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GEOHERMAL APPLICATIONS
FOR HIGHWAY REST AREAS

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ABSTRACT

This report describes a feasibility study, made for the South Dakota Department of Transportation, regarding geothermal applications for highway rest areas. This preliminary information indicated that the retrofit of the heating systems in the rest area structures was feasible. Specific design assumptions, equipment selections, costs, and other data are reported. This information is conceptual in nature.

FOREWORD

The Geothermal Technical Assistance Program was developed under the premise that the majority of groups or individuals with available geothermal resources do not have the experience or manpower necessary to do a preliminary engineering and economic feasibility evaluation for geothermal energy projects. In order to disseminate technical information and to facilitate expanded use of geothermal energy resources, assistance was provided through FY-1981 in a consulting format on a first-come, staff-and-funds-available basis. Technical assistance can relate to conceptualization; engineering; economics; water chemistry implications for environmental, disposal, and material selection considerations; and planning and development strategies. This report is one of a series adapted from consultation provided to requesters either through in-house efforts or through limited efforts subcontracted to local engineering firms. The Geothermal Technical Assistance (GTA) reports in this series, which are listed below, will be available early in 1982 to those with interest in specific geothermal applications.

<u>GTA Report No.</u>	<u>EG&G Report No.</u>	<u>Title</u>
1.	EGG-GTH-5512	<u>Aquaculture Facility Potential at Boulder Hot Springs, Boulder, Montana</u>
2.	EGG-GTH-5521	<u>Preliminary Geothermal Disposal Considerations, State Health Laboratory, Boise, Idaho</u>
3.	EGG-GTH-5573	<u>Geothermal Conversion at Veterans Hospital, Boise, Idaho</u>
4.	EGG-GTH-5574	<u>Geothermal Applications for Highway Rest Areas</u>
5.	EGG-GTH-5575	<u>Geothermal Applications for a Tannery</u>
6.	EGG-GTH-5599	<u>Preliminary Conceptual Design for Geothermal Space Heating Conversion of School District 50 Joint Facilities at Pagosa Springs, Colorado</u>
7.	EGG-GTH-5617	<u>Selected Geothermal Technical Assistance Efforts (comprising short descriptions of ten space heating projects, five district heating projects, and three heat exchanger projects)</u>

<u>GTA Report No.</u>	<u>EG&G Report No.</u>	<u>Title</u>
8.	EGG-2137	<u>Geothermal Source Potential and Utilization for Methane Generation and Alcohol Production</u> (subcontractor report)
9.	EGG-2138	<u>Geothermal Source Potential and Utilization for Alcohol Production</u> (subcontractor report)
10.	EGG-2139	<u>Potential Geothermal Energy Applications for Idaho Elks Rehabilitation Hospital</u> (subcontractor report)
11.	EGG-2144	<u>Technical Assistance Report on a Geothermal Heating Utility for Lemmon, South Dakota</u> (subcontractor report)
12.	EGG-2145	<u>Economic Analysis for Utilization of Geothermal Energy by North Dakota Concrete Products Company</u> (subcontractor report)
13.	EGG-2146	<u>Geothermal Feasibility Analysis II for Polo School District No. 29-2, South Dakota</u> (subcontractor report)
14.	EGG-2147	<u>Preliminary Feasibility Study of Heating and Cooling Alternatives for Nebraska Western College, Scottsbluff, Nebraska</u> (subcontractor report)
15.	EGG-2148	<u>Inventory of Thermal Springs and Wells Within a One-Mile Radius of Yucca Lodge, Truth or Consequences, New Mexico</u> (subcontractor report)
16.	EGG-2149	<u>Space Heating for Spa Facilities at Ojo Caliente, New Mexico</u> (subcontractor report)
17.	EGG-2150	<u>Geothermal Heated Office Building at Glenwood Springs, Colorado</u> (subcontractor report)
18.	EGG-2151	<u>Final Report--Dickinson Geothermal Study, Dickinson, North Dakota</u> (subcontractor report)
19.	EGG-2152	Cancelled
20.	EGG-2153	<u>Comparison of Two Options for Supplying Geothermal Energy to the Veterans Administration Medical Center at Marlin, Texas</u> (subcontractor report)

