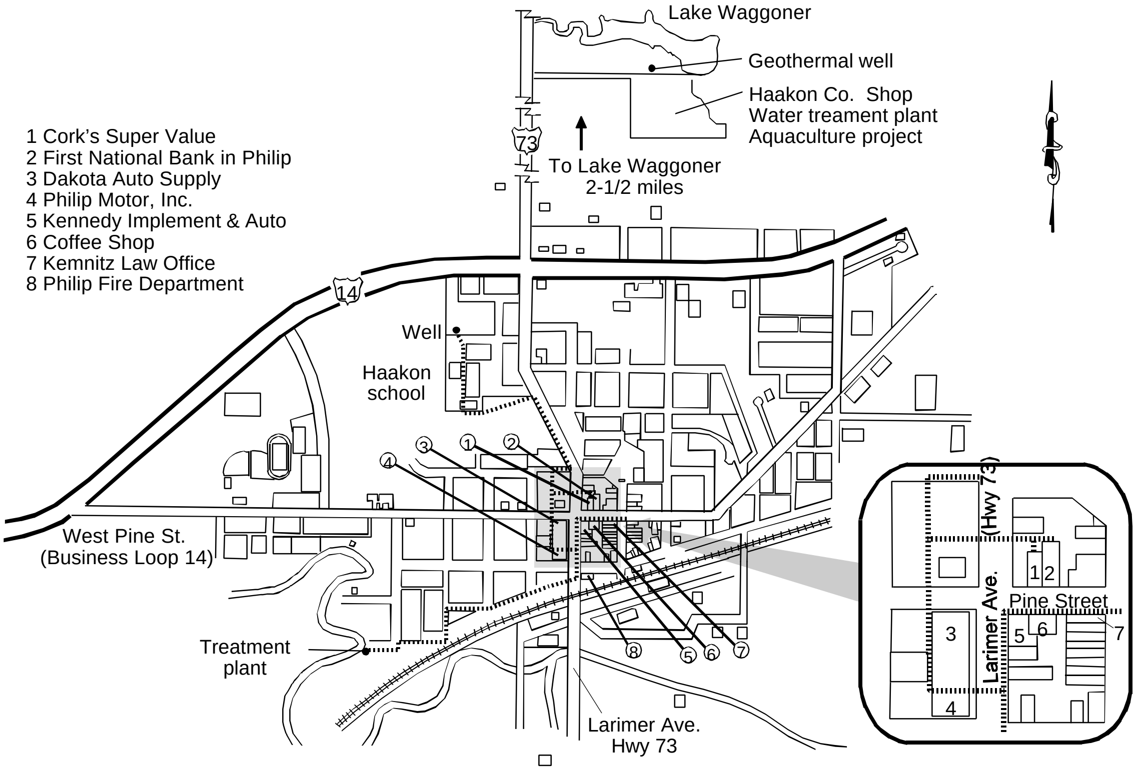
GEOTHERMAL DISTRICT HEATING SYSTEM
PHILIP, SOUTH DAKOTA



Philip district heating system schematic.

LOCATION

Philip, South Dakota in located in the southwestern part of the state, on U.S. Highway 14, about 87 miles west of Pierre. It has a population of about 1,100. The district heating project was one of 23 cost shared by USDOE starting in 1978. The city project was added on to the original USDOE cost shared project for the Haakon School, located on a hill above town. Waste water from the school has been used to heat eight buildings in the downtown area since the 1981-1982 heating season. The Philip Geothermal Corporation (for profit) was formed to maintain and operate the downtown system, and pays the school district for the use of the water.

RESOURCES

The town overlies the Madison Formation which is a large-area aquifer. The aquifer has a demonstrated capability to produce geothermal water. A single 4,266-foot deep well was drilled in 1980 which provides a maximum artesian flow of 340 gpm at 157EF. The dissolved solids content of the water is 1,112 ppm and a pH of 7.4. Radium-226 at 100 pCi/L as radium sulfate, must be removed from the spent water with a barium chloride mixture before discharging to the Bad River. The treatment plant has two 90 ft x 158 ft x 10 ft deep storage ponds that will each hold 374,000 gallons of the sludge. The geothermal fluid is first used by the grade school and high school before being sent to the city at around 140EF, and then is disposed of between 119 and 140EF, depending upon peak or no energy demand from the system. In warm weather, only 12 to 15 gpm is required.

