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OPEN-FILE REPORT NO. 81-3

APPENDICES OF AN APPRAISAL FOR THE USE OF GEOTHERMAL ENERGY IN STATE-OWNED BUILDINGS IN COLORADO

34

Section A: Alamosa
Section B: Buena Vista
Section C: Burlington
Section D: Durango
*Section E: Glenwood Springs
Section F: Steamboat Springs

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DEPARTMENT OF NATURAL RESOURCES
STATE OF COLORADO
DENVER, COLORADO

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DISCLAIMER

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GLENWOOD SPRINGS

The State Highway Department Buildings in Glenwood Springs have been evaluated in this appraisal for the use of geothermal energy in state-owned buildings. Glenwood Springs is the location of surface hot springs and has been assessed by various parties for several geothermal appliations. A recent geothermal utilization analysis has been performed by the Denver Research Institute (1980) on the engineering and economic feasibility of heating a group of municipal buildings. The study showed that a geothermal district heating system for the public buildings in the downtown area of Glenwood Springs is feasible.

The resource assessment for this appraisal study is based largely upon the DRI evaluation. The resource characteristics indicate geothermal water at 150°F from 500 to 800 feet deep wells and flowrates of 1000 gpm per well. The total dissolved solids are high at 17,000 to 20,000 mg/l. A geothermal well can probably be drilled on the site of the Highway Department Buildings.

The Glenwood Highway Department Buildings consist of an office building and a maintenance garage. These two buildings currently use an array of natural gas forced air furnaces and electric heaters for space/heating purpose; a propane unit is used for one water heater. Retrofit engineering for geothermal heating is based upon a central plate-in-frame heat exchanger coupled to several fan coil heaters and unit heaters. Design heating can be accomplished with 150°F geothermal water at 140 gpm.

The geothermal energy economics are evaluated for a single deep well, with and without a proration of the total production well cost for the required 140 gpm out of the 1000 gpm production capacity. Only the prorated well cost option provides an economically feasible geothermal system. The feasibility, therefore, depends on the use of the excess geothermal water by private or municipal facilities.

The principal institutional/environmental issue for a geothermal heating system for the Highway Department Buildings is the question of whether or not the State owns the geothermal rights on the State property. A title search is required to make this determination. If the State does not own the geothermal rights, then geothermal leases would have to be acquired.

Resource Assessment for Glenwood Springs

Surface expressions of subterranean heat are found in the Glenwood Springs area in up to 31 hot springs (Figure 32). Massive basalt flows of recent Quaternary age, also an indicator of geothermal energy, are common through-

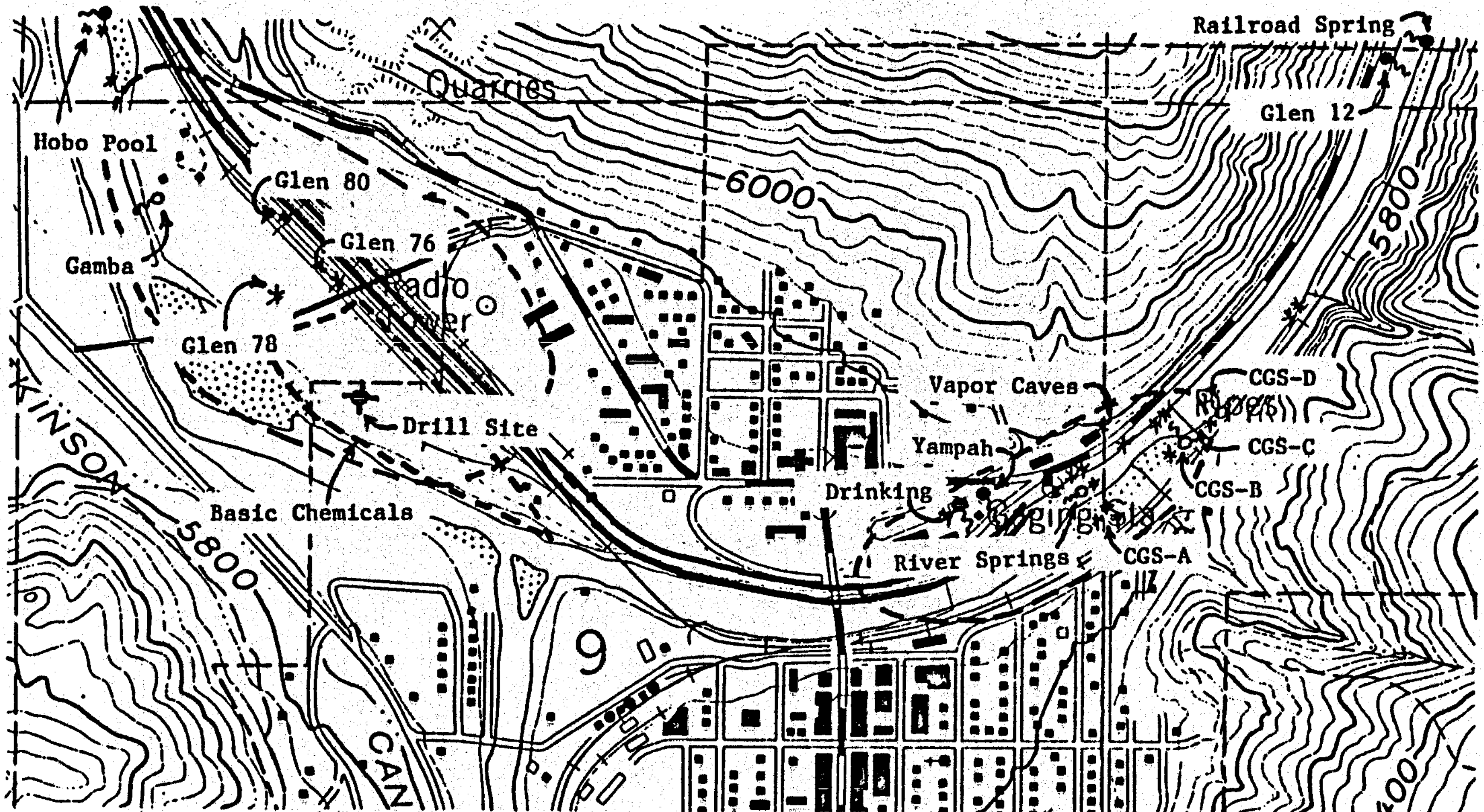


Figure 32. Anomalous geothermal resource areas in Glenwood Springs, Colorado. The dashed lines outline geophysical target areas. Also shown are the locations of hot springs with approximate flow rates represented by:

