Topical Report
GT-27041-4

KELLEY HOT SPRING GEOTHERMAL PROJECT

Kelley Hot Spring Agricultural Center
Conceptual Design

MASTER

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June 1980

Prepared for the Department of Energy
Under Contract DE-AC-03-79ET27041

DISCLAIMER

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INTRODUCTION

This report is intended to document the Conceptual Design of the Kelley Hot Spring Agricultural Center. This effort encompasses the Criteria Development, Trade Studies and Conceptual Design and the preliminary Economic Analysis at the Conceptual Design level. For completeness, the Reservoir Assessment and Environmental Considerations are summarized. The Conceptual Design in this report is documented in accordance with the configuration reported at the Midpoint Review on March 31, 1980. For completeness, those considerations being investigated during the Preliminary Design effort are summarized at the end of this report.

The Kelley Hot Spring Agricultural Center was conceived in 1977 as a direct use application of the geothermal resources under lease to Geothermal Power Corporation in southern Modoc County, California. Between that time and the time of contracting in September, 1979, the concept evolved and incorporated the results of the Mountain Home Geothermal Project[65]. It should be noted that the Project is a phased program and that the Phase I effort encompasses only the design and analysis activities.

The proposed core activitiy in the KHSAC is a nominal 1,200 sow swine raising complex. The swine raising is to be a totally confined operation for producing premium pork in controlled environment facilities that utilize geothermal energy. The complex will include a feedmill for producing the various feed formulae required for the animals from breeding through gestation, farrowing, nursery, growing and finishing. The market animals are shipped live by truck to slaughter in Modesto, California. A complete waste management facility will include manure collection from all raising areas, transport via a water flush system to methane (biogas) generators, manure separation, settling ponds and disposition of the surplus agricultural quality water. The design is based upon the best commercial practices in confined swine raising in the

U.S. today. The most unique feature of the facility is the utilization of geothermal hot water heat for space heating and process energy throughout the complex. For the Conceptual Design effort, Site 1 (Figure 2-1) was selected as the site for the swine raising complex. In that an Archeological Survey was underway at the time the site selection had to be made, the final site selection will have to be made after archeological clearance is given for one or more of the candidate sites.

This report has been compiled from contributions as submitted by the Team Members. The Geothermal Power Corporation's Kelley Hot Spring Project Team Members are:

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CHAPTER 1 -- PROJECT OVERVIEW

Summary

The technical effort in Phase I effectively commenced on the first of December, 1979. In December, it was discovered that additional environmental work would be required in addition to the normal investigations associated with the environmental assessment activities. This deferred the formal selection of a facility site and was a major factor in preventing further well clean-out work that had been started in the GRI-1 well near Kelley Hot Spring. The early well clean-out activity was to provide engineering data to assist focusing the design effort.

Through proper design of the facility, potential environmental impacts have been avoided. An initial concern was that a large facility, with a major influx of new employees from outside of the area, could result in crowding in the Kindergarten through Ninth Grade in the southern Modoc County school system. However, with the projected 17 person employment level of the 1,200 sow complex, this is not expected to be a problem.

The resources are described in detail in the Drill Site Selection and Justification Report[58]. In summary, extensive prior exploration data have included: reconnaissance level geologic mapping and gravity surveys, an aeromagnetic survey, at least 30 square miles of electrical resistivity surveys, a reconnaissance-type telluric survey, a ground noise and micro-earthquake survey, geochemical analyses, and extensive temperature gradient surveys over a 15 square mile area. Two exploration wells have been drilled to depths in the range of 3,200 feet with similar bottom hole temperatures and lithology. The GRI-1 well, originally drilled in 1969, was re-entered early in Phase I with the intent to clean-out, reaffirm bottom hole temperature, make chemical analyses, and, if possible, achieve flow in the well. After initial clean-out, a probe lowered in the hole encountered a bridging obstruction. It was determined at this point, due to the required environmental studies, to defer further field activity until Phase II.

The engineering effort was divided into three overlapping and interconnecting activities: Criteria Development, Trade Studies, and Conceptual Design. An extensive field survey was made to review commercial swine raising enterprises in the United States: review of research facilities and discussions with swine raising equipment suppliers, methane production facilities and feedmill operations. From this survey and a review of published literature, fundamental design criteria were established, evaluated and applications criteria developed. Final selection of criteria was made in conjunction with the Trade Studies. Engineering options were evaluated through Trade Studies, with final selections decided on the basis of the economic criteria for the Project. Conceptual Design was conducted utilizing the aforementioned criteria and the results of the Trade Studies.

Based upon the emerging Conceptual Design, construction planning was initiated. Costs were obtained through quotes, catalogs and authoritative estimating sources. Cost estimating was conducted to a greater depth than would normally be required for a Conceptual Design in order to prepare a detailed backup for the Phase II proposal. Using data excerpted from the Engineering and Construction Plan Studies, an economic assessment of the facility was prepared.

These studies were all completed at the end of March. In that the economic assessment could not be made until the other studies were completed, very little time remained to make an overall assessment of the results. Therefore, it became evident just prior to the Midpoint Review that capital costs of the facility were deemed excessive. Consequently, some significant changes in approach to capital facility design were initiated through the Conceptual Design effort. Concurrently, evaluation was made of the overall level of pork production, methods of producing animal feeds and the concept of power cogeneration through the sale of methane to the local utility, along with consideration of alternative means of applying geothermal energy. Even though these activities occurred after the completion of Conceptual Design and Midpoint Review, the improvements in the economics of the overall concept are significant and therefore included in summary form as Chapter 7 in this report. These concepts are to be considered in the definition of the Preliminary Design.

Findings and Conclusions

1. Modern confined swine raising techniques, at a nominal 1,200 sow complex size, can efficiently utilize a hydrothermal, direct-energy geothermal resource. The 1,200 sow size was chosen to be large enough to utilize the output of a commercial feedmill, which is essential to the economics of swine raising in other than the mid-west. Further, economic methane generation facilities require a facility of at least 500-600 sow operation[9].

2. The waste management system, utilizing methane generation, has been a focal point for in-depth engineering analysis and design, economic analysis and a major consideration for operational permitting. In this project, consideration of a form of cogeneration with the local utility. developed from the waste management studies. This is being explored further in the ongoing Preliminary Design. The use of moderate temperature geothermal heat was found essential to the economic generation of methane. It was found that sales of the methane to the utility, rather than generating power in-plant would result in more profitability, less technical risk and less operational complexity. These are preliminary findings (see Chapter 7).

3. The purifying action of this methane generation greatly simplyfies permitting.

4. It has been found that a field experiment with phased programming and a descrete design effort precludes consideration of some novel low-cost family-constructed and operated facilities. However, the totally confined (capital-intensive) concepts considered herein represent the trends in swine raising in the U.S. and reflect technology developed and utilized extensively in the Scandinavian countries, Western and Eastern Europe and Canada. This type of facility is utilized to produce premium fresh pork with a maximum in quality, productivity and animal health.

5. The operational philosophy utilized greatly affects and in many cases controls final design direction. The operational methodology upon which this design is based encompasses these major features:

- Total confinement
- Maximum automation and minimum labor for uniform productivity, quality and animal health
- Concentration of labor in the areas of productivity, preventive health practices, and feed production efficiencies
- Breeding and weaning cycle timing and genetics management
- Maximization of feed conversion efficiencies through environmental control
- Cost-effective feed-production practices.
- Minimizing animal stress through optimum animal management practices.