UTILIZATION

The geothermal discharge from the schools is transported in a single pipe through the downtown area. A disposal line begins at the upstream end of the business district and parallels the supply line from the schools to the last user on the system, the fire station. From there, a single line continues to the radium removal plants and disposal to the Bad River. The eight buildings connected to the system used either Modine heaters, unit heaters, or by piping in the floor. The bank building uses plate heat exchangers to isolate the geothermal fluid. The control points for the system are at the high school and the fire station. Equipment in the fire station controls system pressure and regulates flow through the business district loop. A motor operated flow control valve on the return line is set to be full open at 20EF and full closed at 65EF outside air temperature. A second valve maintains back pressure in the distribution piping to minimize calcite precipitation. When the outside temperature is below -10EF and hydronic fluid temperature is below 90EF, a backup boiler is turned on and automatically valved into the system.

Water leaving the business district flows to the water treatment plant where Radium-226 is removed. Barium chloride is added to the water at 2.6 ppm $BaCl_2$ at maximum flow. The solution is added at a baffled trough which empties into a pond. Sludge collects on the pond bottom at a rate of about 85 ft^3 per year. Sufficient liquid volume will be maintained throughout the pond's 30-year life. Radioactivity accumulates at 0.06 curies/year. At the end of the pond life, the sludge can be removed to a disposal site or mixed with cement to form the bottom for a new pond built directly over the old one.

The geothermal supplies 75 to 90% of the heating requirements of the eight buildings covering 56,500 ft^2. In addition, the floor slab of the chemical treatment plant building is heated with geothermal energy. A new bank building of 12,500 ft^2 will come online soon. The peak design delivery of the system (schools and business) is 5.5 million Btu/h (1.6 MWt), with an annual energy delivery of 9.5 billion Btu. The schools removes about 16EF and the business district about 11EF from the peak flow of 340 gpm, which is only about 83% of the system capacity. As a result, the city uses about 41% of the output of the system or 2.25 million Btu/h peak (0.65 MWt) and 3.9 billion Btu/yr. The heating season is normally from October 1st to May 1st.

OPERATING COST

The capital costs of the entire system are estimated at $1,218,884 of which 77% was DOE funds. Annual operating and maintenance cost for the entire system is nearly $8,000 (updated from 1983 data). The initial retrofit costs to the city businesses was for cast iron heat exchangers at $30,000. However, due to corrosion, these were replaced with stainless steel heat exchangers. The Philip Geothermal Corporation now pays the school district $5,000, carries a $1,000 liability policy, pays taxes, and spends about $500 for repairs, for a total annual cost of about $6,500. Each user pays a share of the cost based on the percentage of water used. The total savings of all eight buildings is $120,000 annually, whereas the school district saves $200,000. Thus, the consumer pays about 20% of the corresponding cost of propane or fuel oil, the alternate fuel in the area.

REGULATORY ISSUES

A discharge permit is required by the South Dakota Department of Environment and Natural Resources. This is renewed every two years. Samples of the discharge water (after the barium chloride treatment) are send to Pierre. EPA in Denver requires flow and temperature readings every two to three weeks. The Radium-226 must be reduced to 5 ppm (from 80 ppm) with a maximum daily reading of 15 ppm.

PROBLEMS AND SOLUTIONS

The cast iron heat exchangers had to be replaced with stainless plate heat exchangers due to corrosion. Since then, there has been no problems with scaling and corrosion in the city system. However, the iron pipes in the school well have to be replaced every four to five years due to corrosion. Plugging of pipes at the water treatment plan has been a significant operating problem. Sulfate deposits initially partially plugged the mixer and pipe downstream, thus requiring frequent cleaning. Installation of the current trough system for the barium chloride additional and mixing has solved this problem. The pipe from the second cell to the creek has to be augered every two years at a cost of $250 to $300. The control system operation has been very satisfactory as far as the users are concerned; however, it has been unsatisfactory in terms of utilizing the resource efficiently. The system only supples 75 to 90% of the energy demands for the city buildings. A backup boiler is provided from the school system installation to peak the system during the colder periods (-10EF outside and 90EF fluid temperature).

CONCLUSIONS

Except for some inefficiency in the energy utilization, and the requirement for treating the Radium-226, the system appears to be operating well. Building owners are only paying about 20% of the corresponding cost for alternate fuels. However, it should be pointed out that the initial capital cost of the system was subsidized (77%) by a USDOE grant. The system probably would not have been feasible otherwise.

