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# GEOTHERMAL DISTRICT HEATING SYSTEMS

MASTER



by

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Work Supported by the
U.S. Department of Energy
Contract DE-AM03-76SF00700 and
Contract DE-AC07-76ID01570

Prepared for Presentation at the
1982 International District Heating Association Conference
Chateau Mont St. Anne, Quebec, Canada
June-14-16, 1982

## DISCLAIMER

# GEOTHERMAL DISTRICT HEATING SYSTEMS

## Introduction

The use of geothermal energy for direct heat purposes by the private sector within the United States has been quite limited to date. However, there is a large potential market for geothermal energy in such areas as industrial processing, agribusiness, and space/water heating of commercial and residential building. Technical and economic information is needed to assist in identifying prospective direct heat users and to match their energy needs to specific geothermal reservoirs. Technological uncertainties and associated economic risks can influence the user's perception of profitability to the point of limiting private investment in geothermal direct applications.

To stimulate development in the area of direct heat use, the Department of Energy (DOE), Division of Geothermal Energy, issued two Program Opportunity Notices (PON's). These solicitations are part of DOE's national geothermal energy program plan, which has as its goal the near-term commercialization by the private sector of hydrothermal resources. Encouragement is being given to the private sector by DOE cost-sharing a portion of the front-end financial risk in a limited number of demonstration projects.

Ten of the district heating type demonstration projects are described in this paper. Five are contracted out of the San Francisco office of the Department of Energy. These five projects are:

Klamath County YMCA (Oregon)
Susanville (California) District Heating
Klamath Falls (Oregon) District Heating
Reno (Nevada) Salem Plaza Condominium
El Centro (California) Community Center Heating/Cooling

Technical support to DOE on these projects is provided by the Energy Technology Engineering Center. The other five projects are contracted out of the Idaho Operations Office of the Department of Energy. The five projects are:

Haakon School and Business District Heating
(Philip, S. Dakota)
St. Mary's Hospital (Pierre, S. Dakota)
Diamond Ring Ranch (near Midland, S. Dakota)
Pagosa Springs District Heating (Colorado)
Boise District Heating (Idaho)

Technical support to DOE on these projects is provided by E.G.&G. Idaho, Inc.

The following provides a brief description of each of these projects and their present status.

Klamath County YMCA

This project consists of the design, construction, test, and demonstration of a geothermal heating system for the Klamath County YMCA. The system is to provide heat for the building, domestic hot water, and the swimming pool. It replaces a gas-fired heating system which is being retained as a backup system. The geothermal system satisfies the total heating requirements of the YMCA.

Figure 1 is a schematic diagram of the geothermal heating system. Geothermal fluid from the production well flows through a plate type heat exchanger where heat is given up to a secondary water circuit. Geothermal fluid is 250 gpm (15.8 l/s); inlet and outlet temperatures are 146°F (63°C) and 142°F (61°C), respectively. The secondary fluid outlet temperature is 146°F (63°C). The plate heat exchanger is more than adequate for its expected duty.

Table 1 summarizes the principle features of the system. The flow requirement at peak load with a geothermal temperature of 146°F is 250 gpm (15.8 l/s). The variable speed drive pump operates over a load range of 60 to 250 gpm (3.8 to 15.8 l/s).

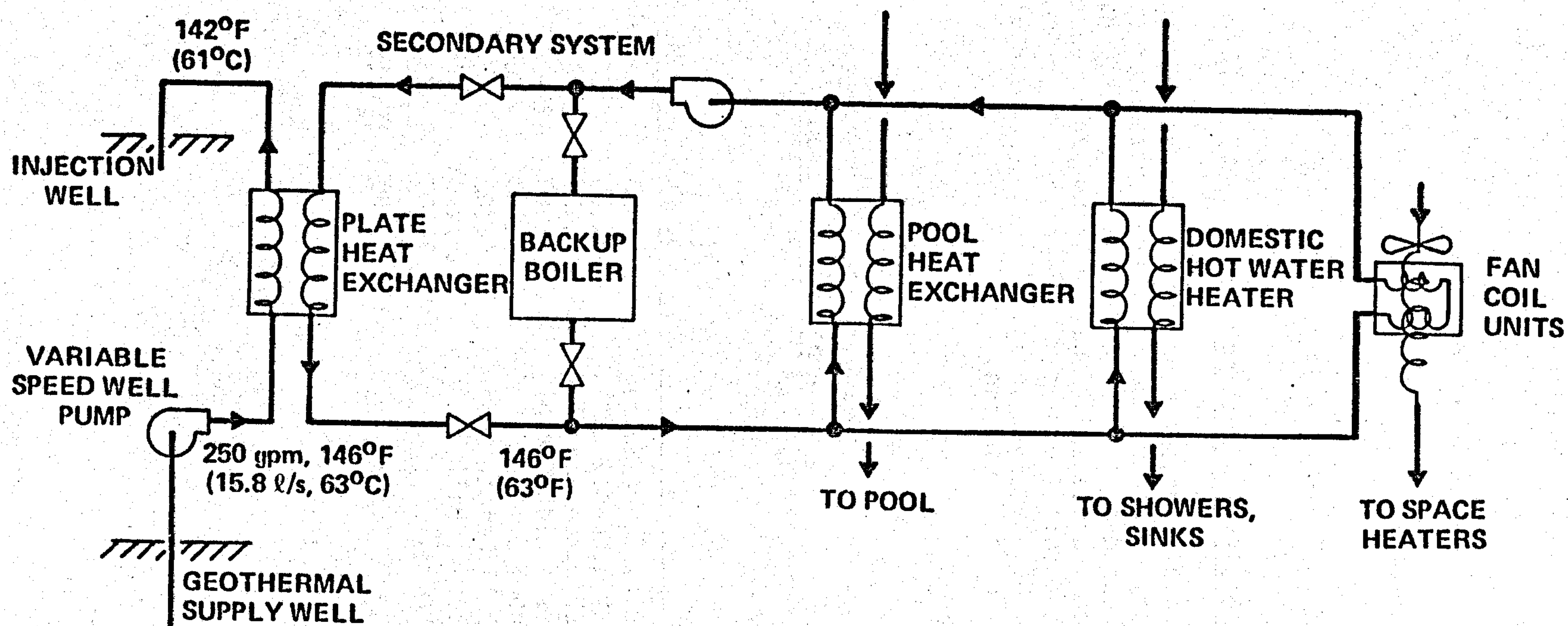
Table 1

Klamath County YMCA
System Characteristics

| | | |
|---|---|---|
| **Production Well:** | | |
| Depth | 1410 ft. | (430 m) |
| Wellhead Temperature | 147°F | (64°C) |
| Flow | 310 gpm | (19.6 l/s) |
| Static Level Depth | 91 ft. | (28 m) |
| Drawdown | 179 ft. at 250 gpm (54.6 m at 15.8 l/s) | |
| **Pump:** | | |
| Motor Power | 40HP (30kw) | |
| Flow | 250 gpm (15.8 l/s) at 62 psi (427 kPa) discharge pressure | |
| **Heat Exchanger:** | | |
| 66 plate, stainless steel | | |
| **Injection Well:** | | |
| Depth | 2016 ft. | (614 m) |
| Injection Temperature | 142°F | (61°C) |
| Injection Pressure | 31 psi | (214 kPa) |
| **System Heat Loading:** | | |
| Total | $7 \times 10^9$ Btu/yr | ($7.4 \times 10^9$ kJ/yr) |

FIG 1

# KLAMATH COUNTY YMCA SYSTEM SCHEMATIC

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The geothermal heating system at the YMCA was completed in April 1980 and has been operational almost continually ever since. It supplies 100% of the heat energy needs of the YMCA.

## Susanville District Heating

This project consists of the design, construction, testing, and operation of a geothermal energy system for space heating of 14 publicly owned or leased buildings. The system has provision for expansion to include additional buildings and a park of commerce. The area of the buildings and heat loads on the system are listed in Table 2. Geothermal energy will meet approximately 80% of the total heat load of the buildings.

Table 2

Susanville Public Buildings
Area and Heat Loads

| | Size Sq. ft. | Sq. M. | Total Heat Load $10^6$ Btu/Hr | Watts |
|---|---|---|---|---|
| County Court House | 22,000 | 2,040 | 1.26 | .37 |
| City & County Jail | 7,100 | 660 | .37 | .11 |
| Washington School | 11,600 | 1,080 | 1.56 | .46 |
| Lassen High School | 139,000 | 12,900 | 7.23 | 2.12 |
| School Office | 3,200 | 300 | .21 | .06 |
| School Maint. Shop | 5,000 | 465 | .76 | .22 |
| Veterans Hall | 14,400 | 1,340 | .60 | .18 |
| Fire Hall | 7,900 | 730 | .36 | .11 |
| | 210,200 | 19,515 | 12.35 | 3.63 |

Figure 2 is a schematic diagram of the system. The project encompasses only existing buildings which require various types of retrofits to utilize geothermal energy. Figure 2 depicts typical heat loads in the various public buildings.

Table 3 summarizes the system characteristics.

