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COLLEGE OF IDAHO
GEOTHERMAL SYSTEM,
Caldwell, Idaho

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College of Idaho
Caldwell, Idaho

Introduction

The College of Idaho (Figure 1) campus is located in southwestern Idaho in the town of Caldwell. Originally established in 1891, its campus still employs some of the original buildings. Fifteen major structures are located on the campus with a total of approximately 350,000 square feet of area. Primary energy is supplied in the form of natural gas to individual building boilers. Because of the diverse nature of the buildings, mechanical systems vary from one pipe cast iron steam radiators to high velocity double duct systems.

Annual natural gas consumption amounts to about 375,000 therms/year. As a result, energy costs are a considerable operating expense.

Caldwell lies in an area believed to be underlain by a geothermal aquifer. Resource temperature, which is expected to be in the 160°F range, would be well suited to space heating.

For this reason, the college administration is enthusiastically pursuing the possibility of geothermal use at the site. This report explores the feasibility of geothermal space heating for the campus.

Summary

There appears to be a good potential for a 160°F resource at the College of Idaho site. Both existing well data and recent geologic and hydrologic investigations suggest that such a temperature should be available at a depth of approximately 3500 feet.

Use of a temperature in the 160°F range would not permit a 100% displacement of present natural gas use for space and domestic hot water. Because these systems were typically designed for 200°F water or low pressure steam (~ 220°F), the performance of the existing equipment would be less than peak building requirements. However, even without major system modifications (the cost of which would be unreasonable), a geothermal system based on the above resource temperature would be capable of displacing about 78% of current natural gas consumption attributable to space and domestic hot water heating. The system outlined in the report would consist of a 3500 foot production well which would

supply geothermal fluid to 12 major buildings on campus (Kirkpatrick, Covell and Blatchely Halls were not included in the system). Geothermal water would be passed through heat exchangers in each building. The heat exchangers would deliver heat to the existing heating loops. Most buildings would still require a small amount of input from the existing boiler during the coldest periods of the year. After having passed through the system, the geothermal water would then be injected into a disposal well. This is a key factor in the overall economics of the system. The assumption has been made that a full depth (3550 foot) injection well would be required. It is possible, though unclear at this point, that injection could be accomplished at a shallower depth into a similar aquifer. Since the injection well amounts to 24% of the total system capital cost, this is an important factor.

Table 3 outlines key system costs. As shown, total system savings would amount to 315,053 therms/year and at a value of 44¢/therm, this results in a figure of \$138,623/year. Total capital cost is calculated to be \$1,325,000. The gross simple payback is then 9.5 years. Table 4 illustrates the effect of inflation rates on the system. As you can see, it shows a somewhat faster payback of 7.23 years. This table is based on a 6% annual inflation rate and rates of approximately 2% for energy values.

Availability of Geothermal

The College of Idaho site lies in an area of recognized geothermal resources. The first recorded warm water well in Caldwell was drilled by the city in 1930 for heating the municipal swimming pool. The 1015 foot deep well had a production temperature of 84°F. According to the driller's log a warmer aquifer was encountered; however, due to the desire for cooler temperatures, the casing was perforated allowing mixing to take place. Health Department objections to the use of this water caused the well to be sealed off during the early 1970's.

In 1945 the city drilled a shallow (375 foot) well on the College of Idaho campus. This well was reported to be capable of flowing 450 gpm at 67°F.

In 1956, an oil and gas exploration well, the Richardson #1, was drilled to a depth of 2132 feet. In 1978, a bottom hole temperature of 146°F was measured.

FIGURE 1

The College of Idaho Campus

-3-

1. Sterry Hall — Administration building, classrooms
2. Terteling Library — Seminar rooms
3. Finney Hall — Women's residence
4. Simplot Hall — Women's & Men's residence and all-college dining hall
5. Anderson Hall — Men's residence - Port of Hope
6. Alpha & Omega — Residences for interest groups
7. Blatchley Hall — Art gallery, music department, classrooms
8. Student Union Building — Student services, placement, nurse
9. Tennis Courts — (lighted for night play)
10. Strahorn Hall — Classrooms, faculty offices
11. William Judson Boone Hall — Science, mathematics and classrooms
12. Covell Hall — J. A. Albertson, School of Business
13. Kirkpatrick — P.E., health and recreation and classrooms
14. Symms Athletic field
15. Soccer, softball, jogging
16. Art Center — Studio, crafts, classrooms
17. Jewett Chapel-Auditorium — Chapel, classrooms
18. Morrison Quadrangle
19. Lindenwood — President's Home
20. Vorhees Hall — Men's residence
21. Hayman Hall — Men's and women's residence

More recently, J.R. Simplot Inc. drilled a 2212 foot well in Caldwell. This well showed a bottom hole temperature of 151°F and had an artesian flow rate of 38 gpm. Production temperature was only 110°F. This indicates that some mixing of colder surface water was occurring in the well. This conclusion is supported by the temperature gradient of the well (see appendix).

