

GEOHERMAL ENERGY AT NEW MEXICO STATE UNIVERSITY IN LAS CRUCES

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INTRODUCTION

In 1949, the Clary and Ruther State 1 oil test adjacent the southeast boundary of the NMSU campus encountered hot water and "steam." Later in the mid-to-late 1950s, a couple of shallow domestic wells drilled within a half mile south of the campus east of I-25 in the present day Las Alturas neighborhood encountered "warm and salty" water (Figure 1). Until the 1970s, these reports of geothermal heat in the area were largely treated as a curiosity. Then during a period of five years between 1973 and 1979, New Mexico State University experienced a major increase in the cost of natural

gas that exceeded 400 percent. Through the vision and leadership of Gerald Thomas, former NMSU President and Harold Daw, former NMSU Vice President of Research, campus expertise in renewable energy was mobilized to find a cost effective solution. Because of reports of hot water adjacent to campus, NMSU faculty, staff and students began a campus geothermal exploration program that identified a potential geothermal resource with geologic and geophysical studies including the drilling of shallow heat flow holes (Dicey and Morgan, 1981; Gross and Icerman, 1983; Jiracek and Gerety, 1978; King and Kelley, 1980; Swanberg, 1975). Deeper exploration drilling and testing confirmed that suitable low temperature geothermal resource existed beneath the eastern end of the campus (Chaturvedi, 1979 and 1981; Cunniff, et al., 1981).

An appropriation from the New Mexico Legislature provided funds for the design and construction of the NMSU Campus Geothermal Project (Cunniff, et al., 1983). Additional funds for well drilling, project management and monitoring for one year also became available with a USDOE Cooperative Agreement. The NMSU Campus Geothermal Project under the leadership and engineering design of Roy Cunniff was the first large-scale demonstration of geothermal energy in New Mexico. The system was built by NMSU staff and a large crew of student employees, and assisted by temporarily employed skilled trades construction workers (Cunniff, et al., 1983). Began in 1981 and completed in 1982, the NMSU Campus Geothermal Project provides domestic hot water and space heat to dorms, athletic facilities, and academic buildings on the eastern part of campus.

Geothermal use at NMSU does not end with the district heating system. In 1985 under the leadership of Rudi Schoenmackers, Southwest Technology Development Institute (SWTDI), staff and students built the Geothermal Greenhouse Facility (GGF) with a combination of industry donations and state of New Mexico funding. The project was conceived by Larry Icerman to promote economic development in New Mexico with direct-use geothermal. Finally in 1994, the Geothermal Aquaculture Facility (GAF) was built by SWTDI (Zachritz, et al., 1996).

Today, NMSU has an enrollment of about 24,300 with 15,300 undergraduate and graduate students on the main campus. NMSU is New Mexico's land grant university with



Figure 1. Location map of the Tortugas Mountain area on the NMSU campus.

strong and active engineering, agriculture, and geoscience-related programs that have played the major roles in stimulating and forwarding geothermal resource development in New Mexico.

GEOLOGY AND HYDROGEOLOGY

The NMSU geothermal resource is a part of the larger Las Cruces East Mesa geothermal system that extends from US Highway 70 on the north to Vado and Anthony on the south (Iceman and Lohse, 1983). The Las Cruces East Mesa geothermal system is contained within a fractured horst block of mid-Tertiary volcanics and Paleozoic limestone (Gross and Iceman, 1983). Most of the horst block is buried under ancestral Rio Grande axial fluvial deposits and alluvial fan deposits shed westward from the Organ Mountains to the east (Figure 1). The Tortugas Mountain or 'A' Mountain area is the locus of the geothermal upflow on the NMSU campus. The current production wells on campus and the thermal wells in the Las Alturas neighborhood are completed in Tertiary Santa Fe Group basin fill of the outflow zone adjacent the parent reservoir in fractured Paleozoic limestone beneath and around Tortugas Mountain, a partially alluvium buried inselberg on the horst block (Figure 2).

Four geothermal production wells and one injection well have been drilled and completed on campus (Table 1). Only two of the production wells are in current use. All of the wells are completed across lower Santa Fe basin fill sediments. However, the lower 40 ft of PG-4 may be completed in a fault zone or karst at the Tertiary basin fill–

Paleozoic limestone contact. The production wells PG-1 (Photo 1) and PG-4 are currently rotated for campus district heating and the greenhouse (GGF) and aquaculture facility (GAF).

