PROPOSAL FOR A GEOTHERMAL SPACE-HEATING DEMONSTRATION PROJECT

SUBMITTED TO

NEW MEXICO DEPARTMENT OF ENERGY AND MINERALS
SANTA FE, NEW MEXICO

SUBMITTED BY

AMERICAN GROUND WATER CONSULTANTS, INC.
CONSULTING GROUND WATER GEOLOGISTS & HYDROLOGISTS
ALBUQUERQUE, NEW MEXICO

Mr. Gary Carlson
New Mexico Department of
Energy and Minerals
Post Office Box 2770
Santa Fe, New Mexico

Dear Mr. Carlson:

American Ground Water Consultants is pleased to submit herewith our proposal entitled: Proposal for a Geothermal Space-Heating Demonstration Project. This proposal presents a demonstration project for the use of widely available ground water at normal temperatures to supply the space-heating and space-cooling needs of two possible buildings at the University of New Mexico. This project is not a research and development project; it is one in which currently available technology will be used to evaluate the feasibility of the proposed project.

We believe that our proposal will result in the maximum benefit to the people of New Mexico because both space-heating and cooling will be accomplished and because ground water at normal temperatures is used rather than the relatively rare hot water occurrences which, in any event, can't be used for space cooling.

We look forward to working with your agency and for the people of the State of New Mexico.

Sincerely,

Dr. William M. Turner

President

WMT/sskk

PROPOSAL

GEOTHERMAL SPACE HEATING DEMONSTRATION PROGRAM

Date Submitted: December 27, 1978

TITLE OF PROPOSAL: A Proposal for a Geothermal Space-Heating Demonstration Project

Principal Investigator(s)

NAME(S): Dr. William M. Turner
Dr. Bernard Mathey,

PROJECT PERIOD: 6 months - 1 year

STARTING DATE: ASAP

INSTITUTION: American Ground Water Consultants, Inc.

COMPLETION DATE:

ENERGY AREA: Geothermal Energy

AMOUNT REQUESTED: $109,000

Abstract of Proposed Project: (400 words or less)

The proposed project involves the utilization of ground water which occurs at normal ground water temperatures (close to the mean annual air temperature) for space-heating and space-cooling of either of two high priority buildings on the main campus of the University of New Mexico. The project will evaluate the feasibility from an economic point of view of the concept in comparison with other more conventional energy sources.

The proposed project is not considered by the principal investigators as a research project because the technology is presently available to construct such systems. In fact, the Simms Building in Albuquerque, New Mexico currently has such a system.

The principal investigators believe that the concept of using normally available ground water for space-heating and cooling requirements is superior to the concept of using geologically rare occurrences of hot ground water for space-heat only. We believe that the greatest benefit will derive from the concept presented in this proposal for study and evaluation.

SIGNATURE:

Principal Investigator(s)

December 27, 1978
Date

ENDORSEMENT:

President

December 27, 1978
Date

SUMMARY

American Ground Water Consultants, Inc. together with Bridgers and Paxton, Consulting Engineers, proposes to utilize ground water occurring beneath the main campus of the University of New Mexico for the heating and cooling requirements of either of two high priority buildings at the University of New Mexico. Bridgers and Paxton was a pioneer in this field 25 years ago when they installed a similar system in the Simms Building in Albuquerque. The system functions well to this day. American Ground Water Consultants will evaluate the geotechnical feasibility of the concept and Bridgers and Paxton will provide information on the heating and cooling requirements of the buildings under consideration.

The concept addressed in this proposal, we believe will have the greatest benefit to the people of New Mexico in that ground water at normal ground-water temperatures will be used. This is in distinction to the concept of using geologically rare occurrences of hot ground water for space heating _only_.

In this endeavor, American Ground Water Consultants and Bridgers and Paxton will have the full cooperation and support of the University of New Mexico.

TABLE OF CONTENTS

ILLUSTRATIONS

TABLES

LIST OF ATTACHMENTS

Attachment

INTRODUCTION

In chapter four, Laws of 1978 passed by the Legislature of the State of New Mexico, the New Mexico Department of Energy and Minerals was assigned the responsibility for administering space heating projects which utilize geothermal resources as the source of the heat. Geothermal resources are commonly thought of as energy resources which may be recovered and made available to mankind from abnormally hot wet or dry zones within the earth's crust. The most commonly thought of geothermal energy source is abnormally hot ground water; that is, ground water which is at a temperature significantly higher than the mean average temperature at the land surface. Indeed, hot ground water of this type is used to heat all of the homes and public buildings in Reykjavik, Iceland. Undoubtedly there are other areas where abnormally warm ground water is extracted from the subsurface and passed through heat exchangers of one type or another and the heat extracted used to heat buildings.

Unfortunately, abnormally warm ground water is a geologically rare occurrence in comparison with ground water which occurs at temperatures close to the mean average air temperature. There exist isolated localities in New Mexico where ground water occurs at elevated temperature. These include the Ojo Caliente, Truth or Consequences and Animas Valley areas and other areas. Water from some of the deep aquifers in the San Juan Basin is commonly at temperatures of about 105° Fahrenheit. So, while it is possible to locate occasional sources of hot ground water, ground water in the most populated part of the Rio Grande Valley exists at temperatures of about 60° Fahrenheit. To provide the maximum benefit to the citizens of New Mexico, it is desirable to demonstrate that ground water--at more usual temperatures and which is not commonly classified as geothermal water--does in fact contain sufficient heat to heat buildings. It will be equally important to demonstrate that ground water at more normal temperatures can be used for space cooling as well; something which will not easily be possible with water from hot springs and the more commonly thought-of geothermal waters.

The feasibility of utilizing ground water at more normal temperatures for space heating and cooling is not a new concept. Bridgers and Paxton mechanical engineers pioneered this concept in the American Southwest more than 25 years ago with the installation of such a system in the Simms Building in Albuquerque. More recently they have installed a similar system in the new office building belonging to the Church of Jesus Christ of the Latter-Day Saints in Salt Lake City. Information on these installations is included in this proposal as attachment 1.

The feasibility of utilizing normal ground water for space heating and cooling really came about with the development of heat pumps which extract about three calories of heat from ground water for every calorie of electrical energy used to power the pump. A description of ground-water heat pump operations is given in attachment two. For this reason, a heat pump can be a means of cutting energy costs and use, especially in areas which rely upon electrical resistance heating. As the cost of natural gas increases and as gas supplies dwindle, ground-water heat pump applications will become more and more attractive in the United States as they already are in Europe. Attachment three is a cost estimate for heating of a Columbus, Ohio building with a heating load of 75,000 Btu's at -5° F. The temperature of the ground water is 55° F.

The use of normal ground water as a source of heat in the winter and a sink for heat in the summer is not widespread for several reasons including:

1) initial and operating costs made them generally unattractive until recently

2) mechanical difficulties plagued earlier generations of heat pumps

3) the great uncertainty about the availability of suitable ground water in many areas; and

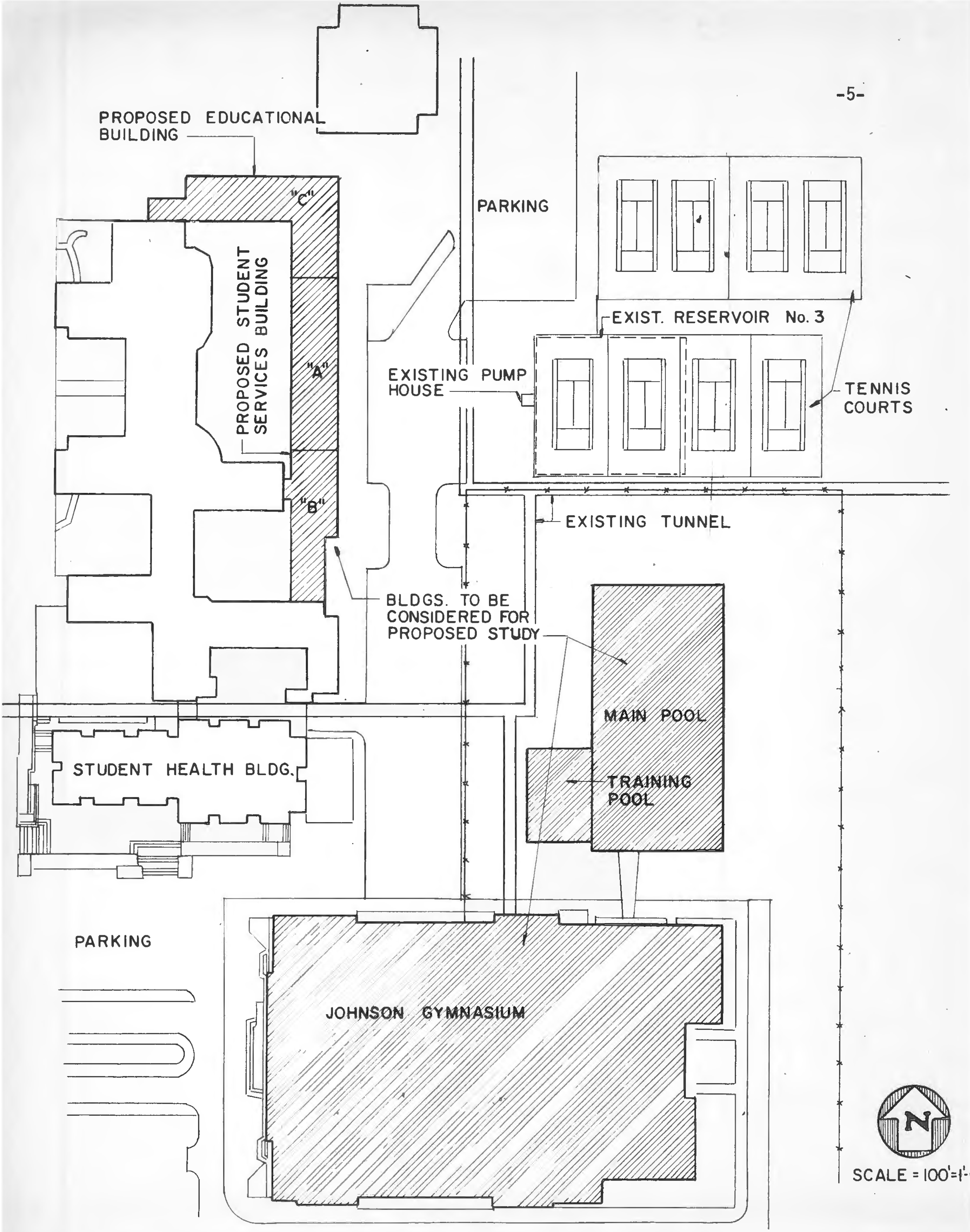
4) the problems of disposing of thermally altered water back into the ground.

