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FEASIBILITY OF
USING GEOTHERMAL WATER
AT TIMBERLINE LODGE

GRANT: DE-FG51-81R001329

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Prepared by:

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Project No. 1614-10
March 30, 1982

MASTER

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INTRODUCTION

The purpose of this preliminary study is to determine the technical and economic feasibility of utilizing geothermal fluids as a heating source at the Timberline Lodge complex. It was understood that if feasibility was demonstrated by this study, that more detailed engineering study and possibly contractor estimates would be the next step.

The engineering decisions in this study were based on judgment and experience, not detailed calculations or design. Budget limitations did not allow for testing and other field work needed for more detailed analysis.

Richard G. Bowen, President, WY'EAST Exploration & Development Company, headed the engineering study team composed of C. W. Timmer Associates, Inc., R. A. Wright Engineering, Inc., and Perkins Engineering, Inc.. Timmer Associates was responsible for mechanical engineering, Wright Engineering for civil, and Perkins Engineering for electrical work. Timmer Associates coordinated the engineering efforts and the writing of this report.

GEOHERMAL RESOURCE

The anticipated location of the production well is at the bottom of the Pucci chairlift (5330' elevation), approximately 3650 lineal feet below the Main Lodge (5940' elevation). The injection well (5780' elevation) is located near the maintenance building to the south and east of the Lodge complex.

Earlier tests of the production well indicated that approximately 150 GPM of continuous flow could be expected. Measured fluid temperatures were in the range of 170 to 180 degrees F at the well head. The design basis of our calculations was 150 GPM and 170 degrees F fluid temperature at the well head.

Preliminary water chemistry tests indicated that the fluid is somewhat corrosive, but beyond that general analysis, more detailed water chemistry tests were not made because they were outside the study scope.

LOADS

The amount of load occurring depends primarily on outside temperature with maximum loads occurring at the design condition of -10 degrees F. The loads calculated for the two lodges are as follows:

MAIN LODGE

Space heating, east wing only	791 MBH
Domestic water heating	833 MBH
Pool heating	2500 MBH
Snow melting	<u>1000 MBH</u>
	5124 MBH

DAYLODGE

Space heating	2194 MBH
Domestic water heating	260 MBH
Snow melting	<u>1400 MBH</u>
	3854 MBH

Graphs in the Appendix show how these loads, individually and combined, vary with outside temperature.

Not all space heating loads in the Main Lodge can be economically modified to use the geothermal resource. The older part of the Lodge is heated with steam and this system would be costly to convert. The majority of the Main Lodge loads can be converted and are considered in this study.

The Daylodge mechanical system was designed in anticipation of the possibility of using geothermal fluids at some future date. Comparatively it is a relatively straightforward conversion at the Daylodge.

The Main Lodge loads are now supplied by two oil-fired steam boilers and the Daylodge loads are supplied by two oil-fired hot water boilers. Detailed oil use records for the Main Lodge were provided by operating staff covering a six year period. The Daylodge oil use had to be estimated since a full year of operation has not been completed. However, the basis of this estimate is three winter months of operation this past winter. Included in the appendix is a tabulation showing the actual usage at the Main Lodge and the estimated Daylodge oil use by month.

SYSTEM ARRANGEMENT

Even though the Daylodge was designed to use geothermal fluids, it was found that the Main Lodge could make better use of geothermal fluids on an annual basis. The Main Lodge year-around pool heating and domestic water heating provide an opportunity to use geothermal on a continuous basis. The seasonal Daylodge loads are smaller and would use less total energy. Additionally, the Main Lodge has insufficient boiler capacity to handle the loads at peak times of the year. By using geothermal, the boiler load would be reduced to the point where sufficient capacity would be available.

The Main Lodge loads to be supplied from geothermal are the swimming pool, domestic water heating, and east wing space heating. A schematic diagram is provided in the Appendix. A 20,000 gallon storage/settling tank, located in the general area of the swimming pool, would provide approximately two hours of operating capacity. A plate type heat exchanger would be provided for each of the loads. The purpose of the domestic hot water preheat exchanger is to "wring out" as much energy as possible from the geothermal fluids. The heat transfer system cost is summarized in the Appendix.

