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# GEOTHERMAL HEATING FACILITIES OF UNITED CHURCH OF CHRIST (CONGREGATIONAL CHURCH)

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**DISCLAIMER**

# CONGREGATIONAL CHURCH

## Introduction

The Congregational Church (United Church of Christ) is located at 2154 Garden Street in Klamath Falls. The property presently contains two buildings. The largest structure is composed of the main worship area, pastor's office, and a large meeting room with kitchen and restroom facilities. In addition, a second detached building is used for Sunday school activities and, more recently, the Head Start program. The smaller building (approximately 1,225 $ft^2$) is of uninsulated frame construction and is served by electric resistance wall heaters with an inactive furnace in the basement area. The main church building (approximately 1,700 $ft^2$) is also of uninsulated construction with a tall cathedral-type ceiling. This building is served by a downflow gas furnace supplying a crawlspace duct system. The remainder of the larger building (an addition of approximately 1,730 $ft^2$, built in the early 1950s) is of frame, flat roof construction with minimal insulation. This area is heated by a combination of gas-fired wall heaters and electric resistance heat. A second addition is being planned to the larger building and will be composed of approximately 850 $ft^2$ of classroom and office area. As part of this improvement program, the church is interested in exploring the potential for geothermal at the property. The following report explores the engineering and economic feasibility of such a system.

## Summary of Conclusion

Based on the assumptions made in this study, a geothermal system for the Congregational Church is not economically feasible at this time. A retrofit of the church for geothermal would result in a capital cost of $37,600 (see Table 2) including the geothermal well. When this figure is considered in conjunction with the $1,892 first-year savings (present fuel cost minus geothermal system O&M cost) and inflation over a 20-year period, a simple payback of 12 years results. In addition, we have generated an internal rate of return figure of 8.7 percent. This indicates that the project would have to be financed at less than 9 percent to be economically feasible over a 20-year period. As mentioned above, this study incorporated the frame building. Had this building not been included, the capital cost would have been somewhat reduced. However, the annual savings would have been substantially reduced as a result of the high electrical usage in that area as indicated by Table 1. The success of any geothermal retrofit is highly dependent upon the assumption that the church be financially responsible for that usage.

The system for the proposed addition has a less significant impact since the basic components would have to be installed to supply the existing restrooms and kitchen in any case. In addition, the new construction is assumed to be better insulated and less energy-intensive than the frame building.

It is possible that the economic results could be improved to some extent by congregation members performing some of the work. However, the major cost items (well, DHE, equipment) would remain unchanged.

## Availability of Geothermal

The Mills Addition, in which the church is located, is a comparatively unexplored area of Klamath Falls. In order to determine the probability of a successful well at the location, existing information on the area was consulted. This research yielded the following data.

1. There are five "hot" wells within 900 feet of the property. These are characterized by the following data:

| # | Depth | Temperature | Address |
|---|---|---|---|
| 225 | 514 | 190 | 2142 Home |
| 112 | 525 | 175 | 2140 Home |
| 70-1 | 780 | 170 | Mills School |
| 70-2 | 810 | 180 | Mills School |
| 70-3 | 960 | 196 | Mills School |

2. From Lund's 1978 study "Geothermal Hydrology and Geochemistry of Klamath Falls," the following data:

   a. The church property is located very close to the 80°C isotherm (actually crosses through the middle of Garden Street directly in front of the church).

   b. The area is characterized by a 23°C ground temperature.

c. The property lies directly on the 200°C/km temperature gradient line.

d. Area static water level is approximately 10 feet below the surface. From the above data, it is reasonable to estimate that an approximately 600-foot well depth on the church property would yield a temperature of about 160°F with a 10-foot static water level. These figures were used in this study for purposes of system design and cost estimating.

