GEOTHERMAL HEATING AT THE CALIFORNIA CORRECTIONAL CENTER, SUSANVILLE. CALIFORNIA

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INTRODUCTION

Since the early-1980s, there has been significant geothermal development in the Honey Lake Valley of northeastern California. Surveying in the late-1970s by the U.S. Bureau of Reclamation indicated the potential for geothermal development in the area, spurring the interest of public and private agencies (Templeton, 2002). Since then, the city of Susanville has taken advantage of a 23-67ºC geothermal reservoir for a sizable district heating system, the California Correctional Center (CCC) near Litchfield (Figure 1) has installed a 72-74ºC geothermal heating system and greenhouse, and two small binary flash steam power plants have been constructed in Wendel and Amadee using a 95-107ºC resource (Culver, 1990; Majmundar, 1983; Nichols, 1999; Short, 2002).

In 1980, the state of California and the city of Susanville collaborated to install a geothermal heating system to supplement the existing diesel-powered system at CCC (Short, 2002; Templeton, 2002). Two wells, approx. 460 m deep, were installed on a tract of land some 3.2 km east of the prison site by the Carson Energy Group, Inc. of Sacramento. Temporary funding was provided by the Bank of America (Templeton, 2002). Geothermal heat is used for 50-80% of the prison's space and domestic water heating, as well as for a medium-sized greenhouse. CCC houses around 5,800 minimum custody inmates, and some 1,100 custodial and support staff are employed at the 4.5 km^2 site (CDC, 2002). The geothermal heating is used for inmate dormitories, but generally not for staff areas (Cantrell, 2002). While the system experiences occasional problems, it has proven to be cost-effective, clean and low-maintenance. Moreover, both the Susanville and CCC geothermal systems have provided substantial savings when compared to the alternative of fossil fuels (Cramer, 2002; Cantrell, 2002; Short, 2002; Templeton, 2002).

Figure 1. CCC in foreground, Honey Lake Valley and Diamond Mountains to the south (photo: CDC, 2002).

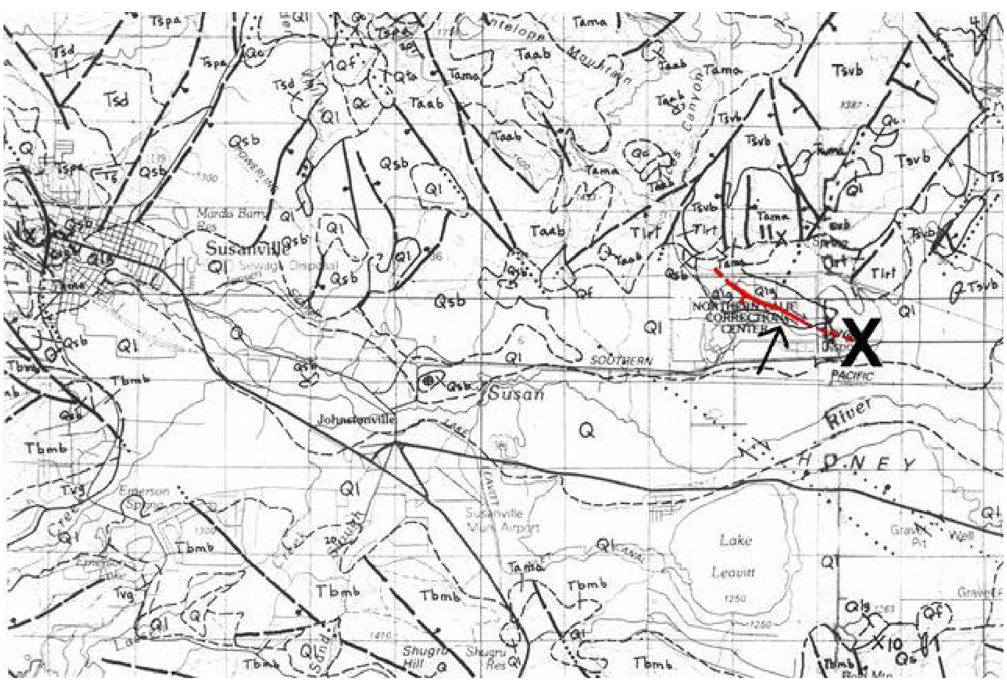

Figure 2. Geological map of Susanville area. Well and transverse fault marked with "X" and arrow, respectively (Grose, et al., 1990).

