of the Nazarene
Congreg. United Church of Christ
First Baptist
First Christian
First Church of Christ Scientist
First Lutheran
First Presbyterian
Foursquare Gospel
Grace Episcopal
Jehovah's Witnesses
Mountain Heights Baptist
Mountain View Church of Christ
Pentecostal Church of God
Poncha Springs Church of Christ
St. Joseph's Catholic
St. Rose of Lima
Temple Baptist
Seventh Day Adventist
United Methodist

CLEANERS-LAUNDRIES

Band Box Cleaners
Buena Vista Cleaners & Laundry
Easy Self Service
Halverson's Laundry & Dry Cleaning
Tolle's Coin-Op Laundry

CONSTRUCTION -CONTRACTORS

Acme Electric
Antero Electric
Arkansas Valley Contractors

CONSTRUCTION CONTRACTORS, CONT.

Avery Structures, Inc.
Betco Construction Co.
Buena Vista Heating & Sheet Metal
Buena Vista Truss Co.
Butala Construction Co.
Chaffee Heating & Service Co.
Cummins Construction
Continental Home Builders, Inc.
Cooper Plumbing
Deluca Gas Co., Inc.
Dey Electric
Farwest Houses
Robert L. Kane
Kay's Karpentry
Lou's Electric
Lowry Crane Service
M and M Backhoe Service
Mill and Cabinet Shop
Mountain Enterprises
Ouray Construction
Pickrel Construction, Inc.
Pridemore Construction
Rupp Plumbing & Heating
S & M Specialties
George Sabin
Salida Builders
Scott Electric
Sneddon Plumbing & Heating
Unique Concrete
United Construction of Colo.
Vista Electric
Y & K Excavation

FINANCE, INSURANCE, REALTY

Buena Vista Bank & Trust Co.
Buena Vista Realty
Chaffee County Bank
Chuck Lee Realty
Collegiate Peaks Realty
Don Porco
Farmers Insurance Group
First National Bank
Harold R. Koster
John Peeples Realty
M & K Realty and Auction Co.
Mountain Realty
NWP of Salida
Realty One
Salida Brokerage

TABLE 4 CONTINUED

FINANCE, INSURANCE, REALTY CONTINUED

Salida Building & Loan
Salida Industrial Bank
Salida Land & Investment
Salida Realty
South Insurance Agency
State Farm Insurance
Strout Realty
Tally Realty
Western Partners
World Savings & Loan Assn.

FURNITURE, APPLIANCES

A-1 Service
Acme Electric
Brainbridge Furn. & Upholstery Co.
Canon Furn. Warehouse & Appliance
Church's Appliance and Refrigeration Service
Ed's Upholstery & Furniture
Greenberg Furniture
Hartman's Furniture
Lind Repair Service
McDonald's Refrigeration
Montgomery Ward & Co.
Rest Better Water Beds
Teller St. Econo Shop
Turnabout Shop
Vista TV and Furniture
Your Furniture Store

GROCERS

Burmac Enterprises
Circle Super Grocery
E-Z Way Stores
Gunsmoke Trading Post
High Valley Center
Loaf/Jug Store
Minit Market
Oxford's Market
Seven Eleven
Super Foods
Vista Super Market
The Way Station

LODGING, RESORTS, GUEST RANCHES, GUIDE SERVICES

Aspen Leaf Cottages
Buena Vista Hotel
Chateau Chapparal Lodge
Circle R. Motel
Colorado Lodge
Coronado Motel
Cottonwood Creek Log Cabins
Deer Valley Ranch
Hi-Lander Motel
Jackson Hotel
Lakeside Motel
Little River Motel
Log Cabin Court
Lost Creek Ranch
Moline Hotel
Monarch Motor Lodge
Monarch Ski Area
Motel Martha
Motel Westerner
Mt. Princeton Hot Springs
Mt. Shavano Cabins
Mountain View Motel
The Palace Hotel
Park Motel
Pinon Court
Ponderosa Guest Ranch
Rainbow Motel
Ranch House Lodge
Red Log Motel
Redwood Lodge
Rocky Mountain Lodge
Shavano Motel
Silver Wheel Motel
Stagecoach Motel
Sumac Lodge
Thunder Lodge
Topaz Lodge
Trail Head Ventures
Vista Court
Wagon Wheel Ranch
West Wind Motel
Western Holiday Motel
Woodland Brook Cabins

TABLE 4 CONTINUED

MEDICAL

Chaffee County Ambulance Service
Cline, Donald W., M.D.
Firestone, Stephen W., DDS
Jones, Ron, DDS
Leonardi, Leo J., M.D.
Lons, Bruce, DDS
McCallon, T.D., M.D.
McGowan, R.A., M.D.
Mehos, William G., M.D.
Rowland, Jack R., DDS
Sandell, Thomas G., M.D.
Smith, Robert B., M.D.
Spray, S.M., M.D.
Steinauer, J.J., DDS
Veltri, Victor, DDS
Weber, Mark W., M.D.

RESTAURANTS

Aspen Leaf
Casa Del Sol
Club Rio
The Corral
Corral Steak House
Cranberry Kitchen
Delaney's Depot
Dinner Bell Cafe
Dooley's Bar
Four K's Cafe
Jackson Hotel
Lamplighter Restaurant
Lariet Cafe and Bar
Little River Cafe
Luigi's Cafe
Main Bar and Steak House
Mother's Kitchen
Monarch Ramada Inn
Neil's Cafe
The Office
The Other Place
The Palace Cafe
Patio Pancake Place
Pizza Hut
Poncha Malt Shop
Poncha Truck Shop
Salida Inn
Samara Inn

RESTAURANTS CONT.

The Spa
Sportsman's Center and Cafe
Strandberg's at Joe Furphy's
The Sub Store
Super Bowl
Swissvale Manor
Three Thieves
Tinker Tavern
Tisings Stage Coach Cafe & Lounge
Uncle Dick's
Valley Country Kitchen

TRANSPORTATION

Salida Flying Service
Shavano Air Service
Trailways Bus System

MISCELLANEOUS

Antique Shops
Architects
Barbers
Beauty Salons
Book Dealers
Dairies
Department & Clothing Stores
Engineering Consultants
Florists
Greenhouses
Gift Shops
Liquor Stores
Office Supplies

SOURCE: Mountain Bell, March 1979

Table 5 lists employment and wage statistics for 1976, 1977 and 1978. A steady growth in most categories is shown in number of units, persons employed and wages. This growth is evident in Table 6 where labor force and unemployment is listed. A comparison of Chaffee County unemployment and Colorado unemployment shows the county has slightly higher unemployment than the state average, but not by a significant amount. Spendable income per household is listed on Table 7.

Tables 8 and 9 show community business indicators, debts, budgets and taxes for Buena Vista and Salida. As can be seen from Table 9, the sales taxes are contributing less than the maximum allowable tax of 4 percent. Additional revenue for development could be collected from this source, if necessary.

## ATTITUDES

Residents contacted in Chaffee County are generally in support of geothermal development in the area. However, a large scale project, if damaging to the environment and scenic beauty of the county would be highly undesirable. Large industry within the county is not anticipated to become a large contributor to the area's economic base. Residents and local officials are favorable to small commercial, residential and tourism-related developments which are compatible with Chaffee County's steady increase in economic development.

The Chaffee County Comprehensive Plan prepared in 1976 recognizes the potential for geothermal development in the area and resultant growth and development (UAACOG, 1976). Geothermal exploration and consulting firms working in Chaffee County, while emphasizing their particular interests, are willing to work with local officials and residents in order to promote development compatible with area interests and priorities.