## Energy Balance

In order to evaluate the requirements of a geothermal heating system at the church, it was necessary to first determine the heat loss of the various structures. This task was carried out by two methods. First a conventional heat loss calculation was performed. This calculation was then checked using actual utility billing figures. The following figures summarize the results of the calculations:

| | |
|---|---|
| Frame building: | 72,800 Btu/hr |
| Worship area: | 116,400 Btu/hr |
| Old addition: | 67,500 Btu/hr |
| Proposed addition: | 29,750 Btu/hr |
| | 286,450 Btu/hr |

The above figures reflect certain assumptions made during this calculation. For all purposes, an outside design temperature of 0°F was used in conjunction with an inside design of 68°F. In addition, assumptions were made concerning the number of hours per week which various areas were occupied. All areas were considered to be maintained at 68°F during occupied intervals and 50°F during unoccupied hours. The exception to this rule was the church building which was analyzed based on a 65°F/OFF mode. In addition, certain assumptions were made concerning the construction of various structures in the absence of detailed drawings. Both the church building and the separate frame building were considered to be completely uninsulated. Should this be found not to be the case, corresponding decreases in fuel use and savings credited to the geothermal system over the conventional system would result. Also all calculations included the proposed addition. The heat loss for that portion of the building was estimated to be 35 Btu/hr $ft^2$ under peak conditions, a figure characteristic of commercial construction. For economic purposes, it was assumed that the addition would employ a gas-fired heating system. All calculated heating loads compared reasonably well with the existing installed capacity with the exception of the frame building. The calculated heat loss of this building (72,800 Btu/hr) far exceeds the current installed capacity of 17 kw (58,021 Btu/hr) of electric heat. This indicates either the presence of some insulation in the walls or ceiling or that the existing system was only designed to warm certain areas of the building. Energy requirements were based upon the calculated heating load figures and reflect an average bill of $106 for the months October through May. These figures agree well with the experience of the last tennant in the building. Table 1 summarizes the energy use figures for both the existing system and for the proposed geothermal system.

Energy Conservation Measures

In the course of the energy balance calculations, a few areas of potential improvement in energy use were found. The economics of some however are questionable in view of the present operation of the buildings (thermostat set back, etc.).

1. The floor in the church building is currently uninsulated. Adding 6 inches (R-19) of insulation would reduce the annual fuel use by about 275 therms/yr of natural gas.

2. The frame building was assumed to have an uninsulated ceiling and single glass construction. Adding 6 inches (R-19) of insulation and treating the windows similar to those in the church building would result in a savings of about 5,500 kwh/yr.

3. The existing entrance arrangement creates large flows of outside air in the hall area. Although this area is unheated, this large infiltration of outside air places a substantial load on adjacent areas (primarily the large meeting room). This installation of doors on the opening to the large room would reduce this problem and cause the room to be a great deal more comfortable at a lower themostat set-points (in the absence of cold drafts). It is difficult to quantify the energy savings which would result from such a retrofit as it is highly dependent upon the number of outside door openings.

4. The duct system under the main church is constructed of "hardboard" type rigid fiberglass material. It is common for this type of construction to fail at the taped joints after a number of years, allowing conditioned air to escape. The condition of the ductwork should be visually examined prior to the heating season to determine the degree of such leakage. In addition, the hardboard provides the equivalent of 1 inch of insulation on the ductwork. For unheated areas this is considered the minimum allowable by today's standards. In order to determine whether this amount of insulation is sufficient, a quick test can be performed. On a cold day (less than 30°F) measure the temperature immediately out of the furnace. Measure the supply air temperature at the furthest register from the furnace. If the difference is greater than 5°F, some consideration should be given to adding more insulation to the ductwork.