It is the objective of the present proposal to demonstrate that ground water in the Albuquerque area may be beneficially used for both heating and cooling purposes. It is proposed that the demonstration project should include heating and cooling for facilities at the University of New Mexico which currently have the highest priority. Those highest priority items are the remodeling of Johnson Gymnasium and the university athletic facilities on the main campus and the construction of a student services building.

Figure 1 shows the locations of these projects on the UNM campus. Both of these programs will have significant heating and cooling requirements. To evaluate the feasibility of a ground-water heating and cooling system for these buildings American Ground Water Consultants and Bridgers and Paxton mechanical engineers will evaluate the heating and cooling requirements for each of the new facilities. American Ground Water Consultants will act as the prime contractor and the study team will evaluate long-term efficacy of the ground-water extraction and injection activity to provide sufficient heat in the winter and cooling in the summer. These geotechnical items are commonly the greatest unknowns in the design of such a system which must be answered before a system can go forward. Because of the fact that ground water used for space heating and cooling is classed as a beneficial use of water, it will be necessary to obtain the necessary permits from the Office of the New Mexico State Engineer. Futhermore, because the injection of water back into the ground is classed as a disposal activity, it will be necessary to obtain a discharge permit from the New Mexico Environmental Improvement Division. American Ground Water Consultants is completely familiar with the acquisition of the necessary permits and will make the necessary filings for permit approval.

EXISTING FACILITIES

Both the Johnson Gym/athletic facilities program and the student services building program are located in close proximity to each



GROUND WATER HEATING & COOLING PROPOSAL

FIG. No. 1

other and to the university reservoir. Furthermore, the university owns one well adjacent to the reservoir and to other wells in the vicinity. It is likely that one or more of these wells will eventually be used in the ground-water heating and cooling system to be studied in the following proposed work program. As a consequence, it is anticipated that no drilling costs will be incurred in the proposed work program. And, if construction takes place, overall drilling costs will be reduced significantly.

TECHNICAL WORK PROGRAM

The following technical work program has been ordered into a logical sequence of tasks to insure efficient program management and control. The tasks and the contractor responsible for them are designated below.

TASK 1. Evaluation of Geotechnical Parameters (AGW)

The ground-water heating and cooling system as envisioned will be designated a cyclic system in which water is withdrawn during the winter from one well and passed through a heat pump in which heat is removed from the water. Following passage through the heat pump, the water will be injected back into the aquifer from which it was originally obtained. During the summer, the system is reversed, and cool water from the injection well is now extracted and used to absorb heat from the buildings. The waste heat stored in the ground water is injected and withdrawn for heating the following winter, and so on. To evaluate the efficacy of such a cyclic system temperature of the water, it is necessary to measure the temperature within the subsurface. AGW equipment is capable of resolving 0.005° Centigrade in the field. Temperature data will be collected from the three existing wells on the UNM property.

SUBTASK 1-3. Evaluate Thermal Characteristics of the Aquifer

The computer codes also require estimates of the thermal conductivity of the solid-fluid complex as well as the specific head of the solid-fluid complex. AGW will review the drillers' logs and any lithologic logs of the holes to evaluate the thermal conductivity and specific heat of the solid-fluid complex. Information on the effective porosity determined in subtask 1-1 will be necessary to this subtask.

SUBTASK 1-4. Evaluate Rate and Direction of Ground-Water Flow

Ground water within the Albuquerque area is normally recharged along the front of the Sandia Mountains and by percolation of runoff water through the beds of the many arroyos in the area. The water moves in the subsurface to the west where it eventually discharges into the Rio Grande. The rate of ground-water flow will affect the efficiency with which heated or cooled ground water which has been injected into a well in one season can be recovered in the following season. That is, if warm water is injected into an aquifer in the summer, natural ground-water flow may sweep it away making it difficult to recover the water the following winter. Consequently, the computer codes require information on the rate of natural ground water flow.

it is necessary to accurately determine the hydraulic and thermal characteristics of the aquifer system such that computer simulations may be made to determine optimal well spacings and longterm temperature changes in the subsurface which could limit the usefulness of the system. These questions must be addressed before any capital can be committed to construction.

SUBTASK 1-1. Determine Aquifer Transmissivity and Storage Coefficient

The University of New Mexico currently has three wells which are located in reasonably close proximity. Aquifer-performance tests will be carried out on these wells to evaluate the transmissivity of the aquifer. The transmissivity is a parameter which describes the rate at which ground water will flow through the aquifer. To evaluate the storage coefficient, AGW will carry out a pulse tracer test the results of which will yield effective aquifer porosity which will be close to the storage coefficient of the aquifer. If the pulse tracer test is unsuccessful it may be necessary to drill one small-diameter observation hole near an existing well to evaluate the storage coefficient of the aquifer.

SUBTASK 1-2. Obtain Temperature Profiles

The computer codes which calculate temperature distribution within the aquifer system as a result of the cyclic operation of injection and production wells consider, among other items, the density of the water. Because density is a direct function of the

To evaluate the rate of natural ground water flow, ground-water-flow-net methods will be used. Water levels will be measured in nearby water wells to establish the gradient at the surface of the water table in the area. The transmissivity determined in subtask 1-1 will be used also in this subtask.

TASK 2. Computer Simulation Energy Analysis to Compare the Energy Cost of Utilizing Ground Water for Heating and Cooling Versus the Use of the Campus Steam and Chilled Water from the Central Energy Plant (B & P)

Bridgers and Paxton will utilize their in-house computer and energy analysis programs to determine the temporal energy requirements for both the proposes student services building and the remodeled Johnson Gymnasium. A synopsis of this computer program is included in attachment one. After the energy requirements are determined, a comparative estimate of the capital expenditure necessary for the two systems to be compared will be made. This will involve a cost estimate of the mechanical systems together with the mechanical systems utilizing heat pumps, heat exchangers compared to using the steam and chilled water from the central campus energy plant. A comparison will also be made on a conventional system utilizing natural gas for heating with a natural gas boiler and cooling with electric driven refrigeration with air-cooled condenser, in order to compare it with a more normal case for commercial buildings. This work program will be carried out in the following subtasks.

SUBTASK 2-1. Computer Simulation Energy Analysis for Student Services Building

SUBTASK 2-2. Cost Estimate of Mechanical System Utilizing Ground Water

SUBTASK 2-3. Cost Estimate of System Utilizing Steam and Chilled Water from Central Campus Plant

SUBTASK 2-4. Economic Analysis Comparing the Use of Ground Water Versus Steam and Chilled Water from Campus Plant

SUBTASK 2-5. Economic Analysis Comparing the Use of Ground Water Versus a Conventional Gas-Fired Boiler and Electric Driven Refrigeration Plant

SUBTASKS 2-6 through 2-10. The Above Tasks Would Be Repeated for the Remodeled Johnson Gymnasium

SUBTASK 2-11 Report Writing

TASK 3. Simulations (AGW)

All geotechnical information and all information on the time rate of heating and cooling requirements for both the Johnson Gym/athletic facilities project and the student services project will be entered into computer codes operated by AGW. The output from the computer model will include:

1. The proper spacing of the injection-extraction well couplet for optimal operation
2. Time rate of ground water extraction to provide the heating and cooling requirements of both projects
3. The temperature distribution within the aquifer at any point in time

Information from the simulations will be used to support applications which must be made for permits from the State Engineer and the Environmental Improvement Division.

TASK 4. Report

The final report of the project including all pertinent information, results and conclusions will be prepared in this task. The project completions report will recommend additional action necessary to implement the project.

TASK 5. Obtain Permits to Appropriate the Waters of the State of New Mexico (AGW)

In the event that the beneficial use of water for the ground-water heating and cooling project exceeds the limit of the rights currently held by the University of New Mexico, AGW will make the appropriate applications for permits to the New Mexico State Engineer in consultation with the attorneys for the University of New Mexico.

TASK 6. Obtain Discharge Permits from the Environmental Improvement Division (AGW)

AGW will prepare a discharge plan for submittal to the EID. The discharge plan will contain information obtained in Task X as well as recommendations for monitoring the performance of the system. It is anticipated that the approval from the EID will be quickly forthcoming. AGW has obtained discharge permits for industrial clients already.