GEOLOGY

The California Correctional Center is located just to the south of the widespread Tertiary to recent basalts, mafic andesites, and tuffs of the extension- and subduction-induced Modoc Plateau volcanic region (Donnelly-Nolan, 1988; Hirt, 1998). The wells themselves are located on lacustrine gravels and near-shore deposits of pluvial Lake Lahontan, cut by a small west-northwest striking right-lateral fault (Figure 2) that correlates directly with the geothermal reservoir (Grose, Saucedo, and Wagner, 1990). The recent work of Colie, Roeske, and McClain (2002) indicates that shearing associated with the Walker Lane in Nevada and eastern California extends beyond the Honey Lake fault zone northwestward through Eagle Lake and beyond (Figure 3).

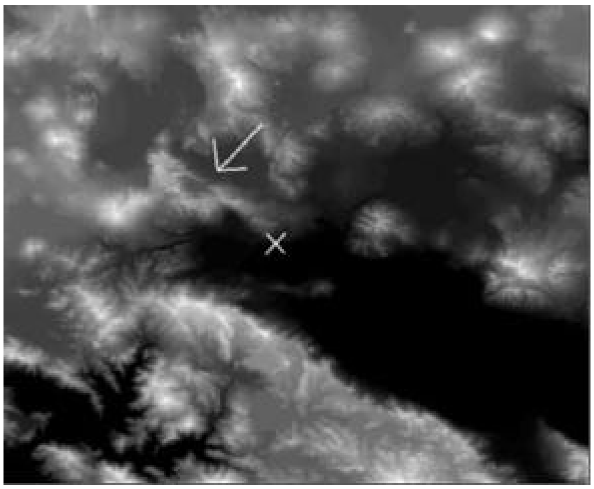

Figure 3. ***Digital elevation model of Honey Lake Valley and Eagle Lake area. Apparent transverse zone marked by arrow. CCC area marked by "X" (USGS, 2002).***

Available mapping (Grose, et al., 1990) suggests that the transverse fault associated with the prison's geothermal reservoir is directly related to the relative motion between the North American plate and the Pacific plate, causing the region between the San Andreas fault and the Walker Lane to rotate counterclockwise, with faulting on the northeast margins (Colie, Roeske, and McClain, 2002). The crustal thinning and high thermal gradients associated with Basin and Range extension, Walker Lane transverse faulting and fracturing, and the nearby subduction-related volcanism of the Cascades all appear to contribute to the presence of a viable geothermal reservoir at the CCC site. From a geologic viewpoint, the discovery and use of yet other geothermal reservoirs in the region seems likely.

SYSTEM DESCRIPTION

CCC's geothermal system consists of two production wells, several heat exchangers linked to a closed heating loop, an application area, and an evaporation pond. The wells are owned and operated by the city of Susanville, while the well area is owned by the state and used by the prison for agriculture and water resources (Short, 2002). For contingency, two wells were drilled during the initial construction of the system, one producing water around 76ºC, and the other delivering 72-74ºC water. Unfortunately, in 2001 the casing on the hotter well collapsed and was deemed too costly to repair, and the cooler well has been used since then (Cantrell, 2002).

Use of the thermal water is "take-or-pay," meaning that the water is paid for whether it is used for heating or not (Cantrell, 2002; Cramer, 2002). According to Rice (2002), the city collects a minimum of $17,062/month, based on the calculated use of 525,000 therm/year, and working out to a cost of $0.39/therm. Compare this with the $1.22/therm rate that the city charges residents and property owners for natural gas heating (Susanville, 2002). A portion of the fees collected are paid to the former owner of the well property as royalties (Templeton, 2002). If measured usage exceeds the standard 525,000 therm threshold, $0.39/therm in addition to the contracted fee is billed to the state. However, payment is not collected if geothermal water is not produced for more than 30 consecu-tive days by the city (Cantrell, 2002; Rice, 2002). This has happened several times in the past, in which case 162ºC steam from the diesel boilers is pumped through a heat exchanger adjacent to the geothermal equipment (Cantrell, 2002).

