HEATING FACILITIES

Klamath Lutheran Church
Klamath Falls, Oregon

August 1980

DISCLAIMER

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The following report is the result of a request to the Geo-Heat Center for Technical Assistance.

INTRODUCTION

The Klamath Lutheran Church is located at 1715 Crescent Ave. in Klamath Falls, Oregon. The main church building, dated 1942, is a masonry structure with cathedral ceiling containing approximately 5800 sq. ft. of floor area. This building is currently heated by two duct furnaces and a unit heater all of which are gas fired. An Educational Wing of approximately 6300 sq. ft. was added in 1958. This building, containing 2 assembly rooms and a number of classrooms is of uninsulated frame construction, with extensive glass area. A gas-fired boiler supplying finned tube radiators currently heats this wing. Due to the rising cost of fuel, church officials have asked if the facility can be heated geothermally.

As a result of this request, we have examined four specific options for displacing all or part of the heating duty with geothermal. These options are outlined below.

Case 1 - Drilling a production and injection well on the property and using the resultant hot water (180°F) to heat the entire facility.

Case 3 - Using effluent from the Klamath Union High School to heat the entire facility. No well drilling required.

Case 2 - Using effluent from the Klamath Union High School to heat only the church building. The present gas boiler would heat the Educational Wing.

Case 4 - Drilling a production and injection well on the property and using the resulting water (70°F) to supply a water-to-water heat pump.

SUMMARY OF CONCLUSIONS

Of the four cases examined in this study, case 3 (heating of both the church building and educational wing with effluent from the Klamath Union High School) seems to offer the greatest potential and earliest simple pay-back period. (See Table 6) This scheme involving the installation of a pipeline from the high school boiler room to the church, replacement of the radiators on the educational wing and installation of new heating equipment in the main church building. As indicated in Table 3 the estimated capital investment for the option is about $57,000 and yields a first year savings on natural gas and electricity of $3,530. Taken together these two figures, when examined over a 20-year period with escalation considerations, yields a rate of return of 8.2%. Tables 2 and 5 indicate the economic aspects of Case 2. This option yields a rate of return of only 2.4% indicating that money for the necessary modifications would have to be available at that rate of interest before this case could be economically feasible.

Tables 1 and 4 show the economic results of Case 1. As indicated in Table 4 the rate of return for this case is only 5.4%. This rate is not now economically feasible. Also, it must be remembered that Case 1 involves the risk of drilling a well, the results of which are currently difficult to predict. The use of a heat pump for the church does not appear in the economic analysis as it was determined at an early stage that this would not prove to be an economical approach.

AVAILABILITY OF GEOTHERMAL WATER

There is evidence of a geothermal resource in the vicinity of Klamath Lutheran Church. Seven wells within a radius of 900' are currently producing 160^{o} to 207^{o}F water at depths of 200' to 400'. However, all of these wells are located in the area of Modoc Field and are on the opposite side of the canal from the church property. No information is available on wells closer to the church site.

For purposes of this study, data on the Modoc Field wells was used to determine the results to be expected at Klamath Lutheran. Based on this, a well depth of approximately 400' would likely produce water at 180^{o}F, a temperature sufficient to generate all the space heating needs of the facility. In the event that the well does not produce hot water, we have investigated the feasibility of a heat pump installation.

A second, more reliable resource of geothermal water is also available in the area. The effluent from the Klamath Union High School heating system could be used if a pipeline was installed between the church boiler room and the high school mechanical room. (See Figure 4)

ENERGY BALANCE

The church buildings are of two different types of construction. The church proper, is a masonry structure with cathedral ceiling and was considered to be uninsulated. Because of the significant heat storage capacity of this type of construction, an outside design temperature of 9^{o}F was chosen for heat loss calculations. This, in conjunction with an inside design temperature of 67^{o}F, yielded a peak heat loss as shown in the following table.

The educational wing is a frame structure with extensive glass area. This large amount of single glass together with the uninsulated walls combine to make the building sensitive to low outside temperatures. For this reason an outside design temperature of $4^{o}F$ was chosen. Inside design remained at $67^{o}F$. These temperatures together with the type of construction yielded the following heat loss figures:

Church proper	107,000 Btu/hr
Church assembly area	31,000 Btu/hr
Educational wing	
assembly - 1st floor	31,000 Btu/hr
- 2nd floor	36,000 Btu/hr
East classrooms	76,000 Btu/hr
West classrooms	96,000 Btu/hr
Total -	377,000 Btu/hr

Certain energy conservation measures could reduce these figures. However, the proposed design is based on the present conditions.