Table 3

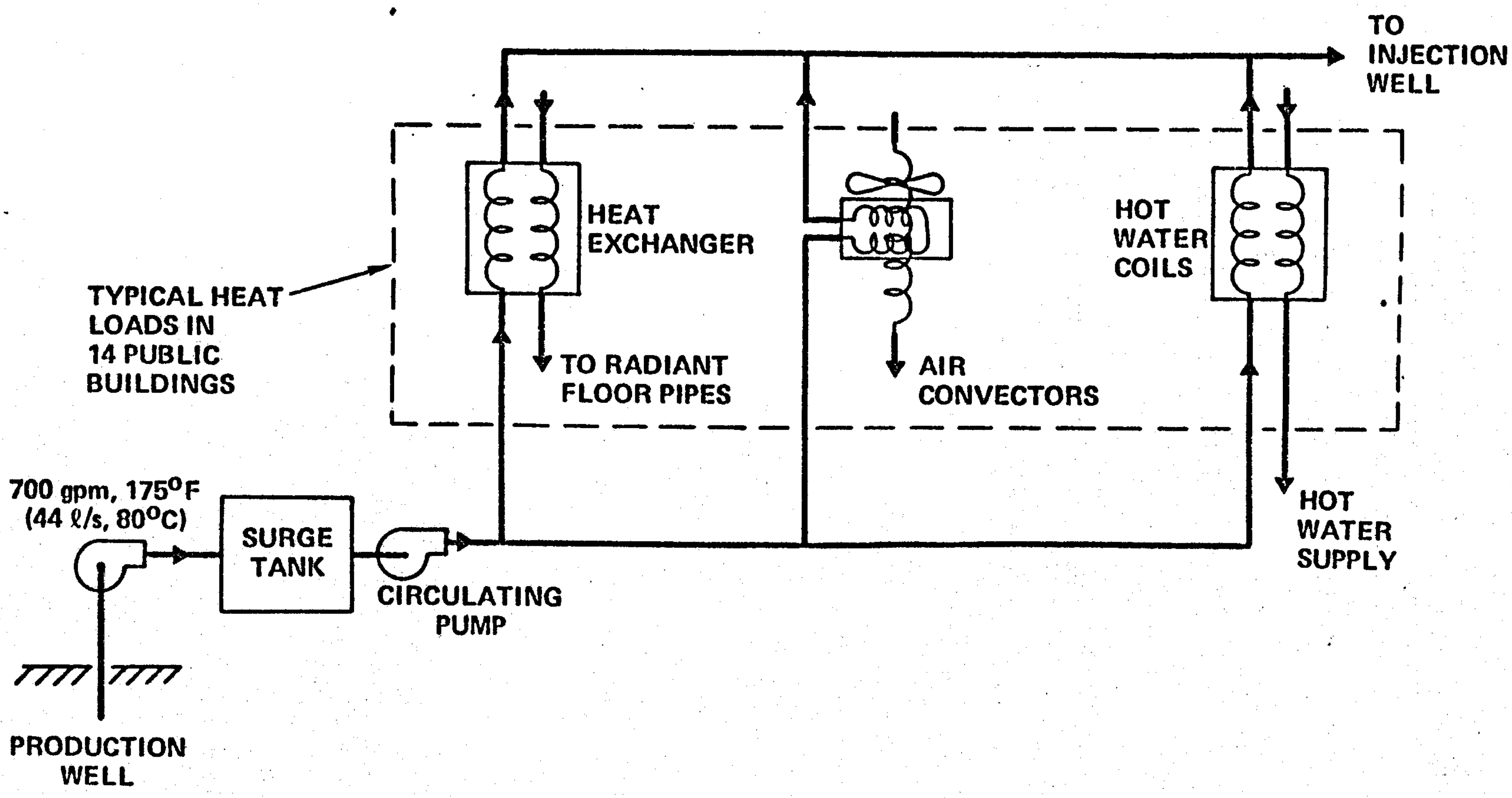
Susanville System Characteristics

| | | |
|---|---|---|
| **Production Well:** | | |
| Depth | 927 ft. | (283 m) |
| Wellhead Temperature | 175°F | (80°C) |
| Flow | 700 gpm | (44 l/s) |
| Drawdown | 140 ft. | (43 m) |
| **Pump:** | | |
| Motor Power | 60HP | (45kW) |
| Flow | 700 gpm | (44 l/s) at 120 psi (827 kPa) |
| Constant speed drive | | |
| **Injection Well (est.):** | | |
| Depth | 400 ft. | (122 m) |
| Injection Temperature | TBD | |
| Injection Pressure | TBD | |
| **System Heat Load:** | | |
| Total | $15.9 \times 10^9$ Btu/yr | ($16.8 \times 10^9$ kJ/yr) |
| Design | $12.35 \times 10^6$ Btu/hr | (3.6 Mw) |
| Required Flow | 566 gpm | (36 l/s) |

The first geothermal heat was delivered to Building 6 of Lassen High School on December 31, 1981. Buildings were added to the system as retrofits were completed. The final building was placed on line in April 1982.

FIG 2

# SUSANVILLE DISTRICT HEATING SYSTEM SCHEMATIC

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Klamath Falls District Heating

This project consists of design, construction, test, and operation of a geothermal district heating project which, initially, will serve 14 city, county, state and federal buildings. The system consists of two main circuits. Geothermal fluid flows from a production well through approximately 4,000 feet of 8" pipe to heat exchanger building. After passing through the heat exchangers, the geothermal fluid is injected into a well adjacent to the building.

The water in the secondary circuit is pumped through approximately 7,000 feet of piping reducing from 10" to 3" in size as water is supplied to various buildings for heating.

Figure 3 is a schematic diagram of the Klamath Falls district heating system.

Table 4 summarizes the system characteristics.

Table 4

Klamath Falls
System Characteristics

| Production Well: | No. 1 | No. 2 |
|---|---|---|
| Depth | 350 ft. (107 m) | 350 ft. (107 m) |
| Wellhead Temperature | 218°F (98°C) | 218°F (98°C) |
| Flow | 650 gpm (41 l/s | 800 gpm (50 l/s) |
| Drawdown | 60 ft. (18 m) | 10 ft. (3m) |

| Pump: | |
|---|---|
| Motor Power | 2-75HP (56 Kw) each |
| Flow | 350 gpm (22.1 l/s) each |
| Variable speed drives | |

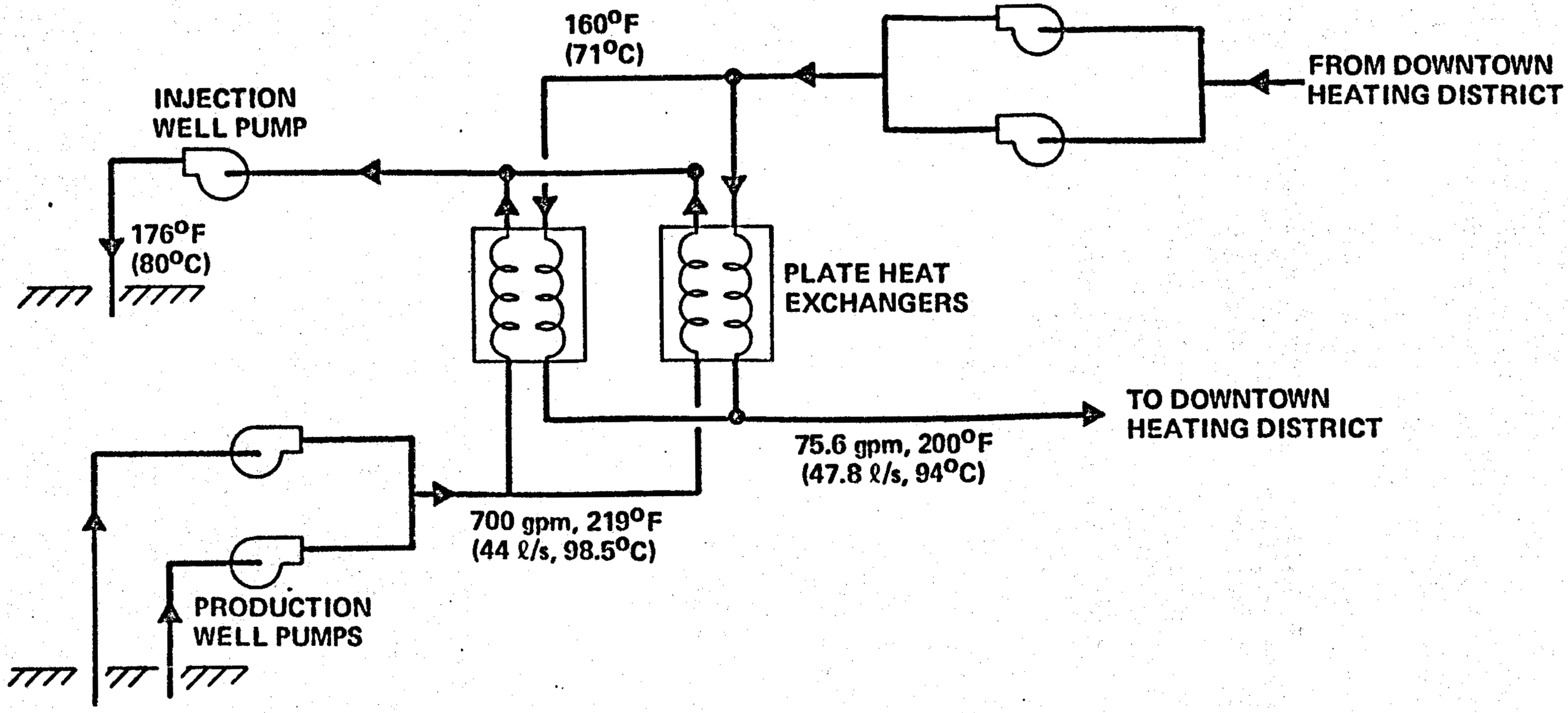
| Injection Well: | |
|---|---|
| Depth | Not available |
| Injection Temperature | 176°F (80°C) |
| Injection Pressure | 8 psi (55.1 kPa) |

| System Heat Load: | | |
|---|---|---|
| Total | $40.2 \times 10^9$ Btu/yr | ($42.4 \times 10^9$ kJ/yr) |
| Peak | $15.3 \times 10^6$ Btu/hr | (4.5 Mw) |
| Required Flow | 768 gpm at 220°F | (48.5 l/s at 99°C) |

| Heat Exchanger: | | | |
|---|---|---|---|
| Type Plate | 150 stainless steel plates, EPDM gaskets | | |
| Geothermal Side | Inlet | 219°F | (98.5°C) |
| | Outlet | 176°F | (80°C) |
| | Flow | 350 gpm | (22 l/s) |
| Secondary Side | Outlet | 200°F | (94°C) |
| | Inlet | 160°F | (71°C) |
| | Flow | 378 gpm | (23.9 l/s) |

FIG 3

# KLAMATH FALLS DISTRICT HEATING SYSTEM SCHEMATIC

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82-A5-46-3

## Reno Condominium Heating

This project consists of the design, construction, testing, and operation of a geothermal heating system for space heating, domestic hot water and swimming pool heating for the Salem Plaza condominium complex. The complex consists of two large L-shaped buildings, 2 stories in height, containing 150 units.

Figure 4 is a schematic diagram of the proposed facility. The geothermal system will provide the thermal energy presently supplied by the boiler.

Table 5 summarizes the system characteristics.