RELEVANCE OF DEMONSTRATION PROGRAM

It is our belief that the approach taken here will find very wide applicablility to large public and private buildings as well as to private residences. Regarding the residential applications, it is conceivable that a cluster concept would develop where several homes draw their heating and cooling ground water from a single couplet of wells which have been properly designed.

Because the concept uses water which is available nearly everywhere it is more widely applicable than the concept which uses only abnormally hot water. The concept addressed in the proposal also has gone beyond the intent of the program in proposing to use the ground water not only for space heating but for cooling as well. With the concept outlined here twice the benefits may be reaped for the expenditure required making the concept more attractive economically.

RELATED RESEARCH

As mentioned earlier, Bridgers and Paxton have pioneered in the field of ground water utilization for space heating and cooling. Related information is contianed in attachment 1. Other relevant research on the geotechnical aspect of the concept is given in the bibliography contained in attachment four. The bibliography is by no means complete, for this area of research has been reviewed by many workers.

American Ground Water Consultants does not believe that the proposed demonstration project will lead to significant theoretical advances in understanding because the technology for accomplishing it is so well known theoretically but so rarely placed into practice because of the absence of geotechnical firms and mechanical engineering firms with a high level of expertise in the area and because of the problems stated in the introduction. Advances in understanding will come from operational results which may encourage the wider use of the concept.

PROJECT SCHEDULING

All tasks and subtasks follow each other in a sequential manner. The maximum time for completion of the project would be about six months. It is not anticipated that there would be any milestones reached before the end of the project.

PROGRESS REPORTS

To keep the New Mexico Department of Energy and Minerals fully apprised of project developments monthly progress reports will be submitted in which work accomplished during the reporting period is set forth and in which work planned for the next reporting period is also set forth. The progress reports may be used to indicate the rate of budget expenditures if desired. Any problems in the execution of the work program will be fully discussed in the progress reports. Personnel of the Department of Energy and Minerals will be invited to witness any significant field activity such as the aquifer-performance tests on the university wells.

TIME AND COST ESTIMATES

The estimated time and cost requirements of each of the tasks and subtasks presented under the technical work program are set forth in the table on the next page. The estimated cost of the geotechnical work is based upon past project experience. To ensure that all likely contingencies have been included the costs have been inflated somewhat to ensure sufficient funds. The estimate is on the high side because it is the experience of AGW that when dealing with real world situations in the earth sciences operational problems can and do commonly arise which cause unexpected increases in budgets. The costs given herein have tried to anticipate these problems.

TASK	TIME	COST[1]
1-1	two months	$40,000
1-2	three days	1,500
1-3	one day	3,500
1-4	five days	2,500
2-1	one month	5,000
2-2	two weeks	2,500
2-3	one week	1,500
2-4	one week	1,500
2-5	two weeks	3,000
2-6	one month	5,000
2-7	two weeks	2,500
2-8	one week	1,500
2-9	one week	1,500
2-10	two weeks	3,000
2-11	two weeks	3,000
3	one month	10,000
4	one month	5,000
5	three days	1,500
6	one month	15,000
	TOTAL	$109,000

[1] Includes estimated salary, overhead, transportation, equipment rental, data processing, computer charges and other related costs

AMERICAN GROUND WATER CONSULTANTS

As principal investigator, American Ground Water Consultants will carry out all geotechnical aspects of the proposed project. Information on past project experience and general information on American Ground Water Consultants are given in attachment five together with the resumes of key project personnel.

BRIDGERS AND PAXTON, CONSULTING ENGINEERS

Bridgers and Paxton, Consulting Mechanical Engineers have a long and distinguished record of mechanical engineering in the Southwest and nationally. Of importance to the proposed project are their proprietary computer codes for analyzing the energy requirements of buildings and their long association with the University of New Mexico. Indeed Bridges and Paxton long ago pioneered the concept of space heating and cooling utilizing ground water as both the source and sink for heat. Pertinent information on Bridgers and Paxton is contained in attachment six.

ATTACHMENT ONE

INFORMATION ON GROUND WATER SPACE HEATING PROJECTS

Electric Heat Pump System Used to Solve Unique Heating-Cooling Problem in Albuquerque Office Building

ALBUQUERQUE, NEW MEXICO—The flexibility of electric space conditioning seldom is more dramatically illustrated than it is in Albuquerque's 12-story Simms Building. In designing a heating-cooling system for this modern office structure in 1954, engineers Frank H. Bridgers and Donald A. Paxton faced an uncommon problem. The orientation of the building was to be such that there would be exceptionally large south and north exposures of glass areas. In Albuquerque, where in the winter months the sun shines brightly almost every day, this exposure meant that it would be necessary to cool the south side of the building even with outdoor temperatures as low as 18F, while simultaneously *heating* the shaded north side.

To resolve the problem, Bridgers and Paxton designed an electric water-to-water heat pump system that would take excess heat from the south side of the building and redistribute it in the north.

The system they evolved consists of three 100 hp compressors, two 150-ton water chillers, and three 100-ton condensers in connection with two wells—one 60 feet deep and the other 270—from which 67F ground water is available all year. Thus it is essentially a "solar heating system." The way it works is this: During summer operation, water from the shallow well is used as a heat-sink for the condenser, then dumped into deep well for storage at about 100F. In the winter, the process is reversed with water from the deep well used as a heat source, then dumped at about 55F into the shallow well for use during the summer. The higher well water temperature in winter and the lower well water temperature in summer improves the operating performance of the system. Domestic hot water is supplied by a separate heat pump unit which simultaneously cools drinking water.

Another unusual feature of the building is the use of radiant heating and cooling panels of copper tubing buried in the plaster under window sills and around the perimeter of the ceilings, to provide a balanced radiation effect. The flow of hot or cold water to the tubing is controlled by a solar compensator, which consists of a box with the same ratio of glass to wall area as the building, and oriented the same as the south wall. It measures the combined effect of outside temperature and solar heat gain to offset these factors by providing a cool panel surface, or a warm panel surface, adjacent to the glass areas.

SEE REVERSE SIDE FOR DETAIL INFORMATION

1 CATEGORY OF STRUCTURE:
Commercial—Office Building

2 GENERAL DESCRIPTION:
Area: 120,000 sq ft
Volume: 1,320,000 cu ft
Number of floors: 12
Number of occupants: 550
Number of rooms: 350 (moveable partitions)
Types of rooms: offices (shops on first floor)

3 CONSTRUCTION DETAILS:
Glass: single (first floor)
double (other floors)
Exterior walls: North and South: curtain wall. (R/6). U-factor: .15
East and West: brick veneer and tile (R/4). U-factor: .13
Roof or ceilings: concrete with 2" rigid insulation (R/6). U-factor: .12
Floors: concrete
Exposed wall area: 18,273 sq ft
Glass area: 25,722 sq ft

4 ENVIRONMENTAL DESIGN CONDITIONS:
Heating:
Heat loss Btuh: 2,518,000
Normal degree days: 4,300
Ventilation requirements: 14,400 cfm
Design conditions: 0°F outdoors; 75F indoors
Cooling:
Heat gain Btuh: 3,467,182
Ventilation requirements: 14,400 cfm
Design conditions: 96 F dbt, 70 F wbt outdoors; 78 F, 50% rh indoors

5 LIGHTING:
Levels in footcandles: 70
Levels in watts/sq ft: 3.3
Type: fluorescent

6 HEATING AND COOLING SYSTEM:
Electric water-to-water heat pump system consisting of three 100 hp compressors, two 150-ton water chillers and three 100-ton condensers using water from two wells—one 60 feet deep and the other 270 feet deep. First floor is heated with an electric air system.

7 ELECTRICAL SERVICE:
Type: underground
Voltage: 277/480v, 3 phase, 4-wire, wye
Metering: primary

8 CONNECTED LOADS:

Heating & Cooling (300 tons)	224 kw
Lighting	396 kw
Other (pumps and fans*)	700 kw
TOTAL	1,320 kw

*Includes separate heat pump unit which provides domestic hot water and chilled drinking water simultaneously

9 INSTALLED COST:

General Work	$1,625,000	$13.54/sq ft
Plumbing	60,000	.50/sq ft
Electrical (Total)*	240,000	2.00/sq ft
Heating & Cooling*	300,000	2.50/sq ft
TOTAL	$2,225,000	$18.54/sq ft

*Includes electrical portions of the heating-cooling system

10 HOURS AND METHODS OF OPERATION:
9 a.m. to 5 p.m. five days a week.

11 OPERATING COSTS:
Period: 8/11/64 to 8/12/65
Actual degree days: 4,200
Actual kwh: 2,548,800
Average cost per kwh: 1.5 cents
Actual cost: $37,601.20
*Total electrical usage

Billing Date	Demand	kwh	Amount
9/11/64	560	188,800	$ 2,877.93
10/12/64	560	161,600	2,594.65
11/10/64	560	188,000	2,872.63
12/11/64	552	238,400	3,331.43
1/14/65	568	271,200	3,597.88
2/12/65	560	234,400	3,322.45
3/15/65	616	247,200	3,570.40
4/13/65	560	206,400	3,070.51
5/13/65	576	189,600	2,923.45
6/14/65	560	193,600	2,935.53
7/14/65	664	234,400	3,535.21
8/12/65	568	195,200	2,969.13
TOTAL		2,548,800	$37,601.20

12 UNUSUAL FEATURES:
Domestic hot water is provided by a separate heat pump unit which simultaneously cools circulated drinking water. Well water is used to furnish additional heat if domestic hot water demands outbalance chilled drinking water requirements. Building also uses radiant heating and cooling panels and a solar compensator to reset chilled water and heating water temperature based on outside temperatures and solar heat gains.