The currently operating 72ºC well (Figure 4) uses a 75 hp oil-lubricated pump to produce about 1130 L/min for an underground supply line to the prison boiler room. After passing through a sand filter, the supply water is routed to one of two plate heat exchangers (Figure 5) for space heating, and a smaller heat exchanger (Figure 6) for domestic hot water (Cantrell, 2002; Short, 2002). Incoming water on the closed-loop system is at about 21ºC, and outgoing water on the domestic loop is heated to about 51ºC using a stainless-steel plate heat exchanger (Cantrell, 2002). Water going out to the space heating loop is usually heated to 60-66ºC when needed in the wintertime (Cantrell, 2002). Three 30-hp pumps produce flow in the space heating loop as needed (Cantrell, 2002).

Figure 4. ***72ºC well, 3.2 km east of prison (photo: Mark A. Miller).***

After being passed through the heat exchangers, the now 60-66ºC geothermal water is sent to a medium-sized greenhouse half a kilometer to the east (Short, 2002). Here a portion of the hot water is diverted and passed through a

Figure 5. ***Space heat exchanger, located in prison boiler room (photo: Mark A. Miller).***

Figure 6. ***Domestic heat exchanger (photo: Mark A. Miller).***

manifold heating system underneath two lengths of plant trays (Esparza, 2002). This heating is used during cool periods to maintain a fairly constant temperature of 22-26ºC in the greenhouse (Esparza, 2002).

After the geothermal water is passed through the greenhouse, it is hypochlorinated and returned to a dispersion area between the wells and the prison, consisting of a 20-acre application area and an evaporation pond of approximately 81 ha (Short, 2002). The application area uses 20 lengths of 120 m aluminum runners, with 18 sprinklers spaced about every 6 m (Short, 2002). When in use, the geothermal water is sprinkled over the application area to either evaporate or drain to the overflow pond through a small diversion ditch (Short, 2002). Water that is not sprinkled on the application area flows directly into a privately-owned pond (Figure 7) that reportedly supports populations of bass, waterfowl, deer, and antelope (Short, 2002). The author estimates incoming pond water to be approximately 50ºC. Several cottonwood trees and other riparian species have established themselves around the perennial pond (Short, 2002).

Figure 7. ***Evaporation pond, located on private land just northwest of production wells (photo: Mark A. Miller).***

PROBLEMS ENCOUNTERED

The failure of the higher-temperature well was a disappointing occurrence that is apparently too costly for repair (Short, 2002). From time to time, sand and mineral deposits clog the heat exchanger, bringing the system down for anywhere from a few days to a few weeks for cleaning (Cantrell, 2002). Also, occasional well failures have caused other periods of downtime (Cantrell, 2002; Cramer, 2002; Short, 2002). According to Templeton (2002), these problems are routine and can be expected with any well, whether geothermal or not.

In the greenhouse, minor repairs have had to be made to the manifold heating system, in which the standard piping was replaced with high-temperature piping, and the gate valves replaced with ball valves (Esparza, 2002). However, according to Esparza, in the past nine years, the greenhouse heating system has never been down for longer than three days (2002).

While the lack of an injection well could cause reservoir depletion, it has apparently not caused any problems to date. Templeton (2002) states that the city's prior experience with attempts at injection led developers to view an evaporation pond as the best option. It may also be difficult to find a suitably distant injection zone with equal or lesser water quality, as demanded by the Lahontan Regional Water Quality Control Board (Culver, 1990). The application of the alkaline water to the 20-acre area of sagebrush and bunchgrass has caused some damage to plant life, but otherwise no serious environmental concerns have been observed or mentioned.

As a precaution for workers and inmates, the water is hypochlorinated before it is released (Short, 2002). Water dispersed by the geothermal system meets all requirements imposed by the Lahonton Regional Water Quality Control Board, according to Short (2002).

The released water contains dissolved sodium and boron, and the aluminum laterals in the application area warrant replacement about every five years due to corrosion (Short, 2002).