CHAPTER 2 -- ENVIRONMENTAL CONSIDERATIONS

I. SUMMARY OF ENVIRONMENTAL ASSESSMENT

An environmental assessment of the general area of Kelley Hot Spring for the location and operation of an agricultural complex based upon confined raising of hogs was undertaken during the winter of 1979 - 1980. Initial site reconnaissance established six areas acceptable for development, (Figure 2-1). These sites were carefully examined by Mr. Frank Metcalfe for possible purchase. The most promising site (site 3) was appraised by a professional real estate appraiser. Negotiations were begun with the land owner. In addition negotiations have begun with the land owner on site 6. Careful examination of terrain, access, water availability and land acquisitions have established a potential project site on which site 6 would support the geothermal supply well (most favorable from the standpoint of heat probes) and a pipeline access route that crosses to a plant site on site 3, (figure 2-3).

The one most critical constraint environmentally encountered was water quality control in the production of offensive odors arising from the large concentration of hogs. These problems are effectively mitigated by the inclusion of three important features in the design of the complex: (1) a waste collection and transport system; (2) methane generation; and (3) water reclamation.

All animal pens are cleaned several times each day by flushing water into gutters and into a sewer pipe system leading directly into the methane generation plant. This geothermally heated, anaerobic digestion continuous flow system is dependent on thermophilic bacteria that effectively reduce all organic wastes to methane, carbon dioxide, water and minor amounts of other odorless and nontoxic compounds. Inert solids are reclaimed from the ponding system into which digestive materials flow. A system of ponds purifies the water so that it can be recycled through a portion of the waste removal system.

Methane generated is piped to the boundary of the property and delivered to the local utility for their use in an engine generator set to produce electricity that would be put into the electric distribution system. This distribution system would furnish the power to the facility. Discussions of co-generation have been initiated with the Surprise Valley Rural Electrical Cooperative.

Geothermal fluids, after heat extraction, will be used in the makeup water for the methane generation system and for flushing of the farrowing and nursery buildings. The purity of the water permits release of any surplus effluents into the existing overland water drainage systems. Excess water collected in the waste management system will be spray-irrigated onto lands controlled by the operator so that no discharges of effluent waste waters will occur.

A separate system for potable water will provide clean, pure water for domestic purposes, as well as a drinking water supply for the hogs.

Geothermal water is sufficiently low in dissolved solids and environmentally sensitive substances that it can be used as the water source for waste management. Elements such as boron and florine will be removed in the sediments of the ponds or the methane generators.

The methane digestor completely removes objectionable odors of hog waste in the anaerobic process which is entirely a closed system. Discharge waters are free of odors. The methane process is so effective that initial ponds have no odor characteristic of the common aerated tertiary treatment systems of similar non-geothermal operations.

The third area of environmental concern, while minor in impact in the 1,200 sow complex, is the potential influx of new people and their demands on the school system. If the majority of persons required to operate the complex (17) are from the indigenous population or live mostly outside the Canby area, little impact will be felt. It is the intent of this Project to hire as many personnel as possible, including training of such personnel, from the immediate area in southern Modoc County. If additional personnel must be employed from outside the area and they are housed in the plant vicinity, some crowding will occur in the K-9 grade schools which are at capacity now.

Other areas investigated in the course of this assessment were: geology and seismicity, hydrology, soils, flora and fauna, air quality, aesthetics, health and safety, land use conflicts, socio-economics and spill prevention. No adverse impact or impact of cumulative proportion leading to an adverse impact were detected. A very positive socio-economic impact can be expected through increased job opportunities, local cash flow, and increased tax revenues at little or moderate cost to the County.

II. FACTORS AFFECTING DESIGN, OPERATIONS AND ECONOMICS

The factors affecting design, operations and economics, from an environmental standpoint, are principally associated with the waste management system. It was found that conventional anaerobic ponds would be extensive in land coverage, and aerobic ponds would require less area but still more than that required for the methane system. These conventional pond systems would not sterilize the effluent water and hence could spread desease if the water is recycled through the buildings. Hence, additional fresh water would be required. The cognizant Regional Water Quality Control Board expressed doubt that a conventional ponding system of the proposed size could be permitted. In any case, there are instances in Europe, and the U.S. where conventional ponding systems have been shut down. These factors caused the consideration of the methane system. Though the methane system tends to be slightly more costly, ($100,000. increase over conventional ponds) it can be permitted, is more healthy, reduces odors to a minimum, reduces fresh water requirements and may recover the capital difference in one year if the methane is sold at current natural gas prices. Also, there is a possibility that it could offer cogeneration tax advantages.

Though not directly considered, the limitations in school space is in consort with the design philosophy of minimizing the number of full-time Kelley Hot Springs Agricultural Center employees.

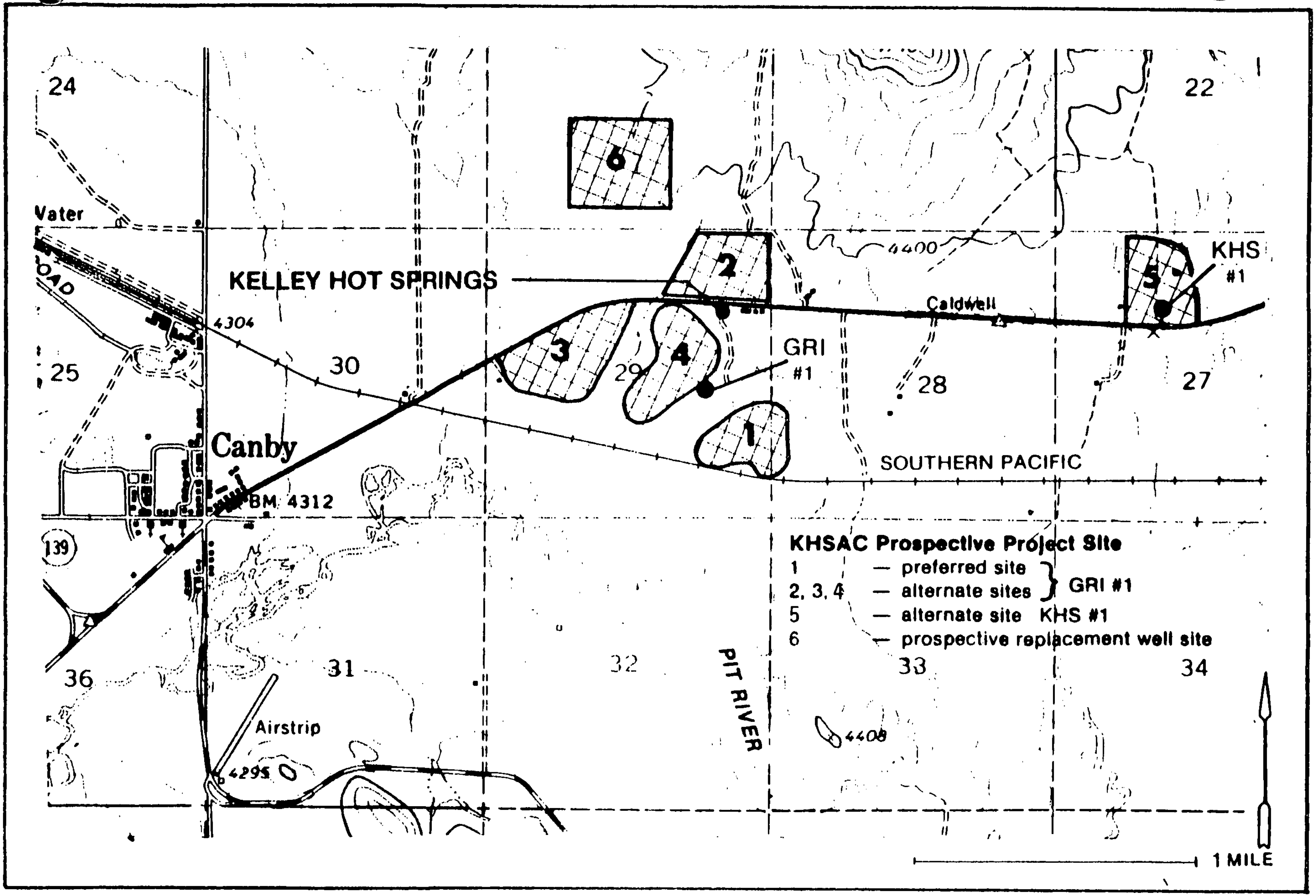

Figure 2-1. Kelley Hot Spring Agricultural Center - Candidate Facility Sites.
Site 1 was utilized for Conceptual Design, and Sites 6 and 3 are being considered during Preliminary Design.