13 REASONS FOR INSTALLING ELECTRIC HEAT:
A study of various types of heating systems revealed that an electric heat pump system would provide lowest total owning and operating costs. The ability of the heat pump system to provide heating and cooling simultaneously was an added factor, since the owner pays for only one service.

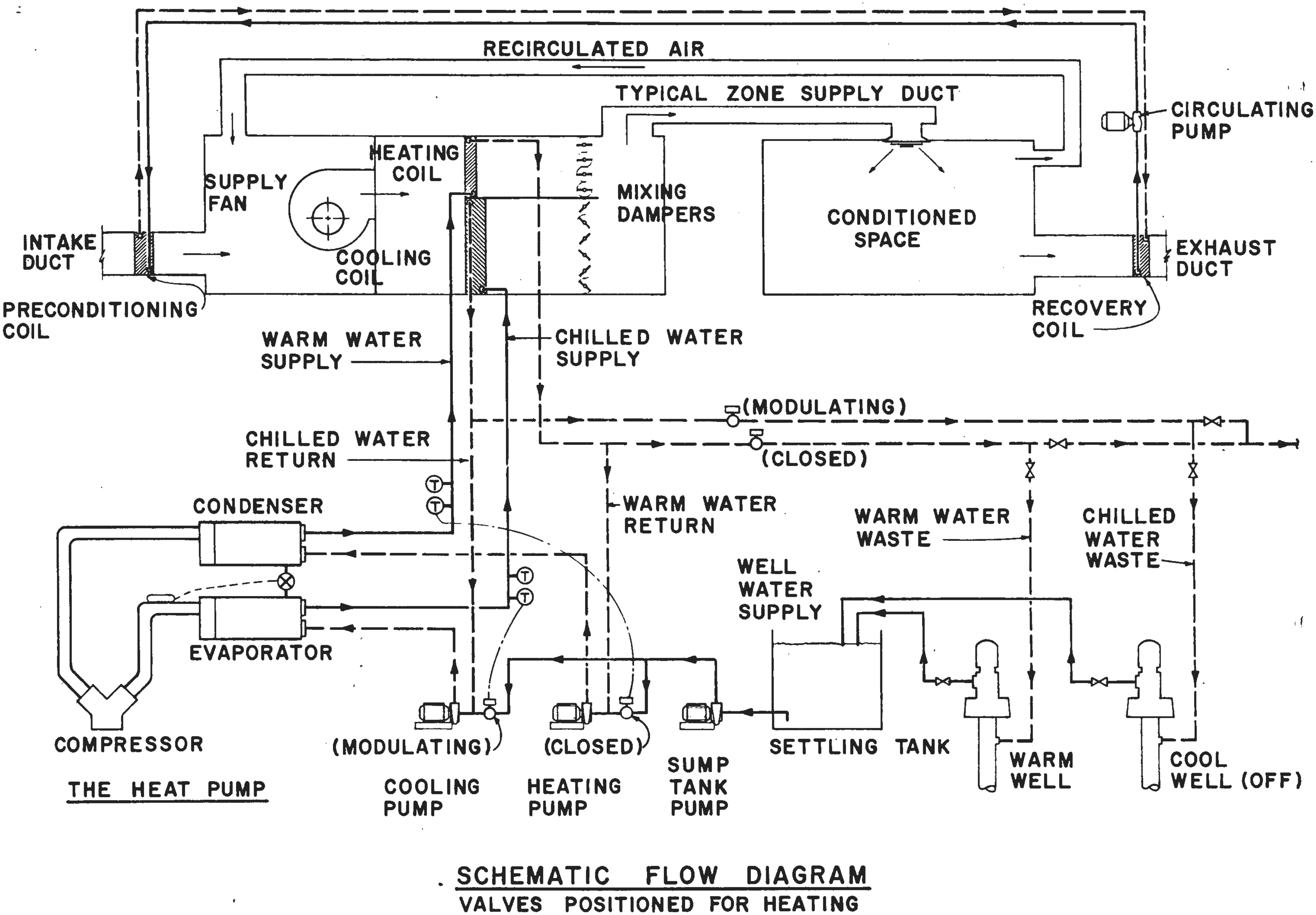
14 PERSONNEL:
Owner: Albuquerque Boys Academy
Architects: Max Flatow and Jason Moore
Consulting Engineers: Bridgers and Paxton
General Contractor: Charles Lembke
Electrical Contractor: City Electric Company
Utility: Public Service Company of New Mexico

15 PREPARED BY:
Donald B. Ratcliff, Sales Representative, Public Service Company of New Mexico

16 VERIFIED BY:
Frank H Bridgers

Frank H. Bridgers, P.E.

The Consulting Engineers Council USA, has confirmed the above categories of information as being adequate to provide a comprehensive evaluation of the building project reviewed.



SLIDE NO. 6 - SIMMS BUILDING HEAT PUMP ARRANGEMENT

A building for the ages

Salt Lake City, headquarters of The Church of Jesus Christ of Latter-day Saints, has a new landmark. It is, appropriately, the church's 28-story office building.

The general church office building, which consolidates church administrative operations that had been spread over 13 locations, rises in the block east of the famous Salt Lake Temple. It was designed by architect George Cannon Young, a grandson of Brigham Young, the church's second president. The 420-foot tower is flanked on east and west by four-story wings.

Although the building is the tallest in Utah, its height is 10 stories less than when plans for the structure were announced in 1960. The original height was reduced in response to criticism that the building would be too overpowering, particularly with respect to the temple. Also during the evolution of the program, some departments that originally were to be housed in separate buildings were brought into the new building. To compensate, space allocations for most departments were reduced and various methods employed to get the most usable space out of the 28 stories. Included in the latter was a wider building than first planned and adoption of an unusual HVC system which opened up three floors for other uses.

Architect George Cannon Young.

Two of the major additions to the building were the church archives and genealogical society, which initially were to have their own 11-story building. Also, the original plan called for the east wing to contain a missionary home, and to provide necessary dormitory space it was to be six stories high. What actually happened was just the reverse: the archives and genealogical society were incorporated into the office structure and the missionary home got its own building.

Although the height of the building was reduced, it was widened by 10 feet from the original plan. Column spacing was not changed, but perimeter tower walls which were to be cantilevered 5 feet on all sides were pushed out on the east and west sides by cantilevering them an additional 5 feet.

Bonus space—Despite the reduction in building size, bonus usable space was realized by adopting an HVC system that did not require cooling towers. Initially, three-story high cooling towers were to be located at the top of the tower. But use of a well water heat pump system eliminated the need for them, and cleared the way for two floors of office space and a third floor for meeting and reception areas.

The tower and wings are joined at the first floor by a main lobby that serves the entire building. From second through fourth floors there is a breezeway on either side of the tower. To get light and air into the breezeway areas, four circular openings are provided in the roof. These openings also reduce a "wind tunnel" effect between wings and tower.

One of the most distinctive building features are the precast exposed aggregate concrete panels used on its exterior. They are 3 feet wide and concave on their exterior face. Windows, also 3 feet wide, are 21 inches behind the exterior panel face. The panels overlap the windows, and the opening between panels is 2 feet wide. Because of this arrangement, it is possible to make the seemingly contradictory statement that the building face is 60 percent glass and 60 percent panel. When viewed at a distance, however, only 40 percent of the surface appears as glass. About 1,000 panels were used. Typical panels are two stories high and weigh 7,600 pounds.

Wider view—Young designed the windows wider than the 2-foot opening between panels because he did not want building occupants to feel they were looking out a narrow slot. By moving from one side of the window to the other, it is possible to obtain views of about 120 degrees.

The panels were selected primarily for their sun control characteristics. Their concave shape also gives the building a soft appearance, because daylight strikes curved surfaces rather than flat ones. "A lot of people think it's a classical building, but all we did was to take the verticals we were using for sun control and adapt the Doric flute on them," Young said. They are reminiscent of the fluting on Doric columns used by the ancient Greeks, he noted. There is no religious significance to the building's strong vertical lines, although "some people may interpret it that way," the architect said.

The only departure from the tower's vertical bands of concrete and glass occurs at the center of its north facade, which has a solid wall punctuated by two balconies on each floor. This was dictated by building code requirements that fire stairs have open-air access. Young said he could have used the same design approach on this north wall that he did on the rest of the building, but he believes the solid wall is an honest expression of the stairway location. Only one fire stair was required by code, but Young elected to provide two so that the recessed balconies would preserve the building's symmetry.

A major design consideration was how well the building would harmonize with existing structures on

Building for the ages . . .

the same block. These include the church's relief society building immediately west of it, the four-story church administration building (designed by Young's father and brother and completed in 1917) immediately south of it, and two houses more than 110 years old that are associated with the history of the church. "We kept the wings of the new building about the same height as the church administration building," Young said. The scale of the tower also was reduced by setting it back from the wing walls 60 feet on the south and 30 feet on the north.

History—The largest single activity housed in the building is the genealogical society, reflecting the church's emphasis on this research. It occupies 20 percent of the total space, including the entire west wing and four tower floors. Under the society's direction, birth, marriage, death, and other records relating to church members are gathered from around the world.