During much of the year, more than enough capacity would be available to satisfy the Main Lodge loads and therefore heat exchangers are provided at the Daylodge to offset the space heating and water heating loads when capacity is available. From the Daylodge the geothermal fluid is piped to the injection well.

The average annual usable capacity available from the geothermal well is approximately 5250 MBtu's per hour. This capacity will essentially offset boiler operating requirements for all loads except the Main Lodge steam heating when the outside temperatures is above 30 degrees F and the wind is not blowing hard. For all practical purposes, this means that all needs during the period June through October can be satisfied from the geothermal well.

During the months when the outside temperature is below 30 degrees F, the well can only support a portion of the total load. Estimates indicate that during this period approximately 10,000 gallons of oil per month can be displaced. The total estimated annual oil displacement is approximately 111,000 gallons a year. This represents 67% of the total annual oil usage of the complex (165,800 gallons a year). The value of this displaced oil at today's energy prices (81 cents a gallon) is \$89,900 a year.

GEOTHERMAL PIPE LINE

The underground geothermal pipeline connecting the production well with the Main Lodge would be a Schedule 80 carbon steel, 4" diameter line with a maximum capacity of approximately 300 gallons per minute. The line would be about 30" below grade and have a maximum operating pressure of 440 pounds per square inch.

The line would be encased in a 10 gage galvanized steel insulated jacket. Expansion would be accommodated by a total of nine below grade expansion loops. Pipeline anchors would be spaced approximately every 400 feet.

The pipeline insulation criteria is based on a 10 degree maximum drop in fluid temperature between the production well and the Main Lodge. The fluid carrier will have a 1-1/2" preformed fiberglass or calcium silicate insulation layer and the void between this insulation and the steel jacket will be insulated as well. The return line from the Daylodge to the injection well will beunjacketed and uninsulated.

A detailed report on the transmission pipeline by R. A. Wright Engineering is in the Appendix.

ELECTRICAL SYSTEM

Power to the well will be provided by means of an underground primary (12.5 Kv) line from the bottom of the Blossom ski lift. The utility will supply the primary conductor in an Owner provided trench between Blossom and the production well. A utility supplied transformer will provide 480 V service to a 300 HP rated outdoor motor control panel. Low voltage power (120/240 V) will be provided by Owner transformers.

Other work included in the electrical cost is control cables between the Lodge and the production well and inside wiring at the Main Lodge and Daylodge to accommodate the heat transfer systems.

A detailed report on the electrical system by Perkins Engineering is in the Appendix.

COST ESTIMATES

The cost estimates provided in this report are based on experience and schematic design, not contractor estimates. Twelve months of inflation has been added at the rate of 1% per month. Also included are engineering design fees and a labor cost premium that takes into account the isolated job site. The total installed cost of the geothermal system between the production well and the injection well is approximately \$882,000. This includes the civil, electrical, and mechanical work. The production and injection wells are excluded.

PROJECT COST SUMMARY

Transmission Line	\$232,700
Electrical System	75,800
Heat Transfer System	342,000
Subtotal	<u>\$650,000</u>
12 Months Inflation, 12%	78,100
	<u>\$728,600</u>
Contingency @ 10%	72,900
	<u>\$801,500</u>
Engineering @ 10%	80,200
	<u>80,200</u>
Total	\$881,700

Use \$882,000

The above cost is based on titanium plate heat exchangers. If more detailed water chemistry tests indicate that stainless steel exchangers can be used, the total cost is reduced to \$862,000.

If oil prices are assumed not to increase in future years, the simple payback on this investment is 9.8 years. This is calculated by dividing the system cost, \$882,000, by the annual cost reduction, \$89,900. If the price of oil is assumed to increase at a rate of 15% per year, the payback period reduces to between 6 and 7 years.

The displaced oil cost reduction should be reduced by the \$16,500 annual cost to operate the production well pump. Doing this increases the payback period to 12 years (882,000 divided by 73,400). If oil and electricity prices increase 15% per year, this payback reduces to between 7 and 8 years.

CONCLUSIONS

There are no apparent unsolvable technical problems that would discourage the use of geothermal fluids at the Timberline Lodge complex. However, it is recommended that a more detailed study and possibly a design development phase with contractor estimates be the next step. The more detailed study effort should include field testing and measurements to provide an information base for engineering decisions.