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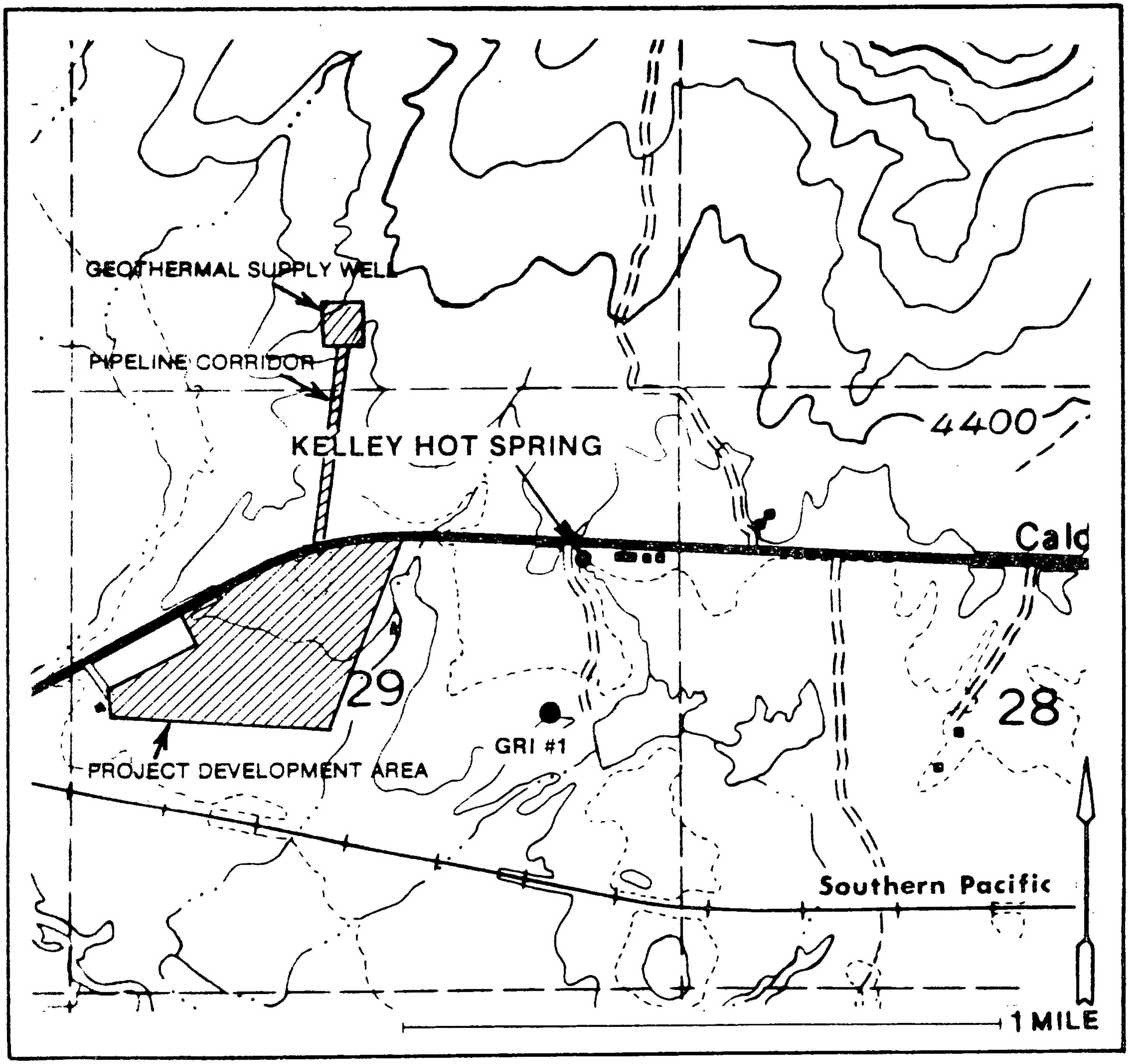


Figure 2-3. Approach to use of Site 3 with well located on Site 6. This is being evaluated during Preliminary Design.

CHAPTER 3 -- GEOTHERMAL RESERVOIR ASSESSMENT

The following information is excerpted from the Drill Site Selection and Justification Report[58].

Resource Description and Prior Exploration

The Warm Springs Valley of the Pit River, a part of the Modoc Plateau province, is highlighted by Kelley Hot Spring, flowing at 96°C (205°F) at 320 gpm from a single orifice. The flow is at boiling for the elevation (4,360 feet). The Pit River Valley contains a thin veneer of stream-channel alluvium, flanked by terrace deposits and older and younger fan deposits. Beneath are sedimentary and tuffacious beds of the Alturas Formation, while overlying on higher hills are basalt flows of Pliocene and Pleistocene age. The principal fault of the region is the northwest-trending Likely Fault, passing about one mile west of Kelley Hot Spring, which appears to be a significant regional boundary.

Extensive exploration data include: Reconnaissance-level geologic mapping and gravity surveys, an aeromagnetic survey, at least 30 square miles of electrical resistivity surveys, a reconnaissance-type telluric survey, a ground-noise and micro-earthquake survey, geochemical analyses, and extensive temperature gradient surveys over a 15 square mile area with 2.5 - 3 HFU across the area and a high of over 20 HFU in certain holes.

Two exploration wells have been drilled. In 1969, Geothermal Resources International drilled the GRI-1 well to 3,200 feet, 1/4 mile south of the spring, with a maximum temperature of 110°C (230°F) at bottom. In 1974, Geothermal Power Corporation drilled the Kelley Hot Spring #1 well to 3,396 feet approximately 1-1/2 miles due east of the GRI-1 well. The maximum bottom hole temperature of 115°C (239°F) was measured in 1977 in KHS-1. The lithology of the two wells is similar. See Figure 2-1 for the well locations.

Reservoir Field Activity

In November of 1979, Geothermal Power Corporation began rework operations on this well, which was to be the supply well for the facility. The operations performed are summarized in the California Division of Oil and Gas Well History and Summary Report contained in the appendix of Reference 58. After rework operations were complete, a flow test was performed. The resultant flow rate proved to be inadequate for the facility. We feel that the main reason for not obtaining the expected flow rate is due to the sealing off of the producing zones during the initial drilling of the well. From the lithologoic log of the initial well, zones of lost circulation were encountered below 1,600 feet. Lost circulation material was added to the drilling fluids in an attempt to seal off these zones. We believe that this material, together with the mud cake formed on the well-bore wall during drilling, has effectively blocked the producing zones of the reservoir. Rather than incur the additional expense of further rework involving a well stimulation program which may not yield the expected flow rates after completion, it was decided to use the proposed standby well as the supply well. Funding for this well has been allocated in the original proposal and which is planned to be drilled in Phase II of the program.

Another mitigating circumstance for not continuing with further rework of GRI-1 well is that this site is in an archeologically sensitive area. During rework operation, it was discovered that one of the largest Indian middens in North America encompasses the area surrounding the GRI-1 well and extends north across Highway 299 for about 200 meters and south for about 800 meters.