Recent geologic and hydrologic studies of the Nampa-Caldwell area (Mitchell and others 1981) offers additional evidence in support of the resource. Quoting their report "In summary, geothermal waters of moderate temperature suitable for space heating can be expected at depths of 450-1200 m (1500-4000 feet) over most of the Nampa-Caldwell area. Oil and gas wells have explored the subsurface, but deep water bearing units have not been tested to assess their water producing capacity. The most favorable driller's targets are along the major youthful faults detected by the seismic reflection survey." A portion of the results of this survey are shown in Figure 2. It is evident that the campus site lies only about 1000 feet northeast of one of these faults. In addition, the college's location is on the downthrown side of the fault. As a result, water upwelling along this fault zone would tend to flow laterally toward the campus.

A second figure (Figure 3) from the same report indicates that the regional temperature gradient is in the range of 40°C/km ($\sim 2.2^\circ\text{F}/100'$). The temperature gradient for the lower portion (below the surface water mixing) of the Simplot well suggests an even more favorable figure of about $3.1^\circ\text{F}/100$ feet.

Using these two gradients and, as a starting point, the temperature of 140°F at 2025 feet in the Simplot well, the expected depth of any particular temperature can be calculated. It should be pointed out that extrapolating temperature gradients to depth is a questionable practice in most instances. However, the evidence from deep existing wells in the area, and the relatively homogeneous nature of the Idaho group rock units into which the well would be drilled tend to support this approach.

The results of these calculations indicate that a temperature of 165°F would be available at a depth of 2800 to 3200 feet. It is the opinion of the Idaho Department of Water Resources that an aquifer, similar to that which underlies

FIGURE 2

R 3 W

SUBSURFACE TEMPERATURE (° F)

- △ J.N. James #1 (14,000 Ft. - 4267.2 M., T.D.)
- Higgenson #1 (3609 Ft. - 1100 M., T.D.)
- Richardson #1 (3048 Ft. - 929 M., T.D.)
- Webber - State #1 (4528 Ft. - 1380.1 M., T.D.)
- ◇ Highland L & L #1 (11,395 Ft. - 3637.8 M., T.D.)
- Ore - Ida #1 (10,035 Ft. - 3064.5 M., T.D.)
- + Deer Flat #1 (9,300 Ft. - 2958 M., T.D.)

FIGURE 3 Geothermal gradients from selected deep wells in the western Snake River Plain.

Boise, and at a temperature of about 160°F would be available in the Caldwell area at a depth of approximately 3500 feet.

For the purposes of this report it has been assumed that a 165°F resource (assumed to produce 160°F fluid) is a good balance between the existing known temperature of 150°F (Simplot) and that which would be required to match current space heating temperatures on the campus (190°F). Use of such a resource would allow existing systems to be employed with no major modifications assuming a small amount of natural gas peaking is used during the coldest period of the year.

Conventional Energy Use

Prior to the evaluation of a geothermal space heating system it is necessary to determine the current conventional energy use for the project. In this case, a large number of buildings are involved. Unfortunately, energy audits are available for only three of the 15 major campus buildings. As a result, energy use for the 12 remaining structures had to be calculated. In order to reduce the amount of time consumed in this task, only brief manual calculations were performed. For space heating, peak building load was calculated for 0°F outside design temperature and 68°F inside temperature. A modified degree day method was then employed to determine annual space heating energy use based on 5500 degree days. It was assumed that 25% of heating requirements were met by solar and internal gain. Overall heating system energy conversion efficiency was assumed to be 65%. Space heating and ventilation components were considered separately. Although this is a rather simplistic approach, results for the three energy audited buildings were within 10% or less of the audit report figures. For the two buildings with the most complex system, generic energy use data per square foot of building area indexed to degree days was used. Results of these calculations are shown in Table 1.

In addition to space heating energy use, domestic hot water consumption was calculated for buildings in which this would be a sizeable figure (residence halls and dining facilities). For these calculations, ASHRAE guidelines were employed on a gallon per student per day and gallon per meal basis for residence and dining halls respectively. Sixty degree source water and 140°F set point