## The Geothermal System

Figure 2 shows the basic layout of the geothermal system. As indicated in the diagram, the system is based upon the proposed modifications to the buildings. Basically, there are five terminal devices or points at which heat is delivered to the space. In the detached frame building, an entirely new system was required. This is due to both the building configuration and the present system. It was felt that the simplest retrofit would be provided by a forced-air system employing a hot water coil, cabinet fan, and ductwork system to be located in the basement of the building. Such a system provides the most effective access to all rooms. The main church area would continue to be served by the existing fan in the gas-fired furnace. However, the source of heat would be supplied by a hot water coil to be installed in the return duct above the furnace. The gas burner could remain as backup. Propeller-type horizontal unit heaters were chosen for heating the entrance and meeting room areas. Due to the relatively low water temperatures involved, these units provided for a lower first cost in comparison to baseboard-type equipment. Finally the kitchen, restrooms, and proposed addition areas would be served by a system similar to that in the frame building. This system however would be characterized by overhead ductwork and ceiling or sidewall-type registers. The cabinet fan and hot water coil would be located in the utility closet presently housing the domestic hot water heater.

The terminal devices would be served by a piping system as shown in Figure 2. For purposes of this study, insulated steel was chosen for both supply and return lines. This piping would be run in trenches close to the building perimeters as indicated. Burial details are shown in Figure 2.

The geothermal well was located as shown for the purpose of minimizing piping costs during installation. As these costs are not a large percentage of the overall costs, moving the well to another location would not significantly affect the overall economics of the project.

Air-delivering-type systems were chosen for all spaces for a number of reasons. The nature of their operation permits the use of a minimum of controls thus reducing first cost. In addition, an average water temperature of 150°F in this application would have resulted in large surface area requirements for a baseboard-type system, thus increasing capital costs. Finally, forced-air-type systems are generally more amendable to delivering heat in areas with a large number of interior rooms such as the frame building and the proposed addition.

Figure 1 shows the basic flow schematics for the system.

In view of the small demand on the domestic hot water systems, they were not considered for retrofit in this study.

TABLE 1

SPACE HEATING
ENERGY USE FOR EXISTING AND
PROPOSED SYSTEMS

| | Present System | | Geothermal System | |
|---|---|---|---|---|
| | Natural Gas[1] | Electric[2] | Natural Gas[1] | Electric[2] |
| Frame Building | --- | 23,848 | --- | 373 |
| Main Church | 487 | --- | --- | --- |
| Pastor's Office | 96 | --- | --- | 75 |
| Meeting Room, Entrance Area, Kitchen | 1,185 | --- | --- | 187 |
| Restrooms | --- | 1,157 | --- | --- |
| Proposed Addition | 428 | --- | --- | 373 |
| Domestic Hot Water | 38 | --- | 38 | --- |
| Circulating Pump | --- | --- | --- | 1,492 |
| | 2,234 | 25,005 | 38 | 2,500 |

Notes: [1]Gas in therms/yr; 1 therm = 100,000 Btu

[2]Electricity in kwh/yr; 1 kwh = 3,413 Btu

TABLE 2

Capital Costs:

| | |
|---|---|
| Geothermal well | 18,000 |
| Downhole heat exchanger | 2,700 |
| Piping system | 2,700 |
| Unit heaters (2) | 900 |
| Circulating pump (1) | 550 |
| Wellhead structure | 800 |
| Ductwork | 2,525 |
| Hot water coils | 1,000 |
| Controls | 675 |
| Labor | 2,900 |
| Cabinet fans (2) | 650 |
| Misc. Mech. and Elec. | 1,400 |
| SUBTOTAL | 34,800 |
| CONTINGENCY | 2,800 |
| TOTAL | 37,600 |

Operating Costs:

| | |
|---|---|
| Maintenance | 165 |
| Insurance | 96 |
| Increased electric use | 87 |
| | 348 $/yr |

Savings:

| | |
|---|---|
| 2201 therms @ .56 $/therm | 1,232 |
| 24,276 kwh @ .035 $/kwh | 849 |
| | 2,081 $/yr |

# ECONOMIC ANALYSIS

The 20-year life-cycle cost analysis appears on the attached table. Inflation rates were taken from the Oregon Department of Energy as follows:

<u>Natural Gas</u>

9% per annum through 1984

9.2%, 1985 through 1989

10.0%, 1990 through 1994

10.2%, 1995 through 2001

<u>Electricity</u>

7.9% per annum through 1987

9.1%, 1988 through 2001

Economic inflation rate was assumed to be 7 percent per annum and insurance was assumed to inflate at 2 percent per annum.