Resource Assessment

The proven reserve described is a body of hot water at over 240°F in a porous reservoir between about 1,600 to 3,400 feet depth covering an area of several square miles. A conservative estimate of the resource assuming an areal extent of four square miles, thickness of 2,000 feet, a reservoir temperature of 240°F, a disbursement temperature (of waste fluid) of 80°F, and volumetric specific heat of 0.6 Calories/cm^3/°C is 3.37×10^{17} Calories of gross heat reserve in the reservoir. Log analysis data from KHS-1 indicate an average porosity of the order of 20 percent in the reservoir. This gives a minimum estimate of the heat in the fluid only of 6.73×10^{16} Calories. However, more heat will be available by conduction from the rock matrix and recharge from a deeper heat source by peripheral recharge into the reservoir.

The expected utilization rate of the hot water at 208°F is less than 325 gallons per minute. Assuming a disbursement temperature of 95°F, the gross energy production rate will be 8.1 X 10^{11} Btu per year. Over a 30 year plant life, the total resource required is 6.12 X 10^{14} Calories, which is less than 1.0 percent of the heat reserved in the fluid alone, as described before. Thus, the reservoir within the drilled depth has sufficient reserve to supply a plant many times the size of the proposed demonstration plant.

Chemically, the fluid is believed to be mildly saline. Measurements of specific conductivity made in KHS-1 at three depths were remarkably similar to that made in the boiling pool of Kelley Hot Spring. Therefore, the chemistry of Kelley Hot Spring is a reasonable model for deeper fluids; total dissolved solids of perhaps 1,000 ppm or slightly higher, with Na the principal cation, and with SO_4 followed in abundance by Cl and HCO_3 amongst the anions. F and B concentrations are about 2 and 4 ppm respectively. The pH is mildly alkaline. SiO_2 concentration is about 100 ppm. From this, no severe scaling or corrosion problems are anticipated, and no problems of toxicity are expected.

Supply Well Development Plan

Proposed Location of Supply Well

The supply well for Kelley Hot Spring Agricultural Center is proposed for Site Location No. 6 (see Map 1). The bases for selecting this location are as follows:

1. Site No 6. is favorably positioned with respect to the areal extent of the modeled reservoir.
2. Site No. 6 has proximity to facility buildings, thereby reducing the distance of pipeline required.
3. Site No. 6 has already been cleared archeologically.

Well Characteristics

The criteria for the design of the supply well included the geologic information used to formulate the interpretation of the geothermal regime together with the engineering design requirements for the agricultural center. The expected well characteristics are shown in Table 3-1. These include drilling to 3,400 feet, where a flow of 325 gallons per minute is

TABLE 3-1

WELL CHARACTERISTICS

	KELLEY HOT SPRING	GRI #1 WELL	KHS #1 WELL	SUPPLY WELL EXPECTED CHARACTERISTICS
TEMPERATURE (°C)	96 (205°F)	110 (230°F)	115 (240°F)	115 (240°F)
DEPTH TO BOTTOM (FT.)	---	3206	3396	3400
FLOW RATE (GPM)	325	NO DATA	NO DATA	325
CASING PROGRAM	---	10 3/4" TO 314' 8 5/8" TO 308' 7" 308' TO 1511'	10 3/4" TO 545' OPEN TO BOTTOM	20" to 40' 13 3/8" TO 500' 9 5/8" TO 1800'

expected at a temperature of 115°C (240°F). The casing program calls for diameters ranging from 20 inches near the surface to 9-5/8 inches from 500 feet to 1,800 feet depth.

Test Plan

A seven day flow test is programmed to determine the sustained yield and temperature of the thermal fluids from the supply well. As the factors which govern the yield of any well are the properties of the natural system and characteristics of the well itself, it is proposed to measure them by using established techniques from ground water hydrology. To test the properties of the natural system including mean hydraulic conductivity, storativity, and boundaries, a 10,000-minute constant-rate pumping test with observation wells is proposed. To test the characteristics of the wells, a short (2-1/2 hour) five increment, step-test is proposed. The step-test will be made first to determine the optimum rate for the constant-rate test.

CHAPTER 4 -- ENGINEERING

I. CRITERIA

A. Resource and Site Criteria - The conceptual design described herein is based on Site 1 as identified in Topical Report GT-27041-2.

The conceptual design has been based on an assumed geothermal supply well flow of 325 gallons per minute (gpm) at 208^{O}F at the wellhead. Water chemistry has been assumed to not present any major problems in operation of the Kelley Hot Springs Agricultural Center (KHSAC) although it is assumed not suitable for domestic use. The PH is assumed to be between 7.4 and 8.6, (Kelley Hot Spring measurements).

Climatic design conditions are based on recommendations of the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) for Alturas, the nearest listed town. Alturas' elevation is 4365 feet above sea level, nominally the same as that of the KHSAC. The climatic design conditions used are the so-called 2½% limits and are: -2^{O}F Dry Bulb (DB) for heating (occurs 2½% or less of the time during December, January, and February); and 93^{O}F DB and 64^{O}F Wet Bulb (WB) for cooling (occurs 2½% or less of the time during June through September). (Reference 4).

The site is relatively level and exposed to strong winds. The Alturas Public Works Department (PWD) recommends a wind loading criterion of 15 pounds/square foot (psf) and advises use of 20 psf.

Based on National Oceanographic and Atmospheric Agency (NOAA) data for Alturas, annual total precipitation is 13.0 inches and annual snowfall is 40.1 inches. The Alturas PWD recommends a snow loading criterion of 30 psf.

The footing depth criterion of 18 inches below grade is also based on Alturas PWD information.

B. Agriscience Criteria

1. Swine Production - Swine production criteria result from the management plan summarized in Table 4-1 below.

TABLE 4-1

SWINE PRODUCTION MANAGEMENT

Item	Plan
Average live and weaned births per farrowing	9.0
Farrowings per sow per year	2.4
Number of breeding sows	1,200
Marketable hogs per year	25,920
Average market weight per hog	228 pounds
Total market weight of hogs per year	5,909,760 pounds

National averages for current practices range from 8.5 to 9.4 average live and weaned births per farrowing (References 94, 51*, 64* 87*); average farrowings per sow per year range from 2.0 to 2.56 (References 15, 19, 23, 33, 94, 51*, 64*, 87*).

2. Building Size and Shape - The sizes and shapes of swine buildings for this 1200 breeding sow complex are chiefly based on the following criteria.

Breeding should be designed to: maximize boar/sow proximity to maximize heat cycle detection, insemination, and conception; maximize operator visual contact with animals; and minimize animal movement.

Gestation buildings require: maximized animal density allowing sow lounging capability; and feeding to eliminate boss sow type pecking order.

Farrowing building layout must allow for: standardized pen equipment; pen scheduling flexibility; piglet heating and separate sow heating.

disease control, sanitation, and isolation capabilities; and specialized air movement considerations.

Nursery buildings should be designed to: utilize standardized pen equipment; provide floor heating; provide ease of sanitation; and maximize operator visual contact with the animals.

Growing and finishing building layouts require: automated drop feeding; minimization of operating personnel; maximum operator observational capability, particularly during feeding; maximum animal density in standardized pens; and design for dunging capability to maximize cleanliness.

Table 4-2 following summarizes current national design criteria on a square foot per animal basis: (References 33, 94, 95, 51*, 64*).

TABLE 4-2

CURRENT ANIMAL SPACE CRITERIA

Building	Square Feet/Animal
Breeding	11.5 - 13.0
Gestation	25 - 30
Farrowing (per sow & litter)	35
Nursery	2.25 - 3.25
Growing	4.25 - 4.5
Finishing	7.2 - 8.0

3. Feed Distribution - Feed distribution is to be automated within the buildings in order to: maximize production with minimum social stress; maximize animal observation with minimum labor; minimize waste; promote even animal weights; and optimize health and sanitation practices.