COLLEGE OF IDAHO - BUILDING SUMMARY SHEET

TABLE 1

Building	Area	Total Inst. Cap. Sp. Ht. & Vent. BTUH	Inst. Cap. Sp. Ht. Only	Unit Cap.	Boiler Size	DHW Inst. Cap.	Storage	#Students	Annual DHW Therms	Annual Sp. Ht. Therms	Annual Vent Therms	Total Geo. Access. Therms
Sterry	24,396 (18,297)	564,000	564,000	30.8	-	-	-	-	-	28,113	0	28,113
Library	34,305	1,811,460	1,316,280	38.4	1,392,000	-	-	-	2,194	42,195	←	44,389
Finney	18,898	727,587	727,587	38.5	5,480,000	173,264	500	104	4,673	15,322	0	19,995
Simplot	48,488	3,288,840	2,822,280	35.1	-	k 466,480 d 375,000	k 375 d 950	180	k 4,549 d 8,087	38,123	15,944	66,703
Anderson	29,564	1,036,240	1,036,240	35.1	?	288,000	75	156	7,009	23,244	0	30,253
Blatchley	6,399	197,089	197,089	30.8	?	-	-	-	-	9,824	0	9,824
Student Union	19,440	1,279,500	739,500	38.0	-	?	100	-	-	16,565	12,110	28,675
Strahorn	13,500	733,402	628,736	46.6	- (2)	150,000*	-	-	4,454 g	11,842 e 42,679	1,303 g	17,599 e 42,679
Boone	54,656	4,332,816	1,312,816	24.0	3,540,000	541,450	1,500	-	-	34,979	←	34,979
Covell	NOT CONSIDERED											
Kirkpatrick	18,500	777,600 458,080	777,600 458,080	42.0 24.8	?	?	500	-	2,518	10,260	0	12,778
Art Center	4,410	220,000	220,000	49.9	220,000	-	-	-	-	2,470	0	2,470
Jewett	16,652	2,133,400	1,400,800	84.2	2,430,000	80,000	75	-	-	14,920	1,369	16,289
Vorhees	14,080	542,100	542,100	38.5	600,000	200,000	500	78	3,504	11,417	0	14,921
Hayman	41,544	1,870,350	1,033,110	24.8	2,400,000	1,200,000	1,160	192	8,626	23,142	20,027	51,795
TOTALS	344,832	19,514,384	13,318,138	38.6	-	-	-	710	45,614	282,416	50,753	378,783

*snow melt

temperatures were used in conjunction with a 65% overall conversion efficiency and a 10% standby loss. Results are shown in Table 1.

In addition to energy use for space and domestic hot water heating, natural gas is used for a few other applications. Kitchen use for cooking is calculated to be 10,125 therms per year. Kilns at the Art Center consumed an additional 11,520 therms per year. Other miscellaneous uses were assumed to use another 5619 therms per year.

Geothermal System

It is very rarely possible, because of corrosion and scaling tendencies, to use geothermal water directly in a building's heating system. A heat exchanger must be used to absorb the heat from the geothermal fluid and transfer it to a "clean loop" of water which is actually used in the system. As a result, a geothermal system for a group of buildings such as the College of Idaho campus can take one of two basic approaches: 1) the geothermal fluid can be delivered directly to the individual buildings with small isolation heat exchangers in each building or; 2) the geothermal fluid can be passed through one large central heat exchanger and "clean loop" water delivered for use in each building.

For a variety of reasons the first approach was chosen for this application. The advantages of this approach include the use of uninsulated return piping for the disposal lines, the ability to maintain current building circulation loops without modification, lower pump energy consumption, and the ability to allow buildings to use existing equipment for peaking purposes.

Figure 4 shows a schematic of the retrofit which would be employed for most of the buildings. Geothermal water, from the distribution system, would be passed through a plate heat exchanger. This heat exchanger would be plumbed into the existing building hot water loop. Heat from the geothermal water would be added to the existing heating loop in the same fashion as is currently accomplished with gas fired boilers. After having passed through the space heating heat exchanger the geothermal water would either be diverted to disposal or to a second heat exchanger for domestic hot water heating. For buildings

FIGURE 4

Retrofit Diagram

so equipped the domestic hot water heat exchangers would be installed in the cold water makeup line to the existing storage tank. In this manner, the water entering the storage tank would be preheated by the geothermal fluid. A tempering valve would assure that makeup water does not exceed 140°F. This "instantaneous" method of domestic hot water heating was chosen for two reasons: 1) the available resource temperature is fairly low in comparison to hot water storage temperatures (140°F vs 160°F); 2) the "cascading" approach or using space heating effluent to heat domestic hot water reduces overall system flow requirements and helps maintain peak flow at a realistic value for a single production well.

Figure 5 shows a layout of the geothermal system. Assuming further refinement of the geothermal resource, a different location may be found for the production well. The location employed for this study results not only in good drill rig accessibility but also minimizes distribution piping impact on existing roads and paved areas. A deep well turbine pump would be placed in the production well to produce a peak flow rate of 790 gpm. The well pump motor, located above ground, and a small amount of well head plumbing would be enclosed in a well head structure of about 8' by 8'. The production well pump motor would be equipped with a variable speed drive mechanism. This device would allow the pump to supply only the flow actually required by the system. This not only conserves the resource but reduces motor electrical consumption. From the production well, geothermal water would be distributed to each of the campus buildings through an insulated fiberglass reinforced plastic supply network. This non-metallic piping is less expensive to install than steel and is immune to corrosion attack. After passing through the individual building heat exchange equipment the geothermal water would enter the disposal piping network. This piping, to be installed in the same trench as the supply piping, would be constructed of the same material as the supply system. However, because temperature loss is not a concern for disposal fluid, this side of the system can be left uninsulated, thus reducing capital costs. For purposes of this report, it has been assumed that disposal of the fluid into the production aquifer will be required. To accomplish this, an injection well of similar depth

to the production well would be drilled. This is a conservative assumption. Generally, injection of fluid is required into "the same or similar" aquifer. Should a "similar" aquifer be available at a shallower depth, drilling costs could be reduced.