A P P E N D I X

TIMBERLINE LODGE
AVERAGE DAILY FUEL CONSUMPTION
IN GALLONS

	<u>1976</u>	<u>1977</u>	<u>1978</u>	<u>1979</u>	<u>1980</u>	<u>1981</u>	<u>Average</u>
January	520	470	516	499	501	480	498
February	598	357	494	533	495	361	473
March	563	624	450	512	537	381	511
April	485	366	410	429	358	401	408
May	375	350	489	327	382	341	377
June	379	235	317	318	286	285	303
July	222	223	203	216	243	336	241
August	256	197	220	224	291	184	229
September	212	332	249	434	315	242	297
October	207	313	295	350	370	342	313
November	346	563	415	389	403	261	396
December	425	552	536	465	439		483

Annual Total 137,576 Gallons

ESTIMATED DAYLODGE FUEL USE

	<u>RAINIER PARADISE D/D</u>	<u>% OF TOTAL</u>	<u>SPACE HTG GALS</u>	<u>DOM WH FUEL GALS</u>	<u>SNOW MELT GALS</u>	<u>TOTAL GALS</u>
Jan	1,180	12	1,728	115	3,147	4,990
Feb	1,030	11	1,584	115	3,147	4,846
Mar	1,100	12	1,728	115	3,147	4,990
Apr	890	9	1,296	115		1,411
May	730	8	1,152	90		1,242
June	560	6	864	90		954
July	350	3	432	90		522
Aug	370	4	576	90		666
Sept	510	5	720	90		810
Oct	760	8	1,152	90		1,242
Nov	940	10	1,440	115		1,555
Dec	<u>1,140</u>	<u>12</u>	<u>1,728</u>	<u>115</u>	<u>3,147</u>	<u>4,990</u>
	9,560	100	14,400	1,230	12,588	28,218

PRELIMINARY GEOTHERMAL FLUID CIRCUIT

HEAT TRANSFER SYSTEM

COST SUMMARY

Storage Tank	\$ 14,000
Pumping Equipment	10,000
Piping Inside	51,450
Outside (to Daylodge)	60,000
Controls	23,000
Heat Exchangers	90,500
Labor	<u>48,400</u>
Subtotal	\$297,350
Contractor O & P @ 15%	<u>44,600</u>
	\$341,950
Use	\$342,000

MT. HOOD GEOTHERMAL HOT WATER TRANSMISSION PIPELINE

1.0 GENERAL

This section presents the feasibility analysis for a geothermal hot water transmission line located on Mount Hood, Oregon, below Timberline Lodge. Included is a description of the project, the delivery parameters, design considerations, installation plans, and a cost estimate.

- 1.1 Description. The hot water would be extracted by a 4,000 foot deep well from a location near the base of Pucci Chairlift. A transmission line would move the water through an underground insulated pipeline to Timberline Lodge. The heat would be used primarily to satisfy main lodge hot water heating requirements for domestic and pool water.

The transmission line would be steel jacketed pipe buried in a trench and backfilled on an average slope of 17 percent, approximately 3,700 feet of jacketed pipe and 800 feet of unjacketed return pipe would be necessary. Thermal expansion will be handled by expansion loops where the inner pipe would be allowed to move within the outer jacket.

- 1.2 Delivery Parameters. The geothermal hot water will be pumped from a proposed 4,000 foot extraction well. Flow rates are estimated to be about 150 gallons per minute and have an approximate maximum capacity of 300 gallons per minute. The water temperature is said to be 170 to 180°F. Laboratory samples of the water show pH at 8.15 and 9.2, calcium content at 110 ppm, sodium content at 270 ppm, and chloride content at 295 ppm. Fluid pressure at the top of extraction well is estimated to be approximately 440 pounds per square inch when the well is pumping at 300 gallons per minute.

2.0 DESIGN CONSIDERATIONS

- 2.1 Pipeline Materials. The pipeline was designed to handle a maximum of 300 gallons per minute of hot water at 200°F under a maximum pressure of 440 pounds per square inch. The Forest Service requirements and operational considerations necessitated that the transmission line be buried.