RECOMMENDATIONS

Regardless of the outcome of the church's plans for geothermal, there are several options which should be explored as a means of decreasing the overall heating load. Primary among these is the addition of weather stripping on outside doors to reduce the infiltration of outside air. This infiltration currently results in 22% of the heating requirements at peak.

In the educational wing some of the loss from the single glass windows (currently 39% of the heat requirements at peak) could be reduced. This could be accomplished for a minimum of cost by placing a 1" thick panel of polystyrene (styrofoam) behind the window. Heat loss through each square of window so treated could be reduced by 85%.

All thermostats should be checked for calibration. It is common for these devices to develop some error during normal use. Setting back a thermostat which is not initially working properly can give a false sense of economy.

In the church area, because of a combination of building and system design, a large amount of heated air migrates to the ceiling where it is ineffective. This can be remedied to some extent by installing ceiling fans. These units drive the heated air back down toward the occupied zone. In addition, the gas-fired duct furnaces serving the church area seem considerably oversized in comparison to the heating load. This condition results in inefficient operation. Some means could be provided to tailor the output of these units more closely to their task. This could be accomplished by a stepped gas input with a sequential or variable gas valve.

The pastor's office and the room above are currently heated by electric resistance heat. If a means could be found to heat these areas with a branch off the gas unit heaters serving the main church area, the operating cost for heating these two rooms could be reduced by about 40%.

THE GEOTHERMAL SYSTEM

Case 1 - Figure No. 1 shows the basic plan for the proposed system. Included are heating loads, flow rates, key temperatures and pressures.

For purposes of a conservative estimate of the piping costs, we placed the production well at the extreme northern corner of the property. Further investigation may yield a different location. A well bore of 12" with 10" casing to a depth of 400' is anticipated. This design should produce the expected flow of 50 gpm of 180°F water. The deep well turbine pump will require a 2 horsepower electric motor to deliver the geothermal water through 3" discharge piping to the plate heat exchanger. The heat exchanger will be piped in such a manner as to allow the use of the existing boiler as back up (see Figure No. 1). The heating system water will circulate through the heat exchanger and rise from 155°F to 170°F at peak conditions.

This water will then be distributed to the terminal units by the existing circulating pumps. One additional circulating pump will be necessary in order to supply the main church building units. Also, new 1 1/2" insulated supply and return piping to the church building will be installed. Some modifications to all three of the existing church heating units is required. In the basement a new hot water unit heater will be installed next to the existing gas-fired model (which will remain as emergency backup). The new unit will provide all of the space heating requirements of this area.

In the main church area the two existing gas-fired duct heaters will have new finned hot water coils added. These will be installed between the fan box and duct furnace. Again, the existing gas-fired equipment can remain as backup.

No modification to the heating units (finned tube radiation) is necessary in the educational wing assuming a 162.5°F average water temperature.

Case 3 - The heating system at Klamath Union High School rejects a large flow of water at a minimum temperature of 135°F on a continuous basis. This case examines the feasibility of using a portion of this flow to heat the church buildings.