>150 gpm = (symbol), 50 - 150 gpm = (symbol), <50 gpm = *

Source: Chaffee Geothermal, Ltd., 1980

out the area. Glenwood Springs is in fact, named for the many hot springs that lie along the banks of the Colorado River for approximately one mile within town. The Yampah Hot Springs has the greatest discharge rate of any hot springs in Colorado at 2263 gpm (Pearl, 1979). Other hot springs in the area have flow rates varying from one to 150 gpm. Surface temperatures are uniform through the springs in the area, ranging from 110°F to 125°F. These hot springs have the highest salinity in Colorado (Pearl, 1972) with total dissolved solids ranging from 17,000 to 20,000 mg/l. The U.S. Bureau of Reclamation (1976) has calculated that the hot springs within a 16-mile region between Glenwood Springs and Dotsero discharge 500,000 tons per year of dissolved solids into the Colorado River.

In a resource model projected by the Colorado Geological Survey (Pearl, 1979), geothermal fluids may be ascending the highly porous and steeply dipping Leadville Limestone. As the geothermal waters ascend through the Leadville Limestone, they may encounter a highly fractured zone near the surface where the Storm King thrust fault intersects with several other northwest and northeast trending faults. This fractured zone may be an area of shallow groundwater mixing, and hotter geothermal fluids could be encountered down-dip in the Leadville Limestone, prior to ground water interference in the fractured fault zones. The localities of the existing hot springs imply definite controls by the Storm King and other local faults in the area but geophysical surveys limit potential geothermal activity to the area immediately adjacent to the Storm King thrust fault. From the resource model projected herein, the hottest geothermal reservoir is probably within the Leadville Limestone southwest of the Storm King thrust fault.

The areal extent of the geothermal reservoir at Glenwood Springs can most accurately be defined by the localities of hot springs and by a seismic survey which was conducted by the Colorado School of Mines.

Hot springs discharge for several hundred yards to the northeast of town and for two miles to the west, as shown by thermal infrared photography (Hansen, 1975). The geothermal resources at Glenwood Springs may include an area of 1.5 to 2.0 square miles with the main reservoir limited to less than 0.5 square miles as shown in Figure 32 .

Estimates by the Colorado Geological Survey (Barrett and Pearl, 1978) and by (Fitzpatrick, 1980) show that subsurface reservoir temperature may be from 140°F to 180°F. At an unknown depth the reservoir temperature probably does approach 180°F but not necessarily immediately beneath Glenwood Springs. At reasonably shallow drilling depths below Glenwood Springs, the targeted reservoir temperatures are estimated to be 150°F.

Assuming the geothermal fluids are moving in the manner hypothesized by researchers, then a geothermal well drilled at the location shown on Figure 32 at a depth of about 500 to 800 feet should produce hot water. The further southwest a well is drilled the greater the depth required, but then the higher the reservoir temperature expected.

The Leadville Limestone, the formation hypothesized to contain the hot water in this area, is known to be a very porous and cavernous formation with execptionally good groundwater movement. Hot springs flowing from the Leadville Limestone generally have good flow rates ranging up to 150 gpm with a discharge of greater than 2200 gpm from the Yampah Hot Springs. Providing proper precautions are taken to prevent scaling in the wellbore, it is anticipated that production rates of 1000 gpm or greater may be feasible from each of several geothermal wells drilled into the Leadville Limestone.

The relative heat content of the geothermal system at Glenwood Springs has been projected by Pearl (1979) to be approximately 23.1 x 10^{11} Btu of useable energy.

A summary of the various geothermal resource characteristics (with the associated validity rating) as projected herein includes:

Reservoir temperature:	150°F (2)
Depth:	500-800 feet (2)
Production/well:	1000 gpm (1)
Areal extent:	0.5 - 2.0 square miles (3)
Formation:	Leadville Limestone (3)
TDS:	17,000 - 20,000 mg/l
Useable heat:	23 x 10^{11} Btu (1)

Glenwood Springs is an excellent location for the use of geothermal energy in state-owned buildings and facilities. A greater than adequate resource exists on-site at reasonable drilling depths. No pipeline would be required to bring geothermal fluids from the geothermal area to the facility and it is probable that sufficient resources exist for the expansion of facilities or the sale of excess energy to other potential users.