Table 5

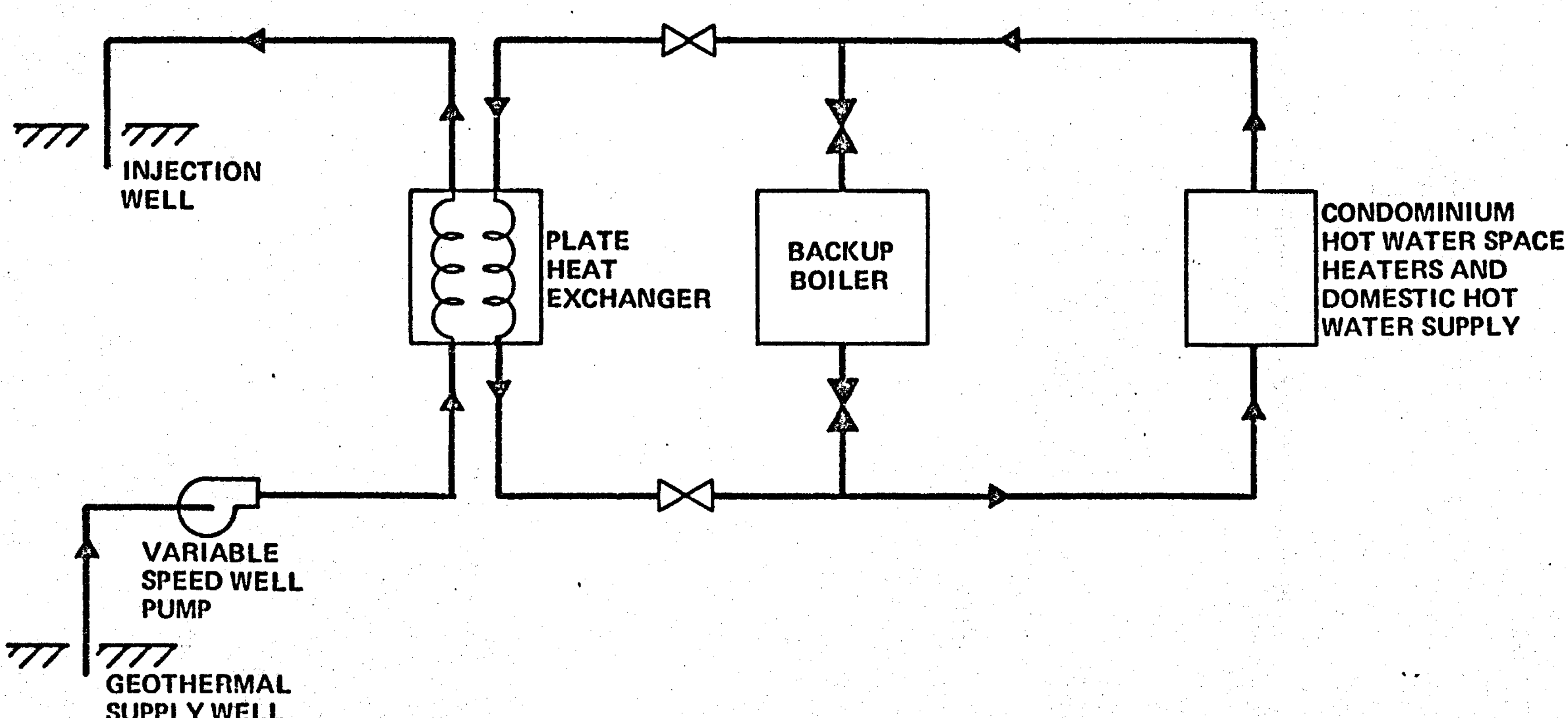
Reno Condominium Heating
System Characteristics*

| | | |
|---|---|---|
| **Production Well:** | | |
| Depth | 1487 ft. | (453 m) |
| Wellhead Temperature | 160°F | (71°C) |
| Flow | 580 gpm | (37 l/s) |
| Drawdown | 287 ft. | (87 m) |
| **Pump:** | | |
| Motor Power | | |
| Flow | | |
| Head | | |
| **Injection Well:** | | |
| Depth | | |
| Injection Temperature | | |
| Injection Pressure | | |
| **System Heat Load:** | | |
| Total | $15.6 \times 10^9$ Btu/yr | |
| Design | $6 \times 10^6$ Btu/hr | |
| Required Flow | | |

*Omitted information to be determined.

FIG 4

# RENO CONDOMINIUM HEATING SYSTEM SCHEMATIC

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## El Centro Community Center Heating/Cooling System

This project consists of the design, construction, testing, and operation of a field experiment for space heating and cooling and domestic hot water heating for the El Centro Community Center, a public recreational facility. Heat in the geothermal fluid will be transferred to water to provide space heating and domestic hot water during the winter. During the summer, part of the heat in the geothermal fluid is used to operate a lithium bromide absorption chiller to produce chilled water at 42°F. The chilled water is used to cool the community center. Figure 5 is a process flow diagram of the system.

Table 6 summarizes the system performance characteristics.

Table 6

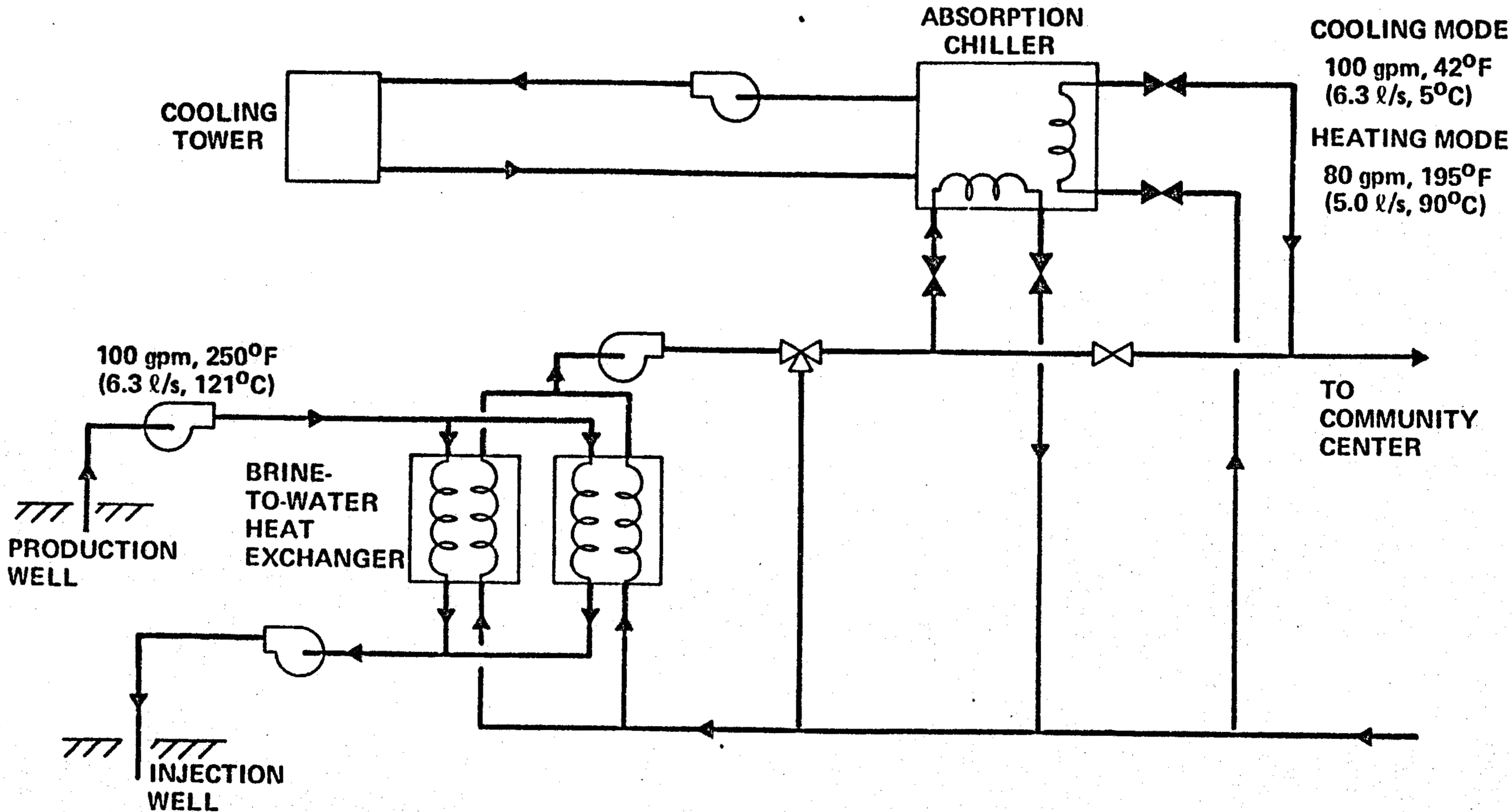
El Centro Community Center
System Characteristics*

| | | |
|---|---|---|
| **Production Well:** | | |
| Depth | 8504 ft. | (2592 m) |
| Wellhead Temperature (BHT) | 303°F | (150°C) |
| Flow (Cooling) | 100 gpm | (6.3 l/s) |
| Drawdown | | |
| **Pump:** | | |
| Motor Power | | |
| Flow | | |
| Head | | |
| **Injection Well:** | | |
| Depth | 4001 ft. | (1219 m) |
| **Injection Temperature | 223°F | (106°C) |
| Injection Pressure | | |
| **System Load:** | | |
| Heating | $0.59 \times 10^9$ Btu/yr | ($0.62 \times 10^9$ kJ/yr) |
| | $0.83 \times 10^6$ Btu/hr | (0.24 Mw) |
| Cooling | $1.27 \times 10^6$ Btu/hr | (0.37 Mw) |

*Omitted information to be determined.
**Design Conditions, Cooling Mode

FIG 5

# EL CENTRO COMMUNITY CENTER SYSTEM SCHEMATIC

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## Haakon Schools

In Philip, South Dakota, space and domestic water heating is provided to five school buildings by the artesian flow of up to 340 gpm (21.5 l/s) of 157°F (69.4°C) water from the Madison Aquifer, Table 7. The water, at 130°F (54.4°C) is then used to heat eight downtown businesses before it is treated with barium chloride to precipitate out Ra-226 in holding ponds. It is then discharged into the Bad River, Figure 7. The heating system has been operating satisfactorily since November, 1980. However, the operation of the Ra-226 removal system is still undergoing development to reduce maintenance.