<u>GTA Report No.</u>	<u>EG&G Report No.</u>	<u>Title</u>
21.	EGG-2154	<u>Geothermal Utilization at Castle Oaks Subdivision, Castle Rock, Colorado (subcontractor report)</u>
22.	EGG-2155	<u>Space Heating for Twin Lakes School Near Gallup, New Mexico (subcontractor report)</u>
23.	EGG-2156	<u>Pumping Tests of Well Campbell Et Al. No. 2, Gila Hot Springs, Grant County, New Mexico (subcontractor report)</u>
24.	EGG-GTH-5739	<u>Geothermal Deicing of Highways and Bridge Structures</u>
25.	EGG-GTH-5740	<u>Assessment of a Geothermal Application at Tucson, Arizona</u>
26.	EGG-GTH-5741	<u>Heat Pump Systems for Spring Creek, Montana</u>
27.	EGG-GTH-5779	<u>Pipe Selection Guide</u>

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GEOHERMAL APPLICATIONS FOR HIGHWAY REST AREAS

STUDY OBJECTIVES

This report presents the results of a feasibility study conducted for the South Dakota Department of Transportation regarding geothermal applications for highway rest areas. The objectives of this study were

- o To determine the feasibility of using the geothermal water available from geothermal wells at the Vivian westbound and Belvidier eastbound and westbound rest areas to heat buildings at those sites.
- o To outline design options and complete a conceptual design. Primary considerations were low system cost and ease of heating system retrofit.
- o To estimate capital, operation, and maintenance costs for the system.
- o To summarize other potential applications for geothermal energy that should be considered by South Dakota's Department of Transportation.

SYSTEM DESIGN

Table 1 shows the assumptions or estimates that were made in the course of the study.

TABLE 1. ASSUMPTIONS MADE FOR EACH REST SITE

	<u>Vivian Westbound</u>	<u>Belvider Eastbound and Westbound (each site)</u>
Outside design temperature	-10°F	-10°F
Inside design temperature	60°F	60°F
Maximum heat load		
Estimated	96,000 Btu/h	52,400 Btu/h
Installed capacity	112,626 Btu/h	62,114 Btu/h
Well data:		
Flow rate	25 gpm	22 gpm
Temperature	105°F	110°F

Heating Systems

The four types of heating systems considered were:

1. Fan-coil unit heaters
2. Baseboard convection heaters
3. Heat pump systems
4. Radiant floor coils.

Although the 105 to 110°F water temperature is very low for space heating, it can be used in a properly designed system. Baseboard convection heaters were eliminated as a design option because of the low water temperature. Furthermore, heat pumps and radiant floor coils were also

eliminated because their installation would require extensive building modifications. However, both options should be considered if new facilities are to be constructed at other rest area sites. Fan-coil unit heaters appear to be the best option for the retrofit of the heating system. Figure 1 shows a schematic of how the heating system would be integrated into the water supply piping for a typical site. Figures 2 and 3 show the Belvider and Vivian building layouts. Estimated heating load calculations for the two sites are given in Tables 2 and 3. Tables 4 and 5 show cost estimates for retrofitting to use geothermal heat.

For purposes of estimating system costs, McQuay heaters, Model No. SCD, ceiling units, were selected.^a

Water Chemistry

A review of the available water chemistry data suggests that calcium carbonate scaling is not likely to be a problem. Calculations were made for both the Langlier Saturation Index and the Ryznar Stability Index. The results of these calculations indicate a slight tendency toward corrosion of low-carbon steel. The extent of corrosion cannot be estimated from the available data, and would have to be determined by corrosion tests. However, the expense of corrosion tests is not deemed necessary for this project.