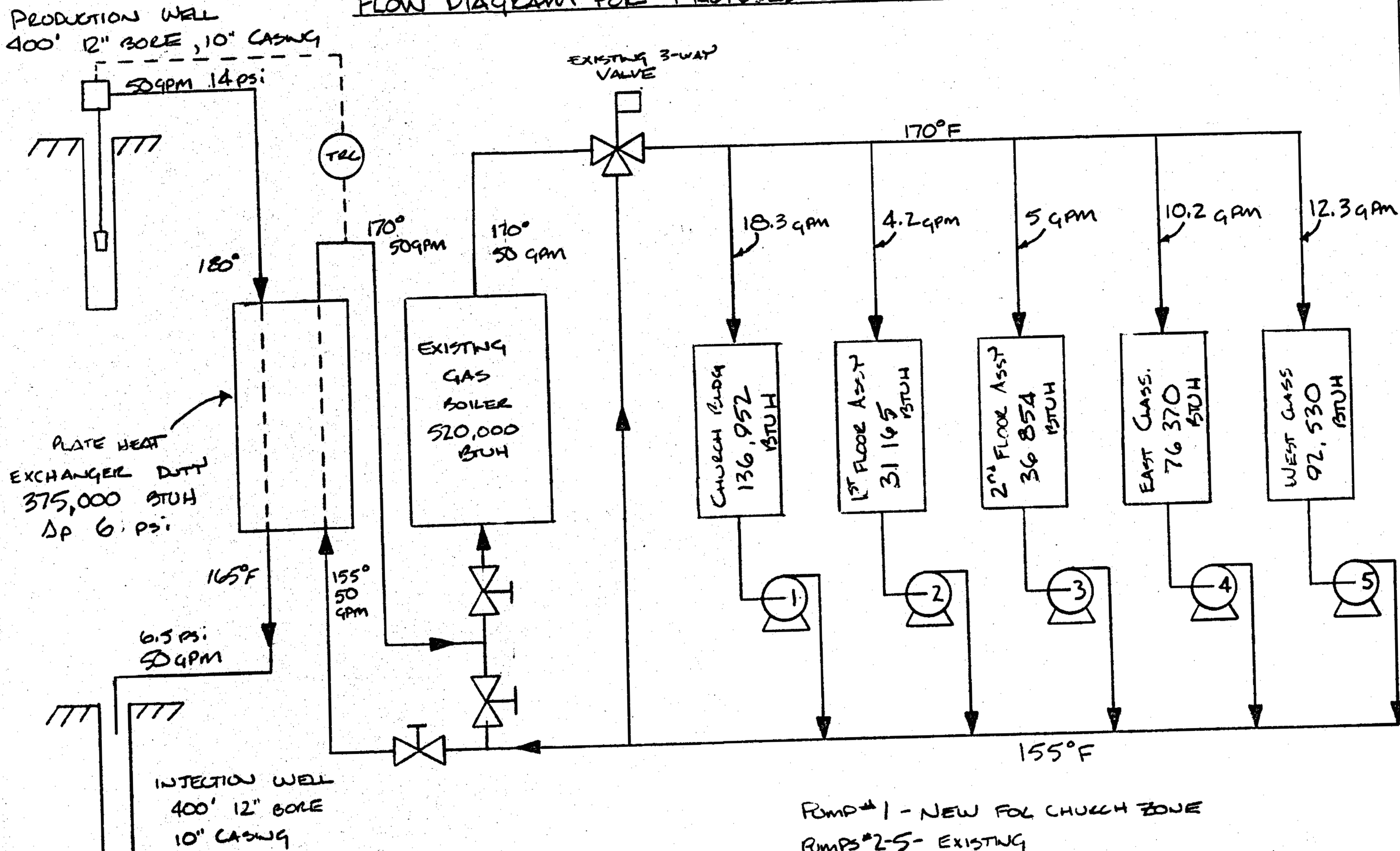
This approach would eliminate the requirement for well drilling at the site. However, due to the low temperature of the effluent, significant modifications would be required in the educational wing to facilitate space heating. This is due to the fact that the existing finned tube radiation would be ineffective at the water temperature available. In order to heat the wing with the lower temperature water, individual fan coil units would have to be installed in each room. To supply these units, some new piping is required. The existing finned tube radiation could be used for some return piping back to the heat exchanger/boiler room, and existing circulating pumps can be employed in the new design. The heat exchange placement as shown in Figure No. 2 is basically the same as that for Case 1 (Figure 1) with the only difference being the source of the geothermal water. In the church building all modifications will be basically the same as in Case 1, however, due to higher flow rates (27 gpm vs. 18 gpm) 2" lines will be required for supply and return of heating water. The geothermal water will be routed from the high school through 3" buried FRP piping with the supply line insulated and the return line uninsulated. Figure 4 shows the routing for the buried pipe. If a means could be found to deliver these lines to the church by a more direct route, substantial savings could result in piping costs. Finally, a new circulating pump (No. 6 in Figure 2) is required to cause the geothermal water to re-enter the return line at the High School.

Case 2 - Again, in this case the effluent from the High School is used for space heating. Figure 4 shows the pipeline routing for this scheme and that of Case 2. This design differs from that of Case 2 only in that the educational wing has been excluded from the geothermal heating system. Due to the extensive modifications required there, only the church building will be heated by the geothermal water (See Figure 3). The existing boiler will continue to heat the educational wing. The church heating system will be the same as that in Case 2 with the only differences being a smaller circulating pump (No. 6 Figure 3) and reduced buried pipe size and heat exchanger capacity.