TABLE 5

CHAFFEE COUNTY
EMPLOYMENT AND WAGES

| INDUSTRY | 1976 | UNITS | EMPLOYMENT | WAGES |
|---|---|---|---|---|
| Agriculture | | 4 | 15 | $ 8,173 |
| Mining | | C | C | C |
| Construction | | 30 | 171 | 13,023 |
| Manufacturing | | 10 | 110 | 8,601 |
| Transportation | | 17 | 198 | 11,927 |
| Wholesale | | 17 | 86 | 7,696 |
| Retail | | 144 | 827 | 4,813 |
| Fin., Ins., & Real Est. | | 23 | 105 | 7,936 |
| Services | | 80 | 554 | 5,525 |
| Public Administration | | 5 | 267 | 15,760 |
| | 1977 | | | |
| Agrigulture | | 4 | 20 | 8,569 |
| Mining | | C | C | C |
| Construction | | 39 | 261 | 10,045 |
| Manufacturing | | 10 | 117 | 9,040 |
| Transportation | | 16 | 155 | 13,774 |
| Wholesale | | 19 | 84 | 7,396 |
| Retail | | 149 | 850 | 5,136 |
| Fin., Ins., & Real Est. | | 24 | 113 | 8,343 |
| Services | | 82 | 550 | 6,149 |
| Public Administration | | 6 | 263 | 16,480 |
| | 1978 | | | |
| Agriculture | | 7 | 41 | 8,420 |
| Mining | | C | C | C |
| Construction | | 46 | 283 | 14,711 |
| Manufacturing | | 12 | 135 | 8,924 |
| Transportation | | 17 | 150 | 14,909 |
| Wholesale | | 19 | 105 | 7,410 |
| Retail | | 144 | 799 | 5,790 |
| Fin., Ins., & Real Est. | | 26 | 120 | 8,752 |
| Services | | 98 | 830 | 7,269 |
| Public Administration | | 12 | 413 | 13,741 |

C = Confidential

NOTE: Figures include only employers contributing to unemployment insurance.

SOURCE: State of Colorado, Division of Employment Research and Analysis

TABLE 6

CHAFFEE COUNTY
LABOR FORCE AND UNEMPLOYMENT
AVERAGE MONTHLY FIGURES

| YEAR | TOTAL LABOR FORCE | TOTAL EMPLOYED FORCE | PERCENT UNEMPLOYED | STATEWIDE PERCENT UNEMPLOYED |
|---|---|---|---|---|
| 1970 | 3717 | 3570 | 4 | 3.5 |
| 1974 | 5052 | 4840 | 4.2 | 3.5 |
| 1979 | 6260 | 5980 | 4.5 | 3.2 |

SOURCE: State of Colorado, Division of Employment, Research and Analysis

TABLE 7

CHAFFEE COUNTY
SPENDABLE INCOME - PERCENT OF HOUSEHOLDS

| | |
|---|---|
| $ 0- 7,999 | 35.9 |
| $ 8,000- 9,999 | 8.9 |
| $10,000-14,999 | 26.4 |
| $15,000-24,999 | 25.0 |
| $25,000 plus | 3.8 |

Median household income $11,074

SOURCE: Sales and Marketing Management - July 1978 in Colorado Community Profiles: Buena Vista and Salida

TABLE 8

CHAFFEE COUNTY
BUSINESS INDICATORS IN SELECTED COMMUNITIES

BUENA VISTA

Major Community Sources of Income: Mining, State Government, Tourism

| | 1970 | 1978 | % CHANGE |
|---|---|---|---|
| Gross Retail Sales ($000) | 6,685,000 | 16,043,000 | 139.9 |
| Residential Building Permits ($) | N.A | 857,000 | -- |
| Non-Residential Building Permits ($) | N.A. | N.A. | -- |
| Bank Deposits ($) | 1,963,159 | 5,173,000 | 163.5 |
| Assessed Valuation of Community ($) | 2,679,540 | 5,460,480 | 103.8 |

SALIDA

Major Community Sources of Income: Trade, Tourism, Mining

| | 1970 | 1977 | % CHANGE |
|---|---|---|---|
| Gross Retail Sales ($000) | 15,219,000 | 36,424,000 | 139.3 |
| Residential Buillding Permits ($) | 0 | 1,080,610 | -- |
| Non Residential Building Permits ($) | 88,539 | 108,630 | 22.6 |
| Bank Deposits ($) | 7,095,722 | 28,553,000 | 302.3 |
| Assessed Valuation Community ($) | 6,045,970 | 12,816,940 | 111.9 |

N.A. = NOT AVAILABLE

SOURCE: Sales and Marketing Management, July 1978, in Colorado Community Profiles: Salida and Buena Vista

TABLE 9

CHAFFEE COUNTY
DEBT, BUDGET AND TAXES FOR SELECTED COMMUNITIES

| | BUENA VISTA | | SALIDA |
|---|---|---|---|
| COMMUNITY DEBT OUTSTANDING: | | | |
| General Obligation Bonds ($) | 370,000 | | 0 |
| Revenue Bond ($) | 712,000 | | 0 |
| Sewer and Street Improvement Bond ($) | 45,000 | | 0 |
| Utility Bonds ($) | --- | | 315,908 |
| Total Debt ($) | 1,127,000 | | 315,908 |
| ANNUAL COMMUNITY BUDGET: | | | |
| Total Revenues ($) | 310,500 | | 901,354 |
| Total Expenditures ($) | 242,600 | | 901,354 |
| SALES TAX | | | |
| Community | 1% | | 0% |
| County | | 1% | |
| State | | 3% | |

SOURCE: Colorado Community Profile: Salida and Buena Vista, March 1977, Colorado Department of Local Affairs

## ENERGY DEMAND

The potential for electric power generation using hydrothermal energy is currently being investigated by exploration firms in the area. Their interests and present activities will be discussed in a later section entitled, "Hydrothermal Energy Development, Development Activities".

In addition to the potential for electrical power generation, it is anticipated that much of the hydrothermal resource found in Chaffee County will be developed for direct thermal use. Wastewater from electric power plants could be utilized in a direct thermal capacity. A comparison is therefore in order for natural gas consumption in the county, which is most likely the energy fuel to be replaced by a direct thermal use development project.

As shown on Table 10, five communities are served by natural gas in Chaffee County. Also, some residences and businesses in close proximity to these communities have natural gas service, with the remainder of the county using propane or electricity for their energy requirements. Natural gas consumption is listed on Table 11, and industrial users are listed on Table 12. It is anticipated that direct heat projects will be constructed in these more densely populated areas of the county. The estimated current and projected thermal energy demand for residential and commercial customers is shown on Table 13. It is estimated that the residential and commercial consumption will increase approximately 3.4% per year between 1980 and 2020.

As can be seen on Table 12, all but one industrial user (Cozinco, Inc.), primarily consumes natural gas for space heating and hot water consumption. Cozinco is a zinc refining operation with 1978 employment of 25 persons with no anticipated change through 1990 (Colorado Department of Local Affairs/Four Corners Regional Commission, 1978). A major portion of industrial use in the county is the Colorado State Reformatory near Buena Vista. Natural gas uses at this facility include: space heating, domestic uses, laundry, and vocational training shops. The reformatory employs approximately 180 persons and has approximately 520 inmates.