On the 26th floor there is a meeting and reception area and an observation deck, glassed in for security, which offers a view of the Salt Lake Valley.

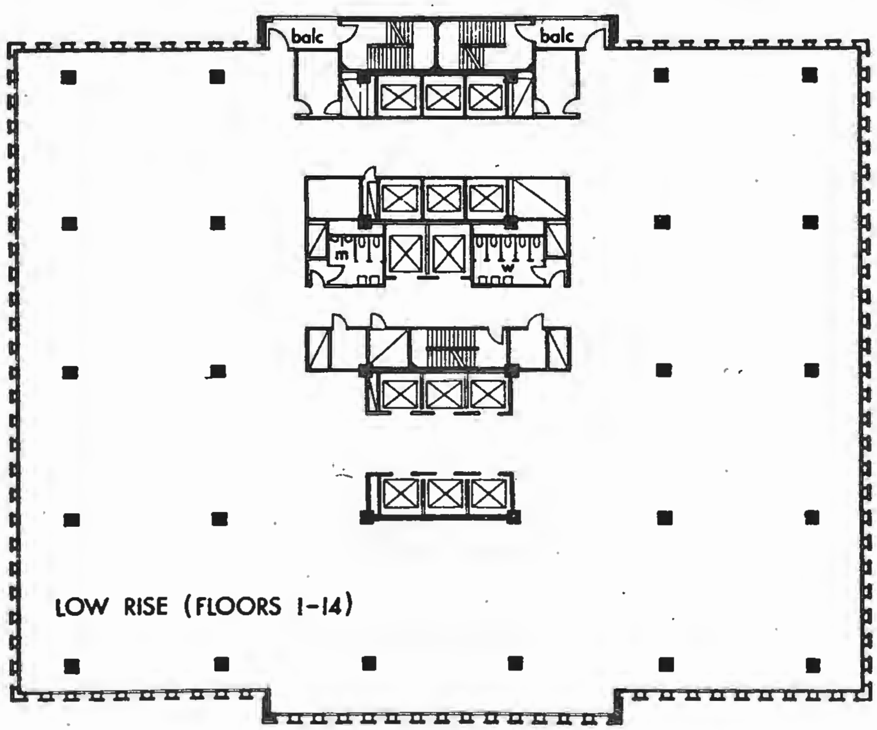
On the north and south walls of the wings are raised outlines of the Eastern and Western hemispheres. These murals, made of precast concrete panels, are 33 feet high and 64 feet wide. They were, Young said, "the architect's contribution to the building, and were not by way of instructions or directives." The Eastern hemisphere represents the "lands of the Bible" and the Western hemisphere the "lands of the Book of Mormon," he explained. These hemispheres are the outgrowth of Young's longheld desire for similar representations on inside walls of the wings. They are not precise projections (ocean areas, for example, were reduced). Jerusalem is located at the center line of the Eastern mural and the Western hemisphere centers on Manchester, N.Y., where, according to Mormon history, gold tablets bearing the everlasting gospel were received by the church's founder, Joseph Smith.

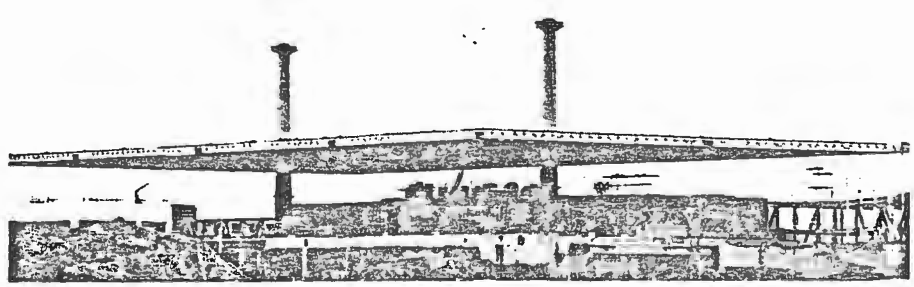
Pedestrian link—There is below-grade parking for 1,400 cars on three levels under the west wing and the plaza. This parking garage was completed five years before construction of the building started. It has circular ramps that are a prominent feature of the building's plaza area. Other facilities located on below-grade levels include a 700-seat employee cafeteria, mail room, and print shop. A corridor through the garage area provides a protected pedestrian link between the new building and the church administration building.

The building's heating and cooling requirements are handled by one of the largest installations of a well water heat pump system. It utilizes four wells, two shallow and two deep. Two wells serve as water supply and two for water disposal, according to Frank Bridgers of Bridgers & Paxton, Albuquerque, the mechanical engineers who designed the system. Since the wells tap different strata, water can be drawn from the deep wells and disposed in the shallow ones, or vice versa, depending on seasonal requirements. Use of the combination of an electrically driven heat pump and the wells was chosen on the basis of lower operating cost in preference to a system that would use steam purchased from the local utility and which also would have required cooling towers, Bridgers said.

Construction will be completed late this year on a block-long plaza south of the building that will be on an east-west axis with the Salt Lake Temple. Central feature of the plaza will be a fountain that will spray water to a height of 52 feet.

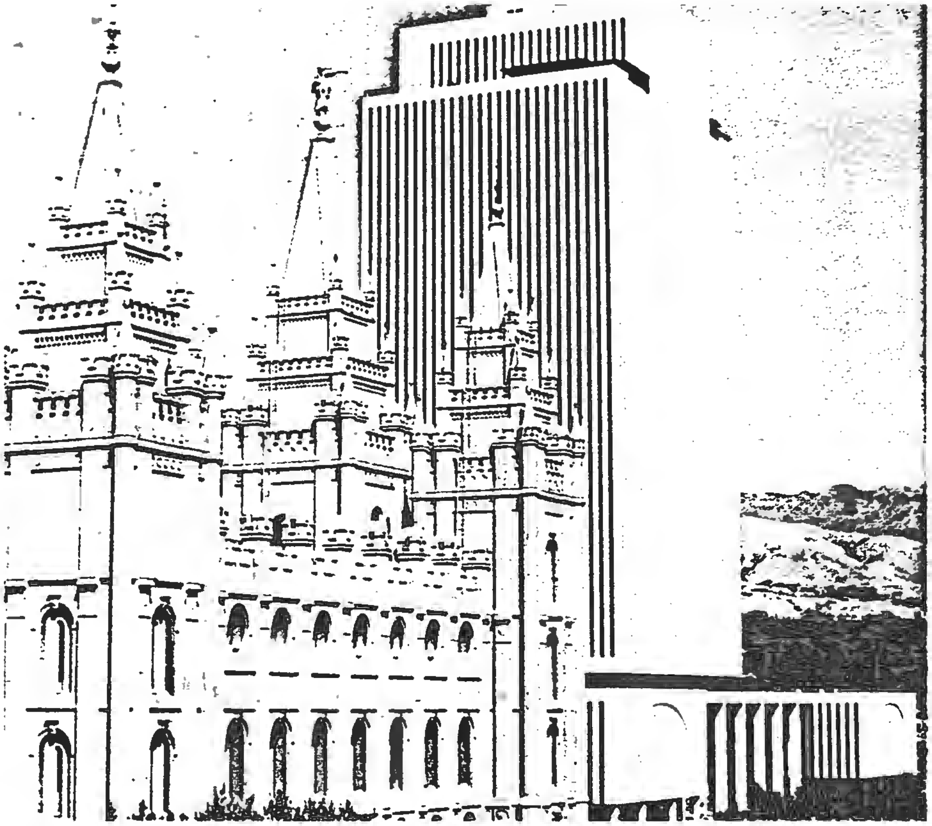
General contractor for the building, which contains 683,000 sq. ft. of office space, was a joint venture of Christiansen Brothers, Inc., Salt Lake City, and W.W. Clyde & Co., Springville, Utah. □