Pump tests of PG-1 and PG-3 indicate much variability in aquifer properties in the Santa Fe Group reservoir with transmissivity ranging from 6,500 to 40,000 gpd/ft. PG-4 has much higher over all transmissivity as a result of the highly productive zone in the lower 40 ft of the well. Specific capacity of about 100 gpm/ft indicates that PG-4 is capable of sustained production in excess of 1,000 gpm at 146 to 148°F.

Overall, chemical quality from the production wells varies slightly with TDS ranging between 1700 to 1900 mg/L. The waters are sodium bicarbonate-chloride composition. Wells PG-1 and PG-3 are associated with very small amounts of hydrogen sulfide that has caused problems with pump columns corrosion.

GEOHERMAL USE

Campus District Heating System

Currently, two wells, PG-1 and PG-4 are outfitted with submersible pumps and are used alternatively to supply 141 to 148°F water at 250 gpm to supply heat to the NMSU campus district heating system, the SWTDI greenhouse (GGF) and the aquaculture facility (GAF). The layout of the district heating system allows for the heating of a total of 30 building and facilities that include dorms and athletic facilities (Figure 3). Hot water from the wells is piped along side Geothermal Drive to a heat exchanger building located adjacent to a

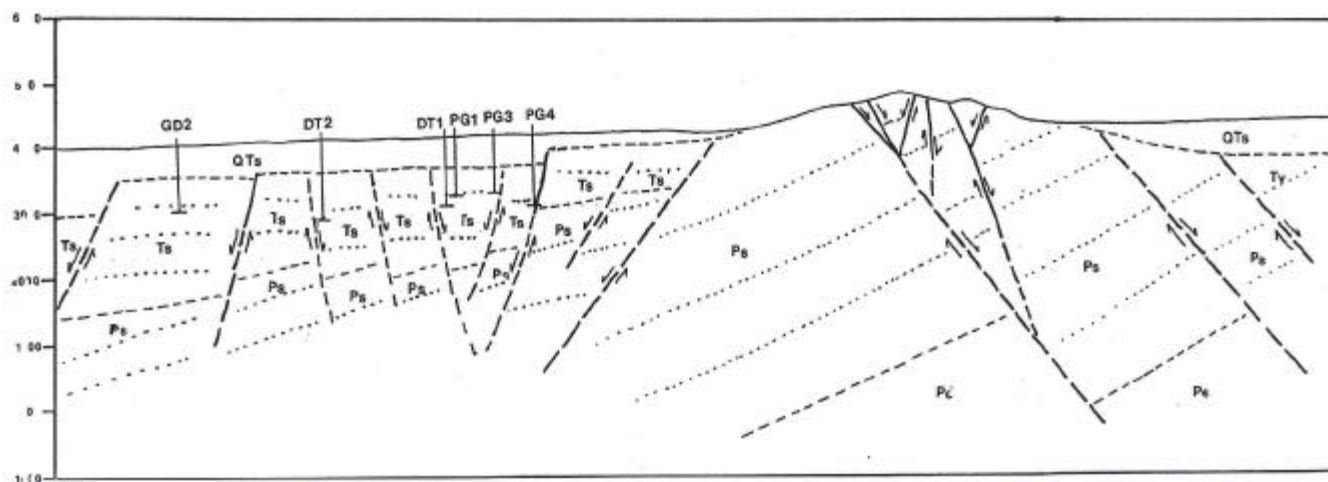


Figure 2. *Geologic cross-section of the Tortugas Mountain area. Wells (see Table 1, DT1 & 2 are temperature gradient holes) are projected on the cross-section and sub-surface structure, and lithology is based on wells, various geophysical surveys and surface geologic mapping. Lithology: Qts - Tertiary basin fill (younger Santa Fe Group); Ts - Tertiary basin fill (older Santa Fe Group); Tv- mid-Tertiary volcanics; Ps - Paleozoic limestone and dolomite; Pe - Precambrian granite. Vertical and horizontal scales are the same. Bars on left side of cross-section are in 1,000-ft increments (Witcher, unpublished).*