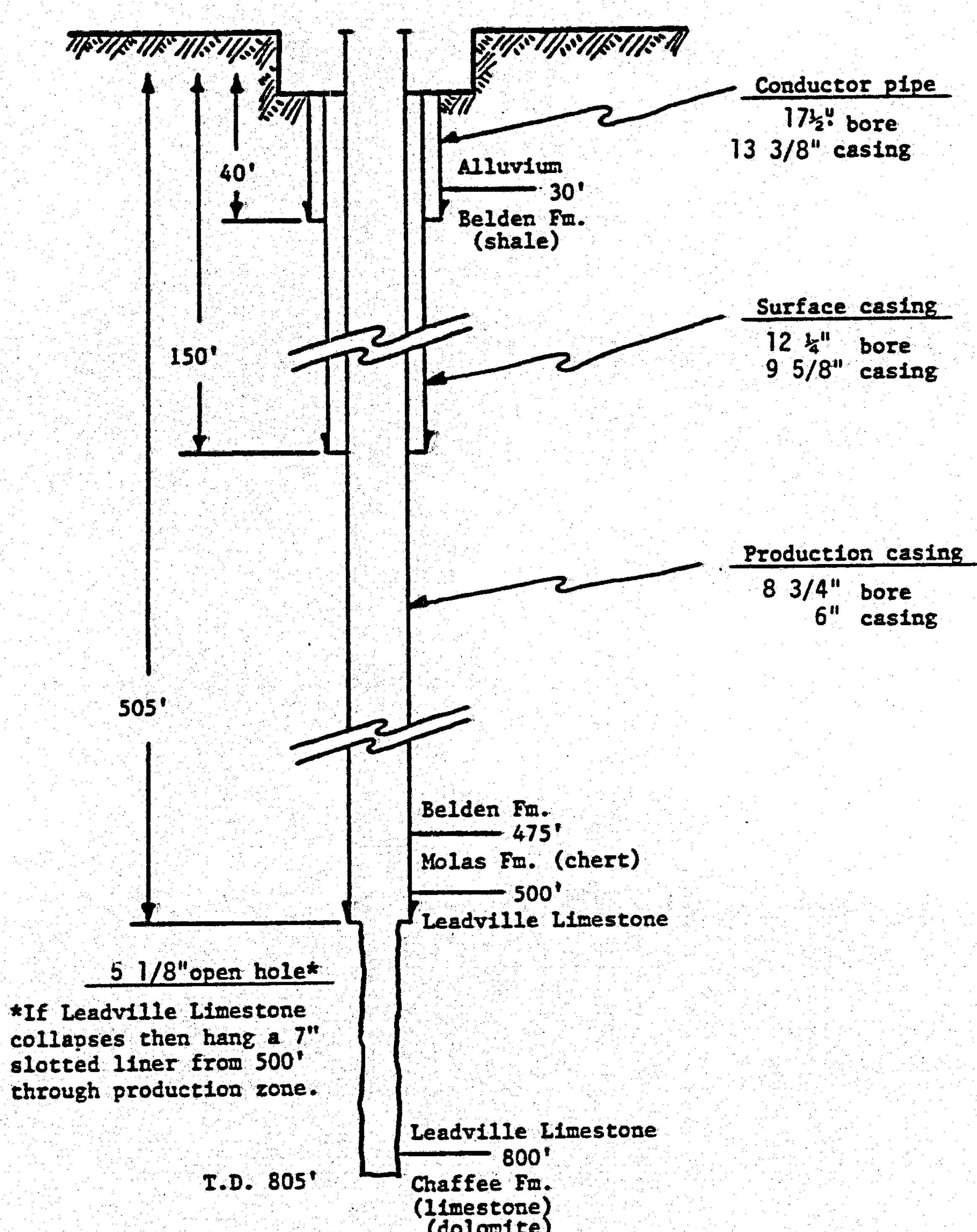
Well Design and Drilling Program

A detailed description of a well design and drilling program is presented here for Glenwood Springs as a specific example of the requisite designs for all geothermal wells in this appraisal. The description is derived from work performed by Chaffee Geothermal, Ltd., for the Denver Research Institute. The design information follows:

Due to anticipated high production rates of 1000 gpm or greater, the exploratory well is designed with a slightly smaller than full-bore to not restrict Artesian flow. Also, the bore is large enough to accommodate downhole impellers or a submersible pump if the need arises. A well profile is shown in Figure 33 .

FIGURE 33

WELL PROFILE FOR GLENWOOD SPRINGS



SOURCE: Chaffee Geothermal, Ltd., 1980

The first exploration well for this project is herein numbered "GS 9-1" because it is in Glenwood Springs and is the first geothermal well drilled within Section 9 (T.6S., R.89W.). As shown in Figure 33, a 13 3/8 inch conductor pipe (grade: F-25, weight: 48 pounds/foot) will be set to a depth of 40 feet or through the surface gravels and river boulders and into the shales of the Belden Formation. Then 9 5/8 inch surface casing (grade: H-40, weight: 32.3 pounds/foot) will be set into the Belden Formation to a depth of approximately 150 feet. It is very important that the surface casing be set prior to encountering any large volume flow rates because blowout prevention equipment will be placed on this casing during final drilling. Prior to beginning the well, all existing wells in the immediate vicinity will be checked to approximate the true depths to flowing aquifers. It is very feasible that the surface casing could be set as shallow as 100 feet if the shales of the Belden Formation prove sufficiently competent to hold a shallow surface casing.

Production casing of 6 inches (grade: H-40, weight: 22 pounds/foot) will then be run from the surface to a depth of 505 feet and anchored into the upper portion of the Leadville Limestone. Since the Leadville is the anticipated production horizon, it will be completed through its total thickness with a 5 1/8 inch open hole. This 5 1/8 inch bore will be drilled until it penetrates the upper limestone sequences in the underlying Chaffee Formation. This will give a proposed total depth for GS 9-1 of near 805 feet. Should the Leadville Limestone not prove sufficiently competent to maintain an open hole through the production zone, then the well can be re-entered, cleaned, and a 3-inch slotted liner can be hung from the 500-foot level of the production casing and through the entire producing aquifer.

The general procedure for drilling a geothermal well to the specifications as described herein is as follows:

1. Level a drilling pad of approximately 100' by 50' and excavate a 10' by 20' mud pit (8' deep). Also excavate a drilling cellar of 5' by 5' (3' deep) and a flow line to the Colorado River (pending Colorado Health Department and U.S. Bureau of Reclamation approval) or to a settling pond (also to be excavated if needed). A plan of the drilling site is shown in Figure 34. The total area to be impacted is less than one-half acre.