A single pipe line carries the geothermal fluid from the well head to the Armory High School Building. Separate supply and discharge lines serve the school buildings. A single line takes the school discharge to the business district heating system which presently serves eight of a planned nine

Table 7. System Characteristics--Haakon School

| | | |
|---|---|---|
| Production Well | Depth | 4266 ft (1300 m) |
| | Wellhead temperature | 157°F (69.4°C) |
| | Flow (maximum, artesian) | 340 gpm (21.5 l/s) |
| | Shutin pressure | 121 psig (834 kPa) |
| | Flowing pressure | (~276 kPa at 18.9 l/s) |
| Pump | None | |
| Heat Exchangers | Flat plate | 316 stainless steel |
| Disposal | Into Bad River after Ra-226 removal | |
| System Heat Loading | $9.53 \times 10^9$ Btu/yr (maximum) | ($10.05 \times 10^9$ kJ/yr) |
| | $5.5 \times 10^6$ Btu/h (design) | (1.61 MW) |

buildings. Separate supply and return lines serve the District and terminate at the City Fire Station where controls maintain flow in response to outside air temperature.

A single line carries the fluid to the treatment plant where Radium 226 is precipitated and allowed to settle in one of the two holding ponds. The fluid then flows into the North Fork of the Bad River. The removal plant is designed to reduce the Radium 226 concentration from 119 pC/l to less than 10 pC/l (5 pC/l background plus 5 pC/l allowable per EPA drinking water standards).

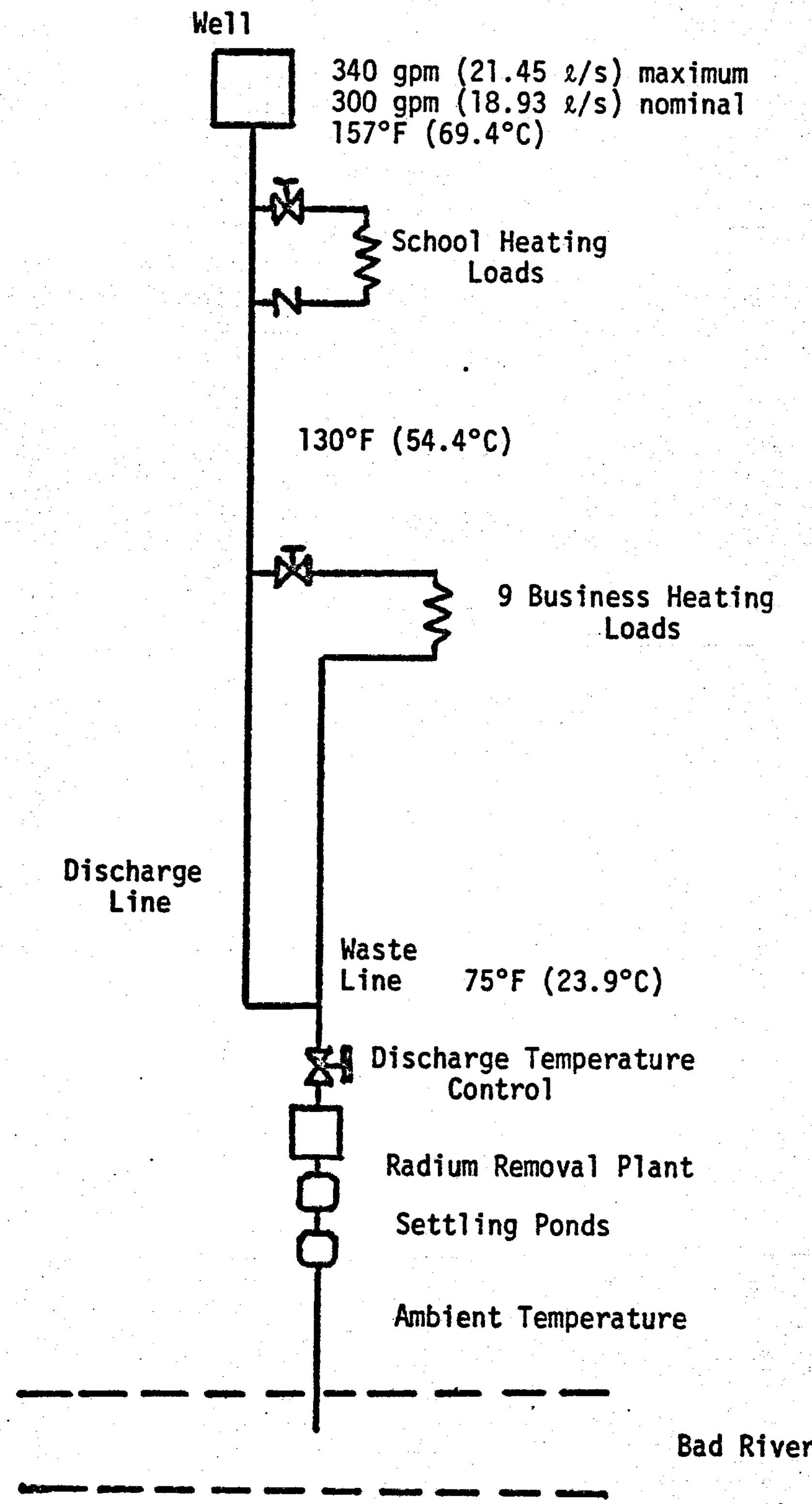



Figure 7. Simplified Philip Schematic

St. Mary's Hospital

At St. Mary's Hospital in Pierre, South Dakota, space and make-up air heating plus domestic water preheat, 100-110°F (38-43°C), are provided to the hospital building and a new addition by up to 375 gpm (23.7 l/s) of artesian flow from the Madison Aquifer at 106°F (41°C). In being cooled to 70-75°F (21-24°C), the geothermal fluid provides energy to a heat pump in the new addition. The older hospital floor area is 83,000 $ft^2$ (7711 $m^2$). The addition has 65,000 $ft^2$ (6039 $m^2$).

The system operated satisfactorily for the 1980-81 heating season, but was shut down for about three months during the summer of 1981 to fix a pressure regulator problem, it was also shut down for four months (December 1981 to April 1982) to replace 120 ft (36.6m) of 6-inch (15.24 cm) diameter mild steel pipe, which was corroded. The replacement pipe is fiberglass reinforced plastic.

Overall system characteristics are listed in Table 8. The pump house contains three heat exchangers, Figure 8. Exchanger No. 1 provides building heat with 100°F (38°C) water. Exchanger No. 2 preheats domestic hot water to 78°F (26°C) with the geothermal discharge from heat exchanger No. 1. Exchanger No. 3 also preheats the domestic hot water. When exchangers No. 1 and No. 2 are operating, it provides additional domestic hot water preheat to 100°F (38°C). If space heating is not required, only heat exchanger No. 3 operates, and it provides the full domestic hot water preheat. The preheated domestic hot water is stored in a 4000 gal (15,142 l) tank.

The existing makeup air handling blower is located in a penthouse above the hospital. A six row chilled water coil existing in this unit will be supplied with the 100°F (38°C) water from the closed loop. Under peak heating conditions, 15,650 cfm (7.386 $m^3/s$) of air are heated from -30° to 68°F, (-34 to 20°C), while 90 gpm (5.7 l/s) of 100°F (38°C) water entering the coil would leave the coil at 63.2°F (17.33°C).

The present heating system in the existing hospital is basically steam perimeter radiation. A fan coil system has been added to provide air conditioning, Figure 9. Chilled water at the average temperature of 50°F (10°C) is circulated in the summer to provide approximately 57° to 59°F (13.9 to 15.0°C) supply air off the coils. Now, in the winter time, 100°F (38°C) water is provided to these coils to produce 90°F (32°C) heated air which is adequate down to outside temperatures of approximately 2°F (-17°C).

