TOWN OF PAGOSA SPRINGS GEOTHERMAL HEATING SYSTEM

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INTRODUCTION

The Town of Pagosa Springs has owned and operated a geothermal heating system since December 1982 to provide geothermal heating during the fall, winter and spring to customers in this small mountain town. Pagosa Springs is located in Archuleta County, Colorado in the southwestern corner of the State. The Town, nestled in majestic mountains, including the Continental Divide to the north and east, has an elevation of 7,150 feet. The use of geothermal water in the immediate area, however, dates back to the 1800's, with use by Ute Bands and the Navajo Nation and later by the U.S. Calvalry in the 1880's (Lieutenant McCauley, 1878). The Pagosa area geothermal water has been reported to have healing and therapeutic qualities.

The Town's geothermal heating system was funded by the Department of Energy (DOE) with additional funds provided by Archuleta County and the Town. The technical consultant during the establishment of the system was Coury and Associates, Inc., with additional contracted support from Hydro-Triad, Ltd. and Chaffee Geothermal, Ltd. The total cost to complete the system was over 1.4 million dollars. Ownership of the system was transferred to the Town following the termination of a three year pay-back contract with DOE (Rafferty, 1989). Currently, the system has 15 customers (2 residential, 13 commercial)(Figure 1) with an average annual operating budget of $40,000. The system is fully operational, with several additional projects underway.

GEOTHERMAL SYSTEM SPECIFICATIONS

The geothermal source for the system is one of two production wells drilled during the initial phase of the geothermal project. The wells (PS-3 and PS-5) are 300 and 274 feet deep, provide geothermal water at 131°F and 149°F, have artesian flow rates of 600 gpm and 800 gpm, respectively (Rafferty, 1989). At present, PS-3 is capped but can serve as a back up to Well PS-5. The PS-5 well head is secured with two new 10-inch stainless steel gate valves. Removal of the original 10-inch iron gate valves, required due to excessive corrosion, was completed by a drilling crew during the spring of 1996.

Geothermal water is piped approximately 300 feet from the well head to the system utility building, which houses heating equipment and machinery. A Y-strainer and air/gas relief valve make up the additional fittings along the route to the utility building. Fiberglass piping (10-inch) is used above the gate valves and on all geothermal water transported to and from the utility building.

Geothermal water enters the system utility building at 146°F and passes through a plate heat exchanger (Figure 2) transferring heat to a fresh-water loop used to deliver heated water to all customers. A flow control valve is located upstream of the heat exchanger and allows manual flow control of the incoming geothermal water. The heat exchanger has a flow rate capacity of 1,000 gpm and a heat transfer area of 2,650.5 ft^2. The exiting geothermal water temperature

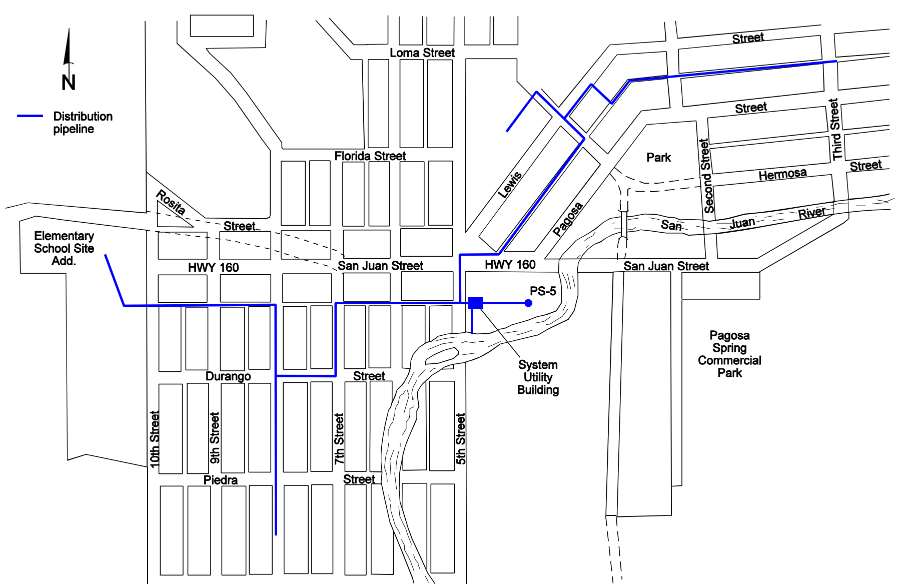

Figure 1. Distribution system layout.