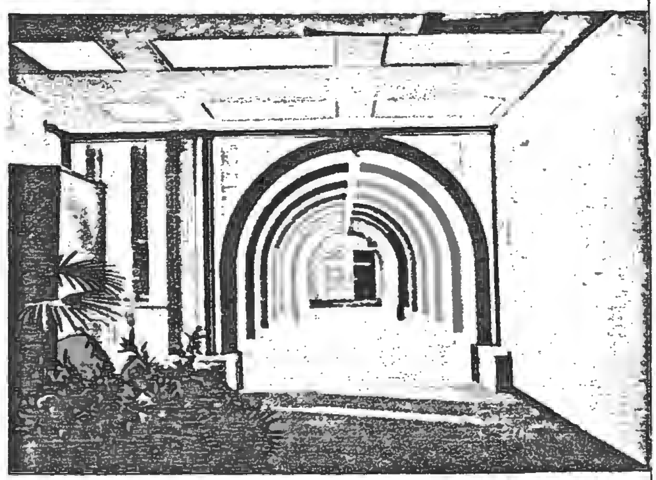


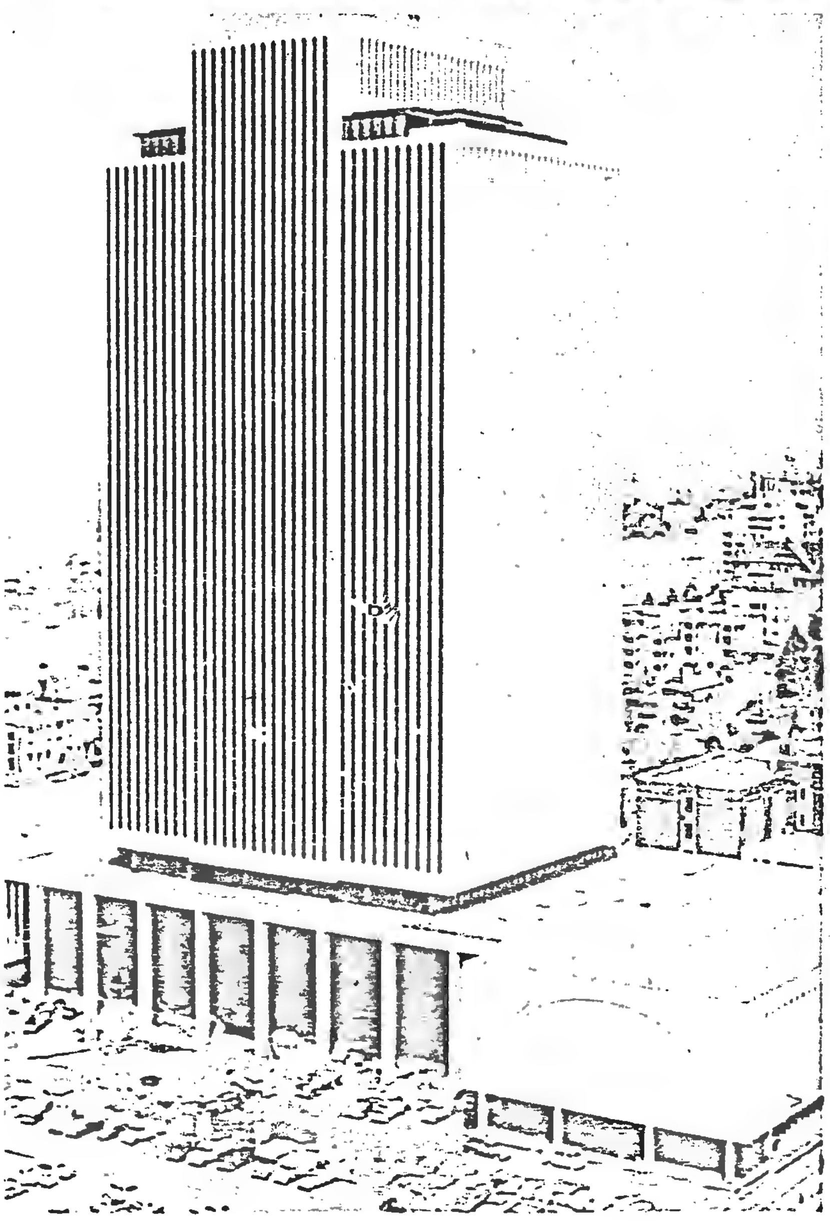
Two-masted complex

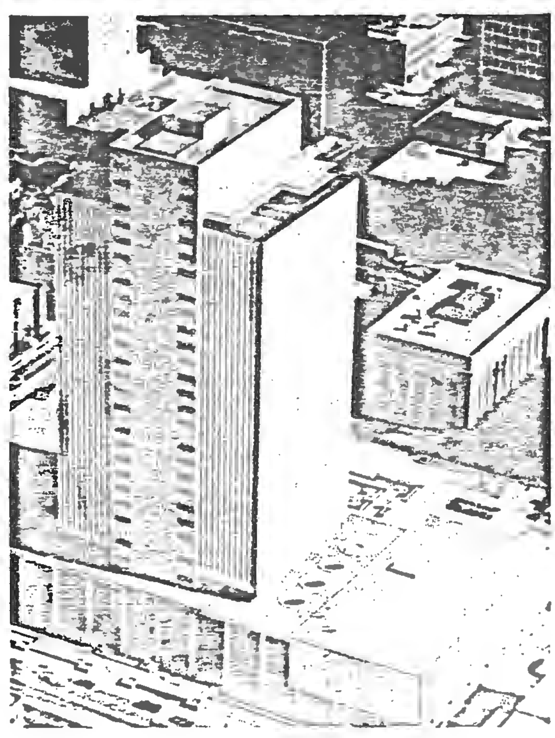
A stayed cable suspended roof is the distinguishing feature of the central facilities building that is part of the new Baxter Laboratories headquarters complex under construction near Deerfield, Ill. Upper cables are suspended from two masts, and cables on the underside of the roof also are used. The building, one of eight in the complex, will contain a cafeteria and other facilities. Architects are Skidmore, Owings & Merrill.



Office building is located in the block adjacent to the Salt Lake Temple (left). View of south side of general church office building, which fronts on block-long plaza, shows observation deck at 26th floor and mural of Eastern hemisphere on wing wall (bottom left). Connecting walkway between wings and tower at plaza level is covered with acrylic panels (below). Center of tower on north side has solid wall with recessed balconies to meet requirements for fire stairs. Circular roof openings ventilate breezeways between tower and wings. Four-story church administration building is in background (bottom right).







ATTACHMENT TWO

DESCRIPTION OF GROUND-WATER HEAT PUMP OPERATIONS

ATTACHMENT TWO

THE HEAT PUMP SYSTEM

A heat pump operates like a giant reversible refrigerator: it transfers heat from the ground to a building during the winter, and from the building back into the ground during the summer.

The heating process works as follows: a liquid refrigerant (freon) cireculates through the heat pump system. As it passes through the heat exchanger coil located at the energy source, it abosrbs heat energy and evaporates, becoming a gas. The gas travels to a compressor, which makes the gas denser and hotter.

The gaseous refrigerant then is pumped into the heat exchanger of the building. The heat exchanger extracts heat for the building and distributes it via a forced-air heating system. Because a heat pump system heats air to only 105° (compared to 140° for a fossil fuel system), more heated air must pass through the building. So, larger air ducts and a slow-turning fan are required.

In the summer, the flow of the refrigerant is reversed as it absorbs heat from the building heat exchanger and evaporates. The gas passes through the compressor where its temperature increases.

In some heat pump systems, heat contained in the refrigerant can be utilized to generate domestic hot water. However, most of the heat of the gaseous refrigerant is expelled to ground water via the water-to-refrigerant heat exchanger. Then the refrigerant, cooled and condensed into a liquid, returns to the air-to-refrigerant heat exchanger to extract more heat from the building.

ATTACHMENT THREE

COST ESTIMATE FOR HEATING OF A COLUMBUS, OHIO BUILDING

ATTACHMENT THREE

SPACE HEATING COSTS

Installation and maintenance costs for a ground water heat pump will vary widely, depending on the size and construction of the building, the ground water in your area, and the price of electricity or fossil fuels.

Annual cost estimates for a Columbus, Ohio home with a heating load of 72,000 Btus at -5° F. are given below. The temperature of ground water in the Columbus area is approximately 55° F. (Source: National Water Well Association)

PROPANE GAS	
1,720 gal. fuel @ $.54/gal.	$ 928.00
500 kw electricity @ $.03/kwh (for operating generator)	16.50
Tank rental	150.00
	$1094.50
ELECTRIC FURNACE	
24,238 kw electricity @ $.03/kwh	$ 727.14
OIL FURNACE	
1,145 gal. fuel oil @ $.46/gal.	$ 527.16
753 kw electricity @ $.03/kwh (generator costs)	22.59
	$ 549.75

NATURAL GAS

152,128 cu. ft. natural gas @ $.20/100 cu. ft.	$ 304.26
550 kw electricity @ $.03/kwh (generator costs)	16.50
	$ 320.76

GROUND WATER SOURCE HEAT PUMP

7,788 kw electricity @ $.03/kwh for operating pump, compressor and blower	$ 233.64

ATTACHMENT FOUR

BIBLIOGRAPHY OF RELEVANT RESEARCH

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ATTACHMENT FIVE

BACKGROUND ON AMERICAN GROUND WATER CONSULTANTS

BACKGROUND INFORMATION

AMERICAN GROUND WATER CONSULTANTS provides a broad range of state-of-the art hydrogeological services for the exploration, evaluation, development, management, protection and reclamation of groundwater for industrial, agricultural, and municipal use, as well as the solution of specific groundwater-related problems.

AMERICAN GROUND WATER CONSULTANTS conducts contract service work for the extractive and process industries, municipal water supply companies, and government agencies both domestic and foreign.

AMERICAN GROUND WATER CONSULTANTS utilizes Thermonics which is becoming regarded as the most powerful geophysical method of groundwater exploration currently in use. Other state-of-the-art methods used by AMERICAN GROUND WATER CONSULTANTS include Zeta-SP and neutron logging for seepage and leak detection; a new class of inexpensive tracers, and biological reclamation of hydrocarbon contamination.

Hydrogeologic services offered by AMERICAN GROUND WATER CONSULTANTS include investigations, reports, and the conduct of projects relating to:

- GROUNDWATER EXPLORATION
- GROUNDWATER RESOURCES EVALUATION
- WATER WELL DESIGN AND CONSTRUCTION
- GROUNDWATER QUALITY
- WASTE WATER DISPOSAL
- DISCHARGE AND MONITORING PLANS
- GROUNDWATER RECLAMATION
- HYDROCARBON DECONTAMINATION OF GROUNDWATER
- IN-SITU LEACHING
- UNDERGROUND GAS STORAGE
- SEEPAGE DETECTION
- FOUNDATION LEAKAGE
- AQUIFER SIMULATION
- GEOTHERMAL EXPLORATON
- GROUNDWATER CONTROL
- DEWATERING
- SEA WATER INTRUSION

AMERICAN GROUND WATER CONSULTANTS owns equipment and other facilities for the successful completion of contract service work. This includes: field vehicles, Thermonic, Zeta-SP, and neutron logging equipment, tracer injection systems, steel tapes, timers, surveying microaltimeters, recording microbarographs, electronic equipment, and other field equipment.