TABLE 10

CHAFFEE COUNTY COMMUNITIES SERVED
BY NATURAL GAS 1978

Buena Vista
Johnson's Village
Nathrop
Poncha Springs
Salida

SOURCE: Colorado Public Utilities Commission

TABLE 11

CHAFFEE COUNTY NATURAL GAS CONSUMPTION - 1978

| | CONSUMPTION* |
|---|---|
| Residential | 264,168 |
| Commercial | 199,080 |
| Industrial | 95,218 |
| TOTAL | 558,466 |

* MCF at 14.73 psia

SOURCE: Colorado Public Utilities Commission

TABLE 12

CHAFFEE COUNTY INDUSTRIAL NATURAL GAS USERS - 1979

| USER | CONSUMPTION* | BTU's x $10^{10}$ |
|---|---|---|
| Colorado State Reformatory | 77,852.0 | 6.6174 |
| Cozinco, Inc. | 5,701.9 | 0.5326 |
| Chaffee County Court House | 2,818.9 | 0.2633 |
| Salida Hospital | 9,713.6 | 0.9073 |
| Salida High School | 7,061.1 | 0.6595 |
| TOTAL | 103,147.5 | 8.9801 |

*MCF at 14.73 psia

SOURCES: Greeley Gas Company
Colorado Public Utilities Commission

Manufacturers in Chaffee County are listed on Table 14. Energy consumption figures are based upon average national consumption rates for industry categories. It should be noted that Chaffee County industries may be smaller and consume less energy than the nationwide average. This is most likely a reflection of the rural, low-industrial character of the area. Required temperatures for these industries indicate that the resources present in Chaffee County could satisfy much of the area's manfacturing energy requirements.

TABLE 13

ESTIMATED THERMAL ENERGY DEMAND FOR
SELECTED COMMUNITIES IN CHAFFEE COUNTY
(RESIDENTIAL AND COMMERCIAL)

| Community | Estimated Population 1980[1] | Est. Dwelling Units 1980[2] | BTU's x 1010 Est. Residential and Commercial Thermal Energy Demand 1980[3] | Forecast Population 2020[4] | Forecast Dwelling Units | BTU's x $10^{10}$ Est. Residential and Commercial Thermal Energy Demand 2020 | Yearly Energy Consumption Increase (BTU's x $10^{10}$) |
|---|---|---|---|---|---|---|---|
| Buena Vista | 2979 | 1064 | | 7484 | 2673 | | |
| Poncha Springs | 428 | 153 | | 1223 | 437 | | |
| Salida | 5455 | 1948 | | 12368 | 4417 | | |
| TOTAL | 8862 | 3165 | 33.9 | 21075 | 7527 | 80.6 | 1.1675 (3.4%) |

NOTE: Commercial demand assumed to be 0.75 of residential demand.

SOURCES:

1. Colorado Division of Planning
2. Occupancy rate of 2.8 persons/residence (Colorado Division of Planning)
3. Based on 1978 residential and commercial consumption per residential customer
4. Estimated by C.G.S. (from forecasts by Colorado Division of Planning)

Future industrial energy demands in Chaffee County are difficult to estimate. The present major gas customer, Colorado State Reformatory, does not plan any large additions to the facility which would increase energy consumption. Cozinco, Inc., another consumer, does not plan any large growth. The Salida hospital does not make long-term projections. However, if low cost energy were made available in the area, industries may be attracted for agriculture, agriculturial processing and small-scale manufacturing operations, among other industrial processes. It is postulated that industrial energy demand will increase at a rate similar to that of the residential and commercial sector. Industrial energy consumption for the year 2020 is estimated at 21.3509 x $10^{10}$ BTUs. However, this estimate may vary widely from actual conditions in the future. Based upon the industrial activity present in the area now and any new industry moving into the area in the future, this estimate may be too low. However, if incentives are not adequate and a decline in industrial activity occurs in the future, the estimate will be too high.

TABLE 14

CHAFFEE COUNTY MANUFACTURERS - 1979

| INDUSTRY[1] | SIC CODE | NO OF FACILITIES | EST.ENERGY CONSUMPTION[2] ($10^{10}$BTU/Yr) | TEMP. REQ'D(°C) |
|---|---|---|---|---|
| Meat Packing | 2011 | 1 | 3.030 | 177 |
| Ice Cream | 2024 | 0.5 | 0.502 | 77 |
| Fluid Milk | 2026 | 1 | 0.830 | 77 |
| Prepared Feeds | 2048 | 0.5 | 1.481 | 274 |
| Bottled Soft Drinks | 2086 | 1 | 0.969 | 77 |
| Logging Camps | 2411 | 1 | -- | -- |
| Sawmills | 2421 | 1 | 1.000 | 93 |
| Millwork | 2431 | 1 | 0.280 | 93 |
| Newspapers | 2711 | 2 | 0.185 | 149 |
| Commercial Printing | 2752 | 0.5 | 0.183 | 149 |
| Industrial Inorganic Chemicals | 2819 | 1 | 120.000 | 149 |
| Phosphatic Fertilizers | 2874 | 0.5 | 120.000 | 371 |
| Plastic Products | 3079 | 1 | 0.770 | 218 |
| Ready Mixed Concrete | 3273 | 1 | 0.007 | 66 |

SOURCES: 1 University of Colorado, Business Research Division, 1979
2 Solar Energy Research Institute (SERI), 1980

## REQUIREMENTS OF HYDROTHERMAL ENERGY DEVELOPMENT

Specific conditions must be considered with most potential geothermal development programs. These requirements include institutional considerations, environmental considerations, water availability, technical and economic considerations. Any speculation for development must include these parameters.

## INSTITUTIONAL CONSIDERATIONS

Institutional considerations include land acquisition for resource development and resource transport, possible competitive leasing in Known Geothermal Resource Areas (KGRA's), federal, state and local geothermal regulations, drilling laws, financing, zoning and others.

A potential geothermal developer will attempt to lease areas adjacent to the resource. In Chaffee County, where a checkerboard style of land ownership predominates, leases on federal, state and private lands will be required. Land ownership patterns were discussed earlier in a previous section. Leasing activity for geothermal resources in Chaffee County has been quite extensive. As can be seen on Table 15, 12,123.77 acres of state lands are presently leased for geothermal purposes in the county. Table 16 summarizes the status of federal non-competitive leases, which includes 6309.13 acres. There are many lease applications awaiting approval by the U.S. Forest Service and Bureau of Land Management (Petroleum Information, Corp., 1980). These lease applications are listed on Table 17. It should be noted that some of these applications currently awaiting approval or disapproval were filed in 1974. In addition, numerous private leases are in effect along the interior portions of the county, where privately owned land predominates.

Chaffee County also has federal geothermal leases known as Known Geothermal Resource Areas (KGRA). In these areas the leasing process is more complicated and lengthy. These leases are more costly because bonuses must be paid and the leasing is competitive rather than non-competitive. The one KGRA located in Chaffee County is in the Poncha Springs area and is listed on Table 18.