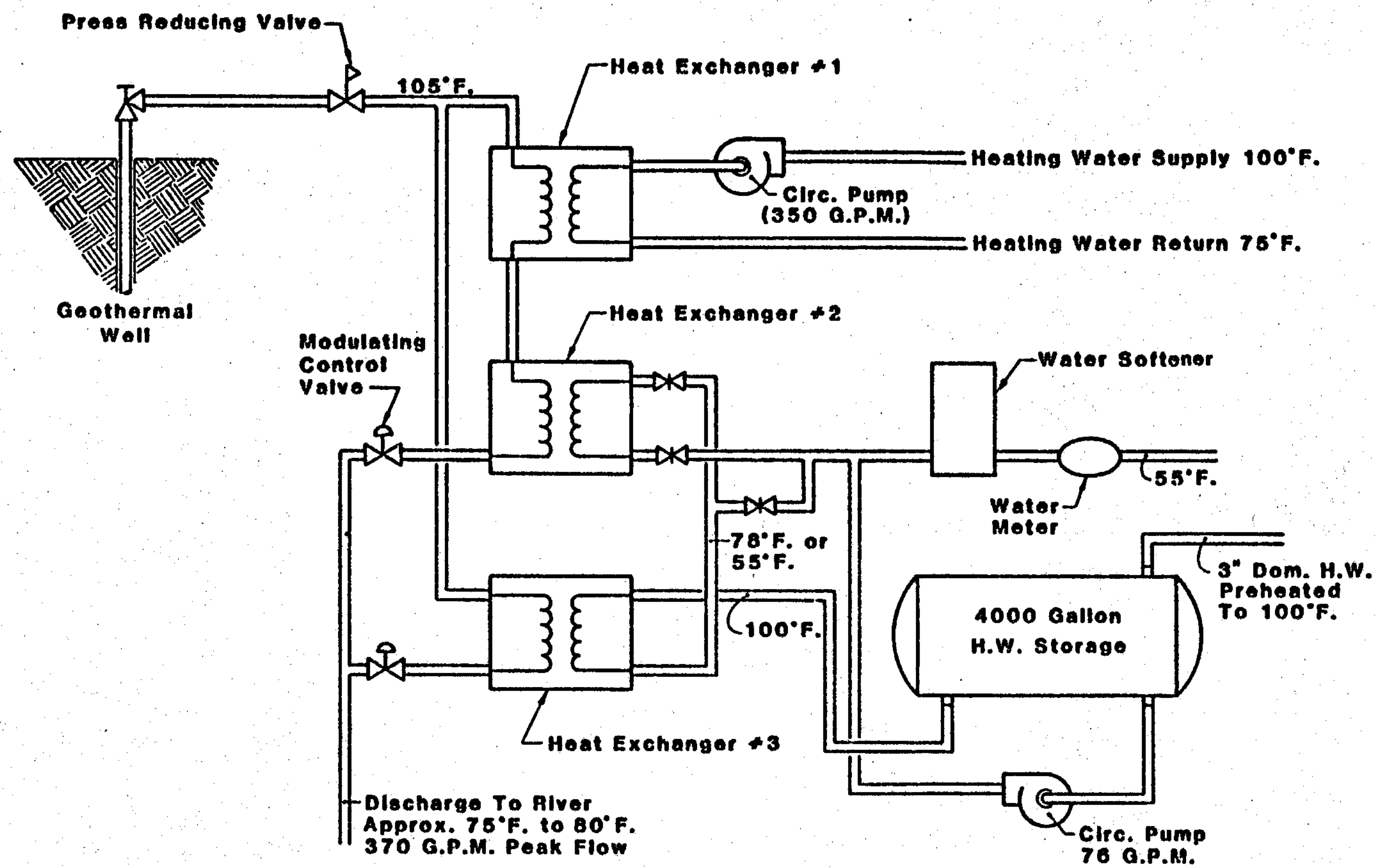



FIGURE 8. WELL HOUSE AND EXCHANGER BUILDING SCHEMATIC

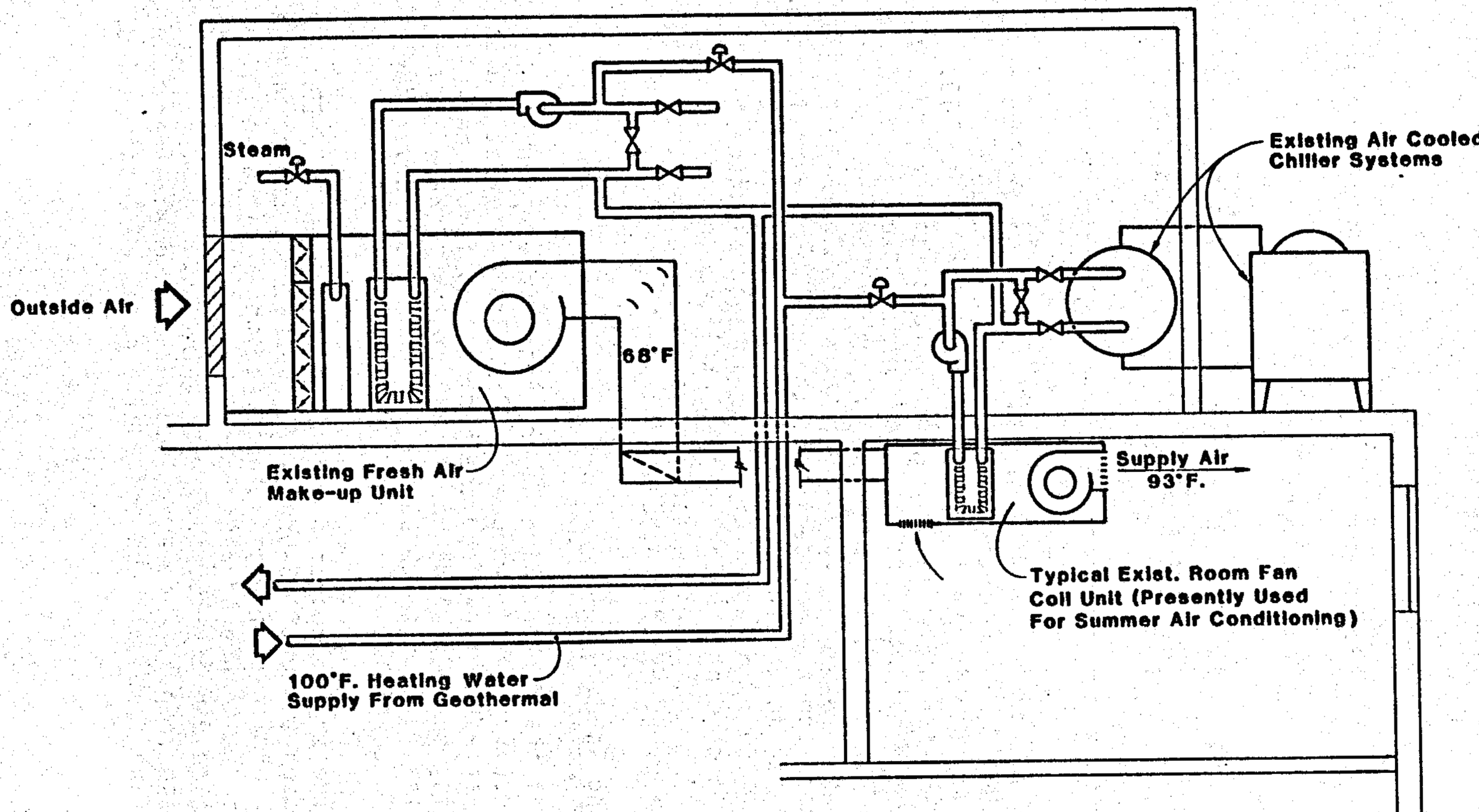



FIGURE 9. EXISTING HOSPITAL DIRECT HEAT APPLICATIONS

Table 8. System Characteristics--St. Mary's Hospital

| | | |
|---|---|---|
| Production Well | Depth<br>Wellhead temperature<br>Flow (maximum, artesian)<br>Shutin pressure<br>Flowing pressure | 2174 ft (662.6 m)<br>106°F (41.1°C)<br>375 gpm (23.7 l/s)<br>480 psig (3309 kPa)<br>27 psig (186 kPa) |
| Pump | None | |
| Heat Exchangers | Flat plate | 316 stainless steel |
| Disposal | Into Missouri River | |
| System Heat Loading | $11.44 \times 10^9$ Btu/yr<br>(peak) $5.5 \times 10^6$ Btu/h | ($12.07 \times 10^9$ kJ/yr)<br>(1.63 MW) |

About 155 gpm (9.78 l/s) of 100°F (38°C) water from heat exchanger No. 1, representing 2,000,000 Btu/h (0.59 MW), is available for use in the new hospital addition, Figure 10. The geothermal energy is utilized in the hot deck coil of the main building air handling units. As the outside temperature drops and the demand for heat increases, additional energy is extracted by directing a portion of the approximate 80°F (27°C) return water from the hot deck into the chiller. Heat is then taken from the condenser or hot side of the chiller in the form of 120°F (49°C) warm water for use in individual space heating coils. This condenser water is also utilized to add heat to the 100°F (38°C) preheated domestic hot water to raise it to a final use temperature of 110°F (43°C).

Diamond Ring Ranch

At the Diamond Ring Ranch, near Midland South Dakota, an existing (1959) well produces 152°F (67°C) water at 170 gpm (10.7 l/s) artesian flow from the Madison Aquifer. The well is now providing space heating to six structures, Figure 11. It also supplies heat to a 700 bushel per hour grain dryer for a few weeks in the fall.

The system operated normally during the 1979-80 heating season and until February of the 1980-81 season when a power failure allowed freezing to damage the recirculating lines. After a change of ranch ownership, full system operation was resumed on January 10, 1982 with antifreeze in all recirculating loops. The upper loop was shut down after four days since the hospital barn and mobile homes were unoccupied.