C. Civil, Electrical, and Mechanical Engineering Criteria

1. Heating and Cooling - A key consideration in KHSAC design

is the range of design temperatures for the buildings in heating and cooling modes. Table 4-3 summarizes these temperatures, a result of combining agriscience and engineering criteria. (References 3, 23, 73, 4, 36, 65*, 91).

TABLE 4-3

HEATING AND COOLING TEMPERATURES

Building	Temperatures, ^{o}F DB Heating	Cooling
Breeding	65±5	75±5
Gestation	65±5	75±5
Farrowing	65±5	80±5
Nursery	73±3	77±3
Growing	65±5	80±5
Finishing	65±5	80±5
Feed Activities	65±5	80±5
Support Facilities	65±5	80±5

2. <u>Building Classification and Codes</u> - Buildings are classified as agricultural under Uniform Building Code (UBC) rules. California's Energy Conservation Code (Title 24) does not apply to agricultural buildings.

3. <u>Building Access</u> - Reasonable access to all buildings for fire fighting and maintenance dictated that the structures be spaced 20 feet apart in directions perpendicular to product flow and 30 feet apart in directions parallel to product flow. The 20 foot separation minimum also precludes fan interferences between buildings, an important health consideration.

4. <u>Building Construction Features</u> - Design of the buildings will be normal commercial practice for 20-year life as a minimum.

Interior surfaces of animal enclosures are to be smooth-finished with no destructible protrusions below 6 feet from the floor (where animals would have a tendency to destroy objects).

Inside surfaces of the farrowing building shall be impervious to water.

All building plywood, if used, is to be marine type to with-stand washdowns.

Flytraps and screens on exhaust openings are not required if negative pressure system is used. Screens are required on air inlets.

Flexible electrical cable use inside the buildings is acceptable.

Each building will require 480 volt, 3-phase power and 110 volt AC power.

5. Lighting - Lighting levels for the project are: 30 foot-candles (F.C.) in the gestation building, 20 F.C. in all other buildings, and 1/10 F.C. for outside areas.

6. Power Supply - Power generation/supply modes will be transferred manually - automatic switching is not required.

7. Employee Facilities - Total employees at site will be 17 operating on 2 shifts per day, with only one or two persons on the third shift. Showers and toilets for both sexes will be provided.

Human waste disposal will be by septic tank with leach field per local codes.

8. Swine Waste Management - Swine manure is to be used in the production of methane gas and saleable fertilizer using a biogas generation subsystem.

9. Emergency Backup - An engine-generator set will be used as standby power in case of main power supply failure. This standby power will be manually switched to provide power for critical functions.

10. Site Facilities - Site will utilize security wire mesh fencing 6 feet high with top strands of barbed wire.

Visitors facilities are not required. KHSAC is to be closed to the general public for sanitation and disease control.

Walkways between buildings for swine traffic will utilize deicing.

D. Economic Criteria

The design should be in accord with normal commercial practice.

The economic analyses (Chapter 6) should consider: rate of return on owner's internal cash flow; rate of return on assets and equity after depreciation, salaries, and all expenses and costs; and land valuation of $750 per acre for acquisition.

II. CRITERIA APPLICATIONS

A. Agriscience

Table 4-4 following summarizes the design parameters (applications) resulting from the agriscience criteria and published data on swine production. These parameters are for a 1200 breeding sow complex.

TABLE 4-4

AGRISCIENCE CRITERIA APPLICATIONS

Building	Number of Buildings	Total Population Design	Total Population Operational	Weeks in Building	Average Weight, Pounds
Breeding	2	400	400	6	350
Gestation	2	944	944	11	325
Farrowing	1	2344 252	2016 piglets 244 sows	4 4	9 360
Nursery	1	4224	4032	5	30
Growing	3	4092	4032	7	85
Finishing	3	4080	4032	7	175*

* average market weight is 228 pounds.

B. Civil, Electrical, and Mechanical Engineering

1. Heating and Cooling - The application of design dry bulb temperatures results in the following minimum air change requirements to preclude building inside moisture buildup exceeding 75 percent relative humidity:

- heating - 8 minutes per building air change
- cooling - 1½ minutes per building air change except for feed and support buildings which will be gravity ventilated.

The air change requirements are likely to require adjustments for final design values to preclude excess humidity buildup in the heating mode and to match total building heat gains in the cooling mode.

Air flow will be down from longitudinal plenums in the ceilings and will be controlled for temperature and volume.

Floor heating will be provided for piglets in farrowing and nursery buildings.

2. Building Features - The following are direct applications of criteria regarding animal building construction features:

- structural roof and walls - based on trade study results in section III B 2.
- floors - brush finish concrete throughout to prevent slipping except smooth trowel finish concrete in farrowing creep area to prevent piglet abrasion
- walls - smooth finish with no protrusions below 6-foot height; washable walls in farrowing and nursery
- pens - to be based on trade study results
- manure collection - slotted floors over gutters
- gutters - flat across with gradual slope lengthwise for drainage and with radii at vertical intersections.

3. Site Facilities - Exterior walkways are to be rough finish concrete with deicing.

III. TRADE STUDIES

A. Agriscience

1. Introduction - The reader should note that, besides cost, operational practices are the main determinant of agriscience trade study outcomes. The scopes and methodoligies of agriscience trades are discussed as applicable in the following III.A.1. subsections; results are discussed in subsection III.C. The selected options are underlined for reference.

2. Gutter Type - Three types of gutter systems were compared: pit under slats; open flush gutter; and flush gutter under slats.

The pit under slats system is subject to manure buildup between labor intensive cleanings that results in gas buildup and threats to health and sanitation. This method requires more gutter space than the other alternatives.

The open flush gutter system, while the least expensive alternative, is the worst case for animal health as there is excess animal exposure to manure through wallowing, with consequent exposure to herd cross-contamination.

The flush gutter under slats system is best from health, sanitation, and operational efficiency standpoints. Of the gutter alternatives, the flush gutter under slats, results in the smallest sized and lowest gas and humidity buildups.

3. Slat Material - Materials considered were polyvinyl chloride (PVC), concrete, aligned fiber composites, and stainless steel. PVC slats have no commercial record of lasting performance.

Concrete slats are relatively difficult to install and maintain and are easily eroded in practice.

Aligned fiber composites have a proven commercial record, are easily sanitized and replaced, are sold with a 5-year warranty, and maintain surface finish such that animal defecation in the dunging area is maximized.

Stainless steel slats, while strong per unit weight, are expensive, have poor surface finish, and feel cold to hogs. Typically, they are only used in farrowing when used at all.

4. Aquaculture - The decision to not include this option was excluded by direction.

5. Feed Source - The cost of milling feed on site from purchased ingredients was compared to purchase of commercially formulated feed. Milling on site indicated a 17-22% cost saving over feed purchase. The actual saving is a function of raw material availability and cost, transportation cost, equipment sizing, and operational techniques. (References 24, 91A, 92, 94, 95, 8*, 12*).

6. Growth and Feed Sprouts - This option was eliminated by the Project Office on a programmatic basis at the conceptual design level; it has been reintroduced for the preliminary design as is described in Chapter 7.

7. Feed Contents - Existing non-proprietary formulations were compared. (References 6, 32).

8. Alcohol Production Byproduct Use - Grain alcohol by-products could be utilized in feed formulations if such a facility were built on-site or nearby. Alcohol production design was not in the scope of KHSAC effort. A power ethanol production facility sized for about 800,000 gal/year could furnish stillage for the feedmill of a 1200 sow complex.