For special situations, AMERICAN GROUND WATER CONSULTANTS fabricates its own field equipment, instrumentation, and automatic data acquisition systems.

AMERICAN GROUND WATER CONSULTANTS maintains commerical user accounts with the computing centers at the University of New Mexico (IBM 360/65), the University of Arizona (CDC 6400), and the Control Data Corporation's nationwide CYBERNET System. Computing facilities for exceptionally large projects are available from the McDonnel-Douglas Automation Company (IBM 370/195) in St. Louis, Missouri.

CONTRACT SERVICE WORK CONDUCTED BY AMERICAN GROUND WATER CONSULTANTS (cont.)

Project	Location	Description	Owner
Phillips Well Water Availability Study	Nose Rock, New Mexico U.S.A.	Determination of legally and physically available water from wells owned by Phillips near Nose Rock, New Mexico.	Phillips Petroleum Company Albuquerque, New Mexico, U.S.A.
Assesment of Moriarty South Subdivision	Moriarty, New Mexico U.S.A.	Quantitative groundwater resource evaluation and water rights study.	Bohannan-Huston Inc. Consulting Engineers, Albuquerque, New Mexico, U.S.A.
Computer Simulation of Impact of a Water Well	Eddy County, New Mexico U.S.A.	Evaluate impact of pumping water from a well on the hydrostatic head distribution within the Capitan aquifer.	Duval Corporation, Carlsbad, New Mexico, U.S.A.
Water Well Inventory	Near Seven Lakes, New Mexico, U.S.A.	Inventory of all water wells within 10 miles of section 31, T. 19 N., R. 11 W., McKinley County, New Mexico	Phillips Petroleum Company Albuquerque, New Mexico, U.S.A.
Becenti Well	Near Crownpoint, New Mexico, U.S.A.	Analysis of water level declining in the Becenti Well.	Phillips Petroleum Company Albuquerque, New Mexico, U.S.A.
Rio Rancho	Rio Rancho, New Mexico, U.S.A.	Determine the optimum location for a water well at Rio Rancho, New Mexico	Albuquerque Utilities, Inc. Rio Rancho, New Mexico U.S.A.
Stewart Well Pump Test	Sandia Park, New Mexico, U.S.A.	Make pump test to determine impact of community development on ground water resources.	Lost Valley Estates, Albuquerque, New Mexico, U.S.A.
Kim-me-ni-oli Wash	Seven Lakes, New Mexico, U.S.A.	Determine impact from uranium mine dewatering wells on groundwater quality along Kim-me-ni-oli Wash.	Phillips Uranium Corporation, Albuquerque, New Mexico, U.S.A.
Groundwater Exploration	Tucson, Arizona U.S.A.	Quantitative ground water resource evaluation.	Horizon Corporation, Tucson, Arizona U.S.A.

CONTRACT SERVICE WORK CONDUCTED BY AMERICAN GROUND WATER CONSULTANTS (cont.)

Project	Location	Description	Owner
San Pedro Lakes Groundwater Development	Regina, New Mexico, U.S.A.	Hydrogeological and Thermonic investigation for the location of a well site. Well design, construction, testing of a 1,500-ft water well.	American Recreational Properties, Inc., Albuquerque, New Mexico, U.S.A.
Sunlit Hills Project	Santa Fe, New Mexico, U.S.A.	Hydrogeological investigation, determination of available groundwater, construction of test wells and observation wells.	Hondo Hills, Inc., Santa Fe, New Mexico, U.S.A.
Angus Cattle Corp. Well	Near Belen, New Mexico, U.S.A.	Drilling and electric logging of pilot hole, well design, and construction of a large-diameter, 400-ft irrigation well near Belen, New Mexico.	Angus Cattle Corporation
McKinley Mine Project	Gallup, New Mexico, U.S.A.	Drainage study of a coal property.	Pittsburgh-Midway Coal Company, Albuquerque, New Mexico, U.S.A.
L-Bar Project	L-Bar Ranch, New Mexico, U.S.A.	Monitoring of seepage from a tailings dump using neutron logging methods.	SOHIO Petroleum Company, Albuquerque, New Mexico, U.S.A.
Hurley Hydrogeology/ Hydrochemistry	Hurley, New Mexico, U.S.A.	Determine if seepage from tailings dumps is taking place and seepage rate.	Kennecott Copper Corporation, Chino Mines Division, Hurley, New Mexico, U.S.A.
San Mateo Mine-Water Phase I	San Mateo, New Mexico, U.S.A.	Evaluate impact of discharging water from the San Mateo mine into San Mateo Creek.	Gulf Mineral Resources Co. Subcontract to William Matotan and Associates, Albuquerque, New Mexico, U.S.A.

Project	Location	Description	Owner
Santa Elena Peninsula Project	Santa Elena Peninsula, Ecuador	Quantitatively evaluate the groundwater resources of the Santa Elena Peninsula as a potential source for major domestic water requirements. Also, evaluate water quality distribution, locate optimum well sites and develop a long range plan for developing the groundwater resources of this 3,000 square mile area.	Empresa Municipal de Agua Potable de Guayaquil, Guayaquil, Ecuador. Financed through the World Bank.
Tucson Basin Groundwater Management Model	Tucson, Arizona, U.S.A.	Construction, calibration, and validation of a hydrodynamic and water quality digital computer model of the Tucson basin groundwater system.	City of Tucson, Tucson, Arizona, U.S.A.
South Santa Fe Aquifer Simulation Model	Santa Fe, New Mexico, U.S.A.	Construct a hydrodynamic digital computer model of a complex aquifer system for evaluating the effects of pumpage upon the groundwater system.	Sunlit Hills Water Supply Co., Santa Fe, New Mexico, U.S.A.
San Mateo Mine-Water Phase II	San Mateo, New Mexico, U.S.A.	Evaluate impact of discharging mine water into the Rio San Lucas.	Gulf Mineral Resources Co., Subcontract to William Matotan & Associates, Albuquerque, New Mexico, U.S.A.

CONTRACT SERVICE WORK CONDUCTED BY AMERICAN GROUND WATER CONSULTANTS (cont.)

Project	Location	Description	Owner
Portales Wastewater Seepage	Portales, New Mexico, U.S.A.	Monitor seepage for four wastewater stabilization ponds using neutron logging methods.	New Mexico Environmental Improvement Agency, Santa Fe, New Mexico, U.S.A.
Northwest Impact Assessment	Bishop, California, U.S.A.	Determine impact of flash floods upon mill site and make recommendations for water development.	Nord Resources Corporation, Albuquerque, New Mexico, U.S.A.
San Juan Basin Hydrogeology and Hydrochemistry	San Juan Basin, New Mexico, U.S.A.	Hydrodynamic and hydrogeochemical evaluation of the ground water systems of the San Juan Great Artesian Basin, including digital computer model.	Phillips Petroleum Company, Albuquerque, New Mexico, U.S.A.
Gulton Industries	Albuquerque, New Mexico, U.S.A.	Waste water discharge abatement study.	Gulton Industries, Inc., Albuquerque, New Mexico, U.S.A.
Beker Injection Well	Carlsbad, New Mexico, U.S.A.	Determine impact of wastewater disposal by injection well upon regional groundwater resources utilizing computer modeling, Thermonics and tracers.	Beker Industries Corporation, Carlsbad, New Mexico, U.S.A.
Rio Rancho Thermonic Study	Albuquerque, New Mexico, U.S.A.	Locate zones of maximum groundwater flow for siting a high yield municipal well.	American Real Estate and Petroleum Corporation, New York, U.S.A.
El Dorado Water Supply	Santa Fe, New Mexico, U.S.A.	Quantitative groundwater resource evaluation and water rights study.	American Real Estate and Petroleum Corporation, New York, U.S.A.
Plateau Solar Evaporation Ponds	Farmington, New Mexico, U.S.A.	Design solar evaporation ponds and develop seepage monitoring program.	Plateau, Inc., Farmington, New Mexico, U.S.A.

CONTRACT SERVICE WORK CONDUCTED BY AMERICAN GROUND WATER CONSULTANTS

Project	Location	Description	Owner
Hermosillo Agricultural Relief Water Supply Project	Hermosillo, Sonora, Mexico	Quantitatively evaluate transmissivity distribution and available water resources of four groundwater basins covering 1,500 square miles.	Secretaria de Recursos Hidraulicos, Mexico City
Tarbela Phase 1	Tarbela, Hazara District, Pakistan	Locate and trace the zones of highest permeability in the reservoir and dam foundation of Tarbela dam.	Tippetts-Abbett-McCarthy-Stratton for the Water and Power Development Administration of Pakistan. Financed through the World Bank.
Tarbela Phase 2	Tarbela, Hazara District, Pakistan	Quantitatively evaluate the permeability distribution of the reservoir and dam foundation of Tarbela dam.	Tippetts-Abbett-McCarthy-Stratton for the Water and Power Development Administration of Pakistan. Financed through the World Bank.
Marampa Groundwater Project	Lunsar, Sierra Leone	Evaluate potential groundwater seepage into a large open pit iron mine.	Sierra Leone Development Corp., London, England
Horizon-Vail Groundwater Exploration Project	Vail, Arizona, U.S.A.	Locate and trace a deeply buried ancient stream channel for well site location.	Horizon Corporation, Tucson, Arizona, U.S.A.
Palo Verde Project	Buckeye, Arizona, U.S.A.	Determine leakage of water from a proposed 200 acre blowdown water pond by means of nuclear methods.	NUS Corporation, Rockville, Maryland, U.S.A. for the Arizona Nuclear Power Plant Project

AMERICAN GROUND WATER CONSULTANTS, INC.