CONCLUSION

The CCC direct-use geothermal system has proven to be a clean, cost-effective, and efficient method for supplementing its institutional heating system. While the system does not have an industry-standard injection well, the environmental impact is by all appearances minimal. Use of this geothermal resource is expensive but still cheaper than the use of diesel fuel to power its boilers. The recent installation of a state-owned natural gas pipeline in the area, however, is expected to replace many of the area's current geothermal operations, including that of the prison. The current contract with the city will expire in 2007, and nearly all involved expect that both CCC and the city of Susanville will retrofit most of their facilities and switch to natural gas equipment (Cantrell, 2002; Cramer, 2002; Short, 2002; Templeton, 2002). Templeton (2002) predicts that for the time being the cost of geothermal energy will not be able to compete with natural gas because of the need for electricity to run the well pumps. The primary drawback, of course, to burning natural gas is the emission of carbon dioxide, methane, and nitrous oxides (EPA, 2002), practically absent from geothermal applications.

Although the future looks grim for the next few years of geothermal development in the Susanville area, the applications currently in operation can serve as real-life examples of the successful use of a non-polluting, economical, and renewable resource. For geothermal developments in the future, it is hoped that the system described herein can serve as a prototype and as a useful precedent.

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REFERENCES

California Department of Corrections (CDC), 2000. "California Correctional Center (CCC)," URL: http://www.cdc.state.ca.us/facility/instccc.htm

Cantrell, Gene, 2002. Personal interview.

Colie, Erin M.; Roeske, Sarah; and McClain, James, 2002. "Strike-slip Motion on the Northern Continuation of the Late Cenozoic to Quaternary Honey Lake Fault Zone, Eagle Lake, Northeast California," The Geological Society of America, Cordilleran Section, 98th Annual Meeting, 13-15 May, 2002, Abstract. URL:http://gsa.confex.com/gsa/2002CD/finalprogram/abstract_34838.htm.

Cramer, Daryl, 2002. Telephone interview.

Culver, Gene, 1990. "Case Histories of Vale, Oregon & Susanville, California," Symposium on Subsurface Injection of Geothermal Fluids, Underground Injection.

Practices Council (UPIC) Research Foundation, Oklahoma City, OK.

Donnelly-Nolan, J.M., 1988. "A magmatic model of Medicine Lake volcano, California," Journal of Geophysical Research, v. 93, no. B5, p. 4412-4420

EPA (Environmental Protection Agency), 2002. "Emissions," EPA Global Warming Site, URL: http://www.epa.gov/globalwarming/emissions/.

Esparza, Tony, 2002. Personal interview.

Grose, T.L.T, Saucedo, G.J., and Wagner, D.L., comp., 1990. "Geologic Map of the Susanville Quadrangle, Lassen and Plumas Counties, California, 1:100,000 scale," California Department of Conservation, Division of Mines and Geology.

Hirt, William, 1998. "Geology of the Medicine Lake Volcano, California," College of the Siskiyous, Weed, CA. URL:http://www.siskiyous.edu/class/geol42/handout98.html

Lienau, Paul. 1997. "Geothermal Direct Heat Utilization Assistance," U.S. Department ofEnergy, Geothermal Energy Technical Site, URL:http://wastenot.inel.gov/geothermal/fy95/dir-use/use01.htm

Majmundar, Hasmukhrai, comp., 1983. "Technical Map of the Geothermal Resources of California,Geologic Map #5," California Department of Conservation, Division of Mines and Geology,

Nichols, Ken. 1999. "Case Histories, Barber-Nichols Small Geothermal Power Plants," Barber-Nichols, Inc. URL: http://www.barber-nichols.com/Papers/geothermal.pdf

Rice, Jay, 2002. Personal Interview.

Short, D.J., 2002. Personal interview.

Susanville, City of, 2002. "Public Utility Information," URL:http://www.cityofsusanville.org/Economic/Utility%20Information.pdf.

Templeton, Louis, 2002. Personal Interview.

USGS, 2002. "Examples of 1:250,000 Digital Elevation Models," EROS Data Center, Sioux Falls, SD. URL:http://edcwww.cr.usgs.gov/geodata/examples.html.