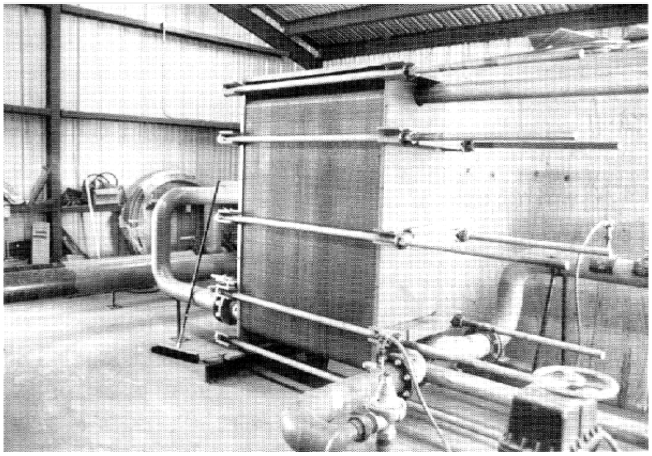

Figure 2. Plate heat exchanger.

varies between 120-130°F, depending on the heating load and the corresponding return water temperature of the fresh-water loop. A flow control valve is located downstream of the heat exchanger and allows manual flow control of exiting geothermal water. The exiting geothermal water flows approximately 200 feet, then through a fiberglass weir which measures water usage and monitors water flow rates and is finally discharged into the San Juan River. Monitoring of discharge geothermal water is also conducted at this site by the Colorado Division of Water Resources.

The fresh-water, closed loop distribution network consists of two independent closed loops supplying hot, fresh water to customers. The supply water temperature is between 135-141°F and varies with different flow rates and heat exchanger characteristics. The return water temperature is between 120-130°F, depending on the heating load. The return water is pulled through the system with two horizontal centrifugal (25 horsepower) pumps piped in parallel. The distribution network flow rate is controlled with manual flow control valves located between the circulation pumps and the heat exchanger. Only one circulation pump is required to circulate the current supply of heated water to all customers.

The system operating pressure, approximately 60 psi, is controlled with a flow regulator situated on the ¾ inch make-up water supply line that is piped into the return loop. In addition, a 2 inch make-up supply water line is also piped into the return loop and controlled with a 2 inch gate valve. The larger make-up water line is normally closed and used only following repairs or during the system charging which is completed prior to start-ups. Figure 3 identifies the piping schematic for the geothermal and fresh-water distribution network.

The fresh-water distribution piping located within the utility building is Schedule 40 steel, seamless pipe and is in 6 and 10 inch sizes. The fresh-water distribution piping buried on both loops is epoxy lined, Asbestos Cement (AC) pipe manufactured by Johns-Manville with pipe sizes in 6, 8 and 10 inches (ID). All fresh-water supply piping has polyurethane insulation with an AC jacket. No insulation is provided on fresh-water return piping.

GEOTHERMAL SYSTEM OPERATIONS

As mentioned above, all controls are manually operated and monitored daily. Operation logs are used to record all temperatures, flow rates, operating pressures and water losses. The original project design included an automated control system with automated flow control valves, the necessary remote sensing ports and a computer to monitor and control the entire project. The automation was not completed due to cost overruns. All the automated valves and sensing ports were installed, however.

Under present operating procedures, the full flow of artesian geothermal water travels from Well PS-5 to the utility building. A manual flow control valve, however, regulates the inlet geothermal water flow rate through the heat exchanger to keep the affect on the aquifer at no greater than the flow rate of the Town's geothermal water rights. The inlet flow rate through the heat exchanger is determined by the required heat load which varies between fall and winter periods. A minimal flow rate is maintained in an effort to conserve the geothermal resource. During normal winter months (December-

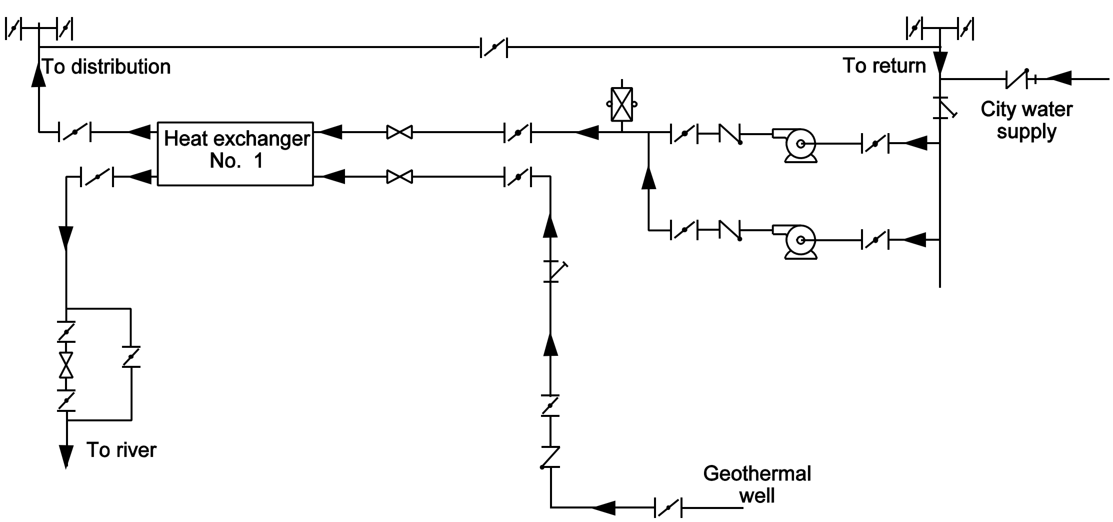

Figure 3. Central mechanical room piping diagram.