2. Cement-line the drilling cellar and install drains. Cover the drilling cellar with steel grating.

3. Move in cable-tool drilling rig and rig-up over the drilling cellar.

4. Drill a little bore to a depth of 40' or through the surface gravels and river boulders.

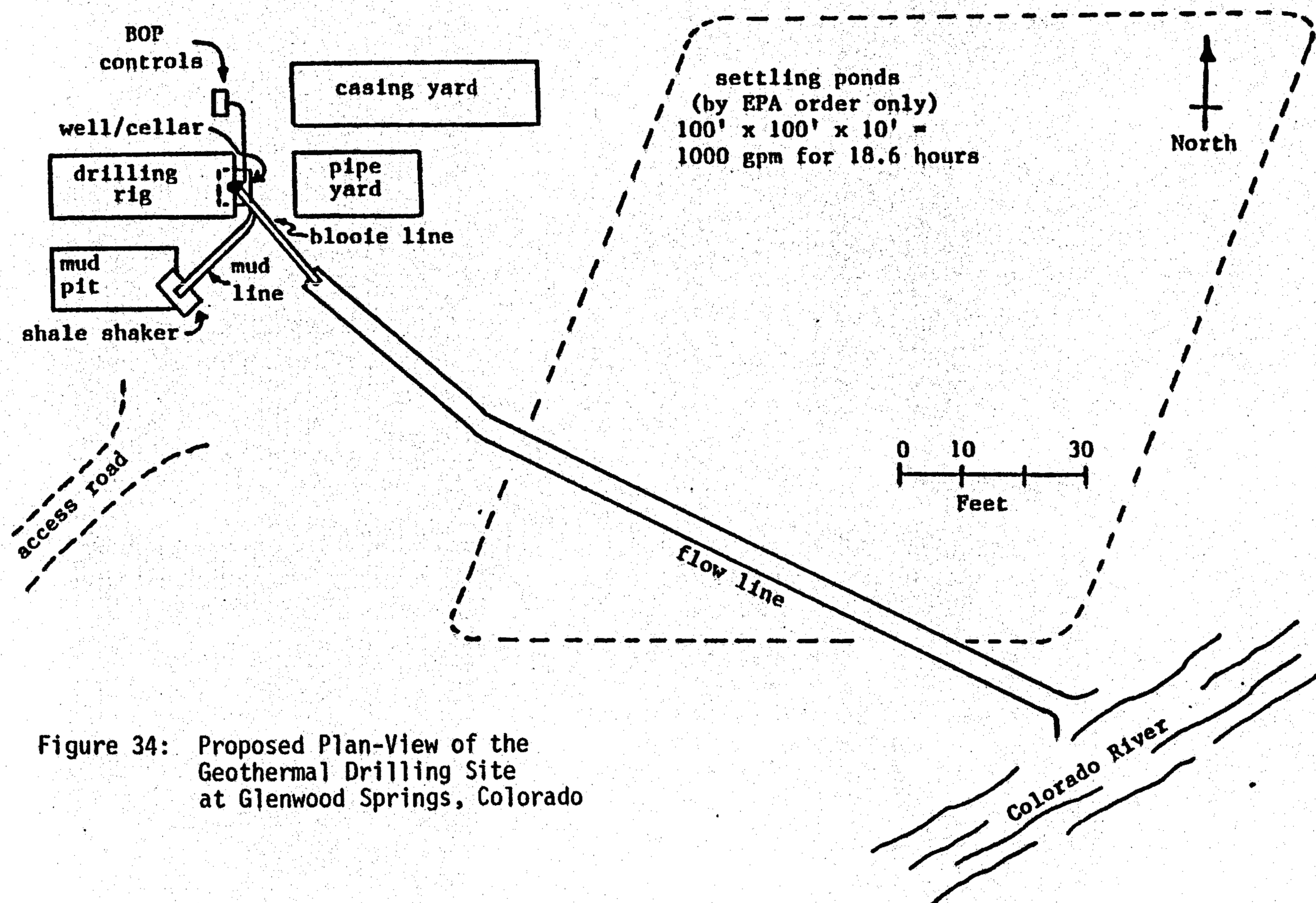


Figure 34: Proposed Plan-View of the Geothermal Drilling Site at Glenwood Springs, Colorado

SOURCE: Chaffee Geothermal, Ltd., 1980

5. Set and cement the 13 3/8" conductor pipe to a depth of 40'. Use ready-mix and wait on the cement to set for 8 hours.

6. Rig-down and move off cable-tool rig.

7. Move in and rig-up rotary drilling rig. Begin mixing drilling mud.

8. Spud-in and begin drilling a 6-3/4" pilot bore to 150' or to whatever depth the surface casing is to be set.

9. Ream hole to 150' with a 6-3/4" pilot and 12¼" cutter bit.

10. Run 9 5/8" casing to 150'. Thread guide shoe on bottom threads and place an insert fill-up valve at the first collar. Weld a centralizer in the middle of the first joint (depth 135') and place centralizers at the bottom collar (depth 120') and the top collar (depth 40').

11. Set and cement 150' of 9 5/8" casing with approximately 125 sacks, or until adequate returns are obtained at the surface, of Class "G" cement with 2% CaCl additive. If returns are not obtained at the surface then grout annulus from the surface with Class "G" cement minus CaCl (if possible). Wait on the cement to set for 12 hours.

12. Pressurize casing to 100 psi and hold for 10 minutes. This will check the threaded connections on the collars.

13. Re-enter the hole to the top of the cement (about 120' or at the insert fill-up valve) and drill-out the insert fill-up valve, the cement, guide shoe and 5' of formation with the 8 3/4" bit.

14. Test the casing seat with 100 psi for one hour. Observe the pressure gauge for leak off. If pressure bleeds off rig-up to squeeze.

    - Pick up RTTS packer and go to 145' and set packer. Pump 20 sacks of Class "G" cement plus 2% CaCl and squeeze casing shoe. Do not exceed 250 psi pressure during squeeze. Keep the bore pressurized and wait on the cement to set for 12 hours.

15. Retrieve RTTS packers and re-enter the hole with the 8 3/4" bit and drill-out the squeezed cement. Retest casing seat to 100 psi. Resqueeze if pressure bleeds off.

16. Thread (weld) casinghead flange on to the 9 5/8" surface casing and nipple-up drilling stack (Figure 35).

17. Enter bore with 6-3/4" pilot bit and begin drilling to 505', or into the Leadville Limestone. This drilling will take place with normal weight mud (9-10 pounds/gallon) even if large flows are encountered. Drilling will continue through flowing zones with