As mentioned earlier, a resource temperature of 160°F has been used for this study. This temperature is lower than most buildings on campus currently employ for heating purposes. As a result, without major equipment retrofits, the existing system will not be able to meet 100% of the heating requirements at this lower temperature. For each building, this situation has been evaluated. The results of this evaluation are shown in Table 2. From the table it is obvious that three of the major campus buildings have not been considered for inclusion in the geothermal system. The reasons for this are discussed in some detail below and relate to the difficulty in retrofitting the existing building systems. For the remaining buildings, the geothermal system would be employed down to some temperature (the value varies from building to building) at which the equipment performance would no longer meet building requirements. At this point, the system would automatically switch over to the conventional system.

This approach, known as "peaking" or meeting the peak load with conventional fuels, has two major advantages. It limits the magnitude of building retrofits to accommodate lower temperature water and it allows the existing natural gas fired equipment to operate in its optimum efficiency range (near maximum load). As mentioned above, the point of the geothermal to conventional system switch-over varies. This is reflected in the % Savings Value column in Table 2. Total space heating natural gas savings is calculated to be 315,053 therms per year. This is approximately 77.6% of current calculated natural gas consumption.

For domestic hot water it has been assumed that the instantaneous water heating approach would meet 80% of current natural gas consumption for heating of hot water. The existing equipment would still supply the remaining 20% and any standby losses from storage. Savings figures for domestic hot water are included in Table 2.

COLLEGE OF IDAHO - GEOTHERMAL SYSTEM SUMMARY

TABLE 2

Building	Design Geo. Load Sp. Ht. Btu/Hr	Geo. Flow Rate GPM	Sp. Ht. Savings Th/Yr	DHW Savings Th/Yr	Total Savings Th/Yr	% of Present Use
Sterry	564,000	37.6	28,113	0	28,113	100
Library	1,412,939	94.0	41,028	0	41,028	92
Finney	480,207	32.0	13,273	2,990	16,263	81
Simplot	2,217,673	147.8	47,038	8,087	55,125	83
Anderson	683,918	45.6	19,990	4,486	24,476	81
Blatchley	0	0	0	0	0	0
Student Union	1,279,500	85.3	28,675	0	28,675	100
Strahorn	583,387	40.8	g 11,304 e 34,143	4,454*	g 15,758 e 34,143	89
Boone	4,166,940	277.8	34,009	0	34,009	97
Covell	0	0	0	0	0	0
Kirkpatrick	0	0	0	0	0	0
Art Center	154,000	10.3	2,470	0	2,470	100
Jewett	1,632,534	109.0	14,428	0	14,428	86
Vorhees	357,786	23.9	9,819	2,243	12,062	81
Hayman	1,234,431	82.3	37,125	5,521	42,646	82
TOTALS	14,767,315	986.4	287,272	27,781	315,053	77.8

*snow melt system

Figure 6 shows a flow scheme for the geothermal system. At peak conditions a flow of 790 gpm would be required. This value incorporates an 80% diversity factor. In other words, the peak flow rate is 80% of the actual sum of all equipment requirements. Due to the vast number of heating devices, it is unlikely that all would require heat at the same moment. The 80% value takes this into consideration. Most existing building systems supply a 20° or 30° Δt for heating circuits. The geothermal system employs a 30° Δt . This results in space heating heat exchanger effluent temperature of 130°F. For buildings equipped with domestic hot water heat exchangers, exit temperatures would be dependent upon hot water demand. Building heat exchangers were assumed to use a 5° approach, resulting in 155°F supply water temperature.

The following paragraphs discuss some of the points relating to individual buildings. Values discussed as installed capacities were taken for the most part from original building documents. It is probable that changes have been made since original construction. However, time did not permit building examinations.

Building Descriptions

Sterry Hall. This building serves as the administration center for the college. In addition, some classroom area is provided on the second and third floors. As one of the oldest buildings on campus, this 24,396 square foot structure was built in 1910. It employs a one pipe cast iron steam radiator heating system. Steam supply originates from Finney Hall and only manual control is employed. Due to the nature of the present heating system, a hot water retrofit could not be accomplished short of replacing the entire building heating system. This is a result of the one pipe nature of the present distribution system.

Installed capacity of the heating system is estimated to be 564,000 Btu/hour. Annual natural gas heating consumption is calculated to be 28,113 therms. This figure is in good agreement with the results of a recent energy audit by Musgrove Engineering. Energy use for domestic hot water is considered to be negligible.

FIGURE 6

Flow Scheme

In order to connect to the geothermal system, a complete system retrofit is required at Sterry Hall. This would consist of removing the existing cast iron radiator and installing new hot water baseboard equipment. In order to accommodate the use of the new equipment additional hot water return piping would have to be installed. A small mechanical area, to house the necessary mechanical equipment (circulating pump, expansion tank, etc) would be installed in the basement. The cost of this retrofit is estimated to be approximately \$46,000.

