CANYON VIEW HIGH SCHOOL
CEDAR CITY, UTAH

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LOCATION & BACKGROUND

The Canyon View High School is located in Cedar City, UT, about 90 miles (145 km) northeast of the point of intersection of Utah, Arizona, and Nevada. It is a two-story building with 233,199 ft^2 (21,665 m^2) of floor space, and construction was completed in 2001.

Average high temperatures in the region in July are about 93°F (33.9°C) and average low temperatures in January are about 15°F (-9.4°C). There are approximately 6100 (3390°C-day) heating degree days and 700 (390°C-day) cooling degree days per year [65 °F (18°C) base].

The Canyon View ground-source heat pump system is considered the first "large" geoexchange system in the Central Rocky Mountain Region.

SYSTEM DESCRIPTION

Ground Source System

The ground source system (Figure 1) is the vertical closed loop type consisting of 300 vertical boreholes, each 300 ft (91.4 m) deep, for a total length of 90,000 ft (27,432 m). The boreholes, installed under the school playing field, are placed in a 15 x 20 grid pattern with a 20-ft (6.1-m) borehole spacing and 25-ft (7.6-m) spacing between run-outs. A single u-tube heat exchanger is installed in each borehole, and the borehole field is piped in a reverse-return arrangement.

The mean annual ground temperature in this location is approximately 53°F (11.7°C). An in-situ thermal conductivity test revealed that the average thermal conductivity of the soil to a depth of 300 ft (91.4 m) is 1.19 Btu/hr-ft-°F (2.06 W/m-°C). The loop field was installed in basin-fill type sediments, consisting of coarse sand and gravel with clay stringers and trace volcanics.

Interior System

The total installed heat pump capacity at the Canyon View High School is approximately 550 tons (1953 kW). Space conditioning is accomplished by over 100 water-air heat pumps, which are installed in ceiling spaces to serve individual classrooms and other zones. Outdoor air is introduced through heat recovery ventilator (HRV) units. The original design called for total energy recovery (ERV) units, but HRV's were installed due their to lower cost. There is little use of domestic hot water in the school, and thus it is generated partially by water-water heat pumps and natural-gas water heaters. The fluid distribution system consists of a central pumping system with a variable frequency drive.

A generalized schematic of the system is shown in Figure 2. Figure 3 is a photograph of the ground-loop headers in the mechanical room and Figure 4 is a photograph of a typical horizontal, ceiling-mounted water-air heat pump.

PROJECT COSTS

The Canyon View High School is an example of a building where a ground-source heat pump system was