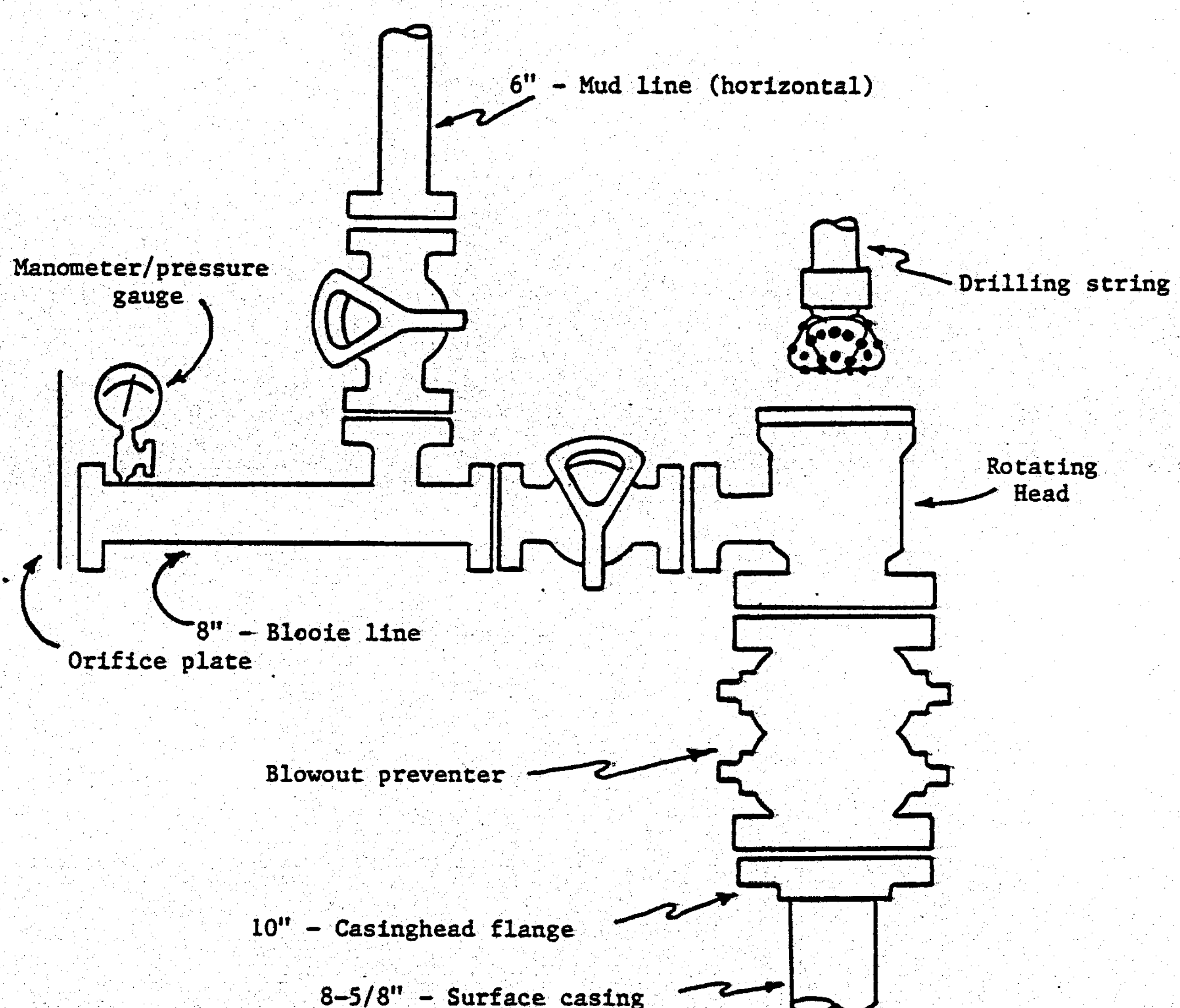


Figure 35: Drilling Stack Assembly

SOURCE: Chaffee Geothermal, Ltd., 1980.

normal weight mud which will lift cuttings up the bore to be flushed out by the producing formation.

- Should mud returns not occur at the surface, then the blow-out preventer (pipe rams) will be suth and lost circulation materials, plus mica flakes, will be pumped into the lost circulation zone until shut-in pressures increase. Then the blowout preventer (BOP) will be opened and mud returns will occur at the surface.

18. Trip out of the hole with the 6-3/4" pilot bit and ream-out the bore to a depth of 505' with a 6-3/4" pilot and 8 3/4" cutter bit.

19. If large flows are encountered while the 8 3/4" bit is in the hole, shut pipe rams (BOP) and begin mixing 14-16 pound/gallon mud (barite additive) or whatever weight is required to kill the flows. When the mud is up to weight, open the pipe rams (BOP) and circulate mud until flow is killed.

20. Trip out of hole and tear down the drilling stack.

21. Run 6" production casing to the bottom of the hole. An insert fill-up valve will be placed at the first collar and a guide shoe threaded to the bottom of the casing. Centralizers will be placed on the bottom joint (depth 490') and then at 440', 320', 200' and 80' of depth.

22. Cement the production casing with 200 sacks, or until returns occur at the surface, of Class "G" cement plus 2% CaCl (3% CaCl if major flows were encountered). Cement weight must be 16 pounds/gallon (depending on pressure of producing zones) and pumped very slowly at 2 barrels/minute. If returns are not obtained at the surface then grout annulus from the surface. No flushing plug of fresh water should be run ahead of the cement. Wait on the cement to set for 12 hours.

23. Repeat steps 12 through 15.

24. Cut off casinghead flange from 9 5/8" surface casing and thread on (weld) permanent casinghead flange to 6" production casing. Nipple-up master valve, banjo box and rotating head.

25. Enter bore with 5 1/8" bit and begin drilling in the Leadville Limestone by using both pumped and produced water as the drilling fluid. Drill through the Leadville or to a depth of approximately 805'. Flow rates during drilling can be measured at the blooie line via an orifice plate and manometer tube.

26. Trip-out of well and shut-in master valve while retrieving 5 1/8" bit through rotating head.

27. Reclose rotating head and open master valve and allow the production zone to produce and clean itself by flowing through the blooie line.

28. Shut-in well, rig-down and move all rotary and support equipment off site.

29. Conduct 24-hour and long-term reservoir tests by flowing production zone through banjo box and blooie line.

20. After reservoir tests, shut-in master valve and unbolt banjo box and rotating head and dismantle mud line and kill line. Bolt on second master valve (if desired for safety) and weld neck flange and connect pipeline to wellhead (Figure 36).

Approximate well costs to drill a six inch geothermal exploration well to a depth of 800 to 1000 feet at Glenwood Springs are estimated herein. A major portion of drilling costs are dependent on drilling rates and these projections are merely estimates. Notice that total well costs include a 25% contingency to cover unanticipated drilling conditions. Drilling costs are estimated at approximately $95,000; but to cover unanticipated drilling conditions and problems, costs could run as high as $118,000.

Retrofit Engineering for the State Highway Department Buildings

The retrofit building engineering design specifications for the Highway Department Buildings in Glenwood Springs are presented below. Figure 37 shows a schematic of the geothermal system using a central plate-in-frame heat exchanger to supply circulating hot water to fan coil heaters and unit heaters in the two buildings.