Case 4 - Involves using the geothermal wells on the property to supply a heat pump, in the event that the temperature is less than that necessary to supply the heating demands directly. Due to the low temperature output of the heat pump, major modifications would be necessary in the educational wing to accommodate use of the water. This would consist of changes similar to those in Case 2. This case was not examined in detail as it was found that the retrofit costs, cost of the heat pump machine, and operating cost (electricity to run the heat pump) was such that the system would not prove to be economically feasible.

FIG #1

FLOW DIAGRAM FOR PROPOSED SYSTEM - CASE 1

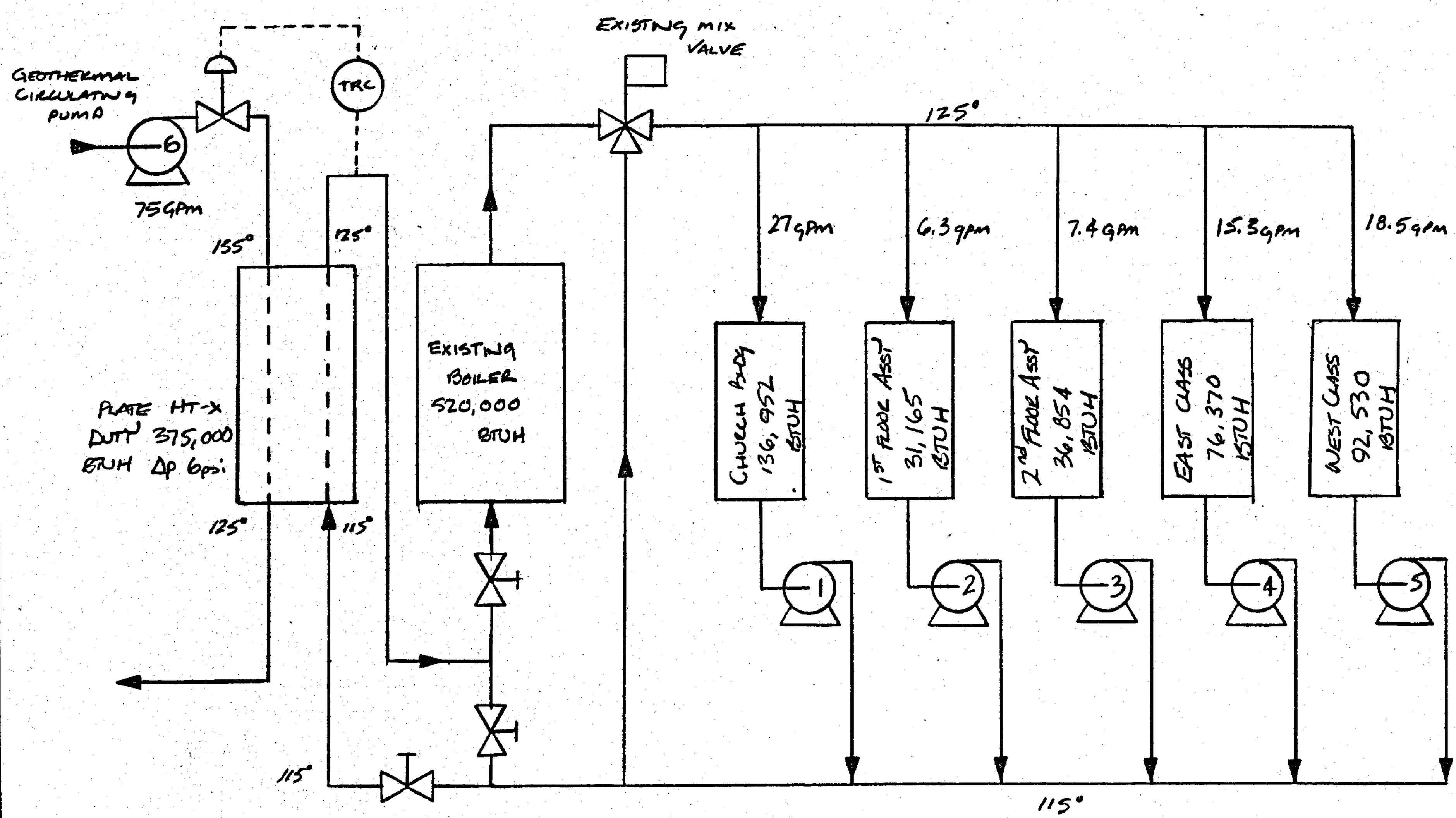


PUMP #1 - NEW FOR CHURCH ZONE

PUMPS #2-5 - EXISTING

FIG # 2

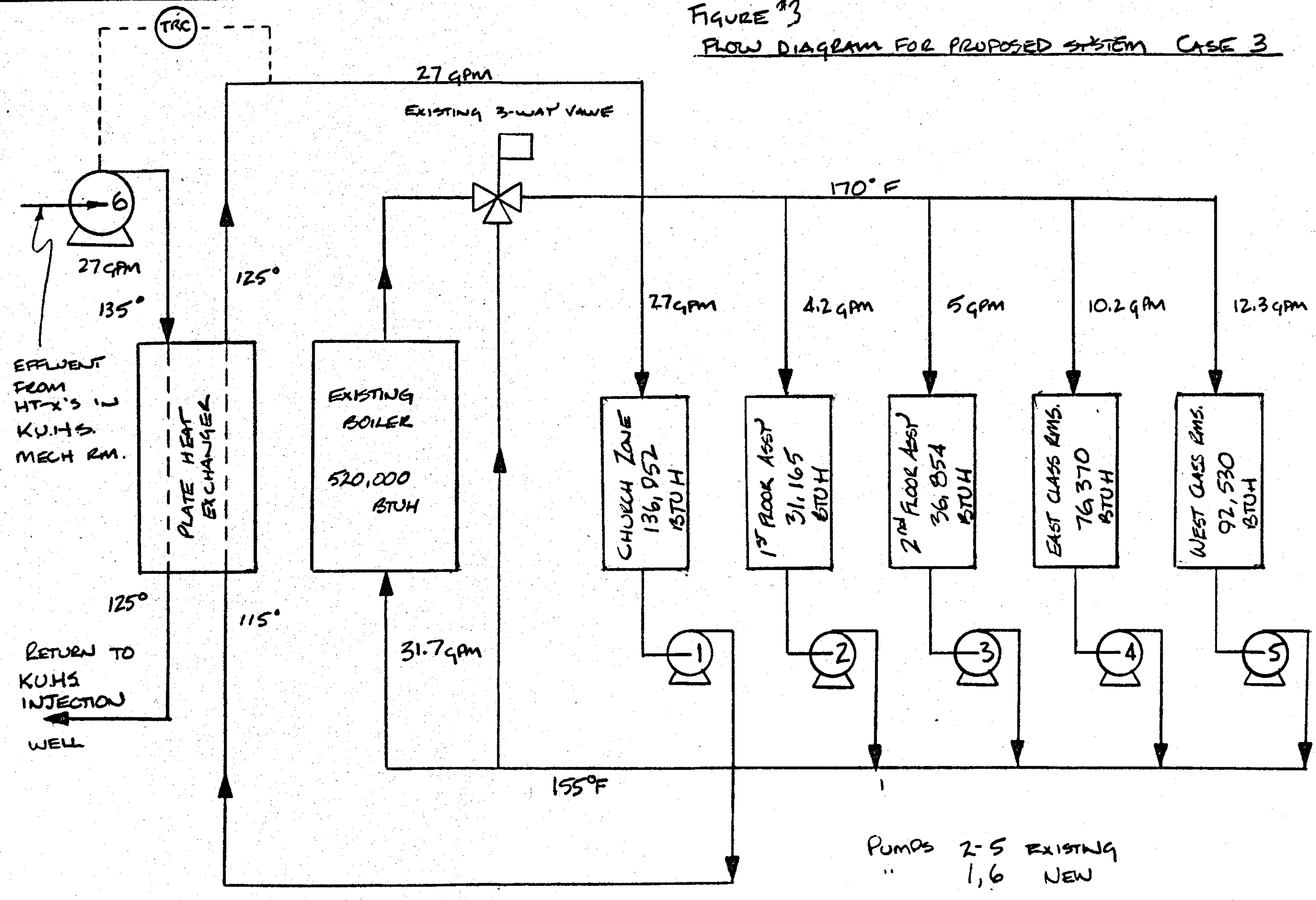
FLOW DIAGRAM FOR PROPOSED SYSTEM - CASE 2



NOTE - PUMPS 2-5 EXISTING, 1 AND 6 NEW
ALL FLOWS AND TEMPERATURES AT PEAK.