Because the new equipment would be designed to use the lower temperature water produced by the geothermal system, 100% savings could be achieved in this building. Required flow rate would amount to 37.6 gpm.

Terteling Library. This 34,305 square foot building, built just 16 years ago, is one of the more modern buildings on campus. It employs a multizone core system with perimeter radiators. This type of system, particularly as designed in pre-"energy crisis" period, can be very energy intensive. The nature of the multizone approach results in a simultaneous heating and cooling of an air stream. The hot and cold flows are then mixed to produce the temperature required at each zone. This results in high energy use by the system. There are a number of control modifications which can be employed to reduce this high energy use. Some of these are resetting hot and cold deck temperatures according to demand, reduce hot and cold deck temperature design set points, change interior zones to variable air volume type distribution. Such system modifications would be evaluated in an energy audit. This building should receive high priority for an audit.

Current installed heating capacity for the building is 1.81×10^6 Btu/hour. Annual natural gas consumption is calculated to be 44,389 therms which includes 2194 therms for domestic hot water.

Retrofit of this building to geothermal hot water would involve only the installation of a heat exchanger and controls as shown in Figure 6. Because of the low annual domestic hot water use, it was not considered advisable to retrofit the building for domestic hot water heating. Total savings for the

building under geothermal operation would amount to 41,028 therms/year or 92% of current use. Because much of the heat is supplied by currently over designed finned coils, the building is able to achieve a relatively high percentage of savings. Required geothermal flow rate would amount to 94 gpm.

Finney Hall. Another of the older buildings on campus, this 18,898 square foot structure was constructed about 1910. It is used as a dormitory with accommodations for approximately 104 students. Since no drawings were available for Finney, it was assumed to have a system similar to that in Vorhees Hall, another dormitory of similar vintage which was remodeled in 1958. This system is a one pipe hot water perimeter radiator "monoflo" system. The capacity of the Vorhees system was ratioed by floor area to arrive at a capacity of 727,587 Btu/hour for Finney. In addition to space heating, a 500 gallon domestic hot water storage tank and boiler are installed in the building. Capacity of the domestic hot water boiler is 173,264 Btu/hour. Two boilers located in the basement of Finney supply steam for this building and four others on campus including Sterry Hall, Strahorn Hall, Simplot Hall, Student Union. Capacity of these boilers is 5.48×10^6 Btu/hour.

Calculated domestic hot water use is 4673 therms/year. Space heating use is calculated at 15,322 therms/year, for a total use of 19,995 therms/year.

This system, since it is currently operating on hot water, would result in a relatively simple retrofit to geothermal as shown in Figure 6. Because the existing system is operated at a 200°F supply water temperature, the geothermal system (at 155°F supply temperature) would achieve an 81% savings compared to present space and domestic hot water heating consumption. This would amount to 16,263 therms/year. Required geothermal flow rate would amount to 32 gpm. Costs for domestic hot water retrofit have been included for this building.

Simplot Hall. This building was constructed in a number of stages from 1946 to 1964. It contains dormitory space for approximately 180 students and the

campus dining hall in an area of 48,488 square feet. As mentioned above, steam is supplied from Finney Hall boilers for space and domestic hot water heating. The space heating system is composed primarily of finned pipe radiators and convection in the rooms, with hallway and bathroom forced air ventilation units. Total installed capacity is 3.29×10^6 Btu/hour. Separate domestic hot water facilities are provided for the dorm and kitchen areas. Capacity of the kitchen units is 466,480 Btu/hour with the dormitory units being 375,000 Btu/hour. Both of these are storage tanks with integral steam tube bundles. Storage capacities are 375 and 950 gallons respectively.

Annual space heating energy is calculated to be 54,067 therms. Domestic hot water heating consumes a total of 12,636 therms for the kitchen and dormitory. Again, the existing hot water system would provide for a relatively simple retrofit as shown in Figure 6. However, because of the separate domestic hot water heating system for the kitchen and dormitory, two domestic hot water heat exchangers would be tied into the outlet of the space heating heat exchanger. Since the system was originally designed for 200°F supply water temperature, savings percentage is roughly the same as for Finney at 83%. This amounts to 55,125 therms/year. A geothermal flow of 147.8 gpm would be required.

Anderson Hall. This dormitory, constructed in 1956, has accommodations for approximately 156 students. A portion of the 29,564 square foot structure is occupied by a drug and alcohol rehabilitation organization. The remainder is used as dormitory space. A large dual fuel (oil/gas) boiler provides heating energy to the 1,036,240 Btu/hour space heating system. Terminal equipment consists primarily of convectors and finned pipe equipment. In addition, a 75 gallon high recovery domestic hot water heater rated at 288,000 Btu/hour provides for domestic hot water needs.