9. Protein Extraction - The practice of manure solids separation and reutilization has been practiced in the beef industry, but has not yet been commercially demonstrated for swine. (References 9, 48, 16*, 45*).

10. Finish Hog Weight - Finish liveweight hogs of 220 to 240 pounds were considered in terms of production efficiency, commercial practice, and existing slaughter facilities. A nominal live weight of 228 lbs. has been used for the conceptual design.

11. Water Disposal - Flushing water disposal methods considered were: injection; disposal to waterways; evaporation and field irrigation.

B. Civil, Electrical, and Mechanical Engineering

1. Introduction - Subject to criteria and criteria applications previously discussed, alternative design arrangements were evaluated for the civil, electrical, and mechanical engineering features of the project buildings, utilities, and energy systems. Commercial practice, low cost, technical merit, and practical constructability were major factors considered in selecting the most appropriate alternative in each trade study case.

Scopes and methodologies of the trade studies are discussed as applicable in the following B. subsections; results of the trade studies are discussed under C following.

The reader should note that many of the trade studies are performed in an iterative manner with conceptual design and preliminary design developments. Hence results are not always the same as trade studies performed without respect to the ongoing overall design process.

2. Building Type - A comparative cost study was made for six types of building materials and construction methods for the project building:

- reinforced concrete poured-in-place
- precast concrete tilted up
- concrete blocks
- wood framed walls with exterior stucco
- metal stud walls with aluminum siding
- metal stud walls with galvanized iron siding

The cost study determined labor cost, material costs, and the total cost for each item required to construct the walls with each type of building material and method of construction. Since only comparative costs were required, comparisons were made only of relative costs for constructing the exterior walls of each building using the most economical and suitable roof and ceiling systems for each type of construction. Therefore, these studies reflect the relative costs per square foot of usable building space to construct the exterior walls of each building. The 1978 Dodge Construction Systems Costs Calculation Method incorporates a correction factor to account for the different shape and size of each building.

Although the comparative costs per square foot of building varied with building size and shape, metal stud walls with galvanized iron siding were consistently the least expensive option with exterior wall costs per square foot ranging from $0.69 (least expensive building) to $2.17 (most expensive building). Corresponding per-square-foot wall costs for least and most expensive buildings are: $1.65 - $5.23 for pour-in-place concrete; $2.00 - $6.33 for precast concrete; $1.12 - $3.54 for concrete blocks; $0.84 - $2.64 for wood with stucco; and $0.82 - $2.59 for metal stud with aluminum siding (References 28, 99).

3. Insulation Type - Comparative cost studies on a per square foot basis were performed for four types of insulation at various insulation ("R") values. The materials considered were:

- cellulose, fireproof (borate treated)
- sprayed on urethane
- fiberglass batt
- rigid polyurethane

Compatibility with building type was a factor that also impacted selection.

4. Insulation Thickness - Insulation thickness selection was based on a R value of 23 in accordance with the usable wall thickness.

5. Floor Type - Floor type, concrete, was the direct result of agriscience criteria applications.

6. Gutters - Open gutter drains were designed to be flat in cross section for economy of construction, having a curved radius at the intersection with vertical walls for ease of washdown and low maintenance, and of depths and slope sufficient to permit efficient,

sanitary flushing. These gutters will be covered with slats as selected from the trade studies. This trade was resolved through design process. (References 26, 52).

7. Swine Effluent Ponding - Normal matched cut and fill methodology was used for ponds. As ponds are to be lined to prevent groundwater pollution, costs per square foot for bentonite and sheet type film liners were compared.

8. Swine Waste Solids Separation - Three types of swine waste solids separation were studied:

- gravity settling
- screening
- mechanical separation

Gravity solids settling in ponds requires redundant ponds to allow for isolation from the inflow, a period for dewatering of each pond, and then the periodic removal, transport, and disposal of the remaining sludge. This method requires about 10 acres of additional land.

Screens for separation of residues require duplex or continuous operating strainers with a minimum of one operator in attendance. Maintenance work on the strainers would be extensive.

The mechanical separator is more or less a hybrid method of the other two alternatives. It consists of a conveyor belt located on the bottom and sloping sides of a small settling pond. Solids settling to the bottom are then removed by running the conveyors.

It should be noted that this option would be used if manure separation is retained in final design.

9. Manure Transport - Agriscience criteria applications directed use of flush gutters. The use of recycled water for flush was investigated for all buildings except farrowing and nursery (where disease control requires fresh flush water).

10. Human Wastes Disposal - Costs were compared for a

septic tank and leach field system versus a 1000 gallon per day sewage treatment plant.

11. Pig Carcass Disposal - Good "housekeeping" practice requires that the carcasses of occasional pig mortalities be disposed of as fast as possible. Alternatives studied included: a sodium hydroxide tank of precast concrete lined with coal tar; a gas fired incinerator; and use of a rendering truck service. The truck was ruled out because of its likelihood of introducing disease to the KHSAC complex.

12. Floor Heating - The nursery and farrowing areas are to have hot water floor heating for piglets. Floor heating for the other buildings was found to not be cost competitive with space heating.

13. Space Heating - Costs were compared for space, wall, and floor heating. Space heating modes investigated included fan coil units, bare pipe in the supply air plenum, and fin tube pipe in the supply plenum.

14. Wall Heating - Wall heating systems evaluated were: pipe in wall; exposed pipe, pipe with metal guards, and exposed fin tube pipe. None of these options were selected because of high cost.

15. Exhaust Air Heat Recovery - The costs of energy recovery utilizing air-to-air hear exchange methods for preheating building supply air were determined. However, the exhaust air is not discharged into a common duct in any of the buildings and extensive additional ductwork would be required to employ a waste heat recovery system. This was not selected.

16. Cascade Heating System - This system is effective in using geothermal heat for the three ranges of temperatures needed by the three subsystems. Systems are piped in series as applicable to utilize the progressively declining fluid temperatures. Consequently, the geothermal fluid flow is reduced, conserving the pumping energy required and the flow demand from the reservoir. Geothermal fluid will be pumped into a primary heat exchanger and then into the reinjection well to minimize possible scaling or corrosion resulting from geothermal fluid. A closed

loop heating system will be used to flow clean heated water for all subsystem heat applications: into the swine house space heating subsystems in parallel with the methanation subsystem, then to floor heating, and then back to the heat exchanger as is schematically shown in a later section.

17. Type of Buried Geothermal Piping - Four types of piping were compared for per-lineal-foot costs of 6 inch nominal diameter pipe: asbestos cement ($7.15); welded Schedule 40 black steel ($27.00); grooved Schedule 40 black steel (19.50); and "Temp-Tite", a preinsulated asbestos cement type ($11.40). (References 70, 71, 99).

It should be noted that insulation on buried piping is impractical for short runs of pipe where the heat source is effectively unlimited. The maximum heat loss for 6 inch diameter "Transite" (asbestos cement) pipe buried 3 feet deep in soil of high thermal conductivity is only 2^{o}F per 1000 linear feet for 180^{o}F water flowing at 325 gpm with the soil surface at 35^{o}F (Reference 99).

18. Thermal Storage - Costs of thermal storage to levelize loads were investigated. Thermal storage would require a 50,000 gallon insulated tank and appurtenances; these costs were compared to costs for standby geothermal pumping capability. This was not selected.

19. Primary Geothermal to Heating Water Heat Exchanger - Three types of heat exchangers were economically evaluated: shell and tube type; spiral type; and flat plate type heat exchanger.

The design flow for the heat exchangers is 325 gpm with fluid temperature changes of 60^{o}F on both primary and secondary sides of the exchanger. Maximum geothermal design water temperature is 208^{o}F. Type 316 stainless steel in contact with geothermal fluids was selected to minimize corrosion.