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WILLIAM M. TURNER PROJECT DIRECTOR/CHIEF HYDROGEOLOGIST

DATE OF BIRTH: November 21, 1939

PLACE OF BIRTH: Little Rock, Arkansas, U.S.A.

EDUCATION: B. S. Geology, 1961, Rensselaer Polytechnic Institute, Troy, New York

M.S. Geology-Geochemistry, 1965, Pennsylvania State University, University Park, Pennsylvania

Ph.D. Geology-Hydrology, 1971, University of New Mexico, Albuquerque, New Mexico

EXPERIENCE: 1970 - Present, Chief Hydrogeologist, American Ground Water Consultants, Inc., Responsible for all aspects of investigation for a very wide variety of ground water related projects, including seepage studies of major earthen embankments and water retention facilities, ground water contamination projects, regional ground water resource evaluation projects of areas as large as 4,500 square miles, ground water exploration and well siting studies, industrial and municipal well construction, and water law related projects.

Experienced in the utilization of state-of-the-art methodologies including Thermonics, Zeta SP, tracers, and nuclear methods as applied to ground water problems. Also experienced in more conventional methodologies such as flow net analysis, pump test analysis, and hydrometeorological techniques.

Duties include, problem definition, proposal preparation, contract negotiation, logistics, and client relations.

I am a qualified expert witness.

1966 - 1969, Geologist/Hydrologist, Geological Survey Department of Cyprus. Responsible for the geological mapping of 170 square miles of complex alpine type terrane at a scale of 1:5000. Also, was responsible for carrying out the ground water budget of a coastal plain aquifer system. Carried out pumping tests and computer analysis of karst spring systems. Analysed earth resistivity, seismic, and gravimetric data. Results of ground water studies were reported in United Nations publications.

BERNARD MATHEY — GEOTHERMAL EXPERT

DATE OF BIRTH: December 22, 1944

EDUCATION: B. S. Geology and Mineralogy, 1966, University of Neuchatel

M. S. Hydrogeology, 1970, University of Neuchatel

Ph.D. Hydrogeology, 1976, University of Neuchatel

EXPERIENCE: 1978 - Present, Consulting Associate, American Ground Water Consultants, Inc. Responsible for projects involving the use of ground water for space heating and cooling. Primary responsibility is for the computer analysis of groundwater-heat flow systems for determining the efficiency of a space heating and cooling system using ground water and heat pumps and the proper location of wells to assure long-term project viability.

1976-1978, Research Associate, Center for Hydrogeology, University of Neuchatel. Responsible for analysing the transfer of heat within a karstic aquifer system. Carried out studies on: the temperature distribution in an aquifer subject to artificial recharge; thermal resources of an aquifer from which ground water would be extracted to power thermal heat pumps; the possibility of using aquifers as thermal storage reservoirs; also carried out computer-assisted studies on the influence of aquifer heterogeneities on the transfer of heat within an aquifer subject to artificial recharge.

MEMBERSHIPS: Swiss Geological Society
International Association of Hydrogeologists
Swiss Speleological Society

REPORTS:

Mathey, B., Burger, A., Marce, A., Olive, Ph., 1971, Tritium and Oxygen 18 in the Areusse and Serriere Basins

________, Simeoni, G., 1971, Method for calculating recharge based on ground water chemistry.

________, Geothermal and hydraulic gradients in the karst aquifer system of the Areusse Basin

ATTACHMENT SIX

BACKGROUND ON BRIDGERS & PAXTON

EXPERIENCE RECORD OF BRIDGERS AND PAXTON CONSULTING ENGINEERS, INC. IN COMPUTER ANALYSIS SYSTEM SIMULATION FOR ENERGY CONSERVATION AND SOLAR ENERGY APPLICATIONS

September, 1978

Bridgers and Paxton has a record of 10 years experience in the use of computers for energy analysis and system simulation dating back to 1968. The firm was a charter member of the Automated Procedures for Engineering Consultants (APEC). Mr. Robert Hopper, Vice President of Bridgers and Paxton, is presently serving as President-Elect of APEC and has been on the Board of Directors since 1974. He is also presently serving on the Program Development Committee for the APEC Energy Analysis Program (ESP-I), which was developed under a contracting arrangement by Stone and Webster Engineering Corp. of Boston, Massachusetts, and was made available for use by APEC members in June, 1978. Bridgers and Paxton has purchased the APEC Energy Analysis Program (ESP-I) and have an arrangement with large computer network for processing the program through our in-house computer.

For the past six years, Bridgers and Paxton has utilized a proprietory program developed for their "in-house" computer. This program was included in a listing of energy analysis programs prepared by the Arthur D. Little Co. for ASHRAE. A synopsis of the program as listed is attached herewith. This has been accepted as the basis of design for seven solar projects funded under the Solar Demonstration Act/Federal Building Program.

Sheet No. 9A of the 255 Form indicates a partial list of solar energy and energy conservation studies performed by Bridgers and Paxton. We would welcome a verbal or written contact with the owner's representative indicated on the form relative to Bridgers and Paxton's performance with respect to these studies.

In addition to utilizing our proprietory program, we have utilized the Trane "Trace" program for the Shiprock Hospital preliminary submittal in which we compared the energy requirements for several air distribution schemes. This work was done under Mr. Coral Gillham of Health, Education and Welfare in Dallas, Texas.

We have also utilized the AXCESS program developed by the Edison Electric Institute on the proposed $45,000,000 Travis Air Force Base Hospital. This work was done under the Naval Facilities Division located in San Bruno, California. The AXCESS program, which we modified to meet the specific needs, was utilized in analyzing different primary energy systems (total energy, heat pump and solar energy) together with a number of different distribution systems. The Navy wanted to utilize hourly weather data for a "test reference year" rather than a "created average year" which is used in the Bridgers and Paxton proprietory energy program, utilizing 3-hour weather data from the National Climatological Center.

PROGRAM NAME BRIDGERS AND PAXTON ENERGY ANALYSIS PROGRAM

CODE NAME

KEYWORDS SYSTEM SIMULATION ENERGY ANALYSIS SOLAR HEATING COOLING

AUTHOR DALE R. BROUGHTON, BRIDGERS AND PAXTON CONSULTING ENGINEERS, INC.

DATE & STATUS

SCOPE THE PURPOSE IS TO SIMULATE SYSTEM OPERATIONS TO DETERMINE YEARLY ENERGY CONSUMPTION FOR VARIOUS TYPES OF HVAC SYSTEMS. THE PROGRAM CALCULATES THE YEARLY ENERGY CONSUMPTION FOR HEATING AND COOLING BUILDINGS. HVAC SYSTEMS PRESENTLY CONSIDERED INCLUDE CONVENTIONAL DUAL DUCT SYSTEM, CONVENTIONAL SINGLE ZONE SYSTEM, INTERNAL HEAT RECOVERY HEAT PUMP SYSTEM, SOLAR ASSISTED HEAT PUMP SYSTEM, AND SOLAR HEATING AND COOLING SYSTEM. BUILDING HEATING AND COOLING LOADS ARE DETERMINED USING 3-HOUR WEATHER DATA AVAILABLE FROM THE U.S. DEPARTMENT OF COMMERCE NATIONAL CLIMATIC CENTER. SYSTEM SIMULATION IS PERFORMED, CALCULATING BUILDING REFRIGERATION AND HEATING LOADS. FOR SOLAR SYSTEMS, A BUILDING HEAT BALANCE IS PERFORMED. PERFORMANCE OF STORAGE TANK AND COLLECTOR SYSTEMS IS SIMULATED AND ITS OVERALL EFFECT ON BUILDING HEATING AND REFRIGERATING LOAD IS DETERMINED FOR EACH 3-HOUR PERIOD OF THE DAY.

INPUT BUILDING BLOCK LOAD ANALYSIS USING APEC HCC-III PROGRAM, ARCHITECTURAL DESCRIPTION OF BUILDING, WEATHER DATA, TYPE OF SYSTEM DESIRED, DESCRIPTION OF DESIRED SYSTEM OPERATION

OUTPUT DAILY SUMMARY OF REFRIGERATION AND HEATING LOADS ALONG WITH BUILER OUTPUT AND CHILLER INPUT; ON SOLAR SYSTEMS, OUTSIDE TEMPERATURE, STORAGE TANK TEMPERATURE, SOLAR COLLECTOR EFFICIENCIES, HEAT COLLECTED BY SOLAR SYSTEM FOR EACH 3-HOUR PERIOD PER DAY, MONTHLY AND YEARLY TOTALS OF HEATING AND COOLING LOADS AND CORRESPONDING ENERGY REQUIREMENTS

LIMITATION

SOFTWARE FORTRAN

HARDWARE THE PROGRAM IS WRITTEN FOR IBM 1130 WITH 16 ~~8~~K CORE.

AVAILABILITY THE PROGRAM IS MAINTAINED BY BRIDGERS AND PAXTON CONSULTING ENGINEERS, INC. FOR MORE INFORMATION CONTACT:

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