FIGURE #3

FLOW DIAGRAM FOR PROPOSED SYSTEM CASE 3

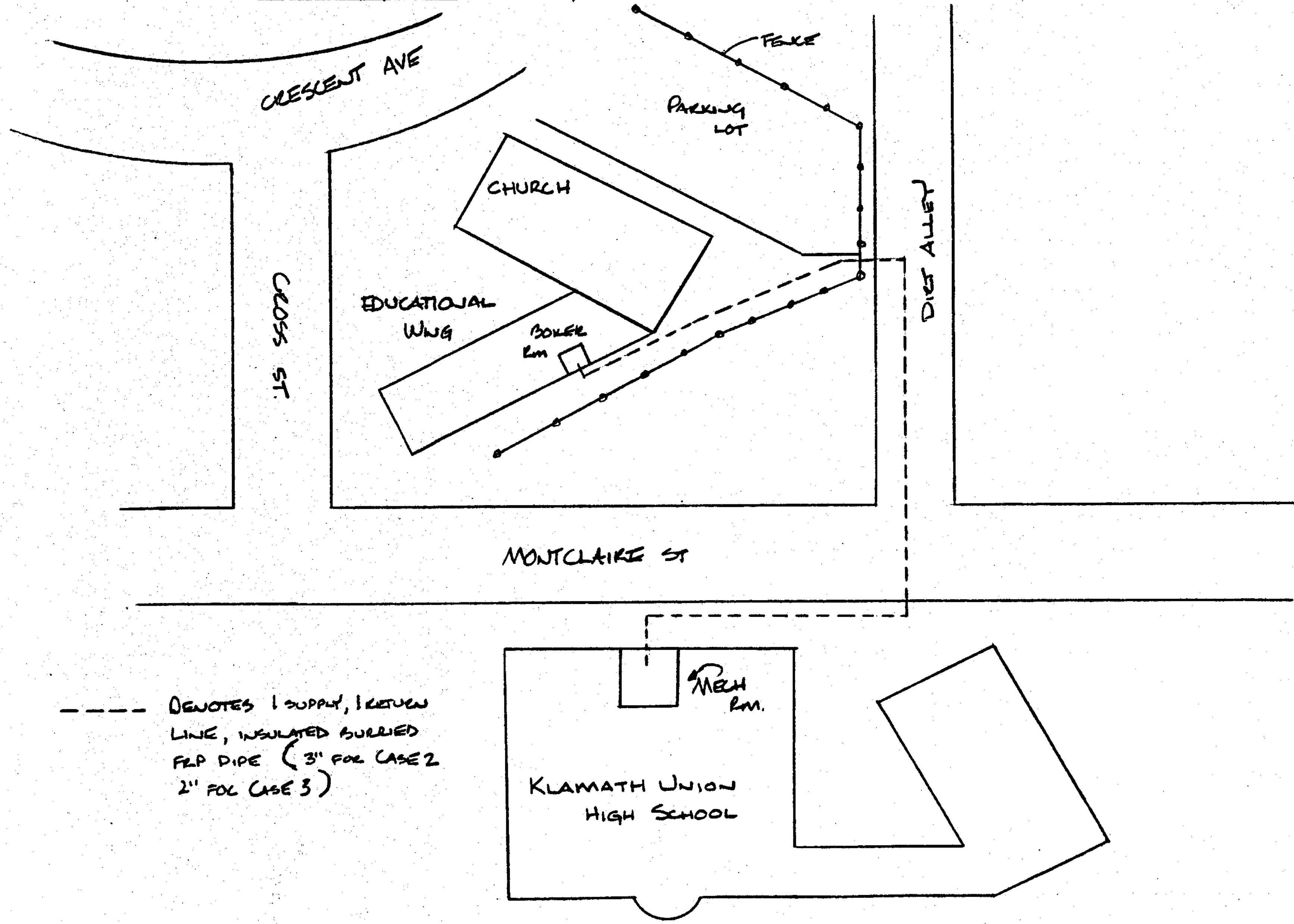


PUMPS 2-5 EXISTING
" 1,6 NEW

NOTE - ALL TEMPERATURES AT PEAK CONDITIONS.