Pipeline materials considered were:

- Non-metallic (PVC, CPE, etc.)
- Fiberglass Reinforced Plastic (FRP)
- Steel

A concrete vault was considered to be too costly. Non-metallic pipe was rejected because of the temperature and pressure conditions. In addition, non-metallic pipe normally has higher coefficient of thermal expansion than steel pipe. Fiberglass reinforced plastic pipe (FRP) is not designed for working pressures required in this project. Further, connections for this FRP pipe are expensive.

Steel pipe was selected for the material of the inner pipe. Specifically, carbon steel pipe would handle the pressure and temperature variations. Shop and field welds must be properly performed because of the combined stresses that could be present. Long radius elbows should be used with slip rings fillet welded in key joints. Inner pipe would be four inch Schedule 80 pipe. Outer pipe would be 10 and 12 inch 10 gage (minimum) smooth wall galvanized steel jacket with welded miter corners as designed.

2.2 Thermal Expansion. The pipeline will probably be constructed during a temperature range of 40 to 60°F. However, the thermal cycle range is assumed to be from 25° to 200°F. Carbon steel will expand over 175°F approximately 1.12 inches per 100 feet or approximately 42 inches over the length of the pipeline. Since the pipeline would be buried, underground expansion loops would be constructed. Anchors would be placed about every 400 feet and expansion would be compensated within the loop.

2.3 Corrosion. The geothermal water was sampled for various constituents and found to be basic (pH 8.15 and 9.2) with dissolved solids of calcium at 110 ppm, sodium at 270 ppm, and chlorides at 295 ppm. There would be a tendency that scale will form in the pipe. Also, there is a possibility that negative electrode potential would exist requiring some cathodic protection. If this project continues to final design, additional laboratory data and analysis in this area must be accomplished.

2.4 Insulation. In order to maintain a change in temperature through the transmission line of less than 10 degrees Fahrenheit, insulation will be added to the inner pipe. Preformed fiberglass or calcium silicate wrapped insulation 1½ inches thick would be used. An annulus spacer made of insulating material will position the inner and outer pipes. The spacer will allow movement of the inner line. The conductivity was assumed to be 0.15 BTU/hour/square/foot/°F.

3.0 INSTALLATION

3.1 Route. . The transmission line would be routed underground from the extraction well located near the lower end of Pucci Chairlift to the west end of the main lodge at Timberline. The pipeline in this route would be jacketed. The pipeline length is approximately 3,700 feet. See Figure 1 for the proposed pipeline route configuration.

About 800 feet of return pipeline would be necessary to the injection well which is located near the maintenance building.

The pipeline route would cross a 12,000 KW underground power line, summer camping access road, and the main lodge parking area. In addition, the pipeline would cross power lines that serve several night skiing lights.

3.2 Construction. The construction of this pipeline would occur during the summer. The trench would be constructed so that field assembly of the pipes can take place. Figure 2 shows section drawings of the pipeline, trench, and backfill. Crushed rock would be used for pipe bedding and backfill. A minimum of six inches of native cover soil should be placed and compacted so that local plants can root. Several hundred feet of trench excavation may require ripping through a layer of rock.

Anchors would be constructed as shown in Figure 4 approximately every 400 feet. Straight sections of pipe would be field assembled welded and insulated. Expansion loops would be field assembled (refer to Figure 3). Inspection during this process would be necessary to assure that welding and insulating are properly done. The pipe would be pressure tested to 150 percent working pressure.

Construction equipment would be required to operate on 17 percent slopes. Backfill rock would be stockpiled at intervals along the pipeline. The pipeline would be constructed by a competent pipeline contractor.

4.0 COST ESTIMATE

The estimated capital cost to design and construct the geothermal hot water pipeline is \$267,600. The following is the cost breakdown.