Indices from these data were developed on the basis of calcium carbonate scales and do not reveal scaling tendencies from other dissolved solids, such as calcium sulfate and silica. Based on the available data, it can be reasonably assumed that scale from calcium sulfate will not be a

a. Additional information on these units can be obtained from:

Richardson Equipment Co.
P.O. Box 8025
Boise, Idaho 83707
(208) 343-4977

Figure 1. Control diagram (typical for Vivian and Belvider sites).

Figure 2. Vivian site building layout.

Figure 3. Belvider site building layout.

TABLE 2. HEAT LOAD CALCULATIONS FOR VIVIAN REST AREA

Components of Load

Exterior walls & roof
 Makeup air & infiltration

U-Factors

Wall

4-in. face brick
 4-in. block
 2-in. rigid insulation
 Inside air surface
 Outside air surface

R

0.4
 0.7
 5.6
 0.7
 0.3
7.7

U = 0.13

Roof

3 layers, felt
 1 layer, shingle
 1-in. rigid insulation (roof)
 3-in. cedar deck
 Inside air surface
 Outside air surface

R

0.33
 0.50
 2.78
 3.00
 0.60
 0.30
7.51

U = 0.13

Building Configuration

Floor dimensions
 Height

30 x 28 ft
 12 ft

Heat transfer through Walls and Roof:

$$\begin{aligned}
 Q &= UA\Delta T \\
 &= (0.13) \left[\begin{array}{l} 28 \times 12 \times 2 = 672 \\ 30 \times 12 \times 2 = 740 \\ 30 \times 28 = 840 \\ \hline 2,232 \end{array} \right] (60 - (-10)) \\
 &= 20,311 \text{ Btu/h}
 \end{aligned}$$

Makeup Air:

$$\begin{aligned}
 Q &= (1.08) (\text{cfm}) (\Delta T) \\
 &= (1.08) (1000) (70) = 75,600 \text{ Btu/h}
 \end{aligned}$$

Total Building Heat Load: 96,000 Btu/h

TABLE 3. HEAT LOAD CALCULATIONS FOR BELVIDER REST AREA

Components of Load

Exterior walls & roof
Makeup air

U-Factors

Walls; 0.13; (similar to Vivian)
Roof, use 0.10 (assumed)

Building Configuration (heated space)

Length & width = 30 x 20 ft
Height = 10 ft

Heat Transfer through Walls and Roof:

$$Q = UA\Delta T = (0.13) \begin{array}{l} 30 \times 10 \times 2 \\ 20 \times 10 \times 2 \\ 30 \times 20 \\ 1600 \end{array} (70) = 14,600 \text{ Btu/h}$$

Makeup Air (assume 500 cfm)

$$Q = (1.08) (500) (70) = 37,000 \text{ Btu/h}$$

Total Building Heat Load = 52,400 Btu/h

(Agrees reasonably with installed capacity of 62,114 Btu/h)

TABLE 4. VIVIAN WESTBOUND COST ESTIMATE^a

	Material (\$)	Labor (\$)	Total (\$)
Fan-coil units, 7 ea. (18,000 Btu/h ea.)	3,200	1,200	4,400
Piping, 180 LF (3/4-in. & 1-in. pipe)	360	540	900
Pipe insulation	200	300	500
Pump	300	250	550
Electrical	400	500	900
Controls	<u>600</u>	<u>400</u>	<u>1,000</u>
Subtotal	5,060	3,190	8,250
Contractor overhead and profit @ 30%			2,500
Escalation to 1980 @ 10%			825
Contingency @ 15%			<u>1,250</u>
Engineering fees Building retrofit ^b			\$ 3,200
Total retrofit cost			<u>\$12,825</u>
Total project cost			\$16,025
Estimate of yearly operation and maintenance cost ^c			\$400/yr

a. The cost of smaller jobs is heavily dependent on the distance a contractor must travel. These estimates should suffice for traveling distances of 50-100 miles. For greater distances, prices would increase accordingly.

b. Cost of building modifications (if required) are not included.

c. Figure includes only annual pump electrical cost; no incremental maintenance cost is associated with the geothermal system.