TABLE 15

COLORADO STATE ACTIVE GEOTHERMAL LEASES
IN CHAFFEE COUNTY
MARCH, 1980

| LESSEE | ACRES | TOWNSHIP & RANGE | |
|---|---|---|---|
| AMAX Exploration, Inc. | 2644.85 | 14S | 78W |
| | 4332.31 | 15S | 78W |
| Occidental Geothermal, Inc. | 360.00 | 49N | 8E |
| Petro-Lewis Corp. | 3506.61 | 50N | 8E |
| | 640.00 | 49N | 7E |
| | 640.00 | 49N | 9E |
| TOTAL | 12123.77 | | |

SOURCE: Colorado State Board of Land Commissioners, 1980

TABLE 16

FEDERAL ACTIVE NON-COMPETITIVE GEOTHERMAL LEASES
IN CHAFFEE COUNTY
MARCH, 1980

| LESSEE | ACRES | TOWNSHIP & RANGE | |
|---|---|---|---|
| Occidental Petroleum, Inc. | 80.00 | 49N | 8E |
| Petro-Lewis, Corp. - 50% | | | |
| Occidental Petroleum, Inc. - 50% | 1549.66 | 49N | 9E |
| | 1280.00 | 49N | 8E |
| | 2113.30 | 49N | 7&8E |
| | 1286.17 | 51N | 8E |
| TOTAL | 6309.13 | | |

SOURCE: Bureau of Land Management, 1980

TABLE 17

FEDERAL GEOTHERMAL LEASE APPLICATIONS
IN CHAFFEE COUNTY
MARCH, 1980

| APPLICANT | ACRES | TOWNSHIP AND RANGE | APPLICATION DATE |
|---|---|---|---|
| AMAX Exploration, Inc. | 2320.00 | 14S,79W | 1974 |
| | 1719.20 | 15S,78W | 1974 |
| | 1754.78 | 15S,78W | 1974 |
| | 1478.62 | 51N, 7E<br>15S,79W | 1974 |
| | 2456.70 | 51N, 7E | 1974 |
| | 2300.00 | 15S,79W<br>15S,78W | 1974 |
| | 2180.00 | 15S,79W | 1974 |
| | 2202.20 | 14S,79W<br>15S,79W | 1974 |
| | 2300.00 | 14S,79W | 1974 |
| | 800.00 | 14S,79W | 1974 |
| D. L. Purcell | 1280.00 | 15S,79W | 1974 |
| | 1039.34 | 14S,79W | 1974 |
| | 1920.00 | 15S,79W | 1974 |
| Occidental Geothermal, Inc. | 640.00 | 51N, 8E | 1979 |
| | 2400.00 | 49N, 9E | 1979 |
| | 2518.00 | 50N, 8E | 1979 |
| | 2528.00 | 50N, 9E | 1979 |
| TOTAL | 31836.84 | | |

SOURCE: Petroleum Information Corp., Denver, Colorado, 1980

TABLE 18

FEDERAL ACTIVE COMPETITIVE GEOTHERMAL
LEASES IN CHAFFEE COUNTY
(KRGA's)
MARCH, 1980

| LESSEE | ACRES | TOWNSHIP AND RANGE |
|---|---|---|
| Occidental Geothermal, Inc. - 50%<br>Petro-Lewis, Corp. - 50% | 915.84 | 49N,8E |

Source: Bureau of Land Management, 1980

Based upon the different types of leases required in an area for geothermal development, the time and effort required for lease acquisition varies. Leases on state lands require approximately six months to acquire, while federal leases may require from a minimum of three months to a maximum of an unknown period of time. Leases on private lands may be acquired easily in a short period of time, while others may be virtually unobtainable.

If land acquisition is necessary for energy distribution, rights-of-way for pipelines or transmission facilities must be acquired. Exploration permits must be acquired if exploratory drilling is proposed. A Colorado Oil and Gas Commission permit is required prior to the drilling of any geothermal well within the state. If water rights are involved in the proposed development, the Colorado Division of Water Resources must analyze the hydrologic conditions in the area before a permit can be issued.

Zoning restrictions can sometimes preclude or delay proposed geothermal development if zoning regulations require adaptation to conform with potential development. Chaffee County's existing zoning regulations were adopted in December, 1974. In addition, the financing of geothermal facilities may be difficult in areas where the energy source is unfamiliar to the lending institutions. Local people have posed the question of reservoir dependability and lifetime. However, based upon historical use of alternative energy sources in Chaffee County, local lenders, given sufficient funds, would probably be likely to finance geothermal ventures. As with any business venture, additional delays may be present through contract requirements and obligations.

For a more intensive discussion of institutional considerations, the reader is referred to the publication, "Regulation of Geothermal Energy Development in Colorado," Coe and Forman (1980).

## ENVIRONMENTAL CONSIDERATIONS

Environmental effects must also be analyzed with a geothermal development project. In addition to Environmental Impact Statements (EIS) that may be necessary, other local, state and federal regulations must be satisfied before

project is approved. If serious environmental damage could result from geothermal development, a project may be denied or delayed. Possible environment considerations that may be involved in geothermal development are air, land, water, flora and fauna, ecological interrelationships and human values (Bureau of Land Management, 1975).

## Air

Air problems may be a factor in geothermal development, both from the pollution aspect and also due to increased noise levels during construction and operation. Dust problems can result to a minor extent during exploration, testing, development and construction. Although some hydrothermal resources contain certain noncondensable gases, this may not be a problem in the Chaffee County region, due to the insignificant amounts of these gases present and the likelihood that the development would probably be a closed system where all geothermal gases and fluids are contained. During drilling and completion of geothermal wells, small amounts of these gases, if present, would be vented into the atmosphere. The potential for air pollution must be evaluated and, if present, steps must be taken to prevent the emission of intolerable amounts of toxic material into the air (Air Pollution Control Commission, 1977).

In addition, increased levels of noise may occur from drilling and construction activities. However, these noise sources will diminish after completion of wells, heat exchanger systems, distribution lines and other necessary components.

## Land

Environmental considerations associated with possible detrimental effects to the land must also be analyzed for any geothermal development. Land subsidence could result from withdrawal of thermal fluids. The amount of subsidence, if any, is dependent upon various factors, including rate of fluid withdrawal and whether the formations present are unconsolidated or well consolidated. The unconsolidated sediments found near the interior of the county may be susceptible to subsidence problems, while in other areas subsidence potential is negligible. Geothermal fluid reinjection techniques are commonly used to overcome any possible subsidence problems. Historical withdrawal of ground water for irrigation purposes has not posed any subsidence problems in Chaffee County to date.

Potential earthquake activity in the area is considered to be moderate (Kirkham, oral comm., 1980). The area is part of the Rio Grande rift zone, where faults associated with this zone may be potential earthquake centers. Any development in the area should include a site evaluation with these potential hazards in consideration.

Surface disturbances during construction of a project may include such problems as soil erosion from increased vehicular traffic and construction and windblown dust. Permanent disturbances include areas difficult to reclaim, wellhead installations and pumping facilities, among others. Slope instability and flood hazard are also present in certain areas of the county. These factors should be included in a study of any potential development.

## Water

The potential for pollution of surface and ground waters should be analyzed. After geothermal fluids are used they must be disposed of properly without adverse pollution to waters of the state. The Colorado Water Quality Control Commission has control over the prevention and abatement of water pollution. Included in their regulations are measures for controlling both surface and subsurface water pollution.

Based upon chemical analyses conducted on thermal springs and wells in Chaffee County, the highest total dissolved content is approximately 700 mg/l (Barrett and Pearl, 1976). Disposal of the geothermal fluid, either by surface or subsurface means, should not degrade water quality in the area due to the relatively good quality of the thermal waters. A recommended measure to minimize water pollution potential is to reinject the fluids into aquifers similar to those from which they were produced (Coury and Assoc., 1978). In addition, thermal pollution of streams and aquifers may be a potential problem which should be analyzed on a site-specific basis.