ESTIMATE CAPITAL COST

Trench Excavation and Backfill	\$ 18,000
Prefabricated Steel Pipe 1	191,800
Pipe Installation 2	21,300
Testing	1,600
Engineering and Contingency (15%)	<u>34,900</u>
TOTAL	\$267,600

1 3,700 lineal feet jacketed supply pipe and 800 lineal feet return line

2 Including ASME field welding

R.A.Wright
engineering
 consulting engineers

Mt. Hood Geothermal
 Hot Water
 Transmission Line
FIGURE 1

PIPELINE SECTION

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1/2" SW. Benthic River
1/2" SW. Benthic River
1/2" SW. Benthic River

Mt. Hood Geothermal
Hot Water
Transmission Line
FIGURE 2

EXPANSION LOOP PLAN VIEW

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Mt. Hood Geothermal
Hot Water
Transmission Line
FIGURE 3

FRONT VIEW

SIDE VIEW

ANCHOR DETAIL

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Mt. Hood Geothermal
 Hot Water
 Transmission Line
FIGURE 4

MT. HOOD GEOTHERMAL HOT WATER ELECTRICAL POWER SYSTEM

1.0 SYSTEM DESCRIPTION

1.1 Power Supply - Well Site

The electrical power system will consist of a Utility supplied primary three phase circuit from the existing Blossom lower terminal chair lift transformer to a new transformer near the proposed extraction Well site. From this transformer 480 volt three phase power will be provided to an outdoor type 300 horsepower rated electric pump panel. There will be additional equipment to provide 120/240 volt power for control equipment and general purpose 120 volt power for lighting and maintenance.

The primary circuit from Blossom to the Well site will be trenched by the installing contract with the cable provided and installed by the Utility. Equipment and transformer grounding is included for the Well site system.

1.2 Control Provisions - Well Site

Power will be provided for operating control equipment as selected by the mechanical design. In addition a multiconductor control cable will be provided between the Well site and Timberline Lodge. This cable will be routed along with the hot water pipeline and will have approximately 25% spare conductors for future use.

1.3 Power and Control - Timberline Lodge

The electrical system will include connection to existing power sources for supply to recirculating pumps. The control will be as required in the mechanical design. Additional provisions include connection of control and monitoring circuits between the Timberline and Daylodge.

1.4 Power and Control - Daylodge

This electrical system will include power connection to existing systems for operation of the new geothermal circulation pumps and controlled as required by the mechanical design. There is an allowance in the budget to interface with the existing boiler/heating systems as required by the mechanical design.

2.0 CAPITAL COST ESTIMATE

The attached Capital Cost Estimate - Electrical includes all required electrical material and labor to install the system as described above. These costs are based on today's prices and should be adjusted accordingly when applied to actual purchase prices at the time of bidding or construction. The basis for quantities and components are from equipment sizing and layout as described in other sections of this report. Any variation from these

C. W. Timmer Associates
Timberline Lodge
Portland, Oregon

Electrical Budget
Project P043.35
8 March 1982

CAPITAL COST ESTIMATE - ELECTRICAL

Utility connections	\$ 5,000
Power cable trenching and backfill Estimate 3,300 feet at \$4.00/ft.	13,200
Transformer pad and primary conduit, 500KVA transformer by Utility.	2,500
Underground 480v. 3 phase, 3 wire service.	2,500
Pump panel and wiring for 300 hp, 480v., 3 phase pump.	18,000
Branch circuit and control wiring at Well site.	6,500
Grounding at Well site.	3,600
Control wiring from Well to Timberline Lodge. Estimate 4,000 feet control wire.	8,000
Timberline Lodge circulating pump, wiring for 6 pumps.	7,000
Daylodge circulating pump, wiring for one pump.	1,500
Provisions for control wiring between Timberline and Daylodges. 600 feet 1½" conduit in trench	4,000
Rewire of existing boilers to accommodate new systems.	<u>4,000</u>
	\$75,800
Contingency @ 10%	<u>7,600</u>
	<u>\$83,400</u>
Engineering @ 10%	\$ 8,400

values; i.e., horsepower increase or decrease, distance changes and the like will adjust costs accordingly.

The estimated capital cost for the electrical is \$83,400 plus engineering at \$8,400. This budget is itemized in the attached "Electrical Budget" sheet.

3.0 DRAWING

Attached is Drawing SK-EI showing proposed routing of the primary power circuit from Blossom chair lift lower terminal to the Well site and the control cable from the Well site to the Timberline Lodge to the Daylodge.