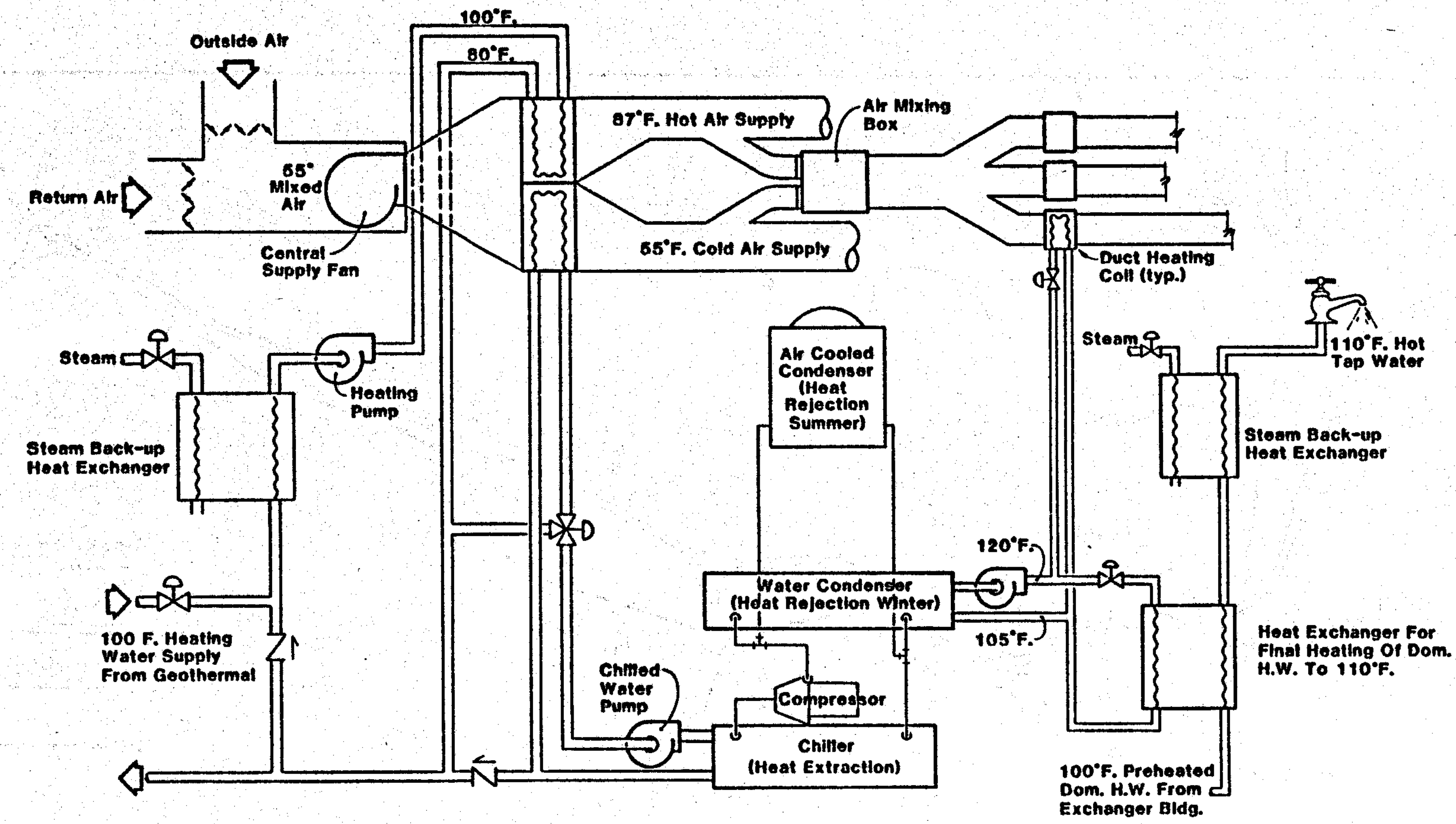



FIGURE 10. NEW BUILDING HEATING SYSTEM SCHEMATIC

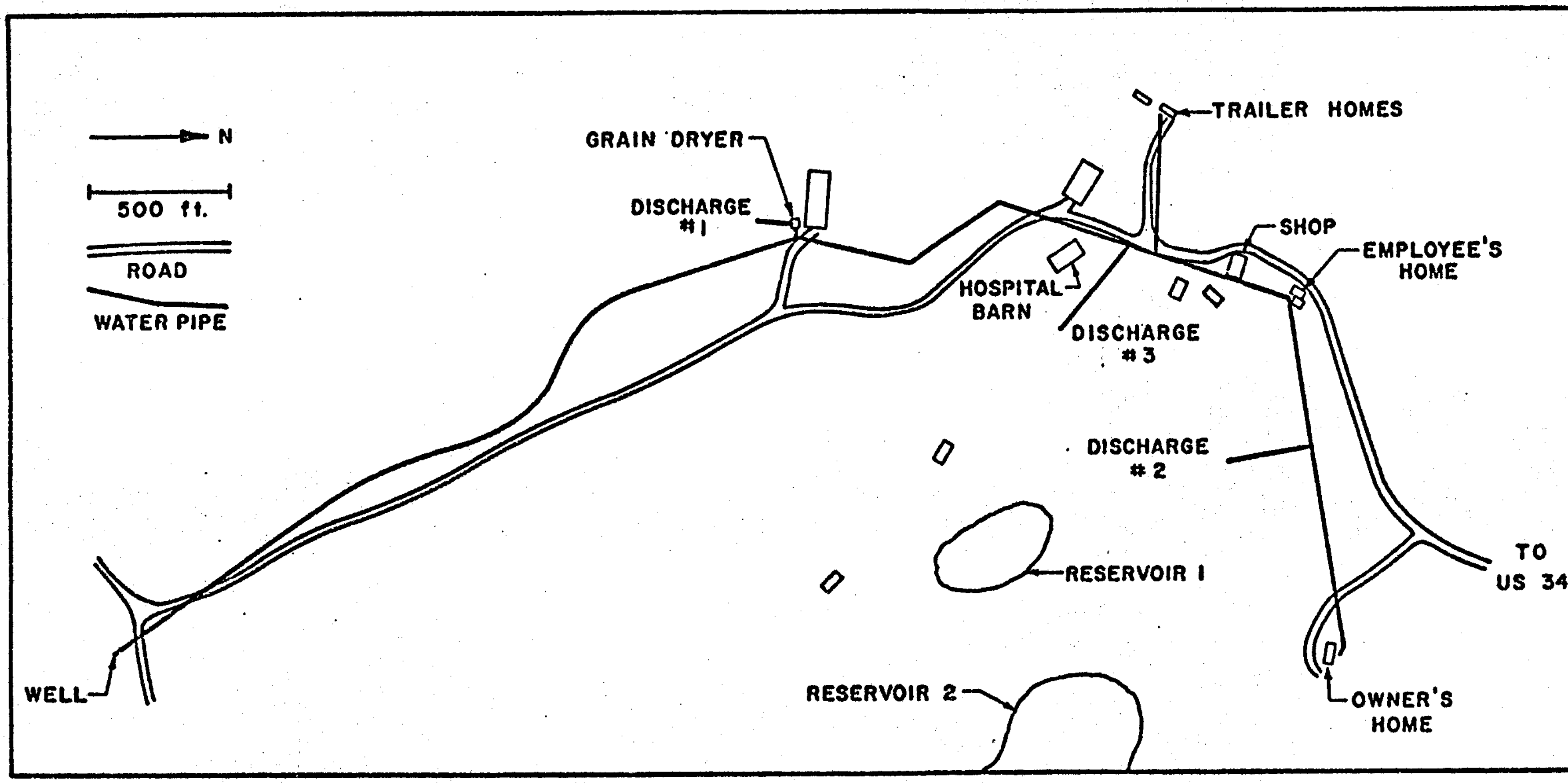



Figure 11. Layout of the Diamond Ring Ranch Geothermal Project

The system operating characteristics are given in Table 9. The system schematic is shown in Figure 12. Two stainless steel plate-type heat exchangers are used to heat recirculating water. One of these exchangers is located at a 700 bushel per hour grain dryer and one in the shop. The exchanger at the grain dryer supplies a hot, inhibited propylene glycol-water mixture to a water-to-air exchanger through which the grain dryer fan pulls hot, dry air. Unlike conventional combustion grain dryers, the moisture content of the air is not increased as a consequence of heating.

The heat exchanger in the shop is used to heat water recirculating in two conventional hydronic loops supplying water-to-air exchangers. One loop feeds the two mobile homes and the hospital barn. The second loop feeds the shop, owner's home, and the employee's home. Temperature sensors at each end-use exchanger can start the recirculating pump in the shop to maintain hot water in each line. This reduces the response time when the space heating thermostat calls for heat.

Table 9. System Characteristics--Diamond Ring Ranch

| | | |
|---|---|---|
| Production Well | Depth | 4112 ft (1253 m) |
| | Wellhead Temperature | 152°F (67°C) |
| | Flow (artesian) | 170 gpm (10.7 l/s) |
| | Shutin Pressure | 5 psig (34.5 kPa) |
| | Flowing Pressure | ~0 psig (~1 kPa) |
| Pumps | Geothermal - artesian and gravity feed | |
| | Recirculating loops only | |
| Heat Exchangers | Flat plate | 304 stainless steel |
| Disposal | Into stock watering ponds | |
| System Heat Loading | $7.87 \times 10^9$ Btu/yr | ($8.3 \times 10^9$ kJ/yr) |
| (peak) | $3.35 \times 10^6$ Btu/h | (0.98 MW) |

## Pagosa Springs

At Pagosa Springs, Colorado, two usable production wells, 131°F and 148°F (55°C and 64°C), were obtained from the three wells drilled. After artesian flow testing, a district heating system was sized for ten public buildings, 54 businesses, and 63 residences. It has a peak flow of capacity 900 gpm (56.8 l/s) while pipelines are sized for 1800 gpm

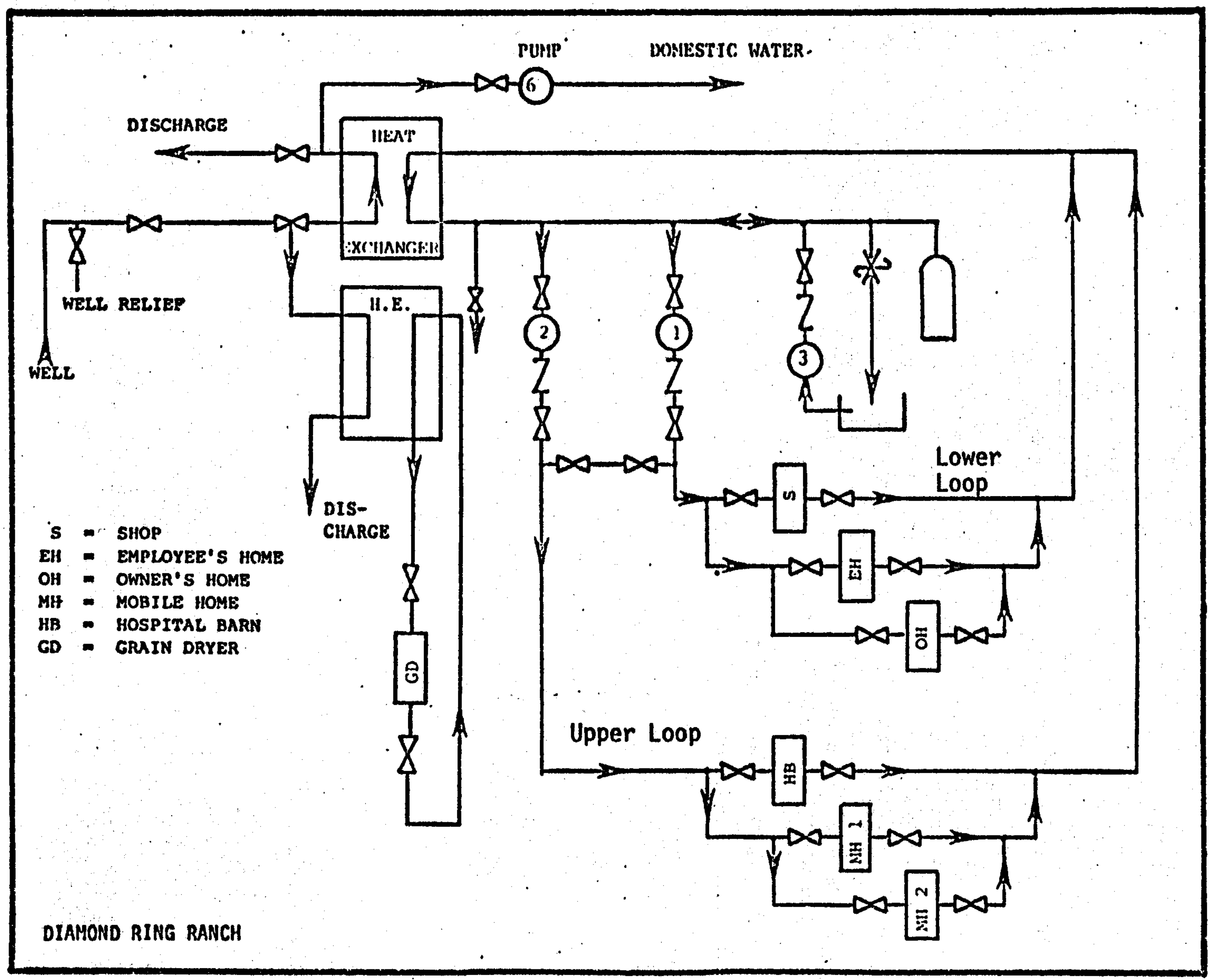



Figure 12. ***SCHEMATIC DIAGRAM OF GEOTHERMAL SYSTEM***

(113.6 l/s). An isolation plate heat exchanger, two recirculation loops and disposal into the San Juan River will be used.