## Flora and Fauna

Adverse effects to existing vegetation from geothermal development would depend upon location and vegetative type. Possible disruptive activities include construction of roads, drilling sites, pipelines, and accessory building.

On the relatively flat valley floor where grasses and low shrubs predominate, vegetative disturbances would be minor and reclamation will be relatively simple. However, on the steeply sloped or wooded areas, reclamation is more difficult and expensive to conduct and visual impacts are more evident to passers-by. (Bureau of Land Management, 1975).

Impacts on wildlife would depend on development location and wildlife habitats and patterns in that area. If the environment of an area changes, species that cannot adjust will be forced to migrate to areas where other land can support them. A loss of wildlife in Chaffee County will detract from its attractiveness (UAACOG, 1976). Developments in these habitat areas should be designed to reduce negative impacts. Analysis should be conducted in development areas to study possible effects to antelope, elk, deer, prairie dogs, eagles, hawks and livestock. In addition, thermal pollution from thermal fluids introduced into cold water streams may be detrimental to trout resources in these areas.

## Ecological Interrelationships

Land use patterns may be expected to change in Chaffee County with the development of hydrothermal resources. This change, however, is expected to be slight, based upon current land use characteristics and resource areas.

With the advent of development, small areas may be ecologically disturbed. If geothermal well production occurs close to a hot springs area, flow rates may decrease at the spring. This could result in a reduction of flora and fauna activity in the immediate ecosystem because of this reduction of warm water introduced to the area.

## Human Values

Human values related to geothermal development may include visual and noise impacts, population increases and generation of new jobs in the area. One of Chaffee County's greatest attractions is its scenic beauty. Any development must be planned to minimize encroachment on the present open space values and scenic vistas of the area. The greatest possible visual impacts will be in areas close to major highways and on the sloped areas where disturbances are

visible for many miles. Dust and noise created during construction periods must be considered in the development plan.

The creation of new jobs and resultant population increases, if conducted properly, would be benefiting to the area. Any project with a controlled growth pattern contributing to the economy of the area would be welcomed in Chaffee County. A sprawling, haphazard development would not be desirable or beneficial to the area's development concepts.

## WATER AVAILABILITY

The most important factor influencing development in Chaffee County is water resources and their manangement (UAACOG, 1976). At the present time, the area's water supply appears to be adequate for municipal, agricultural and domestic uses, using both surface and ground water. However, the Arkansas River and its tributaries are already over-appropriated and any future development will require additional water. Geothermal development may require adequate water supplies for geothermal production wells and also for specific users. A potential developer requiring water for his specific commercial, industrial or domestic needs may be reluctant to make a large investment if the required long-term water supply is not assured.

The Colorado Division of Water Resources, Office of the State Engineer is responsible for administration of water in the state. At the present time in Chaffee County, ground water well permits are only being issued for replacement wells, household use (maximum 15 gallons per minute withdrawal) and domestic use (15 gpm) (Loo, oral comm., 1980). If a production well system does not use a reinjection well, the aquifer must be analyzed to determine if any existing water rights will be injured if the well is approved. If the geothermal fluids are to be reinjected after use, the well permit can be granted without a water right, since no existing water rights would be injured. Most, if not all, of the ground water contained within the geologic formations of the county is considered tributary to surface waters. Both tributary ground water and surface water are subject to prior appropriation. Any planned surface water diversion will probably never be utilized because the water right will be too junior-in-time. The older (more senior) the water right, the more secure the guarantee to receive the water. The Arkansas River has little difficulty

delivering enough water to Kansas, however, there is a problem delivering enough water downstream to users between Pueblo, Colorado and the Kansas-Colorado state line (Loo, oral comm., 1980).

There is enough water in Chaffee County for its growth in population as projected, but agricultural interests may have to be reduced (UAACOG, 1976). Developers may buy up water historically used for agriculture and change its use to municipal, industrial or commercial. Changes in water use will mean changes in the area's appearance and in its rural-agricultural character if development pressures force this change of water use from agricultural to urban. The owners of the county's water rights will greatly influence future growth by their decisions in terms of water use (UAACOG, 1976).

## TECHNICAL CONSIDERATIONS

Technical problems associated with resource characteristics, design requirements, corrosion problems and disposal of geothermal fluids after use must be anticipated and analyzed. If electric power generation is anticipated, technical requirements must be considered during the following phases of development; exploration, test well drilling, production testing, field development, power plant and powerline construction and full scale operation (Bureau of Land Management, 1975).

Resource characteristics must be formulated including parameters involving resource depth, extent, temperature, and anticipated flow rates. Exploration firms such as AMAX and Occidental have conducted or are planning exploration activities in Chaffee County to determine the resource characteristics. The results of these activities will determine how and when the resource is utilized. Of course, this involvement is dependent upon proper lease arrangements discussed earlier in the institutional portion of this section.

Potential corrosion and scaling problems of hardware installations will probably not be a problem with present resources in Chaffee County. Poor qualilty water, high in total dissolved solids, that is present in some areas should not pose a technical constraint in Chaffee County. As discussed earlier, chemical quality of thermal waters in Chaffee County is comparatively good, precluding the necessity of using special installations designed for use with fluids high in corrosive potential.

Adequate and proper disposal of geothermal fluids after use must be considered. Possibilities include surface disposal and subsurface injection. Institutional requirements for both disposal methods must be satisfied. Reinjection of the fluid will add to drilling and project costs, however, if fluid is reinjected to the same aquifer, the geothermal reservoir will be recharged.

## ECONOMIC CONSIDERATIONS

Economic analyses of the use of geothermal resources in Chaffee County with the New Mexico Energy Institute (NMEI) indicate geothermal direct heat application projects could compete favorably with current natural gas installations. Heating districts for Poncha Springs, Salida and Buena Vista were considered using the resources in the area (Cottonwood Hot Springs, Mount Princeton Hot Springs, and Poncha Hot Springs). Energy costs ranged from $2.43 to $3.89 per million BTU (British Thermal Unit) for residential and industrial users based on both private and municipal developments (NMEI, 1979). Current natural gas prices in the county are approximately $2.80 per million BTU (Greeley Gas Co., 1980). Transporting thermal fluids outside the country was economically unrealistic when compared to current fuel prices.

It should be emphasized that natural gas is less expensive than other fuel sources, including propane and electricity. In addition, considering the large increase in fossil fuel prices in recent years and projected increases, geothermal energy costs become increasingly favorable. Possible natural gas hookup moratoriums and interruptable service for industrial users should also be considered in any economic assessment.

Although an energy resource is known to be economically feasible and possibly even revenue producing, financing may be difficult to acquire. Private developers and municipal officals in the area have noted that private and public funds are scarce. Communities and developers that are not familiar with the use and dependability of geothermal energy may be reluctant to incur debt for a project which appears to be a risky venture (Coe, 1980), (Touber, 1980).