Table 1. Geothermal Wells on the New Mexico State University Campus

| Well | Depth ft | BHT °F | Year Completed | Casing in. | Depths ft | Diameter in. | Depths ft | Remarks |
|------|-------------|-----------|-------------------|---------------------------------------|--|-------------------------------------|--|--|
| PG-1 | 860 | 145 | 1979 | 10 ID 10 ID screen | 0-750 | 17 | 0-860 | Produces 142°F T = 6,500 gpd/ft |
| PG-2 | 507 | 122 | 1979 | 6 | 507 | 9 7/8 | 507 | Produces 18 gpm at 118°F from 451 to 171 ft depth; well currently not in use. |
| PG-3 | 870 | 150.4 | 1980 | 18 ID 10 ID 10 ID screen | 0-60 0-750 750-860 | 26 18 18 | 0-60 26-750 750-860 | Produces 146°F T = 40,000 gpd/ft Well currently not in use. |
| PG-4 | 1,015 | -150 | 1986 | 14 8 5/8 8 5/8 screen 5 9/16 | 0-684 658-744 744-971 972-1,015 | 17 1/2 12 1/4 12 1/4 7 7/8 | 0-684 684-733 733-960 982-1,015 | Produces 146°F Specific capacity 100 gpm/ft |
| GD-2 | 464 | -110 | 1980 | 8 5/8 cement 8 5/8 Cement plug | 0-348 348-464 464-486 | 14 3/4 14 3/4 14 3/4 | 0-348 348-464 464-486 | Injection well on NMSU Golf Course Slotted screen at 370-380 ft; 390-464 ft T = 9,000 gpd/ft |

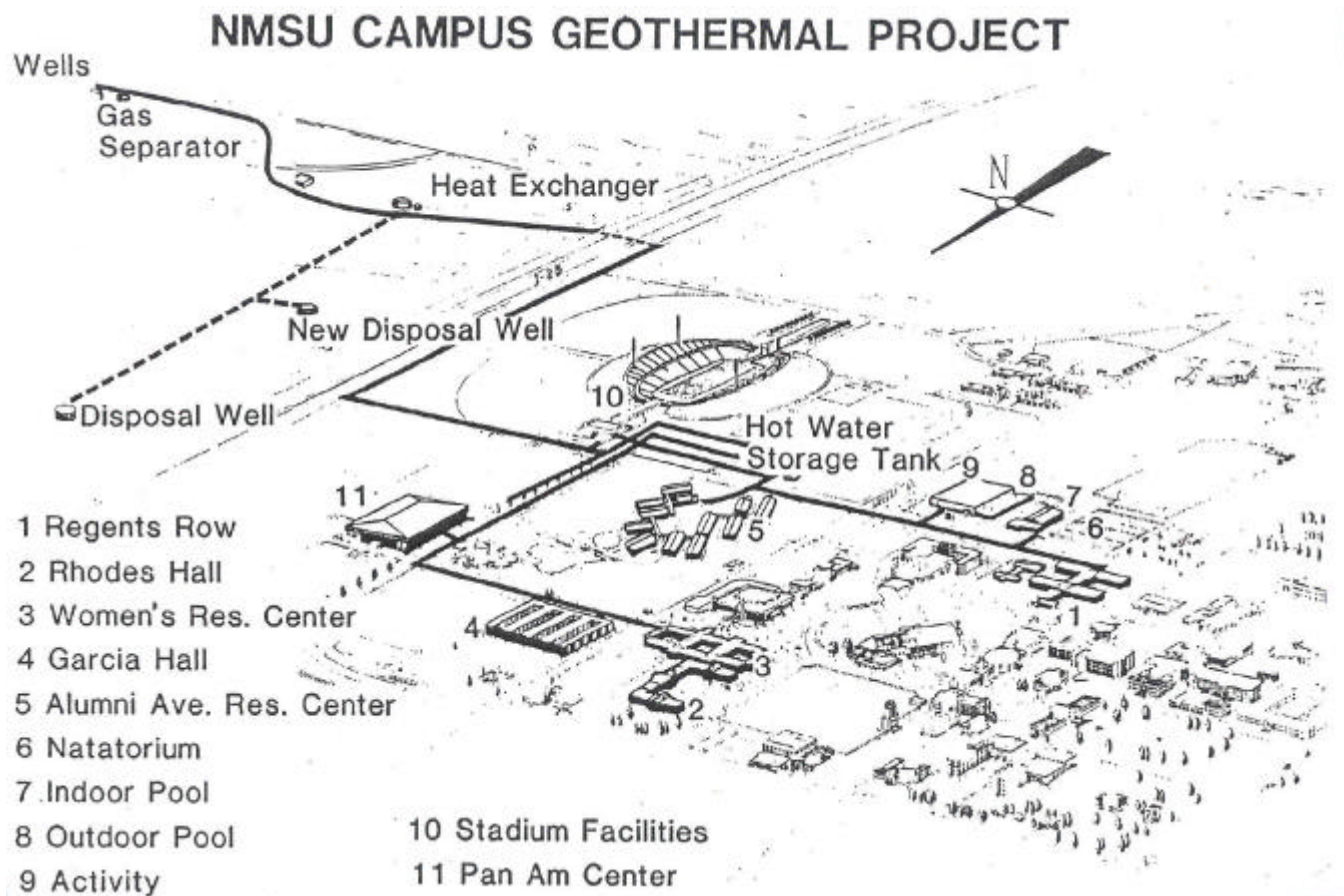


Figure 3. Overall layout of the NMSU campus geothermal project (from Cunniff, et al., 1981).