Annual space heating energy is calculated to be 23,244 therms. An additional 7009 therms are consumed for domestic hot water heating.

Existing hot water system would provide for a retrofit similar to that shown in Figure 6. Again due to the nature of building use, a domestic hot water retrofit is justified. Total savings for the building would amount to 24,476

therms/year or 81% of current use. Peak flow requirements would be 45.6 gpm.

Blatchley Hall. This building, constructed in 1905, contains within its 6399 square feet areas for classrooms, physical plant offices and reception. A small gas fired boiler in the basement supplies steam to a network of two pipe cast iron radiators. Again, drawings were not available for the building and installed capacity was scaled from Sterry Hall for estimating purposes. This results in a figure of 197,089 Btu/hour. Domestic hot water use is small and supplied by an electric hot water heater.

Annual natural gas use for space heating is estimated to be 9824 therms. Domestic hot water use is assumed to be negligible.

Retrofit of this building would require a substantial effort. The existing cast iron radiators would not provide sufficient capacity at the hot water temperatures expected. In addition, existing condensate piping would be inadequate for required water flow rates. In view of these factors and the relatively low annual space heating and domestic hot water fuel consumption (~ 2.6% of total current campus use), this building was not considered for inclusion in the geothermal system.

Student Union. This building was constructed in two stages in 1958 and 1964. It contains 19,440 square feet of area used for various activities. Originally a dining facility was included in the building. Two steam to water converters operating on steam from the Finney Hall boilers supply heat to a variety of terminal equipment. This equipment, in the form of unit heaters, unit ventilators and convectors, supplies heat to the building at a supply water temperature of 160°F. Total installed capacity amounts to 1,279,500 Btu/hour. Again, this building uses very little domestic hot water despite the fact that a large domestic hot water system is installed.

Current annual space heating energy consumption is calculated to be 28,675 therms. This figure assumes that unit ventilators are supplying the originally specified amount of ventilation air on an 18 hour per day basis. If this is the case, ventilation rates should be checked to assure that they are not in

excess of current requirements. Since ventilation is calculated to account for 42% of space heating consumption, there is considerable potential for conservation.

Retrofit of the existing hot water system would be as shown in Figure 6. As a result of the low supply temperature, it was assumed that the system could still meet 100% of heating requirements at the 155°F supply temperature of the geothermal system. This savings would amount to 28,675 therms/year. Required geothermal flow rate would be 85.3 gpm.

Strahorn Hall. Strahorn Hall, constructed in 1926, is a classroom building of 13,500 square feet. Remodeled in 1967 it employs a combination of terminal equipment using both hot water and electricity. One large air handler supplies ventilation needs to the three floors. Some space heating on the first floor is supplied by a finned tube system with the remainder supplied by an air handler for the classroom area. The second and third floors are heated primarily by individual unit electric heaters. These units do have water coils designed for air conditioning purposes (a chiller is located in the basement). In addition to the space heating, a snow melt system is installed in the entrance area to the building. This system, operating from its own heat exchanger, supplies 120°F water to a grid system with a capacity of approximately 150,000 Btu/hour. This system is operated all winter regardless of the weather, consuming 4454 therms/year. More closely monitored operation could conserve energy. Domestic hot water use, supplied by an electric hot water heater, is considered to be negligible. Steam for space heating and snow melt systems is supplied from Finney Hall.

Current annual heating energy consumption is calculated to be 13,145 therms/year and 42,679 kWh/year. This assumes ventilation is as originally specified and is operating only during occupied periods.

Retrofit for the existing equipment using hot water would not be difficult. The remaining equipment would be retrofitted using the cooling circuit. This could be a problem in the intermediate seasons. However, the use of the cooling circuit eliminates the necessity of equipment replacement in these areas. Be-

cause most heating would employ forced air finned coils a relatively high percentage of savings (89%) is possible. Two parallel heat exchangers, one for space heating and one for snow melt, would be employed in the building. Annual savings would amount to 15,758 therms/year and 34,143 kWh/year. Required geothermal flow rate would be 40.8 gpm.

Boone Science Building. This building, constructed in 1968, contains both classroom and laboratory areas. At 54,626 square feet it is one of the largest buildings on campus. As with the library, constructed in the same era, it contains a fairly energy intensive space conditioning system. This system, known as double duct, is similar to the multizone system described in the library section. It also employs simultaneous heating and cooling of an air stream. As a result, there is similar potential for energy savings. Some dual duct systems can be converted to V.A.V. for lower energy costs. During the site visit it was learned that the system chillers were very rarely operated. This reduces energy costs and has been taken into consideration in natural gas consumption calculations. Twin boilers and chillers located in the basement supply hot and chilled water to the seven air handlers. A small number of finned tubes and unit heater terminal equipment is also employed. Total installed capacity amounts to 4,332,816 Btu/hour, only 1,312,816 Btu/hour of which is actual space heating. The remainder is ventilation. As a result, there appears to be large potential for ventilation reduction even in light of the laboratory nature of the building.