Present Conventional Fuel Heating System

BUILDING	SQUARE FOOTAGE	FUEL	HEATING EQUIPMENT	PEAK HEAT LOAD
Office	6,790	Natural Gas	Forced Air Furnaces (2)	277,500
		Electricity	Electric heaters (3)	35,826
Garage	6,720	Natural Gas	Unit heaters(8)	384,000
TOTALS:	13,510			697,326

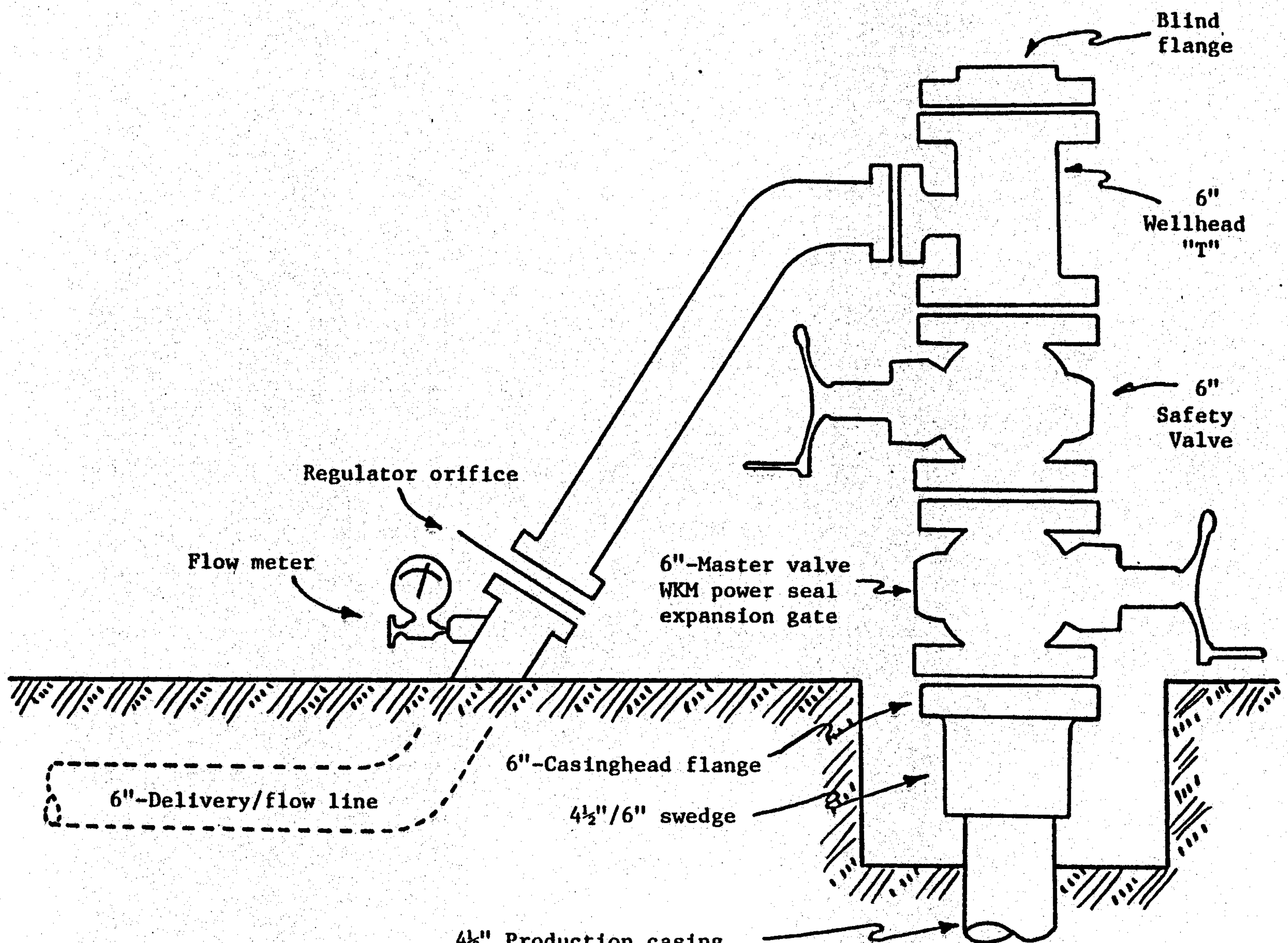
Geothermal System Design Specifications

Proposed System and Modifications:

1. Retrofit to utilize geothermal hot water for space heating.

2. Replace existing gas forced air furnace, unit heaters and electric units with hot water coil units capable of satisfying design loads with low approach temperatures.