TABLE 5. BELVIDER EASTBOUND AND WESTBOUND COST ESTIMATE^a

	<u>Material</u>	<u>Labor</u>	<u>Total</u>
Fan-coil units, 5 ea. (13,000 Btu/h ea.)	\$1,800	\$ 800	\$2,600
Piping, 100 linear feet (3/4-in. & 1-in. pipe)	200	300	500
Pipe insulation	120	180	300
Pump	300	250	550
Electrical	400	500	900
Controls	<u>600</u>	<u>400</u>	<u>1,000</u>
Subtotal	3,420	2,430	5,850
Contractor overhead and profit @ 30%			1,755
Escalation to 1980 @ 10%			585
Contingency @ 15%			<u>880</u>
Engineering fees Building retrofit ^b			\$ 2,300
Total retrofit cost			<u>\$ 9,070</u>
Total project cost			\$11,370
Estimate of yearly operation and maintenance cost ^c			\$250/yr

a. The cost of smaller jobs is heavily dependent on the distance a contractor must travel. These estimates should suffice for traveling distances of 50-100 miles. For greater distances, prices would increase accordingly.

b. Cost of building modifications (if required) are not included.

c. Figure includes only annual pump electrical cost; no incremental maintenance cost is associated with the geothermal system.

problem. Data on the silica content of these waters are not reported. However, since other geothermal fluids in South Dakota have relatively low silica concentrations, scaling from this source is not expected to be a problem.

It is suggested that the Department of Transportation contact the South Dakota School of Mines and Technology, or another organization of similar expertise, to obtain a confirmation of these recommendations.

ADDITIONAL APPLICATIONS

Other potential applications for the geothermal resource include

- o The direct use of the well water for the rest area hot water system. This feature could be integrated into present or new rest area systems.
- o The heating of roadways for deicing and snow melting. Geothermal water has been successfully used to heat roadways in the vicinity of Klamath Falls, Oregon, for several years.

Heating Roadways

Calculations for the heating of roadways were made in order to estimate approximate costs. These calculations were based on

$$H = 1.2 [d_{\ell} h_f + 1.35 (T_s - T_a)]$$

$$Ap = H/K(T_w - T_a)$$

where:

$$H = \text{Btu/ft}^2$$

$$Ap = \text{Pipe area/ft}^2 \text{ surface}$$

$$d = \text{Snowfall rate (ft/hr); assumed 0.083 ft/hr (1 in./hr)}$$

$$\ell = \text{Snow density (lb/ft}^3\text{); assumed 3.5 lb/ft}^3 \text{ at } 10^{\circ}\text{F}$$

$$h_f = \text{Heat of fusion of ice (Btu/lb)}$$

$$T_s = \text{Road surface temperature (}^{\circ}\text{F); assumed } 34^{\circ}\text{F}$$

$$T_a = \text{Air temperature (}^{\circ}\text{F); assumed } 10^{\circ}\text{F}$$

T_w = Mean water temperature ($^{\circ}\text{F}$)

K = Buried pipe heat emission factor;

assumed: $K = 0.7$ for 1-in. pipe under 2.5-in. of asphalt

$K = 0.5$ for 1.25-in. pipe under 4-in. of concrete.

For a geothermal mean water temperature (T_w) of approximately 87°F and flow rate of approximately 5 gpm/1000 ft^2 of roadway, the installed costs of two grid systems were estimated as shown in Table 6.

TABLE 6. GRID SYSTEM COST ESTIMATE^a

	Pipe Size (in.)	Spacing (in.)	Cost/ Ft^2 (\$)
Steel	1	4	13
Plastic	1	3	7

a. These costs do not include costs of the well and associated controls.