The quality of the geothermal fluids has not been verified. In the event that the fluids have minimum scaling affinity and corrosive chemicals are not present in detrimental quantities, then the heat exchanger could be eliminated from the project at a later date with resultant cost savings.

20. Deicing of Sidewalks - The alternatives considered were: embedding 1-inch diameter black iron hot water pipe on 12-inch cneters in the concrete; and use of rock salt. PVC embedded pipe was excluded due to lack of structural integrity in cases of concrete cracking.

21. Geothermal Supply Pump - Engineering experience dictates that the supply geothermal water pumps shall be vertical turbines with oil lubricated drive lines. Each pump shall be capable of delivering 325 gpm of 208^{o}F water at 250-foot total head. This pump should have a minimum 5-year life, depending upon corrosive effects of the fluids.

22. Geothermal Reinjection Pump - The pressure for reinjection at the disposal wells has not been determined. In the event that this pressure is low, no reinjection pump would be required. Normally, the geothermal well pumps supply fluids at a pressure to overcome system friction losses, plus an overpressure which is maintained to reduce flashing of off-gases from the fluids. Off-gases could promote the depositing of carbonate scale. This maintained overpressure should, under normal design conditions, preclude need for a booster pump for well reinjection. However, because of the unknown reinjection strata, the conceptual design includes a reinjection well pump until it is verifield as not required.

A split case horizontal pump was chosen to facilitate repairs or replacements of the pump. This pump should have a minimum 5-year design life and is sized at 325 gpm at 50-foot total head.

23. Methanation Tank - Thermophilic methane production was selected over mesophyllic production based on: intensive use of geothermal heat; smaller major equipment size; and higher yields.

Costs of tank construction were compared. The roof structure and cover of each methanation (or fermentation) tank will be of coated metal construction for minimum weight. The tank cylindrical side walls will be of reinforced concrete or of coated metal construction. The construction bid documents will allow these two competing bid alternatives to be received to determine which has the lowest total cost. The tank bottoms will be concrete sloped towards the fluid outlets. The tanks will be operated at 122-131^{O}F inside design temperature and will have roof and wall insulation. (References 7, 47, 62, 63, 72, 88).

24. Methanation Heating - Alternatives for methane heating were: hot water coil in tank; hot water coil in tank wall; and heat exchange in the fermentation slurry line. (References 5*, 47, 63).

The selection of agitation method was a major impact in heating mode selection, as was existing practice.

25. Methane Slurry Agitation - The slurry must be agitated in order to promote the bacterial action that generates biogas. Methods considered were: recirculation by pump; mechnical stirring in the tank; and percolation of biogas up through the methanation tank from submerged piping headers which are supplied by a gas compressor unit. (References 7, 62, 63).

26. Methane Storage - Use of methane on site will require storage facilities. A compressor will be utilized to reduce storage tank size and cost.

27. Methane Water Usage - Alternatives considered were: recycling or not recycling. Agriscience criteria applications dictated excluding recycled water from the farrowing and nursery buildings.

28. Methane Gas Cleaning - Commercially available systems for removing hydrogen sulfide and carbon dioxide from the biogas were evaluated vis a vis end use of the methane.

29. Methane Use - The use of methane for electrical generation on site has been a programmatic goal for conceptual design.

30. Methane Backup System - The primary or continuous

electrical power will be supplied by the methane powered generator units, which are limited by the quantity of available methane. Additional project power supply alternatives considered were: propane based on-site generation and purchase of electricity from the local utility.

Only the critically needed pumping units will be operated during emergencies or power shortages. (For example, the heating systems must remain in operation in the farrowing and nursery buildings.) Two geothermal pumps are provided. One pump will be shut down during shortages.

31. Air Handling - Experience with swine houses indicates that all air should enter at the ceilings, have uniform distribution throughout the house, and use wall exhaust fans (negative pressure systems).

A primary air handling (positive pressure system) was considered as an alternative design. This system would have pressurized the pig houses and eliminated the wall exhaust fans, but was rejected due to the following:

- Balancing of the air flows to the various rooms and their resulting temperatures would be difficult.
- Air system redundancy could not be achieved (i.e., primary equipment failure could create an emergency).
- Pressurization of the building would cause migration of moisture into the cracks of the structure.

32. Humidity Control - Humidity control is required on this project only to the extent that water vapor is not to be condensed on the interior surfaces of the pig houses. Design was based on criteria applications previously discussed.

33. Cooling Method - Alternatives considered for swine house summer cooling were: evaporative cooling; spray cooling; geothermal absorption refrigeration; and domestic well water circulation. A key

factor in selection was that this area near Alturas has ideal climatological conditions for evaporative cooling systems due to the low ambient wet bulb temperatures that prevail.

34. Geothermal Backup System - Project programmatic decisions dictated that the geothermal heating system shall be supplied by two geothermal wells with either having the capacity for the emergency heat requirements of the complex. Failure of electrical power to critical areas or lack of flow from a geothermal well shall activate an alarm system. Manual controls shall be used to distribute the power to the critical areas of the heating systems in the event of an emergency.

35. Site Work - Conceptual design followed established engineering practice for site preparation with allowances for normal agricultural practice in currently existing swine facilities.

36. Lighting - Flourescent and incandescent lighting were compared on capital and operating cost bases. Emergency lighting will be battery powered.

37. Wiring - Flexible metallic sheathed cable was compared to wiring in rigid conduit.

38. Power System - Power system requirements were based on: total load; largest loads; industrial systems standards, and utility preference. All requirements dictated 480 volts, 3-phase, 60 Hz for distribution.

39. Engine Generators - Methane powered internal combustion generators were selected based on existing practices.

40. Transformers - Costs were compared for purchased versus utility provided transformers.

41. Hazardous Electrical Areas - Hazardous area equipment will be required for the methane and grain handling areas.

42. Outside Wiring - Overhead wiring was compared to buried cable for 480 volt power on the basis of cost and ease of operation.

C. Conceptual Design Options Selected

Tables 4-5 and 4-6, following, summarize the conceptual design options selected based on the discussed trade study areas, methodologies, and options.

IV. CONCEPTUAL DESIGN

A. Agriscience

The agriscience aspects of the conceptual design are summarized in Table 4-7 following with details depicted in Figures 4-1 and 4-2, also following.