Column 1 projects 20-year costs of natural gas for the existing system. Column 2 projects electrical costs of the existing system. Column 3 indicates electrical costs of the geothermal system. Column 4 projects maintenance costs for the geothermal system. Column 5 projects insurance costs for the geothermal system. Column 6 shows the net cash savings of the geothermal system over the present system.

Simple payback occurs in year 12. Simple payback does not consider cost of capital financing of the project. The internal rate of return for this series of savings is 8.7 percent, which indicates that if the project were financed at less than 9 percent it could be paid back by the end of 20 years.

LIFE CYCLE COST ANALYSIS
FOR
CONGREGATIONAL CHURCH

COST OF CAPITAL 12 PERCENT
TOTAL CAPITAL COST 37318

| | 1<br>NATURAL GAS CURRENT SYSTEM | 2<br>ELECTRICITY CURRENT SYSTEM | 3<br>ELECTRICITY GEOTHERMAL SYSTEM | 4<br>MAINTENANCE GEOTHERMAL SYSTEM | 5<br>INSURANCE GEOTHERMAL SYSTEM | 6<br>TWENTY YEAR ANNUAL CASH FLOW |
|---|---|---|---|---|---|---|
| PRESENT COST | 1233 | 850 | 87 | 165 | 96 | |
| YEAR | | | | | | |
| 1982 | 1343 | 917 | 94 | 177 | 98 | 1892 |
| 1983 | 1464 | 989 | 101 | 189 | 100 | 2064 |
| 1984 | 1596 | 1067 | 109 | 202 | 102 | 2250 |
| 1985 | 1743 | 1152 | 118 | 216 | 104 | 2457 |
| 1986 | 1903 | 1243 | 127 | 231 | 106 | 2681 |
| 1987 | 2079 | 1341 | 137 | 248 | 108 | 2926 |
| 1988 | 2270 | 1463 | 150 | 265 | 110 | 3208 |
| 1989 | 2479 | 1596 | 163 | 284 | 112 | 3515 |
| 1990 | 2726 | 1741 | 178 | 303 | 115 | 3871 |
| 1991 | 2999 | 1900 | 195 | 325 | 117 | 4263 |
| 1992 | 3299 | 2073 | 212 | 347 | 119 | 4693 |
| 1993 | 3629 | 2261 | 232 | 372 | 122 | 5165 |
| 1994 | 3992 | 2467 | 253 | 398 | 124 | 5684 |
| 1995 | 4399 | 2691 | 276 | 425 | 127 | 6263 |
| 1996 | 4848 | 2936 | 301 | 455 | 129 | 6899 |
| 1997 | 5342 | 3203 | 328 | 487 | 132 | 7599 |
| 1998 | 5887 | 3495 | 358 | 521 | 134 | 8368 |
| 1999 | 6487 | 3813 | 390 | 558 | 137 | 9215 |
| 2000 | 7149 | 4160 | 426 | 597 | 140 | 10147 |
| 2001 | 7878 | 4539 | 465 | 638 | 143 | 11171 |
| TOTAL | 73513 | 45046 | 4612 | 7238 | 2379 | 104330 |

