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CASE HISTORIES OF FOUR AGRICULTURAL AND MUNICIPAL DIRECT USE PROJECTS IN THE WESTERN U.S.

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ABSTRACT

Engineering and economic studies have been conducted on four agricultural and municipal direct energy projects. Two of the projects located in Northern California are being constructed in 1981 and will be operating in 1981-82. Two others in Northern California and Southern Idaho have not progressed beyond the paper studies.

This paper will summarize the Susanville, Mountain Home, Kelley Hot Spring and Litchfield projects in terms of engineering and economics, institutional, permitting issues and financing and will draw conclusions from the evolution and maturing of geothermal direct use projects in the U.S. in the 1975-81 time period. The institutional, financial and management factors delaying two of the projects are addressed. The characteristics of successful geothermal direct use projects in the U.S. are discussed.

Three of the projects have been funded by the U.S. Dept. of Energy. One of the projects is a private-local government-state funded effort that will displace over 500,000 gallons (2000m^3) of oil per year.

1.0 INTRODUCTION

The major portion of the geothermal resources in the U.S. are most suitable for direct utilization for space heating and moderate-to-low temperature processes. Significant development of these resources has been impeded, initially, by regulatory and other institutional barriers and, more recently, by lack of public awareness and the immaturity of the resource as an investment.

This paper addresses the historical evolution of four direct use projects, occuring between 1974 and 1981. These are the Susanville Geothermal Energy Project--the prototype modern district heating system in the U.S.; the Mountain Home and Kelley Hot Spring Geothermal Projects--integrated agricultural applications; and the Litchfield Geothermal Project--a large scale cascaded system developed through a private developer/local government/state agency joint effort. The degree of success in terms of implementation for these projects and those factors affecting their individual degrees of success are discussed. And finally, those elements and factors found necessary for success in the future are described.

Since technology has not been a pacing factor in direct use development in the U.S., the technical aspects will be only minimally addressed in the paper. The technical aspects are addressed in depth in the published references.

2.0 OVERVIEW OF DIRECT USE GEOTHERMAL PROJECTS IN THE U.S., 1974-1981

Prior to the U.S. Department of Energy (DOE) incentive programs, geothermal, on a commercial scale, was concentrated at the Geysers, north of San Francisco, for power production. Direct use projects were limited to spas and a few small tomato greenhouse operations - most of which were put together by people inexperienced in the greenhouse vegetable raising business and, consequently, most subsequently suffered one or more significant reorganizations and a number of complete business failures. DOE initiated their engineering and economic studies (called PRDAs) in 1975 and their joint funded field experiments (PONs) in 1976. One of the more successful of these programs has been the Susanville Geothermal Heating District. This project started as a community-industry joint effort, research and development funding was made available by DOE, the Bureau of Reclamation and other government entities. (The DOE Geothermal Loan Guarantee Program has been initially inappropriate and subsequently found to be too expensive in front-end costs and calendar time for most direct use projects.) In the 1974-1979 time period, direct use projects were extensively studied by commercial banks, but the immaturity of the resource precluded financing without a federal guaranty. Direct use projects came of age recently when reservoir insurance was made available and, more importantly, when sophisticated private investors found that considerable tax advantage could be obtained through investing in geothermal as an alternative energy, pollution-mitigating natural resource. Hence, in 1980, geothermal direct use came of commercial age with the potential for a broad base of development. The Litchfield Project is a prototype for this type of development.

3.0 FOUR GEOTHERMAL DIRECT USE PROJECTS

The projects are described in chronological order of their initiation. All of the projects were initiated with private industry participation--at least in the project development phase. Federal participation was required for the prototype financing of the first three and was indirectly involved in the "seed" effort that justified private financing of the fourth. Local government was heavily involved in the first project and is an active participant in the fourth project.

3.1 SUSANVILLE GOETHERMAL ENERGY PROJECT

The City of Susanville, California is at 4200 feet (1280m) altitude on the east slope of the High Sierra mountains. Its 7,000 people have an agricultural and forest product-based economy in the rural northeastern part of the state. The core of this project is a fourteen building heating district started in early 1974 as a joint industry-city effort. Being a prototype, the resource was explored by the U.S. Bureau of Reclamation and the principal design and development funds came from the U.S. Department of Energy. A 126-home addition is being funded by the Farmers Home Administration and the Department of Housing and Urban Development. A local non-profit corporation is being established by the community to own, operate and expand the systems. Private developers are being encouraged by the City to develop the commercial and agribusiness uses of energy.