Annual space heating energy is calculated to be 34,979 therms. Domestic hot water consumption is assumed to be negligible.

Retrofit of the existing hot water system would be as shown in Figure 6. Because a large percentage of heat is supplied via finned coils this system is able to achieve a 97% savings as compared to current use. This figure amounts to 34,009 therms/year. Because of the high capacity of the existing space heating system, required geothermal flow rate is correspondingly large at 277.8 gpm.

Covell Hall. This small building (6438 square feet) was recently converted to rooftop air to air heat pumps. Since this type of equipment is very compact and hence difficult to retrofit, this building was not considered for inclusion in the geothermal system.

Kirkpatrick. This building houses the school gymnasium. Constructed in 1941, it has an area of 18,500 square feet. A large boiler located in the basement provides steam for both space and domestic hot water heating. A combination of unit heaters and cast iron radiator type terminal equipment is employed in the two pipe distribution system. Two large air handlers originally supplying heat to the gym have since failed and were not replaced. Original installed capacity amounted to 777,600 Btu/hour. Currently only 458,080 Btu/hour is operational. In addition, a 500 gallon storage tank with integral steam tube bundle supplies domestic hot water needs.

Calculated annual space heating energy use is 10,260 therms. Domestic hot water use is calculated to be 2518 therms/year.

Retrofit of this building as with the other steam buildings would be difficult. Again, the lower water temperatures would reduce system output and condensate lines would not have sufficient capacity to accommodate required geothermal flow rates. As a result of this and the relatively low annual heat use of 12,778 therms/year (3.4% of current annual campus use), this building was not considered for retrofit.

Art Center. The Art Center is a small complex of 4410 square feet located on the fringe of the campus. It is used primarily for ceramics and glass work by the students. Space heating is supplied by two gas fired forced air furnaces with a total capacity of 220,000 Btu/hour. Domestic hot water use is negligible. In addition to the space heating use, two kilns are operated on a continuous basis for most of the school year. Based on conversations with Art Center staff it appears that the kilns consume approximately 11,520 therms/year.

Calculated space heating consumption for the Art Center is 2470 therms/year. Retrofit of the existing system would involve the installation of a hot water coil in each of the existing supply plenums. A small heat exchanger would supply

hot water to the new coils. Retrofit would be similar to Figure 6. Because the current furnaces are considerably oversized, capacity of the geothermal system would be small in comparison at 154,000 Btu/hour. Since the new hot water coils would be designed for the low temperature water, 100% savings could be achieved (2470 therms/year). Required geothermal flow rate would amount to 10.2 gpm.

Jewett Auditorium. This 16,652 square foot building, constructed in 1961, contains the school auditorium (900 seats) and a small chapel. Space heating is provided by a large air handler (for the auditorium area) and a number of small unit heaters, unit ventilators and convectors. Total installed capacity is 2,133,400 Btu/hour supplied by a boiler of 2.4×10^6 Btu/hour capacity. There is a generous allowance for "heat up" in the space heating capacity. Domestic hot water use is considered to be negligible.

Calculated space heating energy consumption amounts to 16,289 therms/year. Retrofit of the existing system would be as shown in Figure 6. Because of the large allowance for "heat up" in the original design, the existing equipment would be able to meet 86% of annual requirements. Since the cost of geothermal operation would be small in comparison to natural gas costs, the building could be maintained at near comfort levels on a continual basis rather than heating up and cooling down as it does currently. Total savings would amount to 14,428 therms/year. Geothermal flow requirement would be 109 gpm.

Vorhees Hall. This 14,080 square foot, three story dormitory was originally constructed in 1912 and remodeled in 1958. It employs a one pipe hot water "monoflo" system using finned pipe radiators. Total installed capacity amounts to 542,100 Btu/hour. Hot water is supplied by a boiler located in the basement. In addition, a 500 gallon hot water storage tank coupled with a 200,000 Btu/hour hot water heater supplies domestic hot water needs.

Calculated annual space heating use is 11,417 therms. Domestic hot water consumption amounts to 3504 therms.

Retrofit of this building would include allowance for domestic hot water

heating as shown in Figure 6. Because the original system was designed for 200°F supply water temperature and primarily finned pipe equipment is employed, annual savings percentage would be 81% or 12,062 therms/year. This system would require a geothermal flow of 23.9 gpm.

Hayman Hall. Hayman is the newest dormitory on campus. The three story building, constructed in 1962, contains accommodations for 192 students in 41,544 square feet. Space heating is supplied by hot water finned pipes in the rooms and a heating and ventilating unit in the hallways and bathrooms. Total installed capacity is 1.87×10^6 Btu/hour. Domestic hot water is supplied by a 1.2×10^6 Btu/hour boiler tied to an 1160 gallon storage tank.

Annual space heating energy consumption is calculated to be 43,159 therms. Domestic hot water consumption is 8626 therms.