Cost analysis studies were conducted for a potential small industrial-commercial park between Poncha Springs and Salida utilizing the Poncha Springs

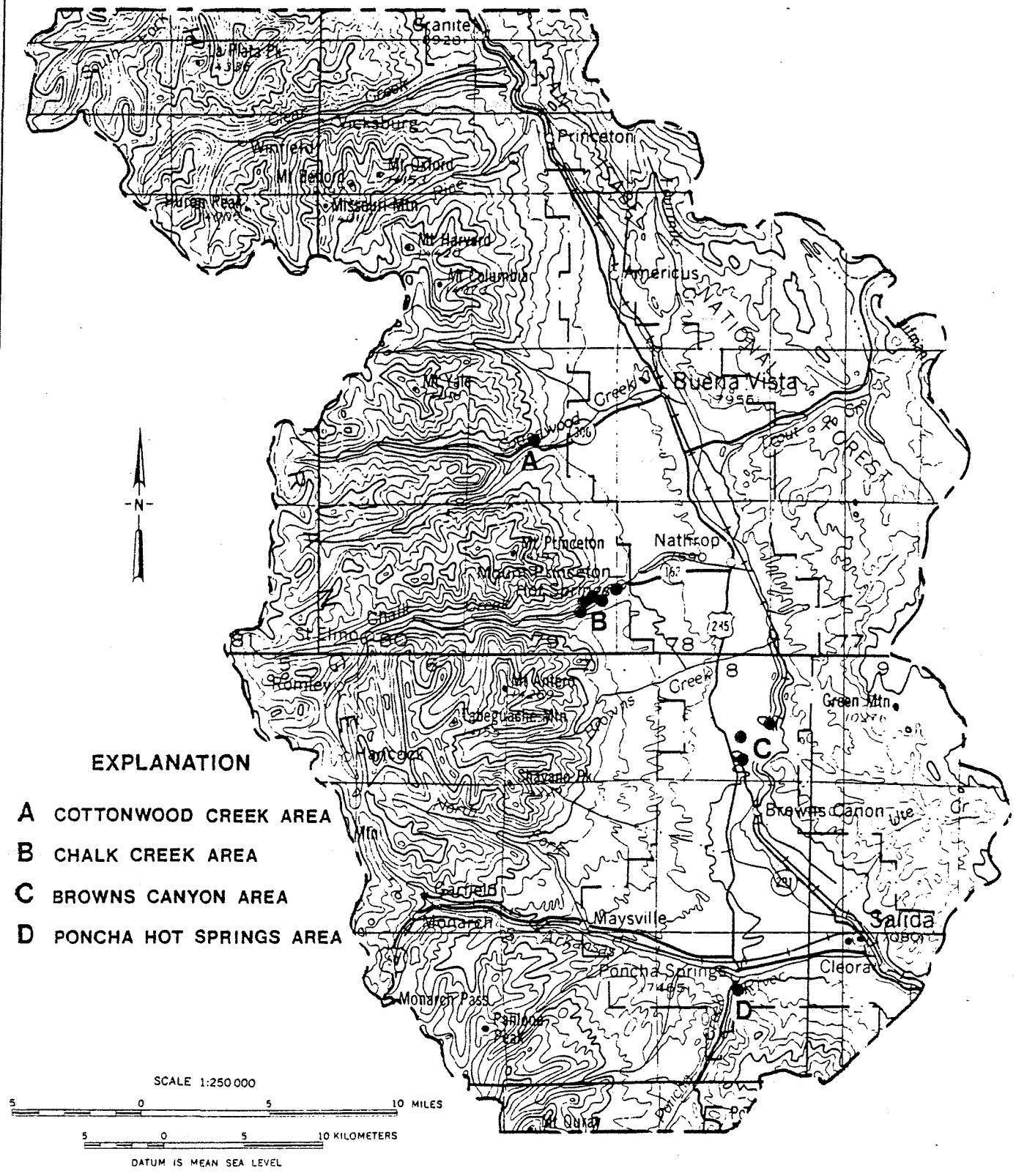
resource. Various parameters, including bond rate, distance from resource and industrial heat demand were varied during the analysis. The price per million BTU which the developer would have to charge would be between $2.26 and $9.62 (NEMI, 1980). The least expensive price ($2.26 per million BTU) utilized the available resource more fully, and this was reflected in the resource being cost-competitive with natural gas in the area. The higher priced resource was not anticipated to be cost competitive until the mid 1990s. The parameters for this analysis were less favorable, including higher bond rates, longer transmission distances and lower industrial energy requirements.

Additional cost estimates were analyzed for a potential new construction subdivision near Buena Vista, utilizing a portion of the resource from the Chalk Creek area for direct heat applications. Analysis showed that 1984 is the first year hydrothermal energy at this development would be cost competitive with natural gas (NMEI, 1980). The major prohibitive cost factor in this analysis was the transmission costs bringing the resource seven miles to the subdivision. If the development were to be built closer to the resource, energy costs drop substantially.

## HYDROTHERMAL ENERGY DEVELOPMENT POTENTIAL

### RESOURCE DESCRIPTION

Four hydrothermal resource areas have been defined in Chaffee County. They include the Cottonwood Creek Area, Chalk Creek Area, Brown's Canyon Area and Poncha Hot Springs (Figure 3). Characteristics of the springs and wells found in these areas are listed on Table 19. These springs are among the hottest in the state, with temperatures ranging from 23°C to 82°C (73°F-180°F). Hortense Hot Springs and Well, in Chalk Creek Valley, are the hottest thermal waters in the state and are both 82°C. Subsurface temperatures at the resources are estimated to range between 50°C and 200°C. (Barrett & Pearl, 1978). Based upon the parameters listed in Table 19, between $1.8183 \times 10^{15}$ and $6.1952 \times 10^{15}$ BTU's (6.1952 quads) of heat are estimated to be present in the thermal reservoirs of the county (Pearl, 1979). These figures are only estimates based upon reconnaissance exploration conducted in the area and should be viewed with caution until refuted or substantiated with adequate exploration data. However, it is anticipated that these estimates may be conservative and more energy may be available from the geothermal resources.




# GEOTHERMAL RESOURCE LOCATIONS

## CHAFFEE COUNTY

## COLORADO

FIGURE 3

TABLE 19

RESOURCE DESCRIPTION - CHAFFEE COUNTY

| RESOURCE | EST. RESERVOIR EXTENT ($mi^2$) | THICKNESS (ft) | TEMP. (°C) | EST. SUB. TEMP (°C) | DISCHARGE (gpm) | TOTAL DISSOLVED SOLIDS (mg/l) | ESTIMATED TOTAL ENERGY CONTENT (BTU'S x $10^{15}$) |
|---|---|---|---|---|---|---|---|
| COTTONWOOD CREEK AREA | 1.38-4.14 | 1,000 | 46-58 | 105-182 | | | 0.3894-1.1672 |
| COTTONWOOD HOT SPRING | | | | | 10 | 370 | |
| JUMP-STEADY HOT SPRING | | | | | 50 | 368 | |
| MERRIFIELD HOT WATER WELL | | | | | - | 301 | |
| CHALK CREEK AREA | 3.14-10.0 | 1,000 | | 150-200 | | | 1.0623-2.6314 |
| MOUNT PRINCETON HOT SPRINGS | | | 44-56 | | 175 (combined) | | |
| HORTENSE HOT SPRING | | | 82 | | 18 | 340 | |
| HORTENSE HOT WATER WELL | | | 82 | | - | 318 | |
| YOUNG LIFE HOT WATER WELL | | | - | | | 259 | |
| WOOLMINGTON HOT WATER WELL | | | 39 | | | 143 | |
| WRIGHT HOT WATER WELL (East) | | | 67 | | | 234 | |
| WRIGHT HOT WATER WELL (West) | | | 72 | | | 313 | |
| BROWNS CANYON AREA | 1.5-3.23 | 1,000 | | 50-100 | | | 0.2256-0.4856 |
| BROWN'S CANYON WARM SPRING | | | 25 | | 1 | - | |
| BROWN'S GROTO WARM SPRING | | | 23 | | 5 | 494 | |
| CHIMNEY HILL WARM WATER WELL | | | 27 | | - | - | |
| PONCHA HOT SPRINGS AREA | 0.6-5.07 | 1,000 | | 115-145 | | | 0.1410-1.9110 |
| SPRING A | | | 50-71 | | 200 | 697 | |
| SPRING B | | | 66 | | 30 | 655 | |
| SPRING C | | | 62 | | 4 | 685 | |
| SPRING D | | | 56 | | 2 | - | |
| SPRING E | | | 60 | | 2 | - | |
| | | | | | | TOTAL | 1.8183-6.1952 |