Like many of the hydrothermal resources in the western U.S., the geothermal fluids exist at typically moderate-to-shallow depth 3200 feet (1000m), moderate-to-low temperatures 206°F (370°K) and are suitable for agricultural or potable uses (total dissolved solids of 1000mg/l). In Susanville, the supply well, Susan No. 1, was drilled to 900 feet (274m) with a temperature of 170°F (352°K) at 800gpm (50.0 l/s). The Heating District, at this stage, requires a nominal geothermal flow of 550gpm (35.0 l/s). The transmission lines--supply and return--are principally asbestos-cement pipe. The supply line is insulated. Above ground, for bridge crossings, etc., they are insulated steel. One branch line is polybutylene donated by the Shell Chemical Co. as a demonstration item. Being all retrofits at this stage, peaking and emergency standby energy will be supplied by the existing heating systems in the buildings.

The HUD 126 home addition will utilize an existing 150°F (339°K) hot water well to supply a peak demand of 500 gpm (32.0 l/s). This is in construction at this time, with transmission line options of steel, asbestos-cement or polybutylene, with insulated supply and uninsulated return. The system will be interconnected to a nearby park of commerce by a Farmers Home Administration funded pipeline.

The pipeline routing and principal facilities involved in the primary Heating District are shown in Figure 1.

3.2 MOUNTAIN HOME GEOTHERMAL PROJECT

Mountain Home is a city in south central Idaho, located on the Snake River Basin hydrothermal resource area. In 1973, a fossil fuel exploratory well, Bostic 1A, was drilled to a depth of 9680 feet (2950m). Artesian flow of 1000gpm (63.0 l/s) occurred for a 2 week period. A bottom hole temperature of 370°F (462°K) was measured. This led EMMA, Ltd., a San Francisco investment firm, to seek development of a direct use project. Through a competitive application, DOE funded an engineering and economic study of a large, vertically integrated agricultural complex.

A system of feed production, swine raising, slaughter, potato processing and waste management was selected, based upon market trends, regional practices, available agricultural technology, use of commercial hardware, geothermal resource characteristics, thermal cascade and mass flow considerations, and input from regional agricultural advisors. The complex covers 160 acres (65 ha), (Figure 2); utilizes a peak energy demand of 1.14×10^8 Btu/hr. (1.2×10^{11}J/hr.) from geothermal heat between 300°F (422°K) and 70°F (294°K), (Figure 3); has an installed capital of \$34.4 million; produces 150,000 hogs per year, 136 million lbs. (62 million kg) of processed potatoes per year, and on the order of 7.5×10^5W of continuous power from methane. The methane is produced from livestock and process wastes in a geothermal heat-augmented, anaerobic digestion system. The total effluent from the facility is 100 gpm (6.3 l/s) of water of irrigation quality and 3.5×10^4 lb./yr. (1.6×10^4 kg/yr) of saleable fertilizer. The entire facility has a peak demand of 1000gpm (63.3 l/s) of 300°F (422°K) geothermal fluid.

To reiterate, this was an engineering and economic analysis of an agricultural complex that was to utilize proven technology and commercial hardware.

3.3 KELLEY HOT SPRING AGRICULTURAL CENTER

Kelley Hot Spring is the second largest boiling hot spring in the U.S., flowing at 300 gpm (20 l/s). It is located at 4360 feet (1329m) altitude in south central Modoc County, on State Route 299 in northeastern California. The resource has been extensively explored and there have been two exploration wells drilled to 3200 feet (975m) and 3395 feet (1035m) with bottom hole temperatures on the order of 240°F (390°K). The fluids are of agricultural quality and are used for watering livestock. The Kelley Hot Spring Agricultural Center (KHSAC) complex would require on the order of 1% of the estimated reservoir capacity in thirty years of operation.

The KHSAC complex was conceived in 1977 as a direct use application of the geothermal resources under lease to Geothermal Power Corporation of California. The Project incorporated the results of the Mountain Home Geothermal Project and between

1977 and 1979, field demonstration funds were sought from the DOE. Alturas, the local county seat, was involved only for purposes of permitting.

The core activity is a nominal 1360 sow swine raising complex. A conceptual design was completed and extensive trade studies conducted to select equipment and design features optimized for swine raising in the project area. Subsequently, a preliminary design, up to, but not including, construction drawings, was complcted. At the same time, a very extensive environmental assessment was conducted. This included an archeological field survey that resulted in definition of extensive archeological middens in the area. These would have to be avoided in final design and construction.