FIGURE 2
FLOW DIAGRAM FOR GEOTHERMAL SYSTEM

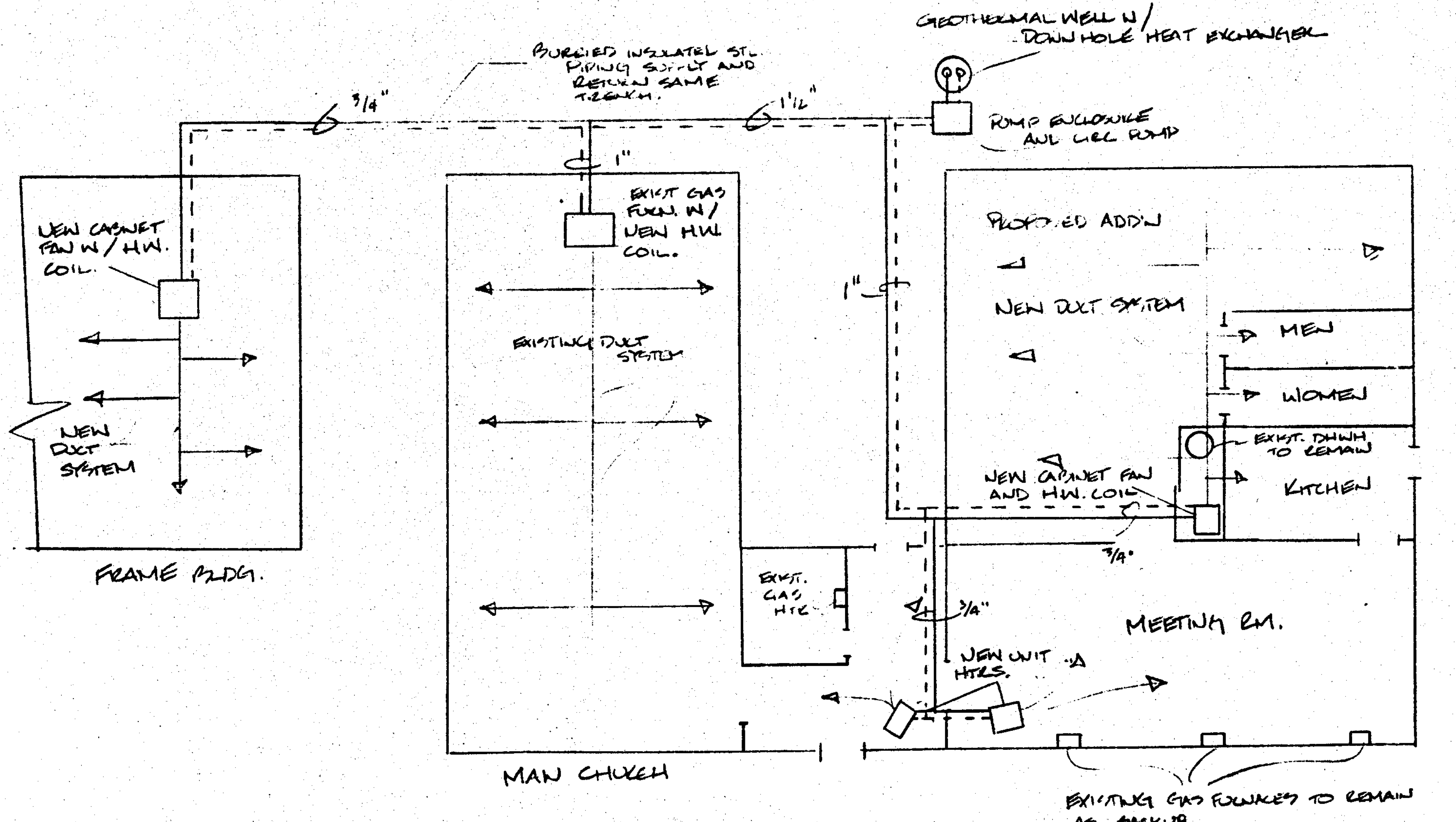


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