SOURCE: Pearl, 1979

Useable energy is that amount of energy which can be extracted from the reservoir and put to use. Therefore, useable energy is not the same as energy (heat) contained in the subsurface geothermal reservoir. An estimate of the amount of useable energy available may be obtained by multiplying the resource estimate by 0.06 (which includes factors of 0.24 to determine extractable energy and 0.25 to determine extracted energy that is actually used). These calculations result in a potential for $0.1091 \times 10^{15}$ BTU's to $0.3717 \times 10^{15}$ BTU's (0.1091-0.3717 quads) of useable heat available from the resource areas in the county (Table 20).

TABLE 20

ESTIMATED USEABLE HYDROTHERMAL ENERGY
CHAFFEE COUNTY

| Resource Area | Estimated Useable Energy (BTU'S x $10^{15}$) |
|---|---|
| Cottonwood Creek | 0.0234 - 0.0700 |
| Chalk Creek | 0.0637 - 0.1579 |
| Browns Canyon | 0.0135 - 0.0291 |
| Poncha Hot Springs | 0.0085 - 0.1147 |
| TOTAL | 0.1091 - 0.3717 |

SOURCE: Pearl, 1979

To insure that the energy "mined" from the geothermal resource will last an adequate length of time, a withdrawal rate is calculated for a 30 year period. If the energy was used at this rate of 1/30 per year, then 0.0036 to 0.0124 quads of heat would be available per year. These figures do not take into account recharge to the geothermal resource area. Since these recharge rates cannot be determined without extensive exploration data, an estimate of recharge rates cannot be made. However, it is expected that any development would be designed to withdraw fluids at rates relatively equal to the determined recharge rates. These methods would conceivably enable a resource to last an indeterminate length of time. In addition, artifical methods of recharge such as the use of injection wells will permit enhanced recharge to the resource.

## HISTORICAL USE

Some of the thermal waters of the county have been used for many years for swimming pools, space heating and greenhouses for both residential and commercial purposes. Although these uses have been relatively minor in comparison to the overall energy consumption for the county, residents in the area are aware of the existence of the resource and some of its potential.

The springs and wells in the Cottonwood Creek area are presently used to heat a residence, swimming pool, and commercial greenhouse. In addition, a resort uses a thermal spring for space heating and domestic purposes.

In the Chalk Creek Valley various uses of thermal waters include resort and domestic uses at swimming pools, cabin and residential heating, and domestic and recreational uses at a camp. The thermal waters in the Brown's Canyon area are presently unused.

Waters from the hot springs at Poncha Hot Springs are mainly piped to heat Salida's municipal swimming pool five miles away. During the summer, a small amount of the waters are used in a pool at the springs. In addition, a caretaker's residence at the springs utilizes the water for space heating purposes (Pearl, 1979).

## DEVELOPMENT ACTIVITIES

Current geothermal construction activity is minor at the present time in Chaffee County. Maintenance and refurbishing of present installations is conducted as necessary.

However, exploration firms, discussed previously in the institutional section, are currently active in the area. These firms, Occidental Oil, AMAX and Petro-Lewis, are primarily interested in electric power generation and are orienting their exploration to this process. Exploration activities by these firms up to the present time has included geologic mapping, literature searches, geophysical studies, and deep and shallow temperature gradient hole drilling and measurement. These firms are still showing interest in the potential for electric power generation, although exploration has slowed

recently due to the difficulty in obtaining geothermal leases on National Forest Lands. These lease applications were applied for in 1974 and have not yet been approved. Currently, the U.S. Forest Service is preparing an Environmental Assessment Report (EAR) for the area, with completion expected in July, 1980.

Proposed exploration activities by these firms will be dependent upon lease approvals and results of temperature gradient analysis in the areas investigated. The next steps may include deep hole drilling for temperature gradients and/or production test wells. If a geothermal facility is constructed in the area, reinjection procedures for geothermal waste would be most desirable, if feasible. However, the possibility is also present for using fluids after power generation for direct heat uses for residential, commercial and industrial applications before reinjection.

A geothermal consulting firm, Chaffee Geothermal, located in Denver, Colorado, is currently investigating and promoting direct heat applications using a portion of the Poncha Hot Springs resource. The firm recently acquired Salida's geothermal leases at Poncha Hot Springs and anticipates to conduct exploration and production development during the summer of 1980. Five small industries, both new and existing, west of Salida have expressed interest in using the resource. (J. Dick, pers. comm., 1980). A commercial greenhouse and a minerals processing firm are among the interested parties. Flow rates desired for the distribution system are approximately 800 gallons per minute utilizing a six inch pipeline (J. Dick, pers. comm., 1980) Exploration and engineering studies planned will determine final design constraints and specifications. The projects constraint presently is inadequate funding capital. The interest and resource are available and with the anticipated capital acquired in the next few months, it is hoped that exploration, development and construction will soon be undertaken.

## DEVELOPMENT OPPORTUNITIES

A comparison of current and projected energy demand and usable energy from the hydrothermal resource is shown on Table 21. It can be seen that the resource available is more than adequate to serve the energy needs of the area at present and in the future.

TABLE 21

COMPARISON OF ENERGY CONSUMPTION
AND AVAILABLE HYDROTHERMAL RESOURCES

| CONSUMPTION (PER YEAR) | CURRENT (EST.) ($10^{10}$BTU) | 2020 (EST.) ($10^{10}$BTU) |
|---|---|---|
| Residential & Commercial | 33.9 | 80.6 |
| Industrial | 9.0 | 21.4 |
| TOTAL | 42.9 | 102.0 |

USEABLE RESOURCE - 10910.0 - 37170.0 x $10^{10}$ BTU TOTAL (if utilized over a 30 year period, then 363.7 - 1239.0 x $10^{10}$ BTU available per year - this figure does not include recharge to the resource reservoir).

SOURCE: Colo. Geol. Survey Estimates

A development scenario was postulated for the area and is listed on Table 22. Due to the present uncertainty of electric power generation in the area, direct heat applications and electric power generation are treated separately. However, this should not imply that these developments cannot occur together. Wastewater from power generation is certainly a source of energy for direct heat uses. It is anticipated that any development of this type should include the "cascading" of thermal fluids from one application to another.

It should be noted that this scenario is merely a hypothesis. Actual development may occur either ahead of this schedule or not at all. It is anticipated that the most cost effective developments will be constructed first, with other uses being applied later as their cost effectiveness becomes more favorable.