Construction of the basic distribution system was completed in November 1981 for the 900 gpm (56.8 l/s) peak flow capacity. Application for a production permit from the State of Colorado is pending. The high school was operated briefly in a system test in December 1981.

The operating characteristics of the system are shown in Table 10. The design flow conditions will not be realized for the first several years, since initially the system will be used to only about 40% capacity.

The control scheme will eventually operate from one to four circulating pumps, one or two heat exchangers, plus one or two geothermal well and pumps to control the temperature of the circulating water leaving the heat exchangers, Figure 13. To reduce costs, the initial project scope was cut to only two recirculating pumps and one heat exchanger which limits current system capacity to 900 gpm (56.8 l/s).

The circulating pumps will be operated based on user flow demand plus 150 gpm (9.46 l/s) which will be continuously circulated through the piping system to keep it hot. For each 500 gpm (31.55 l/s) of flow required, a recirculating pump will be switched on. The sequence in which the pumps are used can be rotated. This permits even utilization of all four pumps. In addition to determining the number of circulating pumps to be in operation, the flow indicator on the recirculation return piping will control the number of heat exchangers in operation. At flow less than 1000 gpm (63.09 l/s), only one heat exchanger will be in service; similarly, only one well pump will be operated. There is a five minute minimum cycle time between on and off modes of the pumps and heat exchangers to avoid unnecessary cycling.

Flow from the geothermal wells will be controlled by the temperature of the circulating fluid supplied to the users. This temperature controller will operate a throttling valve on the geothermal supply line to maintain a constant heat exchanger discharge temperature for the recirculating fluid.

The circulating water at the suction side of the pump is held at a supply pressure of 60 psi (414 kPa) by using a pressure-reducing valve on the city water supply. It is also the source of makeup water. Two check valves prevent backflow into the city water supply system. A pressure relief valve is also provided.

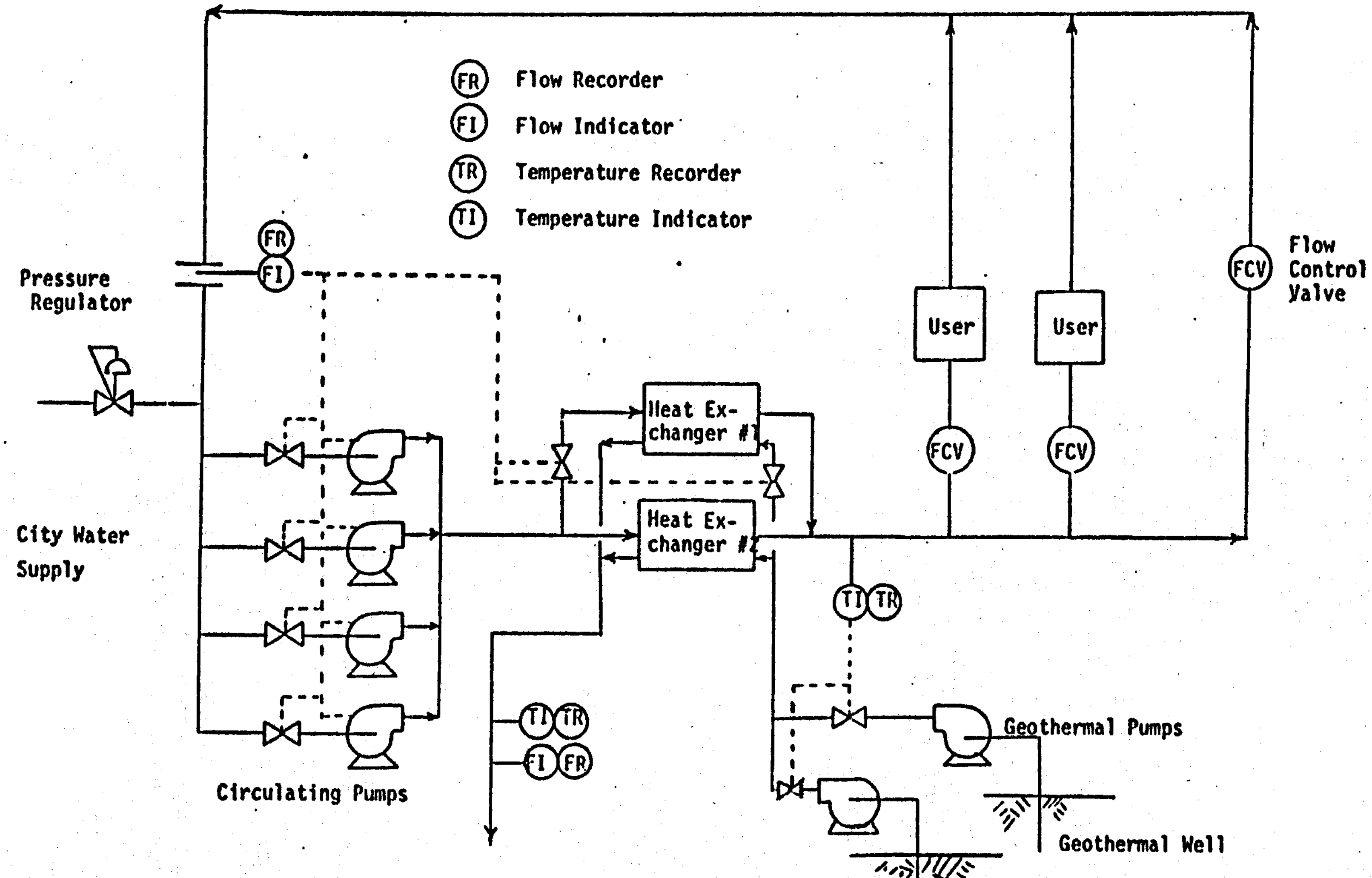



Figure 13. Schematic Diagram of Control System

Table 10. System Characteristics--Pagosa Springs

| | PS-3 | PS-5 |
|---|---|---|
| **Production Wells** | | |
| Depth | 300 ft (91 m) | 275 ft (84 m) |
| Wellheat Temperature | 131°F (55°C) | 148°F (64°C) |
| Flow (peak, design) | 600 gpm (38 l/s) | 1200 gpm (76 l/s) |
| Shutin Pressure | 47.5 psig (328 kPa) | 49.7 psig (343 kPa) |
| **Pumps** | | |
| Production Wells (2) | 300 HP (22.8 kW)<br>1000 gpm at 85 feet<br>(63.09 l/s at 24.4 m) | |
| Recirculation (4)<br>(only 2 installed) | 25 HP (19.0 kW)<br>500 gpm at 160 feet<br>(31.55 l/s at 47.8 m) | |
| Heat Exchangers (2)<br>(only one installed) | Flat Plate | 316 stainless steel |

| | Geothermal Fluid | | | Circulating Fluid | | |
|---|---|---|---|---|---|---|
| | Temp. (°F) | Pressure (psig) | Flow (gpm) | Temp. (°F) | Pressure (psig) | Flow (gpm) |
| Inlet heat exchanger | 140 | 30 | 2000 | 107 | 60 | 1800 |
| Outlet heat exchanger | 114 | 15 | 2000 | 136 | 130 | 1800 |
| Disposal | Into San Juan River | | | | | |
| System Heat Loading | $28.6 \times 10^9$ Btu/yr | | | ($30.2 \times 20^9$ kJ/yr) | | |
| (design) | $27 \times 10^6$ Btu/h | | | (7.9 MW) | | |

The recirculating pumps, at design flow rates, add 70 psi (483 kPa) of head, for a net of 130 psi (896 kPa). Valving and other losses drop the pressure to 133 psi (917 kPa) and the heat exchanger further reduces the pressure to about 90 psi (621 kPa).

A major objective of the control system is to minimize both the operating costs and manpower over a broad range of conditions.

## Boise

The existing Boise Warm Springs Water District (BWSWD) system is being refurbished and a separate system will be built by the City of Boise to serve the Boise central business district. The BWSWD system, Figure 14, provides a peak flow rate of approximately 1700 gpm (107.3 l/s) at 170°F (76.7°C) from the two existing wells. The new pipeline is sized for 3000 gpm (189.3 l/s). The city system, Figure 15, is being designed for an eventual capacity of 4000 gpm (252.4 l/s) but initial well production capacity is expected to be approximately 2000 gpm (126.2 l/s). System characteristics are shown in Table 11.

Under a private partnership agreement, four city wells have been completed, two of which may be able to produce 2000 gpm (126.2 l/s). Preparations are being made to test these two wells. The construction of the BWSWD main lines in progress and the final design for the city system is in the final approval stage. On March 17, 1982, the Idaho Department of Health and Welfare conditionally approved disposing of the water in the Boise River at the Americana Bridge which is much nearer the project site.