The swine raising was planned to be a totally confined operation for producing premium pork, in controlled environment facilities that utilize geothermal direct use energy. The complex would include a feed mill for producing the various feed formulas required for the animals from breeding through gestation, farrowing, nursery, growing and finishing. A barley sprout raising facility was incorporated to produce a green grass constituent for use in the breeding, gestation and lactating feed formulae. The market animals were to be shipped live by truck to slaughter to Modesto, California. A complete waste management facility would include manure collection from all animal raising areas, transport via an enclosed water flush system to a methane anaerobic generator, solids separation, settling ponds and disposition of the surplus agricultural quality water.

The facility would produce over 29,000 marketable hogs/yr at an average weight of 225 lbs. (103kg) each. Methane would be produced at over 1×10^5 ft^3/day (3×10^6 l/day), which would produce about 400KW of electricity. Effluent agricultural quality water would amount to 5gpm (0.34 l/s).

The geothermal system schematic for the complex is shown in the plot plan in Figure 4. Building piping details for space heating are shown in Figure 5.

3.4 LITCHFIELD GEOTHERMAL PROJECT

Litchfield in northern California is located about 16 km east of Susanville and is the site of a medium security, 1200 inmate, State Correctional Center. The Center consumes 750,000 gal. (2840m^3) of oil/yr. for space heating and consumptive hot water. As part of the Susanville project, a geothermal hot water resource was discovered within 2 miles (3 km) of the Center. The City of Susanville acquired the leases for the resource and, as a joint effort with Carson Development Co., initiated project development activities in 1980. The Project includes an energy supply system to the prison with cascading to an adjacent park of commerce and the retrofit of the prison.

This is the first modern geothermal project in the U.S. to be developed as a utility with private financing. Private funds are used to develop the resource; the energy is marketed by a local government entity to a state entity and subsequently to private industry users. Unique institutional agreements had to be reached for this multi-agency-private industry venture. The private developer had to have an agreement with the City that, in turn, acts as the distributor utility and simultaneously that owns the resource rights. The City had to have a sales agreement with a State agency that in turn required close participation of four supporting state agencies. Private financing was arranged through a limited partnership and industrial revenue bonds authorized by the State for a "pollution control" project. State facility financing for the prison retrofit was raised through the legislature in one year instead of the normal three year process. Surprisingly, the Project was developed, financed, had construction design started and a successful well drilled and tested in one year from project start. Other than for some political delays incurred in a tight budget year, this project is a model for future alternative energy projects in California.

The supply well has been drilled to 1400 feet (425m), flow tested to 1500gpm (95 l/s) at 172°F (351°K). It is expected that this resource can be economically used to displace 60+% of the prison fossil fuel consumption. Peak geothermal fluid design flow is nominally 1100gpm (70 l/s) at 170°F (350°K) for the Center.

4.0 STATUS AND UNIQUE FEATURES OF PROJECTS

The author was the lead initiator and either technical director or advisor on the four projects, as well as a participant in similar projects in the west and southern states. Hence, these observations on unique features are relative to a spectrum of direct use projects in the U.S. The unique features are highlighted to identify characteristics that affect the degree and rate of success or lack of success in such projects.

4.1 STATUS

First, the status of the projects as of November, 1981, is as follows:

Susanville: The Heating District is completing construction and subsystem checkout. This project, defined in 1977, is one of few that will complete on schedule and within original allocated funds. The Heating District will go on line in early 1982.

Mountain Home: This engineering and economic study was completed on schedule and within funds. However, as a project, it did not progress beyond the study effort, which was completed February, 1979.

Kelley Hot Spring: This field demonstration completed Phase 1 - Preliminary Design - within funds with the Phase 1 report issued August, 1980. Further work was suspended pending determination of the historical value of the archeological finds in the area.

Litchfield: This project started in 1980 and is entering the hardware stage with a successful supply well and the recent completion of Preliminary Design of the retrofit. The project's final outcome is tied, in part, with the political process of bringing a state facility into use of an alternative form of energy with private investment and local government participation. To date, the Project has progressed extremely well--in fact, better than originally expected by the State agencies involved. Delays have occurred primarily in the political process during a tight budget year.