Photo 1. NMSU well (PG-1).

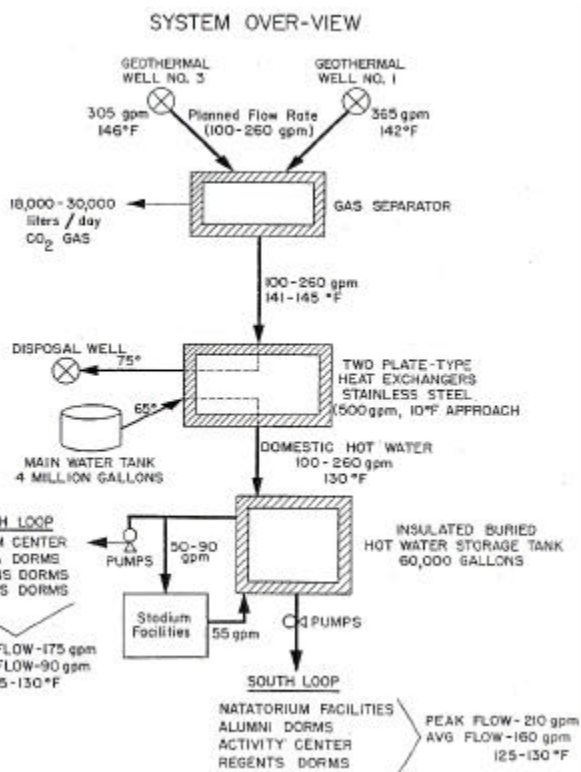


Figure 4. The original NMSU geothermal system design overview (Cunniff, et al., 1981).

adjacent to a 4 -million gallon freshwater storage tank along a ridge on the south side of the NMSU Golf Course. At one time, a gas separator near the production wells was used to extract carbon dioxide gas from the hot water stream. However, this was discontinued because the overall system performance was better without the gas separation step. A stainless steel plate-and-frame Tranter heat exchanger takes 141 to 145°F geothermal water and 65°F freshwater from the large freshwater storage tank and heats the freshwater to 130

to 135°F (Figure 4)(Photo 2). The geothermal stream leaves the heat exchanger at about 75°F and is then piped to an injection well at the NMSU Golf Course where the geothermal water is returned to the reservoir margins. The heated freshwater stream is piped underground beneath I-25 to a buried and insulated 60,000 gallon storage tank adjacent to the football practice field. Two district heating loops are used to supply 125 to 130°F hot water from the hot water storage tank on demand for space heating and domestic hot water. With all heat losses included, 115 to 125°F hot water is supplied to final users on campus. In the first year of operation, the system provided 53×10^9 Btu in February 1982 through the end of January 1983. In 2001, the system provided approximately 36×10^9 Btu. This decrease in use is the result of several changes in the overall campus heating and cooling system since the geothermal district heating system was installed in 1982. Among the major changes include the installation of natural gas turbine co-generation plant to supply 5 MWe of electrical power on campus. As a result, the swimming pool was taken off line from geothermal heating and it is now heated with reject heat from the co-generation plant. While the campus has doubled in size since 1982, the co-generation power has allowed conventional district heating and cooling to increase without additional geothermal direct-use. On the other hand, additional geothermal direct-use is probable as campus is beginning to expand eastward and on to the east side of I-25 on the opposite end of campus from the co-generation plant. The far eastern side of campus is the site of the geothermal reservoir and the SWTDI greenhouses (GGF) and aquaculture facility (GAF).



Photo 2. NMSU plate heat exchanger with Jim Absher and Leo Valenzuela, campus Physical Plant Department.