3. Plate-in-frame heat exchanger is required.



SOURCE: Chaffee Geothermal, Ltd., 1980

Figure 36: Well Head Completion Assembly

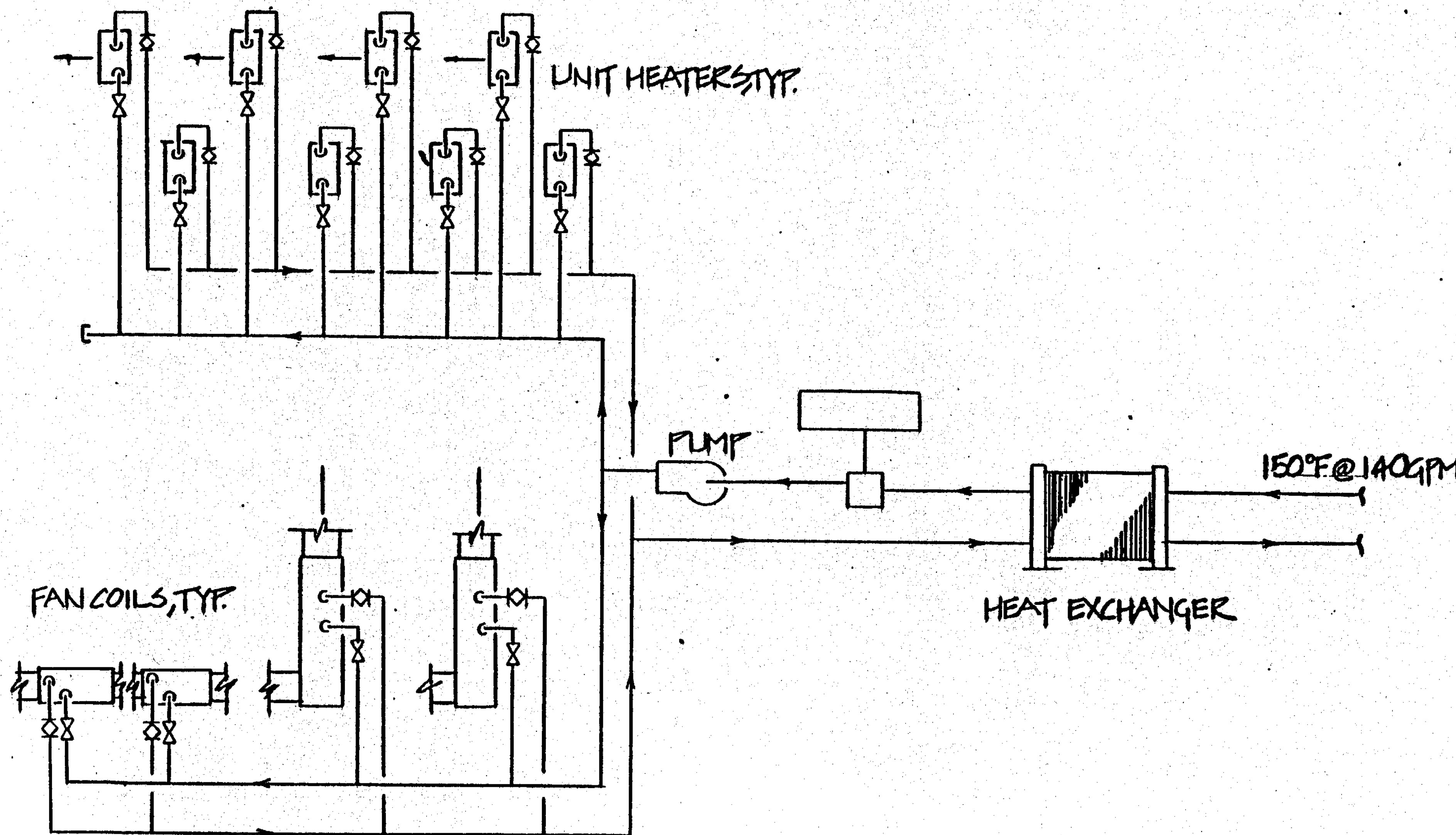


Figure 37

GLENWOOD SPRINGS HIGHWAY DEPT.

4. Heating water pump is required.

5. Air separator and expansion tank are required.

6. Supply and return piping is required.

7. More sophisticated temperature control is required.

8. Assume 150°F geothermal water is available.

Engineering Deisgn:

The design peak heating load of 700,000 Btu/hr can be accomplished utilizing 150°F geothermal into a plate-in-frame heat exchanger with approach of 10°F at 140 gpm; input circulating water of 70 gpm at 140°F will supply the heating load with a $\Delta T = 20^{o}F$.

Equipment Components and Cost Estimates:

	Specifications	Quantity	Unit Cost	Total Cost
• Office Building				
Fan Coils	3000 CFM	4	$1,000	$4,000
Fan Coils	6000 CFM	1	1,000	1,000
Circulation Pump		1	1,000	1,000
Air Separator and Expansion Tank		1	1,200	1,200
Distribution Piping		600'	16	9,600
Insulation		600'	6	3,600
• Garage Building		8	1,000	8,000
Unit heaters	1200 CFM			
Circulation Pump		1	1,000	1,000
Air Separator and Expansion Tank		1	1,200	1,200
Distribution Piping		600'	16	9,600
Insulation		600'	6	3,600
• Heat Exchanger Plate-in-Frame Type 140 gpm 150°F→140°F for geothermal side 70 gpm 140°F→120°F for building side				5,000
• Temperature Controller		1	2,440	2,440
			Subtotal	$51,240
			Contingency (10%)	5,124
			TOTAL	$56,364

Economic Evaluations

On the following pages are presented the itemized geothermal capital improvement costs, the annual operating and maintenance costs for both the geothermal system and the conventional fuel system, and the results of the calculations of the four economic measures for the geothermal option evaluated for the State Highway Department Buildings in Glenwood Springs.

The total geothermal capital improvement cost, based upon a prorated production well system, is estimated to be $114,356; the total capital costs without proration of the production well is $368,580. The first year operating and maintenance cost for the prorated-well geothermal system is $3,985, as compared to $10,214 for the conventional fuel system.

The calculated economic measures (assuming fuel price escalation of 15 % per annum) are summarized as follows:

	Central Heat Exchanger and Prorated Deep Well
Simple Payback Period:	12 years
Total Annualized Costs:	
Geothermal:	$ 20,081
Conventional:	$ 29,974
Total Undiscounted Savings:	$697,883
Total Present Value Savings:	$192,360

The geothermal heating system is definitely economically competitive with the conventional heating systems for the State Highway Department Buildings at Glenwood Springs. The State can recover the capital improvement costs in energy savings over a period of years.

CAPITAL COSTS

Location: Glenwood Springs   Facility: Highway Department Building

Geothermal Option: Heat Exchanger with Deep Well on-site

A. Production Well System	Costs
Exploration	$ 1,680
Reservoir Engineering	3,360
Wells 1 @ $ 120,000 x 140/1000 (500-800 ft, 1000gpm)	16,800
Well Pumps (1) 140 gpm, 140 ft-hd, 9 HP	3,600
Valves and Controls	1,000
Contingency Funds (10%)	Included
Subtotal	
Engineering Design Fee (10%)	Included
Total	$ 26,440

B. Transmission Line System	
Piping (ft.)	0
Pumps ( ) gpm, ft-hd, HP	
Contingency (10%)	
Subtotal	
Engineering Design Fee (10%)	
Total	$ 0

C. Central Distribution System & Garage

Heat Exchanger or	5,000
8 Unit Heaters @ $100	8,000
Auxillary Building	-
Valves and Controls	3,640
Piping	13,200
Circulation Pumps (2) 140 gpm, 40 ft-hd, 2.48 HP	2,000
Miscellaneous	-
Contingency (10%)	2,984
Subtotal	34,824
Engineering Design Fee (10%)	3,482
Total	$ 38,306

D. Building(s) Retrofit HVAC System -Office

Heating Units 5 Fan Coils @ $1,000	5,000
Retrofit Plumbing	13,200
Valves and Controls	1,200
Contingency (10%)	1,940
Subtotal	21,340
Engineering Design Fee (10%)	2,134
Total	$ 23,474

E. Reinjection/Disposal System

Reinjection Well(s): 1 wells @ $ 90,000 x 140/1000	12,600
Piping (500 ft.)	8,000
Pumps ( )	N.R.
Controls and Valves	1,000
Contingency (10%)	2,160
Subtotal	23,760
Engineering Design Fee (10%)	2,376
Total	$ 26,136

F. Grand Total $ 114,356

ANNUAL OPERATING AND MAINTENANCE COSTS
(1980 Dollars)