4.2 PROJECT FEATURES

The unique features of these projects include:

Susanville: The City is a small rural community located in a cold, semi-arid climate. It has a relatively high government employment base and a depressed agricultural and forest product industrial base. However, a spirit of independence and self reliance prevails in the community. The decision for participation in the project was made simply and quickly by the City Council, resulting in a one-page letter of intent in 1974. Since then, the subsequent councils have maintained a very consistent and firm support of the project and its industry team members. This has permitted the industry project developers to consistently commit and follow through on their support of the projects. This local environment, coupled with the dedication and integrity of key city staff persons, has established a strong national and state base of political support. Project leadership has been staffed with persons with persistence, initiative and creativity in management and problem solution, and a strong sense of schedule and accomplishment of cost effective results. Without this total team capacity, the project could have ceased to exist on several occasions from 1974 through 1978.

Mountain Home: This project accomplished what was contracturally required. In fact, is was considered as a good effort. However, the Project, at Mountain Home, did not continue. (The results were picked up in other subsequent projects). The project lead entity was a new, small alternative energy financing company which subsequently has been acquired by a petroleum development company. While having experience in financing, the firm had no experience in agricultural project development and management. Developing such talent or participation from entities experienced in the multiple, very high technology disciplines involved in the $34 million complex became an insurmountable task. The geothermal expertise available in the lead entity applied only to a very small part of the overall project development.

Kelley Hot Spring: The Kelley H.S. project built upon the results of the Mountain Home project. And the Kelley effort started while the Mountain Home project was just completing. Hence, it could not perceive the magnitude of effort rerequired to bring the experienced, high technology talent to bear on a new energy resource and its application to livestock operations. Again, the lead entity was a small firm in the development of geothermal resources. The CEO was an engineer with experience in utilities, but no experience in livestock operations. The original investors committed to a project in 1977 that took until 1979 to go on contract and required another year to produce the preliminary design. Needless to say, the investment environment and the investor targets changed considerably over that time.

Further, the archeological finds became at least a time barrier for further federal or state participation in terms of demonstration project money or financing guaranties.

Litchfield: This project built upon prior work and the existing institutional and political structures for geothermal developments in the City of Susanville. Carson Development Company was selected as a medium-sized, commercial-industrial development firm with a track record of turnkey projects and with a private financing capability for projects of this size. The availability of a slim test hole (by the Bureau of Reclamation), availability of the new reservoir insurance program, the definition and recognition of geothermal direct use as a depletable, alternative energy, non-polluting resource and the attendant tax provisions, the new state-sponsored pollution control industrial revenue bonds, and the state's commitment to cogeneration/alternative energy all contributed to the timely initiation of this project. The meshing of private financing, reservoir insurance and a city-state agreement for long-term alternative energy sales with long-term financing through I.R. bonds is a precedence-setting project that indicates that this resource is a commercially viable opportunity.

Characteristics of the four projects are summarized in Table I. One must recognize that the initiation calendar times and the corresponding stature and maturity of this industry, as well as the con-committent cost of financing, materials and services, tend to preclude absolute comparisons. It is also difficult to compare municipal heating districts with a private business complex. However, in spite of the foregoing, one can observe the potential of geothermal as a competitive resource.

In an overall summary of features of these projects, one can observe that the federal government procurement procedures that had to be used for these supposed seed projects precluded a normal business approach to the programs. The time delays associated with these procurements were completely in discord with normal project investment schedules. This is belatedly being recognized. The success of project completion on time and within funds, once underway, and the relatively accelerated schedule in the Litchfield project, is a result of the unique capability of very talented staff in the federal and state energy offices that permitted a true team approach. This is the exception rather than the rule. The features of the Litchfield project model are obviously a more effective means of accelerating the development and use of the extensive geothermal direct energy resource in the U.S.

5.0 CHARACTERISTICS OF A SUCCESSFUL DIRECT USE PROJECT IN THE U.S.

- First, the project must have a committed (preferably finacially committed) competent "initiator" or "spear carrier" - at least until such projects become more commercially routine.

- The resource and its use must continue to be treated by federal and state taxing agencies on a competitive basis with other natural resources in order to attract the necessary broad base of private investment.

- Direct use resources have their broadest application in the agribusiness and food process sectors of industry. The utilization, in turn, is optimized in the confined, intensive growing or controlled environment applications. And these, in turn, are high technology businesses, requiring staffing with experienced professionals. <u>This is an absolute requirement</u>.

- District heating, especially in the lower population-density western U.S., are economically marginal systems, thus requiring a significant commercial or industrial direct use load to make them attractive for private and commercial financing.