REFERENCES

Childs, F. W.; Kirol. L.D.; Sanders, R. D. and M. J. McLatchy, 1983. "Description and Operation of the Haakon School Geothermal Heating System," *Geothermal Resources Council Transactions*, Vol. 7, Davis, CA, pp. 579-584 (also reproduced in an abridged form in *Geo-Heat Center Quarterly Bulletin*, Vol. 18, No. 4, Dec. 1997, pp. 12-15).

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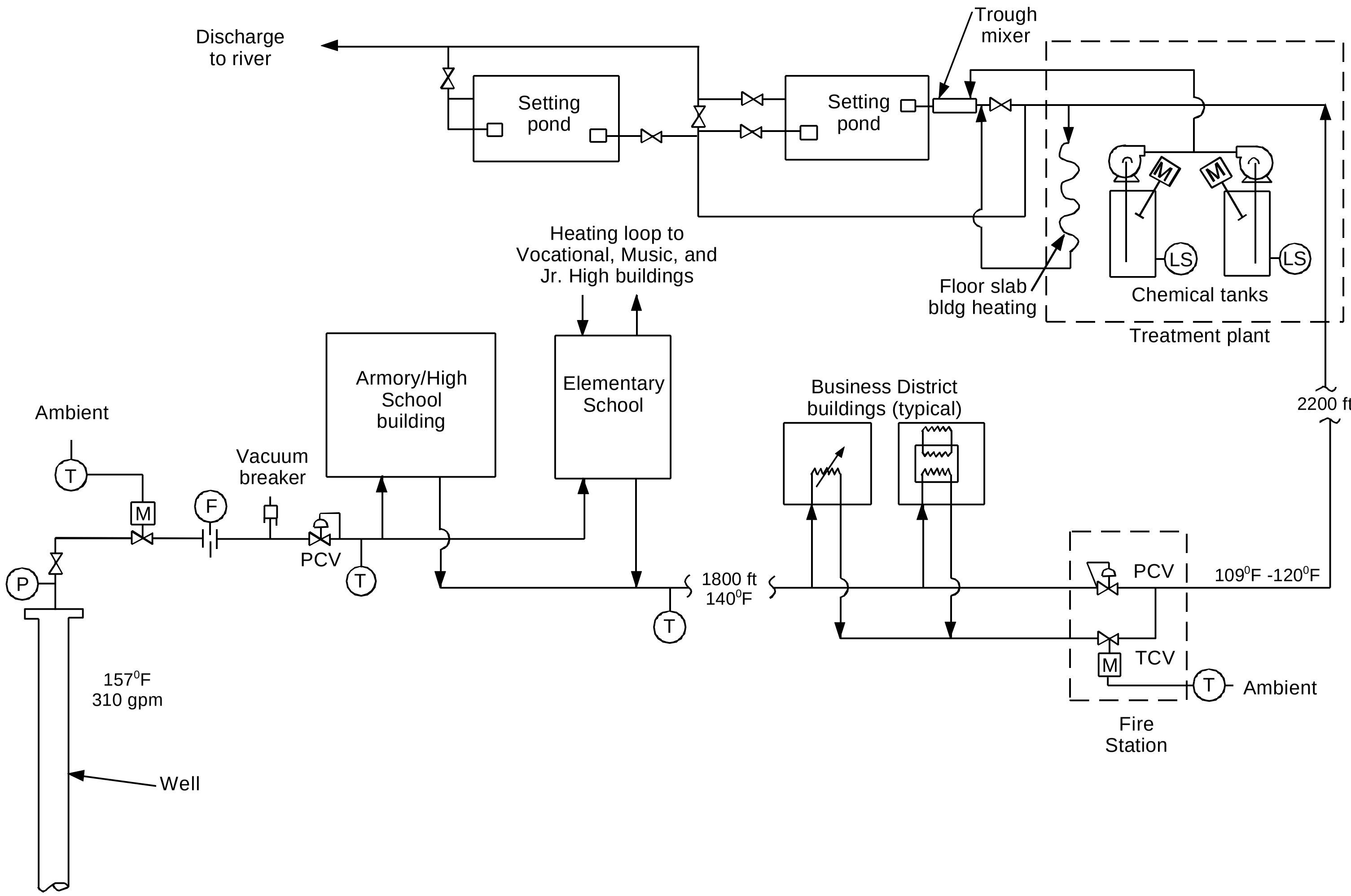

Philip, SD District Heating System Schematic