Retrofit of this building would also include domestic hot water heating. Again because of the nature of the heating equipment an annual savings percentage in the eighties (82%) is achieved. This results in a savings of 42,646 therms/year and would require a geothermal flow rate of 82.3 gpm.

System Costs and Savings

Table 3 outlines key geothermal system costs. Capital costs amount to a total of \$1,325,000. Of this figure, the production and injection wells make up 59%, distribution system 13% and building retrofits 22%. It is evident that a reduction in required depth of the injection well would have a noticeable effect upon overall system costs.

Operating costs for the system consist of maintenance for the distribution system and heat exchange equipment, and electric use by the production well pump. Maintenance cost figures include an allowance for reduced maintenance on the existing system under geothermal operation.

Total savings to be generated by the system amount to 315,053 therms/year or 77.6% of calculated current use. In addition, a small amount of electrical

COLLEGE OF IDAHO
Geothermal System Cost Summary

TABLE 3

Capital Costs

Production Well	\$350,000
Injection Well	240,000
Production Pump & Drive	51,000
Well Head Bldg. & Equipment	10,000
Distribution System	134,000
Building Retrofits	<u>220,000</u>
Subtotal	1,005,000
20% Contingency	200,000
10% O&P	<u>120,000</u>
Grand Total	\$1,325,000

Operating Costs

Maintenance	
Piping	\$804/yr
Equipment	4,104
Electrical Use	3,727

Savings

Natural gas	
315,053 therms/year @ .44 =	\$138,623
Electricity	
34,143 kWh/year @ .019 =	<u>649</u>
	\$139,272

savings for the Strahorn building would result.

Comparing the gross savings to the estimated capital cost results in a 9.56 year simple payback.

Table 4 shows a 20 year life cycle cost summary for the geothermal system. The table assumes a 6% inflation rate and the following incremental or real energy inflation rates.

Natural gas	1985-87	2.0%
	1988-92	2.2%
	1993-97	3.0%
	1998-2004	3.2%
Electricity	1985-90	0.9%
	1991-2004	2.1%

Maintenance costs are assumed to inflate at the general inflation rate.

Column 1 shows the current natural gas cost.

Column 2 shows the cost of the small amount of electricity consumed by the Strahorn heating system.

Column 3 shows natural gas costs under the geothermal system.

Column 4 shows electrical costs for production well pumping and incorporates savings in Strahorn heating costs.

Column 5 shows incremental maintenance costs for the geothermal system. That is, costs over and above those associated with the current system.

Column 6 subtracts geothermal system costs from conventional system costs to arrive at a net savings.

Column 7 shows the cumulative value of this net savings.

Column 8 discounts the Column 6 figures at an annual rate of 10%.

Column 9 presents the cumulative value of these discounted annual cash flows.

The bottom line of Table 4 is a simple payback of 7.23 years and a discounted payback of 11.15 years. A total 20 year net savings of \$6,980,159 would result from system operation. When discounted at 10% this figure amounts to \$2,281,237 which compares favorably to the capital cost of \$1,325,000

TABLE 4

	Natural Gas Present System	Electricity Present System	Natural Gas Geothermal System	Electricity Geothermal System	O & M Geothermal System	Net Energy Savings Cash Flow	Cumulative Cash Flow	Discounted Cash Flow	Cumulative Discounted Cash Flow
Year zero cost	166665	811	28041	3889	4908				
Year									
1985	179998	867	30284	4157	5202	141221	141221	128383	128383
1986	194398	927	32707	4444	5515	152659	293880	126164	254547
1987	209950	991	35324	4751	5846	165021	458901	123982	378530
1988	227166	1059	38220	5079	6196	178730	637631	122075	500605
1989	245793	1132	41354	5429	6568	193574	831205	120194	620799
1990	265948	1210	44745	5804	6962	209648	1040853	118341	739140
1991	287756	1308	48414	6274	7380	226997	1267849	116485	855625
1992	311352	1414	52384	6782	7823	245778	1513627	114657	970282
1993	339374	1529	57099	7331	8292	268181	1781808	113735	1084017
1994	369918	1653	62238	7925	8789	292618	2074425	112817	1196834
1995	403210	1787	67839	8567	9317	319274	2393699	111903	1308737
1996	439499	1931	73945	9261	9876	348349	2742048	110995	1419732
1997	479054	2088	80600	10011	10468	380062	3122110	110091	1529822
1998	523127	2257	88015	10822	11097	415450	3537560	109401	1639223
1999	571255	2440	96112	11699	11762	454121	3991681	108713	1747936
2000	623810	2637	104955	12646	12468	496378	4488060	108026	1855963
2001	681201	2851	114610	13671	13216	542554	5030614	107341	1963304
2002	743871	3082	125155	14778	14009	593011	5623625	106658	2069962
2003	812307	3331	136669	15975	14850	648145	6271771	105977	2175939
2004	887039	3601	149242	17269	15741	708389	6980159	105297	2281237
			2660479						
Total	8796027	38094	2820108	182674	191376	6980159		2281237	
Simple Payback									7.23
Discounted Payback									11.15