- Geothermal direct use systems and their commercial/industrial applications are economic development projects requiring all of the professional disciplines and expertise required to promote and carry forward a conventional commercial economic development project <u>plus</u> the professional expertise to successfully develop an economical geothermal hot water energy system. This expertise requires an experienced understanding of cost-effective geothermal resource development and cost-effective engineering for geothermal <u>direct use</u> energy distribution systems.

- The lower energy density in a hot water system, relative to other forms of energy transmitted through an equivalent system, precludes the tendency to "over-engineer" pipelines and the other elements of energy supply and distribution systems. Reasonable maintenance and repair must be traded off against the high initial cost of a maintenance-free design.

6.0 REFERENCES

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Longyear, A. B. etal, "Mountain Home Geothermal Project," EMMA/Lahontan, Inc., DOE/ET/28442-1, February, 1979.

Longyear, A. B., Editor, "Kelley Hot Spring Geothermal Project," Geothermal Power Corporation/ Lahontan, Inc., DOE/ET/27041-1, August, 1980.

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TABLE I. FOUR GEOTHERMAL PROJECTS SUMMARY

CHARACTERISTICS	SUSANVILLE HEATING DISTRICT	MOUNTAIN HOME	KELLEY HOT SPRING	LITCHFIELD
Initiation Period	1974 - 1977	1977 - 1978	1977 - 1979	1980
Project Size	4.3×10^{10} Btu/yr. (4.5×10^{13} J/yr.)	6.3×10^{11} Btu/yr. (6.6×10^{14} J/yr.)	9.1×10^{10} Btu/yr. (9.6×10^{13} J/yr.)	6.6×10^{10} Btu/yr. (7.0×10^{13} J/yr.)
Energy Supply System Cost	\$1,800,000 (1)	\$1,450,000 (2)	\$406,000 (2)	\$900,000
Application Cost				
Retrofit	\$600,000 (3)	---	---	\$1,520,000
New Facilities	---	\$33,000,000	\$5,000,000	---
Payback Period		Owner:	Owner:	Energy System:
	7 - 10 yr	3+ yr	3+ yr	9 yr
		Debt:	Debt:	Retrofit:
		12 yr	20 yr	7 yr

(1) Commercial costs without prototype costs

(2) Rework existing well plus backup and reinjection wells

(3) Includes \$300,000 revolving fund for current and future retrofits

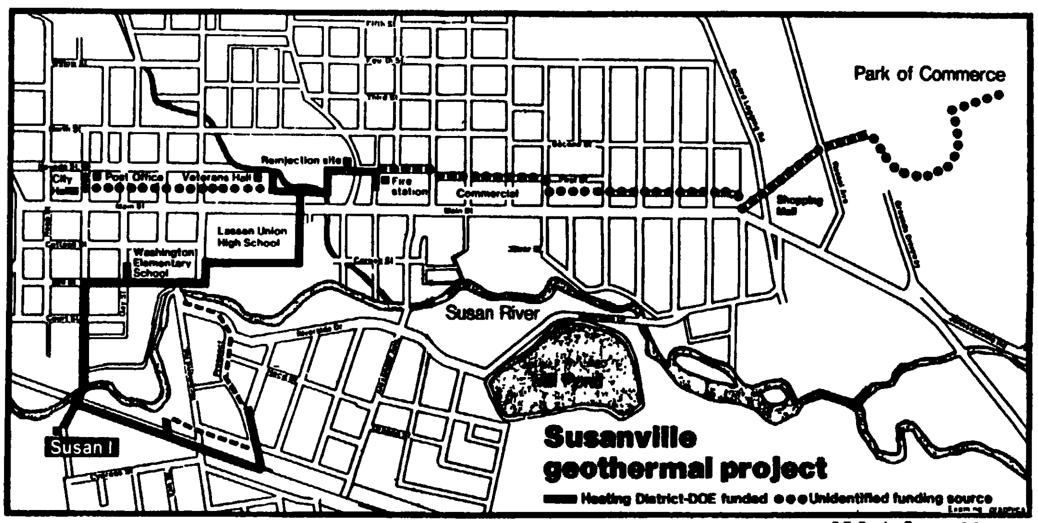

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Figure 1 - Susanville Geothermal Project Pipeline Route