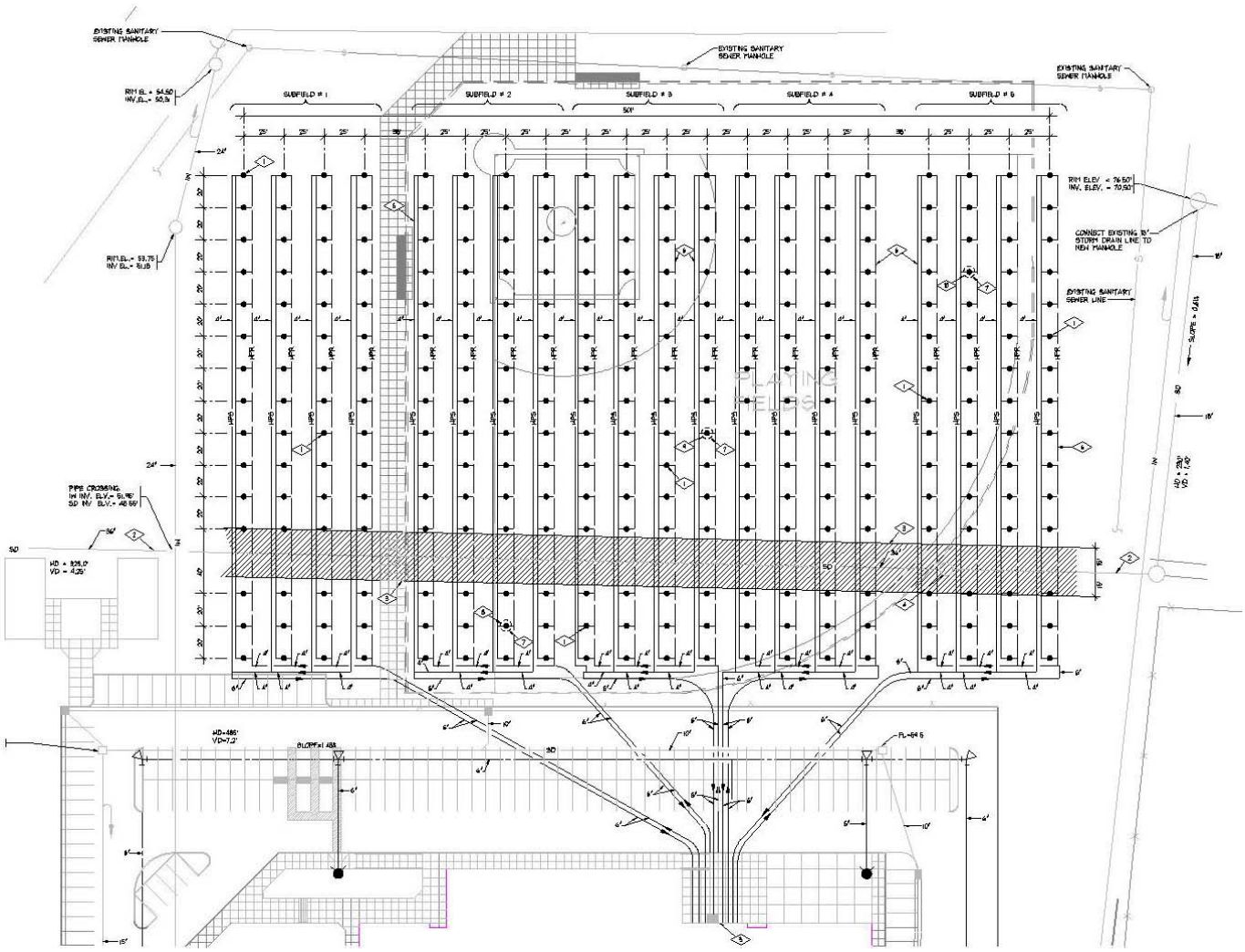

Figure 1. Canyon View High School ground loop field.

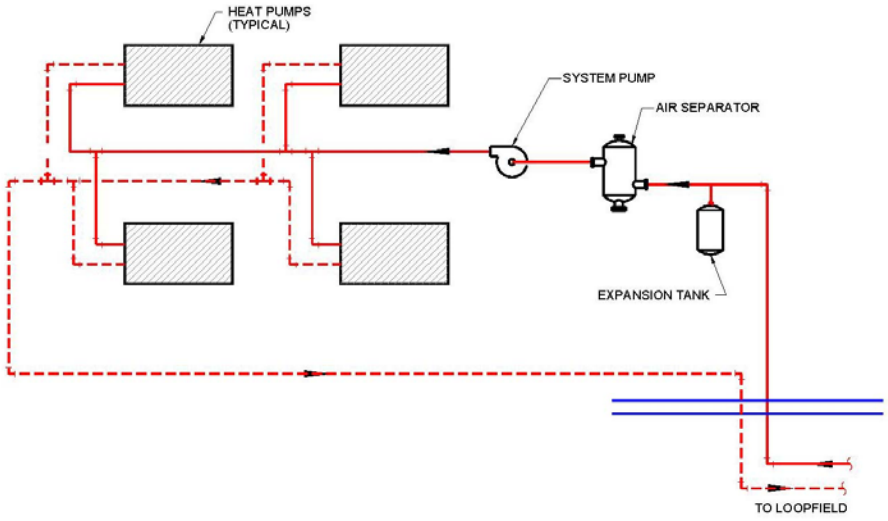

Figure 2. Schematic of the ground-source heat pump system at the Canyon View High School.

cheaper to install than a conventional boiler chiller system. The project costs are summarized as follows:

• Conventional Mechanical System Bid:
$17.00/ft^2 ($183.00/m^2)
• Canyon View High School Ground Source System Bid:
Mechanical/Plumbing bid: $2,457,000
Loop Field bid: $778,000
Total Ground Source bid: $3,235,000
Mechanical Cost/ft^2 (m^2): **$13.87/ft^2 ($149.30/m^2)**
Cost Savings: $3.13/ ft^2 ($33.69/m^2) = **$729,000**

Additional cost savings may be realized if one considers architectural savings in the mechanical room floor space in the ground-source system over the conventional system. For the Canyon View High School, the mechanical room for the ground-source system is 2,680 ft^2 (249 m^2), or 1.15% of the total floor space. Comparing this value to 3.80% of mechanical room floor space to total floor space for average schools, and assuming $50/ft^2 ($538/m^2) cost of new construction, an additional savings of $309,000 may be realized.

Figure 3. Photograph of the mechanical room at the Canyon View High School, showing the ground loop field supply and return headers.

SYSTEM PERFORMANCE AND OPERATING COST

The system has performed as designed. Maximum ground loop temperatures observed in the summer are about 92°F (33.3°C) and minimum loop temperatures in the winter are 40-42°F (4.4–5.5°C). Annual utility costs for 2001-2002 are summarized as follows:

• Annual Utility Costs for Canyon View High School:
Electricity: $135,886.54 (96%)
Natural Gas: $5,446.87 (4%)
Total: $141,333.41
Cost/ft^2 (m^2): $0.61/ft^2 ($6.57/m^2)
• Utility Costs for a Comparable School:
Cost/ft^2 (m^2): $0.86/ft^2 ($9.26/m^2)
(77% electrical, 23% gas)
• Operating Cost Savings: $0.25/ ft^2 ($2.69/m^2)
= $58,300 (or 29%)/year

Figure 4. Photograph of a typical horizontal, ceiling-mounted water-air heat pump.

OPERATING EXPERIENCES

Although the geoexchange system at the Canyon View High School is performing well, it is a large system, and the designer admits that there are ways that the pumping system could have been designed to optimize energy consumption. For example, systems of similar size are being designed with primary/secondary pumping, multiple loop pumps to utilize only as much of the ground loop as necessary, and distributed pumping in the building.

Most heat pumps are installed in ceiling spaces, and access has been a bit tight. Dirt and sand was a problem in the system for about 6 months after start-up, which was attributed to a damaged header pipe, likely caused by landscaping work.

ACKNOWLEDGEMENTS

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OVERALL SUMMARY

Building Description:
Location: Cedar City, Utah
Occupancy: School
Gross Floor Area: 233,199 ft^2 (21,665 m^2)
Number of Floors: 2
Type of Construction: New
Completion Date: 2001
July Avg. High Temp.: 93°F (33.9°C)
Jan Avg. Low Temp.: 15°F (-9.9°C)
Annual Heating Degree Days: 6100°F-day (3390°C-day)

Annual Cooling Degree Days: 700°F-day (390°C-day)

Interior System:

Total Installed Heat Pump Capacity: ~550 tons (1,935 kW)

No. of Heat Pump Units: 100+

Pumping System: Central with VFD

Ground-Source System:

Geologic Materials: Basin-fill sediments

Mean Ann. Ground Temp.: 53°F (11.7°C)

Type: Vertical closed loop, single U-tube

Configuration: 300 boreholes (15x20 grid pattern)
300 ft (91.4 m) deep,
20 to 25 ft (6.1 to 7.6 m) spacing

Borehole per ton: ~164 ft/ton (14.2 m/kW)

Economic Analysis:

Installed Geothermal HVAC Capital Cost:
$3,235,000 ($13.87/ft^2)($149.30/m^2)

Conventional HVAC Capital Cost Bid:
$3,963,363 ($17.00/ft^2)($183.00/m^2)

Annual HVAC Energy Cost (2001-2002):
$141,333 ($0.61/ft^2)($6.57/m^2)

Annual HVAC Energy Cost of Comparable Conventional School:
$200,500 ($0.86/ft^2) ($9.26/m^2)

Annual HVAC Energy Savings:
29%

Estimated Simple Payback Period:
Immediate