Location: Glenwood Springs   Facility: Highway Department Building

Geothermal Option: Heat Exchanger with Deep Well on-site

Geothermal System

Cost Item	Electricity Cost	Maintenance Cost/ (% of C. C.)
A. Production Well System		$ 1,058 (4%)
Pump electricity 9 HP	$ 1,305	
B. Transmission Line System	-	-
C. Central Distribution System		
Heat Pump electricity	-	766 (2%)
Circ. Pump electricity	360	
D. Building(s) Retrofit HVAC System	-	235 (1%)
E. Reinjection/Disposal System	-	261 (1%)
Total	$ 1,665	$ 2,320

Conventional Fuel System

Type of System: Natural Gas Furnances (95%) and Electric Heaters (5%)

Fuel Cost	
Total Annual Fuel Load	$2,200 \times 10^6$ Btu/yr
1980-81 Estimated Fuel Price	$3.60/$10^6$ Btu
1980-81 Estimated Total Annual Fuel Cost	$ 7,524

Maintenance Cost	
Percent of Associated Capital Costs	2%
Estimated Capital Costs	$62,000
Estimated Maintenance Cost	$1,240

Electricity Cost	
1980-81 Estimated Total Annual Electricity Cost	$ 1,450*

*fuel cost

ECONOMIC EVALUATIONS

Location: Glenwood Springs Facility: Highway Department Building

Geothermal Option: Heat Exchanger with Deep Well on-site

A. Simple Payback Calculation

Current Annual Conventional System Cost	
Natural Gas	$ 7,524
Electricity	1,450*
Maintenance	1,240
Total	$ 10,214

Geothermal System Cost	
Capital Cost (1980 Dollars)	$ 114,356
First Year Operating Cost	1,665
First Year Maintenance Cost	2,320
Total	$ 118,241

Simple Payback Period: $\frac{\text{Total Geothermal System Cost}}{\text{Total Conventional System Cost}}$ = 12 years

B. Annual Cost Comparison

(Assume 20-Year Life and 10% per Annum Cost of Capital)

Cost Item	Conventional System Annualized Cost	Geothermal System Annualized Cost
Capital Investment	$ -	$ 13,432
Electricity (9%/yr. escalation)	2,844*	3,265
Maintenance (10%/yr. escalation)	1,809	3,384
Conventional Fuel (15%/yr. escalation)	25,321	-
Total Annualized Cost	$ 29,974	$ 20,081

*For fuel.

ECONOMIC EVALUATIONS (cont'd)

Location: Glenwood Springs Facility: Highway Department Building

Geothermal Option: Heat Exchanger with Deep Well on-site

C. Total Savings and Payback Period

	Conventional System			Geothermal System		End of		Present Value
Year	N.G. (15%)	Elect. (9%)	Maint. (10%)	Elect. (9%)	Maint. (10%)	Year	Annual Savings	(i = 10%)
1980						0		
1981	$7,524	$1,450	$1,240	$1,665	$2,320	1	$6,229	$5,663
1982	8,653	1,580	1,364	1,815	2,552	2	7,230	5,975
1983	9,950	1,723	1,500	1,978	2,807	3	8,388	6,302
1984	11,443	1,878	1,650	2,156	3,088	4	9,727	6,644
1985	13,160	2,047	1,815	2,350	3,397	5	11,275	7,001
1986	15,133	2,231	1,997	2,562	3,736	6	13,063	7,374
1987	17,403	2,432	2,197	2,792	4,110	7	15,130	7,765
1988	20,014	2,651	2,416	3,044	4,521	8	17,516	8,171
1989	23,016	2,889	2,658	3,318	4,973	9	20,272	8,597
1990	26,468	3,149	2,924	3,616	5,470	10	23,455	9,042
1991	30,439	3,433	3,216	3,942	6,017	11	27,129	9,509
1992	35,005	3,742	3,538	4,296	6,619	12	31,370	9,994
1993	40,255	4,078	3,892	4,683	7,281	13	36,231	10,496
1994	46,294	4,445	4,281	5,105	8,007	14	41,908	11,034
1995	53,238	4,846	4,709	5,564	8,809	15	48,420	11,592
1996	61,223	5,282	5,180	6,065	9,690	16	55,930	12,170
1997	70,407	5,757	5,698	6,611	10,659	17	64,592	12,776
1998	80,968	6,275	6,298	7,206	11,752	18	74,553	13,412
1999	93,113	6,840	6,894	7,854	12,898	19	86,095	14,077
2000	107,080	7,455	7,584	8,561	14,188	20	99,370	14,766
Totals							$ 697,883	$ 192,360

Capital Investment $114,356

	Undiscounted	Present Value (discounted at 10%)
Total 20-Year Savings	$697,883	$192,360
Payback Period	9-10 years	14 years

Institutional Requirements

At Glenwood Springs, the resource assessment indicates that a geothermal well can be drilled on site at the Highway Department. If this is so, control of the drilling site is already assured by its State ownership. Geothermal resources may be required, depending upon the results of a title search to determine whether or not the rights are owned by the State at this site.

Water rights are not likely to be required because on-site reinjection is proposed. A well permit from the State would be required along with a disposal permit.

Although the City currently has no regulations specific to geothermal energy, officials have expressed an interest in adopting such regulations if development activity were proposed. The City would require that a plumbing permit be obtained for retrofitting the structure. In Glenwood Springs, a quit claim deed in 1962 conveyed to a Robert L. Nicholas all of the mineral water within Glenwood Springs (Denver Research Institute, 1980). Because it is unclear whether this claim would be supported in a court test, officials have expressed concerns about the legality of drilling a geothermal well in Glenwood Springs (Glenwood Springs Geothermal Advisory Group, pers. comm., 1977).

Environmental Considerations

For Glenwood Springs, a preliminary environmental report on the probable effects of geothermal energy development was performed by the Denver Research Institute for the Colorado Geological Survey (Draft). According to this report, "potentially harmful environmental impacts from the drilling and flow testing of the well (proposed by the CGS) are expected to be minor." Noise, contamination of water supplies and alteration of the existing hydrothermal flow pattern are potential impacts considered in that study to require consideration. Because of the relatively high dissolved minerals content (20,000 mg/l), the potential for negative impacts is greater than in the other areas. The DRI study describes methods for protecting the environment from contamination, the most significant of the methods being reinjection of the fluids (DRI, Draft).