FIGURE # 4

UNDERGROUND PIPING SCHEME FOR CASES 2 AND 3



KLAMATH LUTHERAN CHURCH SPACE HEATING ECONOMIC ANALYSIS

The economic analysis for the Klamath Lutheran Church was based on three alternatives. In each case conventional fuel savings were estimated for electricity and natural gas, and these costs were projected through the year 2000 based on the following inflation forecasts from Oregon's Energy Future, Fourth Annual Report, Oregon Department of Energy, January 1, 1980.

Annual Inflation Rates for Natural Gas

1981-1984	7.6%
1985-1989	8.4%
1990-1994	10.3%
1995-2000	10.6%

Annual Inflation Rates for Electricity

1981-1988	8.9%
1989-2000	8.6%

Maintenance costs were projected to inflate at an economic inflation rate of 7% per annum through the year 2000. Insurance costs were projected to increase at 2% per annum over the 20-year project life.

The method of financing the required capital investment was unknown; therefore, a rate of return on capital investment was calculated for each case in order to allow the church to select the best alternative.

Klamath Lutheran Church Space
Heating Economic Analysis

The optimum alternative is Case 3, which provides the least capital investment per dollar of annual savings. The following tables show 20-year cash flows for each case and indicate the annual rate of return on investment.

SUMMARY OF COSTS FOR CASE 1 - TABLE 1

CAPITAL COSTS

WELLS - 1 PRODUCTION 1 INJECTION	-	28,000
TURBINE PUMP	-	13 000
CIRCULATING PUMP	-	800
FAN COIL REPLACEMENT	-	800
FINNED COILS	-	1000
PLATE HEAT EXCHANGER	-	900
BURRIED F.R.P. PIPING	-	7000
WELL HEAD BUILDING	-	3000
INSIDE PIPING ALLOWANCE	-	2500
MISCELLANEOUS ELECTRICAL AND MECH.	-	2800
SUB TOTAL		60,000
CONTINGENCY		12 000
TOTAL		$ 72000

OPERATING COST

MAINTAINANCE	-	1444
INSURANCE	-	180
ELECTRICAL POWER FOR SYSTEM	-	217
TOTAL ANNUAL OPERATING COST 1ST YEAR	-	$ 1841

NATURAL GAS SAVINGS 7386 THERMS @ .457 $/TH
3375.43

SAVINGS ON ELECTRICITY 3507 Kw @ .0351 $/Kw
123.09

TOTAL SAVINGS 3498.52 $/YR

SUMMARY OF COSTS FOR CASE 2

TABLE 2

CAPITAL COSTS

CIRCULATING PUMP	-	$ 800
FAN COIL REPLACEMENT	-	800
FINNED COILS	-	1000
PLATE HEAT EXCHANGER	-	400
GEOTHERMAL CIRC. PUMP	-	1000
PIPING	-	25000
MISC. MECHANICAL AND ELECTRICAL	-	2100
SUBTOTAL		31,100
CONTINGENCY		6 400
TOTAL		$ 37,500

OPERATING COST

MAINTAINANCE	-	290
INSURANCE	-	223
ELECTRICAL POWER FOR SYSTEM	-	133
TOTAL ANNUAL OPERATING COST FOR 1ST YEAR		$ 646

SAVINGS

NATURAL GAS	2705 THERMS @ .457 $/TH -	1236
ELECTRICITY	5910 KW @ .0351 $/KW -	207
TOTAL SAVINGS 1ST YEAR		$ 1443

SUMMARY OF COSTS FOR CASE 3

TABLE 3

CAPITAL COSTS

CIRCULATING PUMPS	- $ 2000
FAN COIL REPLACEMENT	- 6500
FINNED COILS	- 1000
PLATE HEAT EXCHANGER	- 900
PIPING	- 32000
MISC MECHANICAL AND ELECTRICAL	- 4800
SUBTOTAL	47,200
CONTINGENCY	9500
TOTAL	$ 56,700