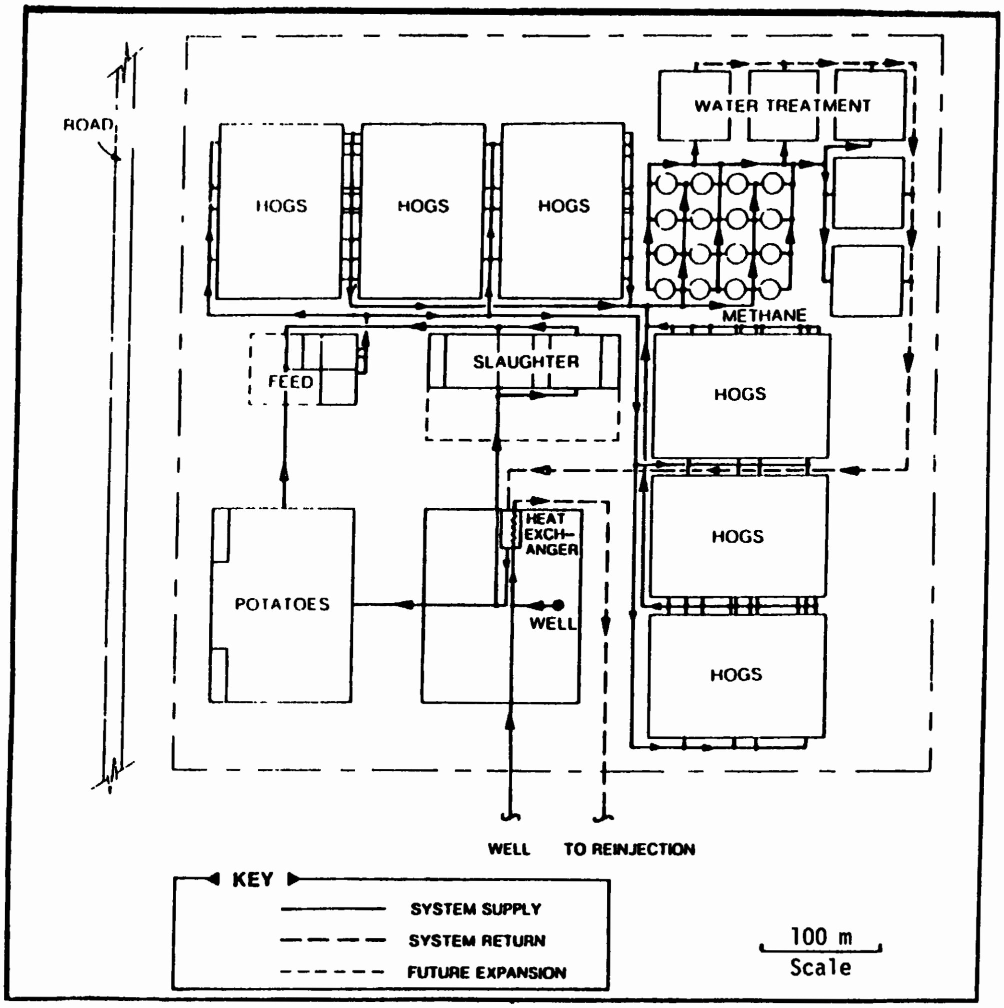

Figure 2 - Mountain Home Geothermal Project Facility and Geothermal System

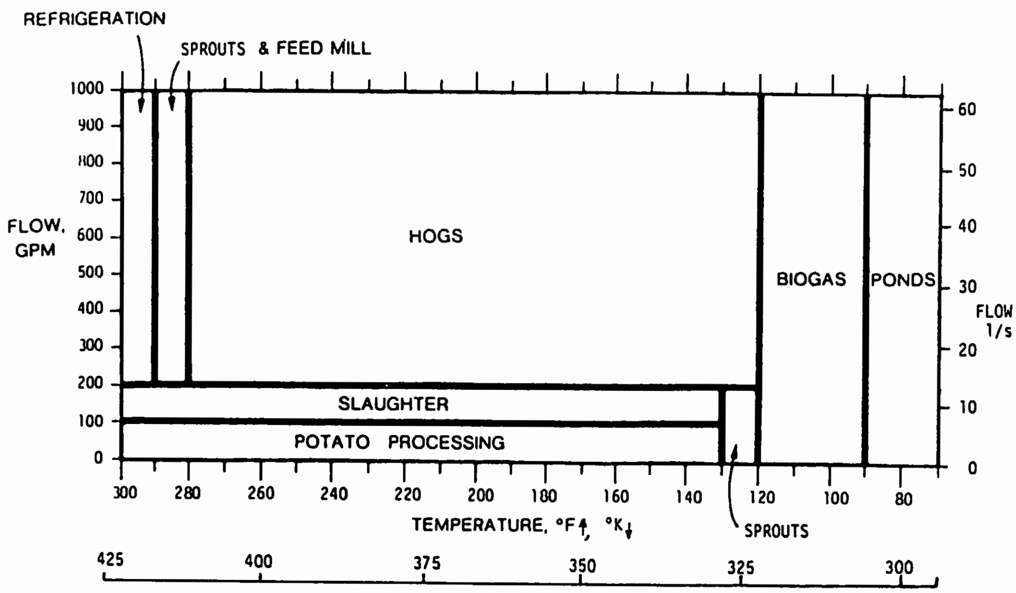

Figure 3 - Mountain Home Geothermal Project Utilization of Geothermal Energy.