February), a maximum flow rate (450 gpm) is typically required in order to provide adequate heating to all customers during peak periods. No back-pressure is placed on the heat exchanger by the throttling of the downstream flow control valve and exiting geothermal water is not restricted.

The fresh-water return flow rate is closely matched to the geothermal water inlet flow rate in order to achieve optimum efficiency. This flow rate is manually controlled with flow control valves located between the circulation pumps and the heat exchanger and monitored with a flow meter. The heat exchanger efficiency varies due to the manual control of the system and the changing heating needs dictated by climate and weather patterns.

The operating pressure of the fresh-water distribution loops is set at 60 psi using a pressure regulator located in the make-up water supply line. The make-up water is provided by the local water district and piped into the return loop, as mentioned above. The average water loss for 15,000 linear feet of pipe is approximately 2,600-3,200 gallons per day or 1.8-2.2 gpm. Adjustments to the system are made when the heat load changes due to weather conditions or if minor adjustments are necessary for balancing loops or accounting for increased water loss.

Customers receive heated water from the distribution loop, circulate the water through various heating units (i.e., baseboard radiators, air distribution units, hydronic heating systems) and return the cooled water to the return loop. Larger customers have by-pass modulating valves that re-circulate water through their various heating units if the water is still hot enough to distribute heat before returning to the return loop. Customer heating systems also operate at 60 psi.

The Town monitors flow rates and the amount of heat (Btu's) used by customers by using a flow meter and temperature sensing probes in conjunction with a Btu meter. The Btu meter consists of two readouts (Btu's and gallons) and a printed circuit board situated within a J-box. The Btu meter tabulates pulses from the flow meter and monitors supply and return temperatures while calculating the correct Btu and flow rate consumption and ultimately displaying the values on the corresponding meters. A few smaller customers do not have Btu meters and are billed based on the average temperature drop of the water used and monitored with a flow meter.

When a new customer comes on line, the Town completes the service tap and includes the supply and return isolation valves, temperature sensing probes and Btu and flow meters. All other piping, circulation pumps and assorted piping fixtures are furnished and installed by the customer. In addition, each customer is also responsible for maintenance of his own system.

The two independent loops have different load requirements and can be manually controlled to balance the different needs. The east loop services the downtown area and requires the majority of the district heating capacity. Customers include the Junior and Senior High Schools, two churches with accessory buildings, two large office buildings, five retail buildings, Town Hall and two residences. The west loop has fewer customers and, consequently, a smaller heating requirement. Customers on the west loop are the Elementary School, a bank, and the Archuleta County government building with a new addition which includes offices, conference rooms and the jail. The public library is also on this loop but presently does not use the geothermal heating system. The retrofitting of the library to receive geothermal heat was inadequately designed.

In addition, two commercial customers, a church and the schools use the heated fresh return water for melting snow on sidewalks adjoining their buildings. To melt snow, hydronic heating systems use a small heat exchanger to transfer heat from the fresh return water to a glycol fluid which is distributed through tubing situated within sidewalks using small circulating pumps. The sidewalks are maintained at approximately 50^{o}F using the hydronic system without any snow or ice accumulation. The snow melt design works extremely well and is well accepted by the customers.

GEOTHERMAL SYSTEM MAINTENANCE

General maintenance on the geothermal system includes repair of failed pipe, cleaning of all strainers in various locations, operation and lubrication of all valves, repair of faulty Btu meters, repair or replacement of various pipe fittings (i.e., check valves, gate valves, temperature and pressure gauges) and overhaul of the heat exchanger and pumps, when necessary. Additional maintenance is required both on other wells and a geothermal fountain owned by the town and on the utility building and the other outbuildings and fences appurtenant to the geothermal system. Larger maintenance projects are completed during the summer months and have included the plugging of older geothermal wells (Brown Well and previously plugged County Well) and the reworking/casing of existing wells (PS-5 and Rumbaugh).

Repairs are made on water leaks as they are discovered and often require the shut-down of the plant during these repairs. A leak detection company hired to find leaks throughout the entire fresh-water distribution system, did not find any leaks. The current minimal water loss is likely a result of several small leaks which are impossible to detect with leak detection equipment.