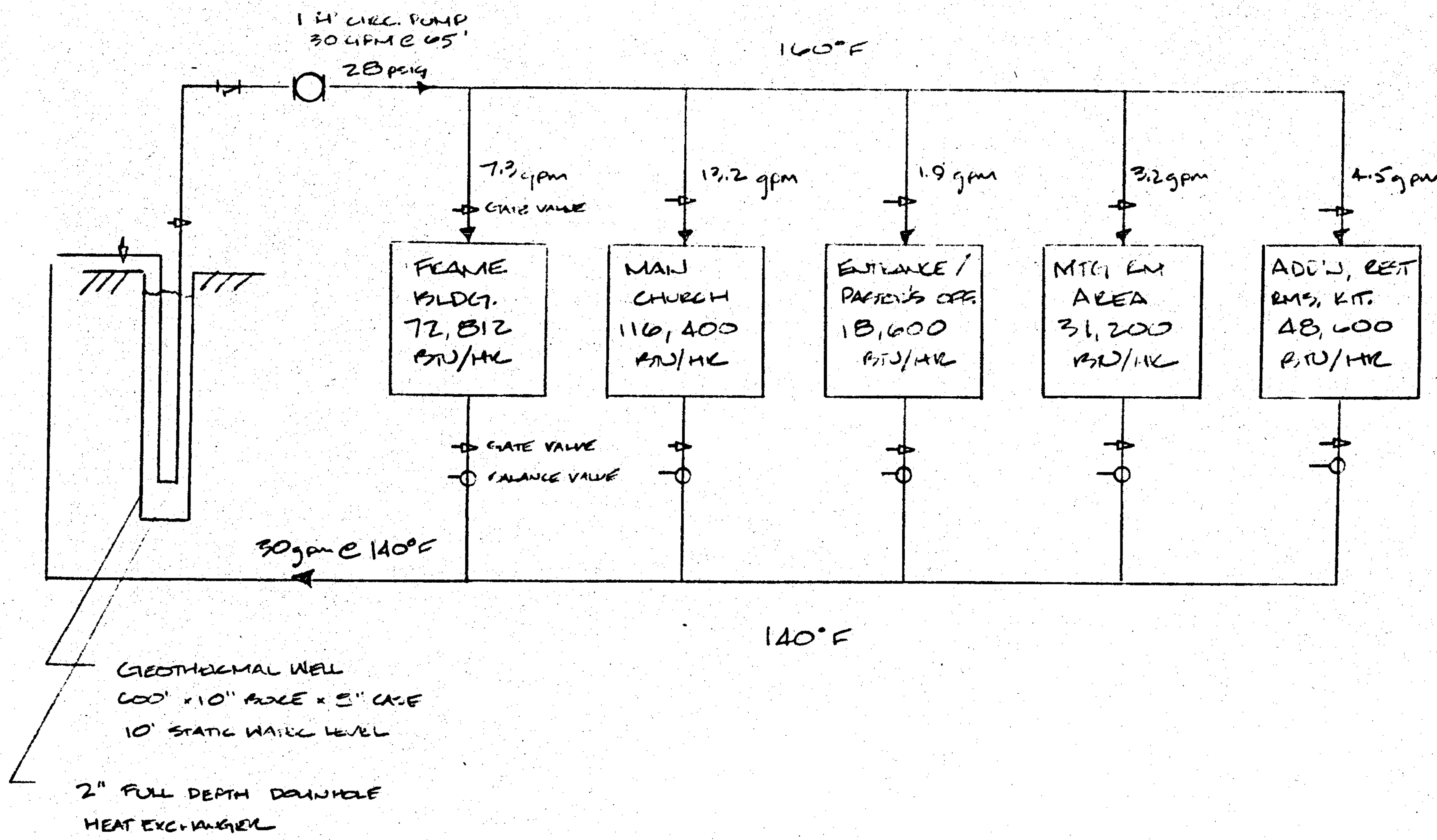
FIG 1

FLOW SHEMATIC FOR GEOTHERMAL SYSTEM

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