OPERATING COSTS

MAINTAINANCE	- 565
INSURANCE	- 340
ELECTRICAL POWER FOR SYSTEM	- 186
TOTAL ANNUAL OPERATING COST 1ST YEAR	- $ 1091

SAVINGS

NATURAL GAS 7386 THERMS @ .457 $/TH	- 3375.43
ELECTRICITY 4395 KW @ .0351 $/KW	- 154.26
TOTAL 1ST YEAR SAVINGS	3529.69

CASE I

TABLE 4

KLAMATH LUTHERAN CHURCH
SPACE HEATING ECONOMIC ANALYSIS

August 12, 1980

20-Year Projected Cost Natural Gas	20-Year Projected Cost Electricity	Geothermal System Electrical Cost	Geothermal System Maintenance Cost	Geothermal System Insurance Cost	20-Year Projected Cash Flow
3631.	134.	236.	1545.	183.	1801.
3907.	145.	257.	1653.	187.	1956.
4204.	158.	280.	1768.	191.	2123.
4524.	173.	305.	1892.	194.	2304.
4904.	188.	332.	2025.	198.	2536.
5316.	205.	361.	2167.	202.	2790.
5763.	223.	394.	2318.	206.	3067.
6247.	243.	429.	2481.	210.	3369.
6772.	264.	466.	2654.	215.	3700.
7469.	287.	506.	2840.	219.	4190.
8239.	311.	549.	3039.	223.	4737.
9087.	338.	597.	3252.	228.	5348.
10023.	367.	648.	3479.	232.	6030.
11056.	399.	704.	3723.	237.	6790.
12228.	433.	764.	3984.	242.	7670.
13524.	471.	830.	4262.	247.	8654.
14957.	511.	901.	4561.	252.	9754.
16543.	555.	979.	4880.	257.	10981.
18296.	603.	1063.	5222.	262.	12352.
20236.	655.	1155.	5587.	267.	13881.

TOTAL
114043.

*Simple Payback

Rate of Return: 5.4%

CASE 2

TABLE 5

KLAMATH LUTHERAN CHURCH
SPACE HEATING ECONOMIC ANALYSIS

August 12, 1980

20-Year Projected Cash atural Gas	20-Year Projected Cost Electricity	Geothermal System Electrical Cost	Geothermal System Maintenance Cost	Geothermal System Insurance Cost	20-Year Projected Cash Flow
1329.	225.	144.	310.	227.	872.
1431.	245.	157.	332.	232.	954.
1539.	267.	171.	355.	236.	1043.
1656.	291.	187.	380.	241.	1139.
1795.	317.	203.	406.	246.	1256.
1946.	345.	221.	435.	251.	1383.
2110.	375.	241.	465.	256.	1522.
2287.	409.	263.	498.	261.	1674.
2479.	444.	285.	533.	266.	1839.
2735.	482.	310.	570.	271.	2065.
3016.	524.	336.	610.	277.	2316.
3327.	569.	365.	653.	282.	2595.
3670.	618.	397.	698.	288.	2904.
4048.	671.	431.	747.	294.	3246.
4477.	729.	468.	800.	300.	3638.
4952.	792.	508.	856.	306.	4073.
5477.	860.	552.	916.	312.	4556.
6057.	934.	600.	980.	318.	5093.*
6699.	1014.	651.	1048.	324.	5688.
7410.	1101.	707.	1122.	331.	6350.
				TOTAL	54215.

*Simple Payback

Rate of Return: 2.8%

CASE 3

TABLE 6
KLAMATH LUTHERAN CHURCH
SPACE HEATING ECONOMIC ANALYSIS

August 12, 1980

20-Year Projected Cost Natural Gas	20-Year Projected Cost Electricity	Geothermal System Electrical Cost	Geothermal System Maintenance Cost	Geothermal System Insurance Cost	20-Year Projected Cash Flow
3631.	167.	202.	604.	346.	2646.
3907.	182.	220.	646.	353.	2869.
4204.	199.	240.	692.	360.	3111.
4524.	216.	261.	740.	368.	3371.
4904.	236.	284.	792.	375.	3688.
5316.	257.	310.	847.	382.	4032.
5763.	280.	337.	907.	390.	4407.
6247.	305.	367.	970.	398.	4815.
6772.	331.	399.	1038.	406.	5258.
7469.	359.	433.	1111.	414.	5869.
8239.	390.	471.	1189.	422.	6546.
9087.	424.	511.	1272.	431.	7296.
10023.	460.	555.	1361.	439.	8127.*
11056.	500.	603.	1456.	448.	9047.
12228.	543.	655.	1558.	457.	10099.
13524.	590.	711.	1667.	466.	11268.
14957.	641.	773.	1784.	476.	12565.
16543.	696.	839.	1909.	485.	14004.
18296.	756.	911.	2043.	495.	15602.
20236.	821.	990.	2186.	505.	17375.

TOTAL
152005.

*Simple Payback
Rate of return 8.2%