SWTDI GREENHOUSE FACILITY (GGF)

Two 6,000-ft² greenhouses and a 2,400-ft² metal storage space, office and work shop comprise the Geothermal Greenhouse Facility (GGF), which has been heated continuously with geothermal since December 1986 (Figure 5) (Photo 3) (Schoenmackers, 1988). A propane boiler provides back up heat in case of geothermal well pump failure. The

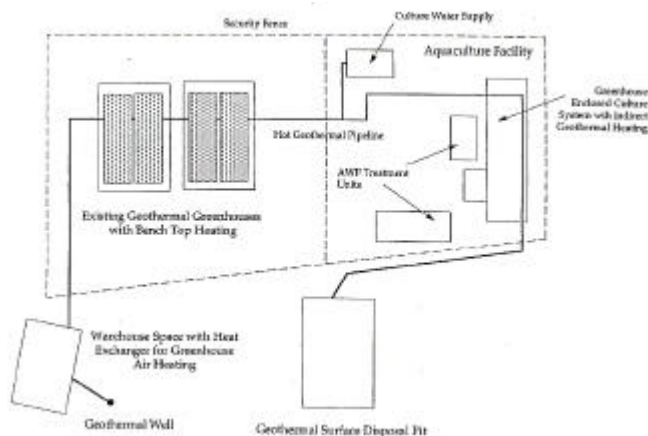


Figure 5. *Generalized layout of the NMSU/SWTDI Geothermal Greenhouse (GGF) and Geothermal Aquaculture (GAF) Facilities (Zachritz, et al., 1996).*



Photo 3. *Interior of SWTDI greenhouse facility.*

GGF is of Dutch design and all structural members are made of galvanized steel that are mounted on 10-inch concrete piers set 24 inches into the ground. A variety of glazing films are used in the doubled glazed panels that contain central dead air spaces. Also, different cooling and ventilation schemes are applied in the two greenhouses that are laid out with the long axes oriented east to west. The south greenhouse has a traditional fan and pad evaporative air cooling system installed

with a typical 75 percent wet bulb depression and a complete air exchange capability of once every minute. GGF temperature increases from the west end pad to the east end fan are about 10 to 12°F when in a cooling mode. The north greenhouse has a fog cooling system that uses 90 fog nozzles that create 10-micron droplets or fine mist to create a distributed evaporative cooling effect without significant lateral temperature gradients. Side and roof vents are used to provide natural ventilation.

The GGF uses between 25 and 60 gpm of 148°F water from well PG-4 for geothermal heating. The maximum flow represents about 25 percent of the currently installed discharge from PG-4. The geothermal water is feed into a Trantor stainless steel (type 316) plate and frame heat exchanger with a designed maximum flow of 80 gpm and an approach temperature of 10°F. The heated freshwater is feed into a closed-loop, hydronic geothermal heating system by 3- inch black iron pipe. Four modine high-efficiency, fan-coil units are outfitted with inflatable 24-inch poly tube with 1-inch holes on 1-ft centers to provide 3,850 cfm of evenly distributed warm air flow (Photo 4). Typical hot water inflow to the four heaters is at 131°F with an exit temperature of 110°F for an installed geothermal heating capacity of about 525×10^3 Btu/hr in the closed-loop hydronic system.

An additional bench top heating system taps geothermal water directly with motorized ball valves before passing through the heat exchanger. The bench top system provides soil heating for horticultural cultivation with a 50,000-ft long series of 5/32 inch ID rubber tubing (Photo 5). The bench top heating system uses about 25 gpm and typically shows a temperature loss of 15 to 30°F for an installed geothermal heating capacity of about 375×10^3 Btu/hr.



Photo 4. *Modine heater with poly tube.*

All heating and cooling in the geothermal greenhouse is monitored and controlled by computer. After exiting the heat exchanger and the bench top heating system, the cooled geothermal water is allowed to flow into a 46-ft by 46-ft by 15-ft permitted disposal pond or is cascaded to the SWTDI Geothermal Aquaculture Facility (GAF).

SWTDI GEOTHERMAL AQUACULTURE FACILITY (GAF)

The SWTDI Geothermal Aquaculture Facility (GAF) was funded in 1993 by the USDOE with the purpose of demonstrating energy use and energy savings and value enhancement of a cascaded direct-use geothermal aquaculture operation that is coupled to geothermal greenhouse heating (Zachritz, et al., 1996). In addition, the facility also demonstrates the application of several wastewater treatment