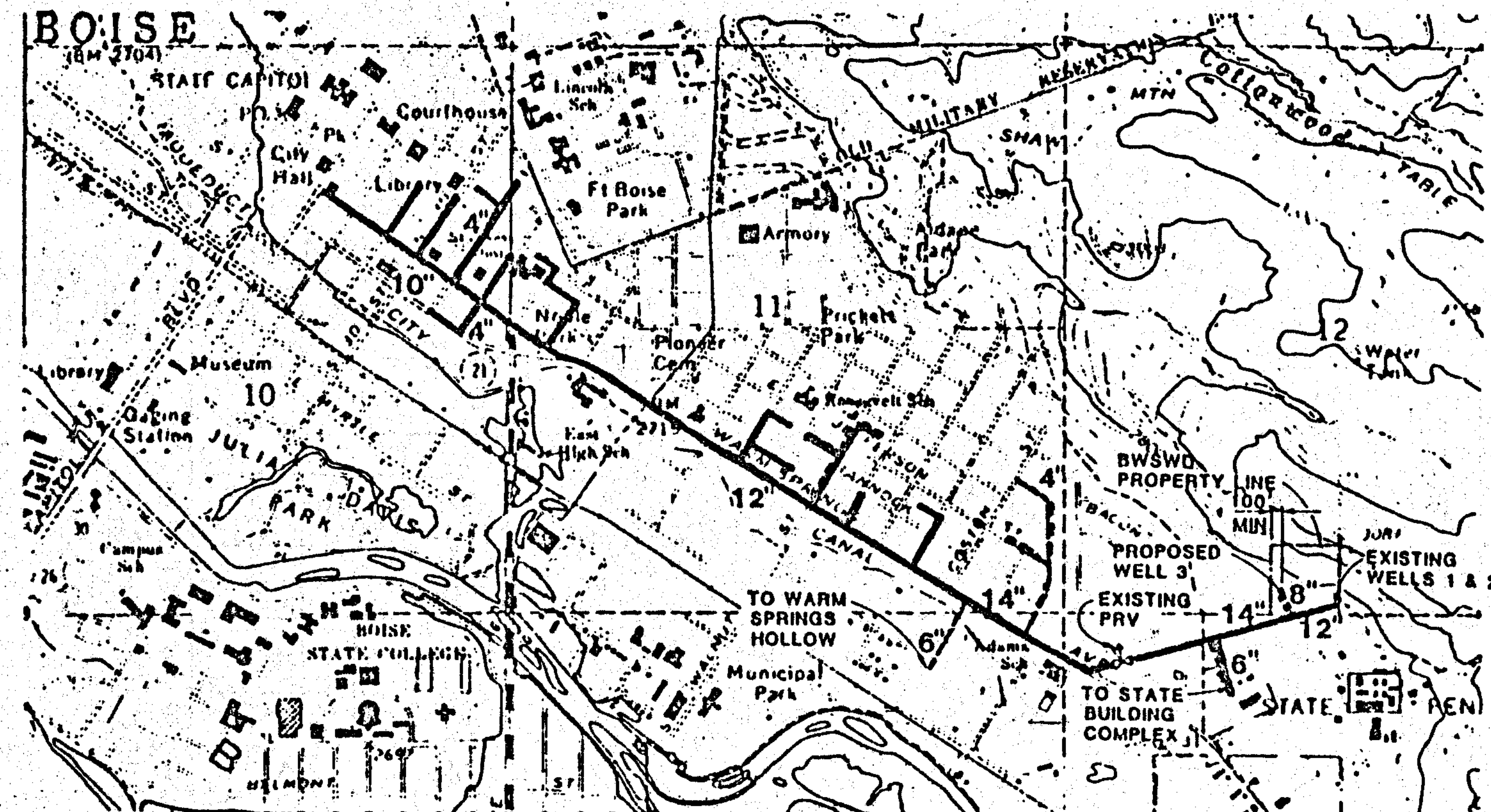
## Conclusions

These projects have demonstrated the technical, economic, institutional and environmental feasibility of using low-temperature geothermal energy for district heating. For example, the availability of a geothermal resource at Susanville has resulted in developing additional projects in the community. These projects are the geothermal heating of 126 homes under a HUD project and geothermally heating a State of California correctional center. In addition, studies are underway to cascade returned geothermal fluids from these facilities through an industrial park.

In some instances, geothermal development has met community resistance because of concern of residents for local water resources for the environment. The City of Klamath Falls project demonstrated that these concerns were unfounded and the prospects for expansion of geothermal energy utilization in the community is improved.

The Haakon project has provided significant experience in the removal of Ra-226 from geothermal fluids by precipitation with barium chloride. The St. Mary's Hospital project has demonstrated that a resource with a temperature of only 106°F can be used and used economically. An annual cost savings of $80,000 per year results in a nine year simple payback; but if savings escalate at 8% annually the payback drops to seven years. Diamond Ring Ranch's grain dryer will provide data on "dry heat" drying.

The Pagosa Springs project is exercising water rights issues and the new state geothermal law which will pave the way for additional projects in the State of Colorado. In addition,




**NOTE:**
UNLESS NOTED OTHERWISE
ALL PIPELINES SHALL BE 2".

Figure 14. **BWSWD GEOTHERMAL SYSTEM PLAN**

N

**LEGEND**

- NEW LINE
- EXISTING LINE TO BE REPLACED
- EXISTING LINE TO REMAIN
- 4" PIPE SIZE
- PRESSURE REGULATING VALVE (PRV)
- PROPERTY LINE

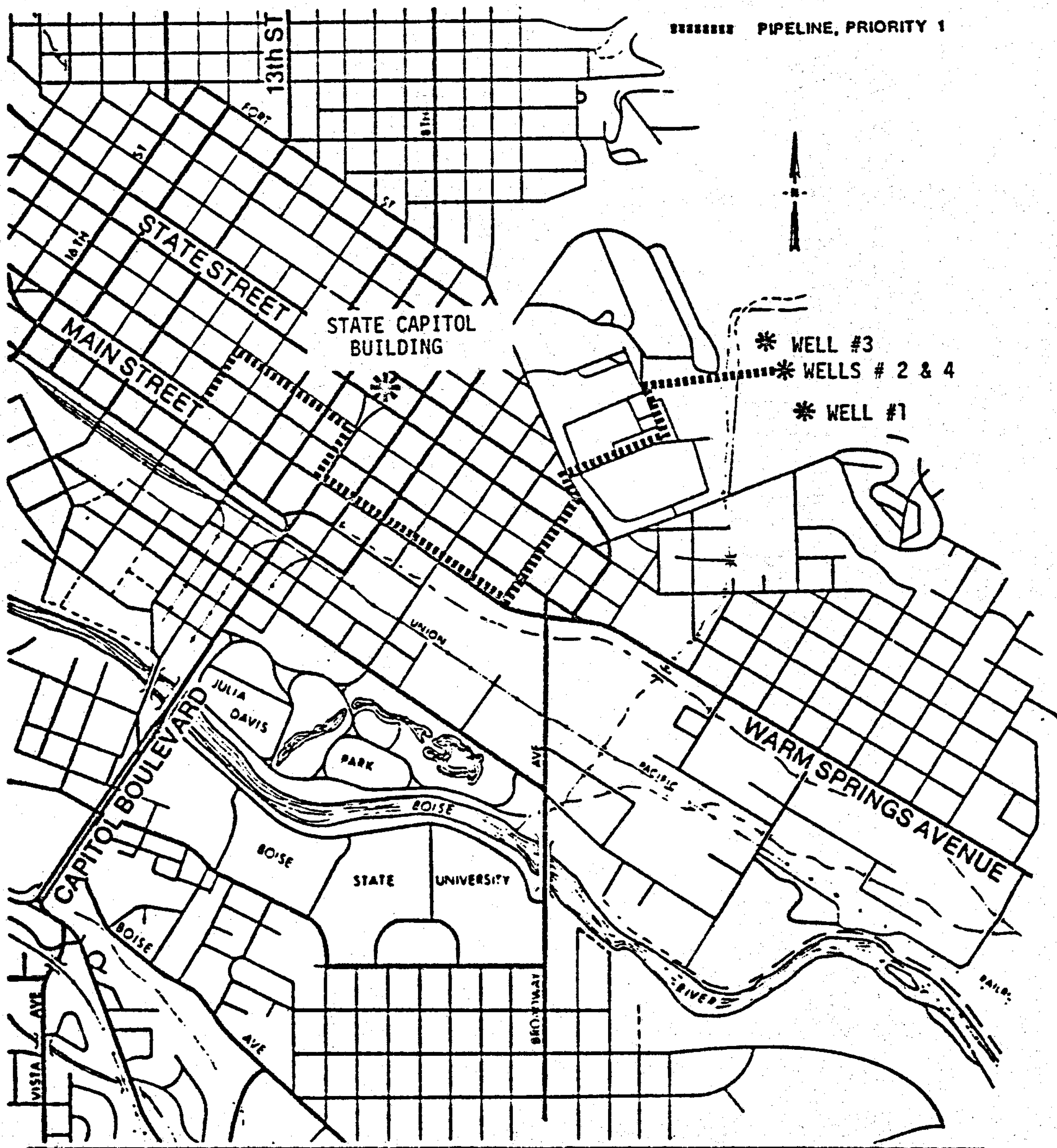



Figure 15. BOISE CITY GEOTHERMAL SYSTEM PLAN

Table 11. System Characteristics--Boise

| | | |
|---|---|---|
| (BWSWD) Production Wells No. 1 and 2 | | |
| Production Wells (existing since 1890s) | | |
| Depth | 400 ft (122 m) | |
| Wellhead Temperatures | 170°F (76°C) | |
| Flow (combined) | 1700 gpm (107.3 l/s) | |
| Shutin Pressure | 7 psig (48 kPa) | |
| Pumped Flow | 1000 gpm at 195 ft (63.09 l/s at 59.4 m) | |
| Pumps (2) | | |
| Horse Power (each) | 60 HP (45.6 kW) | |
| Constant speed type | | |
| Heat Exchanger | None, direct use | |
| Disposal | Individual to Boise River | |
| Boise City Wells (2 of 4) | No. 2 | No. 4 |
| Production Wells | | |
| Depth | 880 ft (268 m) | 1103 ft (336 m) |
| Wellhead Temperature | 164°F (73.3°C) | 168°F (75.6°C) |
| Flow (artesian) | 1200 gpm (75.71 l/s) | 400 gpm (25.24 l/s) |
| Shutin Pressure | 7 psig (48 kPa) | 7 psig (48 kPa) |
| Pumps | Undesigned | |
| Heat Exchanger | None, direct use | |
| Disposal | Into Boise River at Americana Bridge | |
| Combined System Heat Loading | | |
| | $200 \times 10^9$ Btu/yr | ($211 \times 10^9$ kJ/yr) |
| (design) | $100 \times 10^6$ Btu/h | (29.3 MW) |

the Consulting Engineers Council of Colorado has awarded Coury and Associates of Lakewood Colorado the Grand Award for engineering for the Pagosa Springs project. The Boise project is also expected to exercise water rights and permitting procedures in the State of Idaho to facilitate development there.