TABLE 22

POSSIBLE SCHEDULE FOR AREA HYDROTHERMAL DEVELOPMENT
ELECTRIC POWER GENERATION

| DATE | ENTITY | ACTIVITY |
|---|---|---|
| Pre 1977-12/80 | Developer | Preliminary exploration and temperature gradient holes for Chalk Creek-Mount Princeton Electric Power Generation |
| Pre 1977 | Developer | Apply for state & federal leases |
| 1/80-12/80 | Developer | Obtain private leases |
| Pre 1977 and Anticipated 1980 | BLM/USFS | Issue federal leases |
| Pre 1977 | State Government | Issue state leases |
| 1/81-6/81 | Developer | Drill & Test Exploration Well(s) |
| 5/81-9/81 | Developer/ Utility/ Producer | Negotiations - Feasibility Studies |
| 9/81-2/82 | Utility | Obtain water rights, if necessary |
| 9/81-3/82 | Utility | Environmental Impact Statement |
| 3/82-3/83 | State/ Federal | Power plant operations, disposal field development permits issued |
| 3/83-8/84 | Producer | Drill & complete production (and injection) wells |
| 10/83-10/86 | Utility | Power plant facility and utility lines constructed: 50-MWe POWER ON LINE |

TABLE 22 CONTINUED

| DATE | ENTITY | ACTIVITY |
|---|---|---|
| 11/86-11/89 | Utility and Producer | Second power plant & well field constructed: 100 MWe POWER ON LINE |
| Pre 1977-1/81 | Developer | Preliminary exploration and temperature gradient holes for Poncha Springs Electric Power Generation |
| Pre 1977 & 1979 | Developer | Apply for federal leases |
| Pre 1977 | Developer | Apply for state leases |
| 1/80-12/80 | Developer | Obtain private leases |
| Pre 1977 and Anticipated 1980 | BLM/USFS | Issue federal leases |
| Pre 1977 | State | Issue state leases |
| 1/81-6/81 | Developer | Drill & test exploration well(s) |
| 6/81-6/82 | Developer/ Utility/ Producer | Negotiations-feasibility studies |
| 5/82-8/82 | Utility | Obtain water rights, if necessary |
| 6/82-6/83 | Utility | Environmental Impact Statement |
| 6/83-12/84 | State/ Federal | Power plant, operation disposal, field development, etc., permits issued. |
| 1/85-12/85 | Producer | Drill & complete production (and injection) wells |
| 1/86-12/88 | Utility | Power plant & utility lines constructed: 50 MWe POWER ON LINE |
| 1/89-12/91 | Utility | Second power plant and utility lines constructed:100 MWe POWER ON LINE |

TABLE 22 CONTINUED

DIRECT HEAT APPLICATIONS

| DATE | ENTITY | ACTIVITY |
|---|---|---|
| -- 10/80 | Developer/ Users | Negotiate agreements with industrial users and obtain financing for industrial park near Salida using Poncha Springs resource. |
| 1/80-12/80 | Developer | Preliminary exploration |
| 1/80-2/80 | Developer | Obtain geothermal leases |
| 12/80-1/81 | State and Local Agencies | Issue exploration well permits |
| 2/81-4/81 | Developer | Drill & test exploration well |
| 5/81-8/81 | State and Local Agencies | Issue, production well, development and construction permits |
| 9/81-9/83 | Developer | Drill & complete production & reinjection well(s). construct distribution system |
| 9/82-9/83 | Users | Construct plants, greenhouses, etc. |
| 10/83-12/83 | Developer/ Users | System in operation, ENERGY ON LINE, $6 \times 10^{10}$ BTU's. |
| 1/81-12/81 | Developer | Feasibility and preliminary engineering and geological studies for portions of Salida heating district. |
| 12/81-6/82 | Developer | Obtain financing for district heating system. |
| 12/81-6/82 | Residential/ Commercial Users | Obtain financing for retrofit installations. |
| 6/82-9/82 | Developer | Obtain federal, state and private geothermal leases and exploration permits |

TABLE 22 CONTINUED

| DATE | ENTITY | ACTIVITY |
|---|---|---|
| 9/82-10/82 | Developer | Obtain water rights and rights of way |
| 10/82-1/83 | Developer | Drill and test exploration well(s) |
| 2/83-5/83 | State and Local Agencies | Issue production well, development and construction permits |
| 6/82-6/84 | Developer | Drill & complete production & reinjection well(s), construct distribution system, retrofit existing residences and businesses and serve new construction. |
| 7/84-9/84 | | System in operation ENERGY ON LINE $12.4 \times 10^{10}$ BTU's |
| 1/85-1/88 | Developers/ Users/ Government Agencies | Similar process to retrofit remainder of Salida area. ENERGY ON LINE $13.8 \times 10^{10}$ BTU's |
| 1/82-12/82 | Developer | Feasibility and preliminary engineering & geological studies for portions of Buena Vista heating district |
| 12/82-6/83 | Developer | Obtain financing for district heating system |
| 12/82-6/83 | Residential/ Commercial Users | Obtain financing for retrofit installations |
| 6/83-9/83 | Developer | Obtain federal, state and private geothermal leases and exploration permits |
| 9/83-10/83 | Developer | Obtain water rights and rights of way |
| 10/83-1/84 | Developer | Drill & test exploration well(s) |

TABLE 22 CONTINUED

| DATE | ENTITY | ACTIVITY |
|---|---|---|
| 2/84-5/83 | State and Local Agencies | Issue production well, development and construction permits |
| 6/83-6/85 | Developer | Drill and complete production and reinjection well(s), construct distribution system, retrofit existing residences and businesses and serve new construction |
| 7/85-9/85 | | System in operation, ENERGY ON LINE $7.78 \times 10^{10}$ BTU's |
| 1/86-1/89 | Developers/ Users/ Government Agencies | Similar process to retrofit remainder of Buena Vista area ENERGY ON LINE $8.64 \times 10^{10}$ BTU's |
| 1/83-12/83 | Developer | Feasibility and preliminary engineering and geological studies for a new construction subdivision near Buena Vista |
| 12/83-6/84 | Developer | Obtain financing for district heating system, plat subdivision |
| 3/84-9/84 | Developer | Obtain federal, state and private leases and exploration permits |
| 9/84-3/85 | Developer | Drill and test exploration well |
| 3/85-9/85 | Developer | Obtain water rights and rights of way |
| 9/85-12/85 | State and Local Agencies | Issue subdivision approval, production well and and development permits |
| 1/86-1/87 | Developer | Drill and complete production well, construct distribution system. |

TABLE 22 CONTINUED

| | | |
|---|---|---|
| 1/86-1/87 | Users | Residential construction |
| 2/87-4/87 | | Residential construction system in operation, ENERGY ON LINE 1.53 x $10^{10}$ BTU's |
| 6/83-10/83 | Developer | Initiate agreement with Salida to utilize resource for Town of Poncha Springs heating district |
| 11/83-3/84 | Developer | Obtain financing for district system and additional production well(s) |
| 11/83-3/84 | Users | Obtain financing for retrofit installations |
| 4/84-9/84 | Developer | Obtain permits and drill and complete addition production well(s) |
| 9/84-12/84 | State and Local | Issue permits for system construction and operation |
| 1/85-1/86 | Developer/ Users | System construction and residential and commercial retrofitting |
| 2/86-4/86 | | System in operation, ENERGY ON LINE: 2.5 x $10^{10}$ BTU's |

## SUMMARY

Geothermal development potential seems to be considerable in the area studied. Recent activities described in the text indicate that residents and developers are looking favorably, both economically and technologically, at the Chaffee County resource for their energy requirements. This report has attempted to assist these parties in developing the hydrothermal Geothermal development potential seems to be considerable in the area resource. Geothermal energy could serve much of the area's energy requirements in the future, with the potential for additional energy on line in just a few months with larger projects completed in a few years.

## ORAL COMMUNICATIONS

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