A large part of the system's budget is for maintenance, repair, spare parts and emergency contingencies. Maintenance has become a top priority for the system.

A near-term (1-2 years) goal for the geothermal system is to develop the necessary code and procure the necessary equipment needed to automate the geothermal distribution facility. Automation will allow the facility to run more efficiently, reduce costs and further preserve the geothermal resource. Some consultant services may be required in order to complete the project correctly and in a timely manner. In addition, maintenance procedures will need to be developed and training may be required in order to familiarize personnel with the new equipment.

GEOTHERMAL SYSTEM ADMINISTRATION

The system employs one administrator part-time in order to manage all system operations. The administrator's duties include daily system monitoring, monthly meter reading and billing, completing schedule maintenance, coordinating and completing emergency repairs, providing geothermal line locates to utility companies and contractors, troubleshooting customer problems, coordinating new customer installations, coordinating tours and assisting in accommodating all public inquires concerning the geothermal system.

At present, the system budget is approximately $40,000/year, while only approximately $22,000 is generated in revenue. The deficit, funded by the Town, was caused primarily by expenditures for much needed maintenance and other capital improvements. It is expected that the budget deficit issue will be resolved when new customers, included in the customer list above, come on-line for the 1997/98 heating season and when the large maintenance projects are completed.

Customer meter reading and billing are completed monthly. A standard spreadsheet software program is used for the billing. The current rate charged for geothermal heating is $0.45 per Therm ($10^5$ Btu). The current geothermal heating rate is 25% less than the local natural gas rate (in Therms) and 30% less than the local electricity rate (in Kwhr). System monthly revenues vary due to weather conditions and range from $2,100 in October, to $6,300 in January.

The Town provides assistance, including equipment and manpower, to the system administrator from other departments. These departments include the Street and Maintenance Department, Parks and Recreation Department, the Town Administrator and the Town Clerk.

GEOTHERMAL SYSTEM ISSUES

The geothermal system has operated successfully and is well accepted by customers and the public. With new customers coming on-line, the system heating output is approaching peak capacity based on the Town's current adjudicated geothermal water rights for Wells PS-3 and PS-5 of 450 gpm (1 cfs). The original geothermal system was designed for twice the current capacity (1,000 gpm) and included an additional plate heated exchanger and two circulation pumps. The project was downsized during construction and following the drilling and testing of the new production wells, due to increased project expenses.

During the initial phase of the project, test wells were to be drilled in an attempt to determine the hydrogeological and geothermal characteristics of the aquifer (Galloway, 1980). The test wells were not completed as intended because numerous problems were encountered during their drilling. A small fault was encountered during the drilling of a large test well which affected all local geothermal wells and the surface hot spring. The event caused concern over the potential impact of an operating geothermal system on other geothermal wells. When the fault was repaired (cased) and the drilling completed, however, all the monitored wells returned to their previous flow rates and pressures. The DOE aquifer study was, therefore, inconclusive, but much was learned concerning the general nature of the geothermal aquifer and its circulation system (Galloway, 1980).

There is still concern regarding the use of the geothermal resource and the impact of established uses on the aquifer. The Town has applied to the Water Court to allow a transfer of geothermal water rights from the Town's Rumbaugh Well to Wells PS-3 and PS-5 to allow the geothermal system to operate at design capacity and to allow the Town to extend service to additional customers. This transfer case has been pending for several years. Numerous attempts have been made to resolve all disputes without a court trial. The objecting parties are primarily users of geothermal water for recreational (bathing) activities. Since the geothermal system discharges water at 120ºF, a level of heat sufficient to accommodate the geothermal water use of the objectors, the Town proposed the establishment of a pipeline company to distribute the Town's geothermal discharge to affected parties. The pipeline company could supply the affected parties with water in excess of their current water rights and eliminate the need for the use of their wells, further reducing the impact on the aquifer. Following the recreational use and depletion of the available heat of the Town's discharge water, geothermal water could be discharged into the San Juan River. Negotiations are currently underway on the above proposal.

Public awareness regarding geothermal issues will continue to impact the operation of the geothermal system. The Town is a participant in a Geothermal Advisory Committee, formed to resolve issues among geothermal users. The Town will continue to work with other geothermal users to resolve concerns regarding the geothermal aquifer and the geothermal resource.

CONCLUSION

The geothermal system is presently completing various summer maintenance tasks and preparing for the upcoming heating season. Service connections for new customers will be completed during the month of August. Work will continue on the design and installation of the geothermal discharge water pipeline at the conclusion of the water rights transfer negotiations. When water rights are transferred to the geothermal system, work will commence on providing geothermal heating to even more new customers. The Town will then procure additional monitoring equipment and upgrade its current billing procedure to accommodate additional new customers.

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