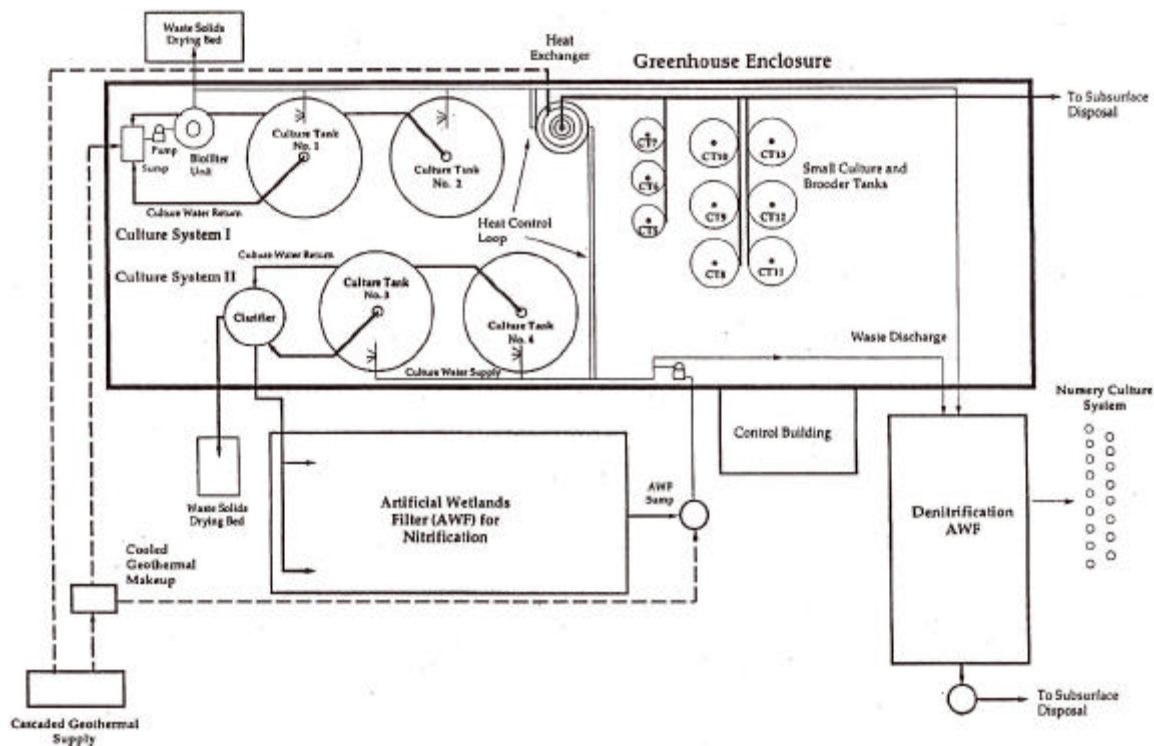


Figure 6. *Process flow diagram of the Geothermal Aquaculture Facility (GAF)(Zachritz, et al., 1996).*

approaches for aquaculture that include an artificial wet land for denitrification and two different approaches of solids removal. The facility was designed for both research and as a business incubator for lease to potential aquaculturalists. Tilapia and striped bass have been grown in the facility.

The layout of the geothermal aquaculture facility is shown in Figure 6. Two large 6,000-gallon capacity intensive culture systems simulate commercial level production while a number of smaller tanks provide for brood stock maintenance and fry production (Photo 6). The culture systems can use freshwater, cooled geothermal water, or custom mixes for marine applications. Each of the two large culture systems uses different wastewater treatment. Flow through or recirculating flows can also be accommodated by the GAF.

Geothermal heating is done by cascading a maximum 25 gpm of geothermal water from the GGF bench top heating system to the aquaculture facility. Cascaded hot water arrives at the heat exchanger at 90 to 135°F for heating culture water in a closed loop fashion. The GAF is contained in a 3,000-ft² double-walled arched greenhouse (Photo 7). Cooling and ventilation is done with cooling pad at one end of the greenhouse and fans at the opposite end of the greenhouse. All heating and cooling is monitored and controlled by computer. The GAF system at 16 to 17 gpm geothermal flow typically shows a temperature loss of 6 to 9°F across the heat exchanger for an installed geothermal heating capacity of about 76×10^3 Btu/hr.



Photo 5. *Greenhouse bench heating system..*



Photo 6. *Large aquaculture tanks.*



Photo 7. SWTDI aquaculture building.

BENEFITS

Geothermal use at NMSU has benefitted New Mexico in several ways. First, the campus geothermal system has an annual energy savings compared to natural gas up to several hundred thousand dollars annually depending upon annual climate, the cost of fossil fuel and maintenance costs for the geothermal system. Since 1986, six clients have leased the GGF and one client has leased the GAF. The GGF has resulted in important rural economic development as five clients have gone on to build successful geothermal and non-geothermal greenhouse business in the state.

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