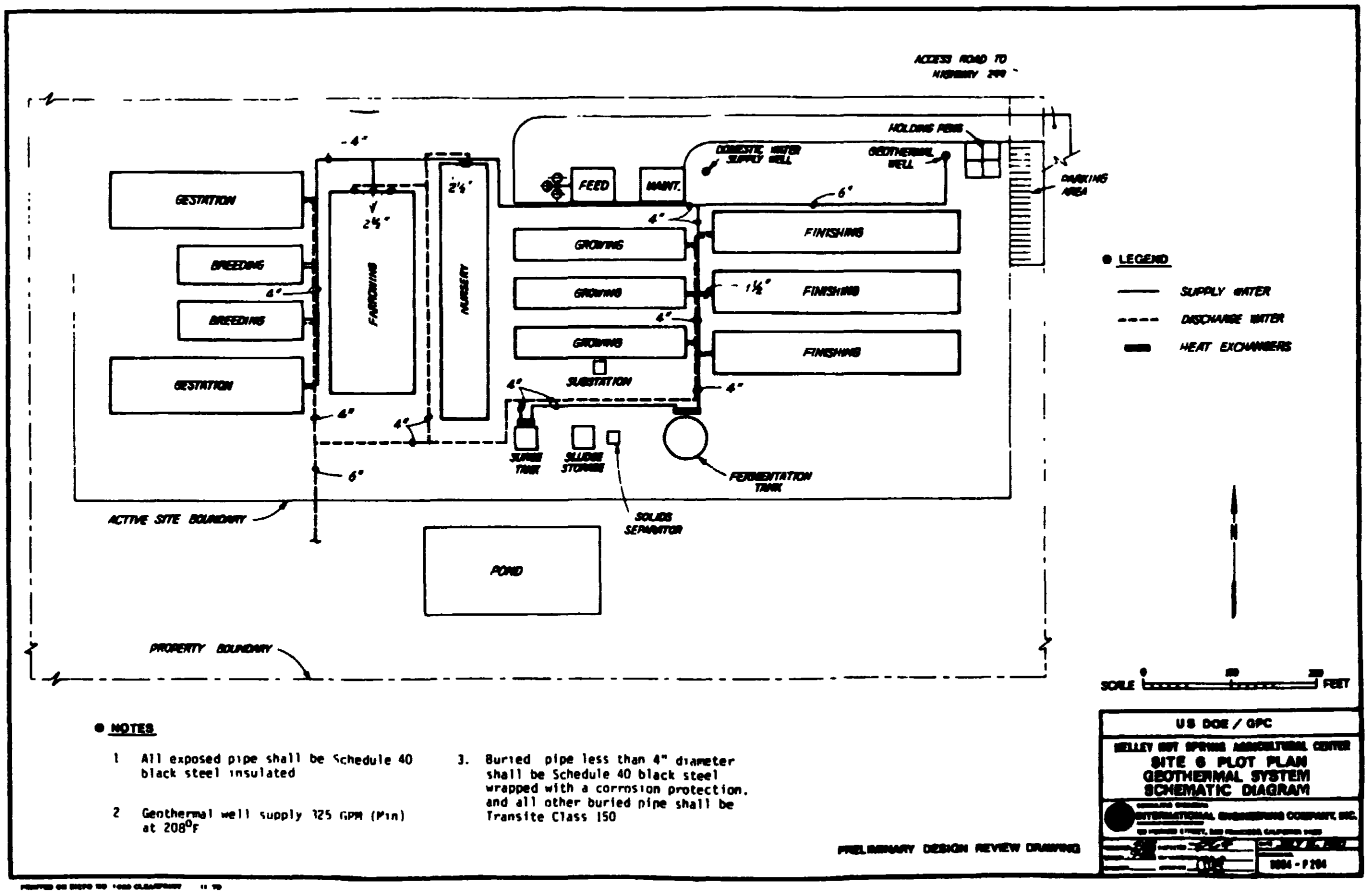

Figure 4 - KHSAC Geothermal System Layout

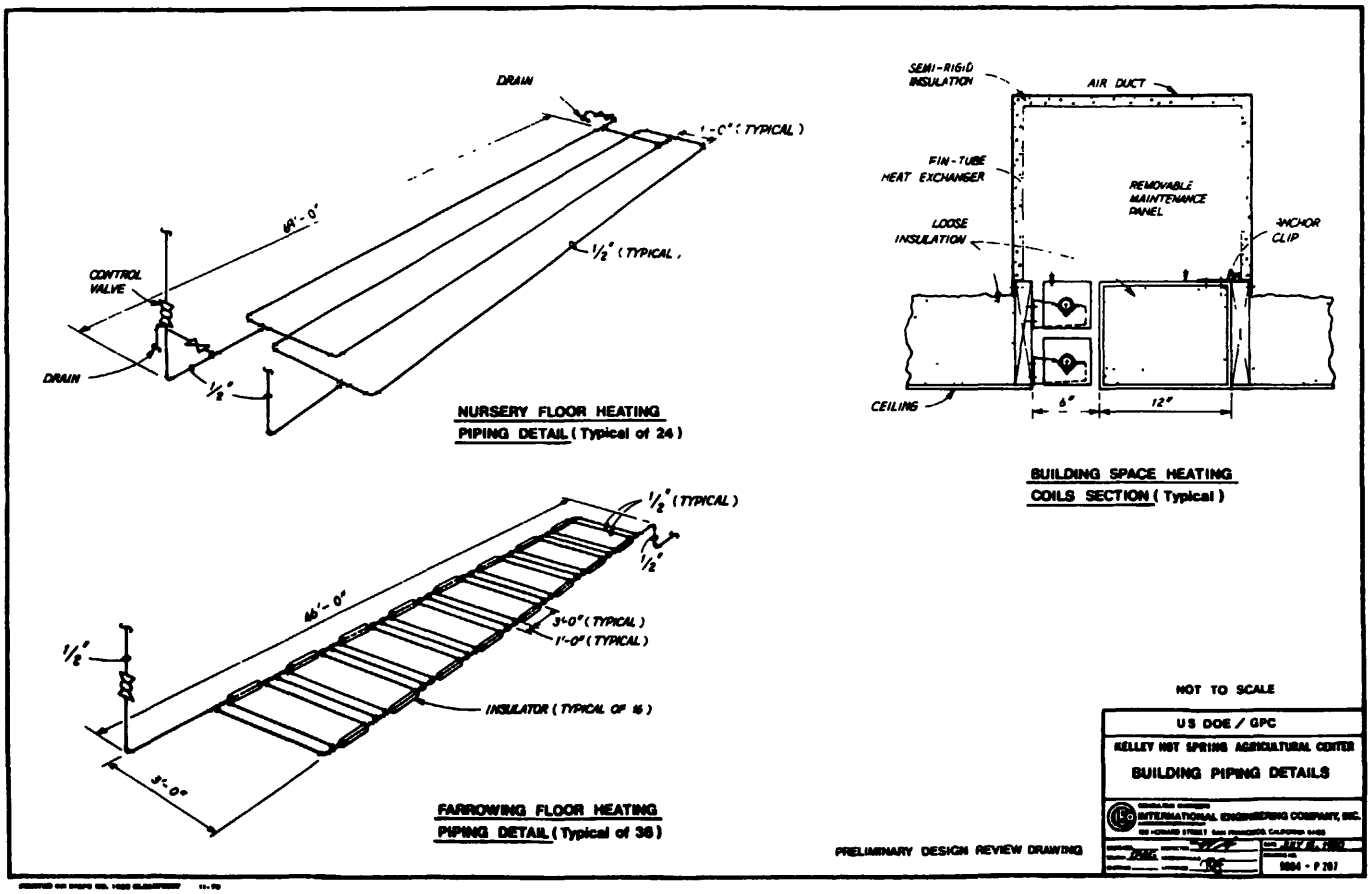

Figure 5 - KHSAC Building Piping Details