B. Facilities Layout

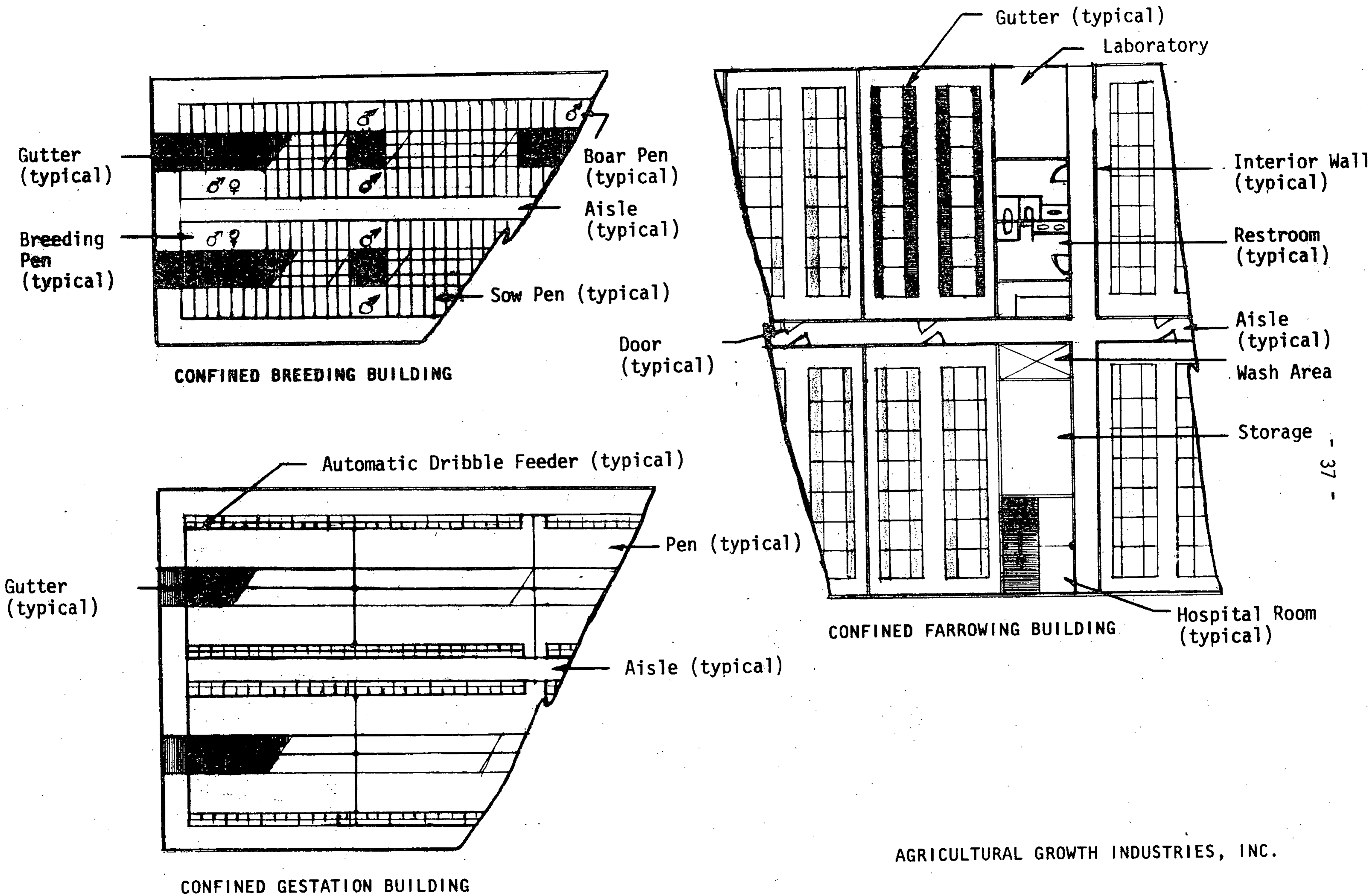
Figure 4-3 depicts the plot plan for the KHSAC conceptual design located at Site 1. The active site depicted is about 16 acres.

Facility arrangement is a result of several major factors, the most important of which is ease and efficiency of the swine growing operations. This operational factor is combined with requirements of the following systems: geothermal; potable and recycled water; and waste, including methane generation.

Previously noted criteria for access, health and safety factors are also taken into consideration.

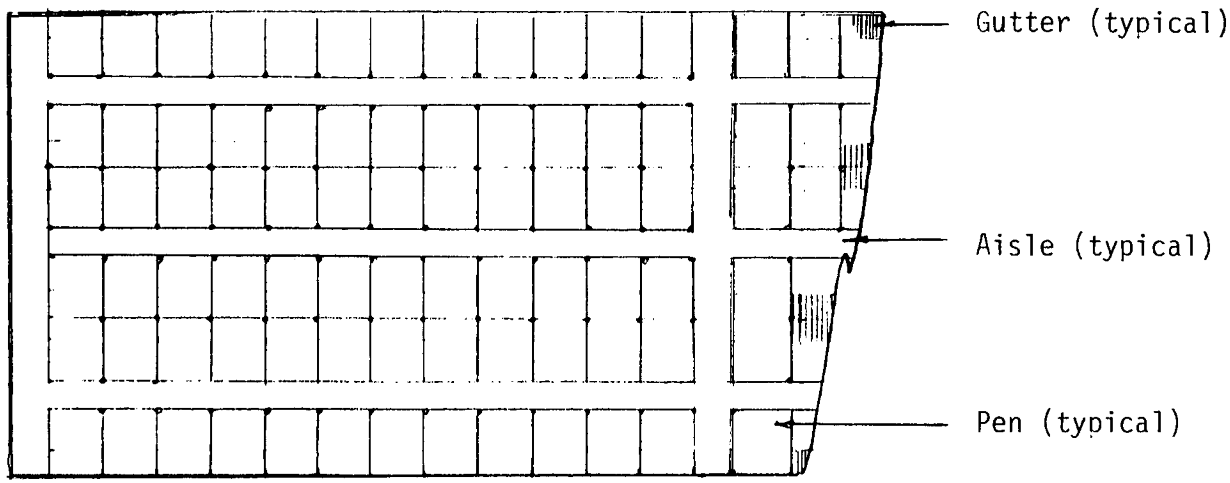
Established engineering practice for site work requires that:

- The site will be leveled to a slope of not more than 3 percent.
- Culverts required for surface water drainage will be prefabricated concrete pipe.
- All building foundations will be reinforced concrete.
- The access road and road around the buildings will be constructed of crushed rock with a top sealer for dust control.
- Access roads are designed for twenty-ton load trucks and semitrailers.

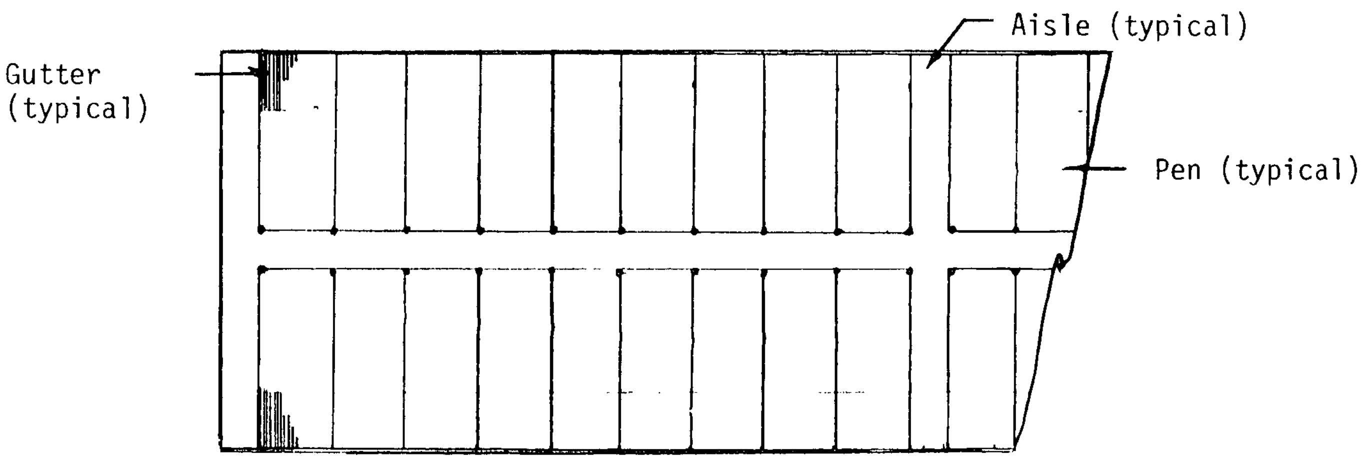


AGRICULTURAL GROWTH INDUSTRIES, INC.

Figure 4-1 - ENVIRONMENTALLY CONTROLLED CONFINED GEOTHERMAL SWINE COMPLEX - BUILDING LAYOUTS



CONFINED NURSERY BUILDING



CONFINED GROWING AND FINISHING BUILDING

Figure 4-2 - ENVIRONMENTALLY CONTROLLED CONFINED GEOTHERMAL SWINE COMPLEX - BUILDING LAYOUTS

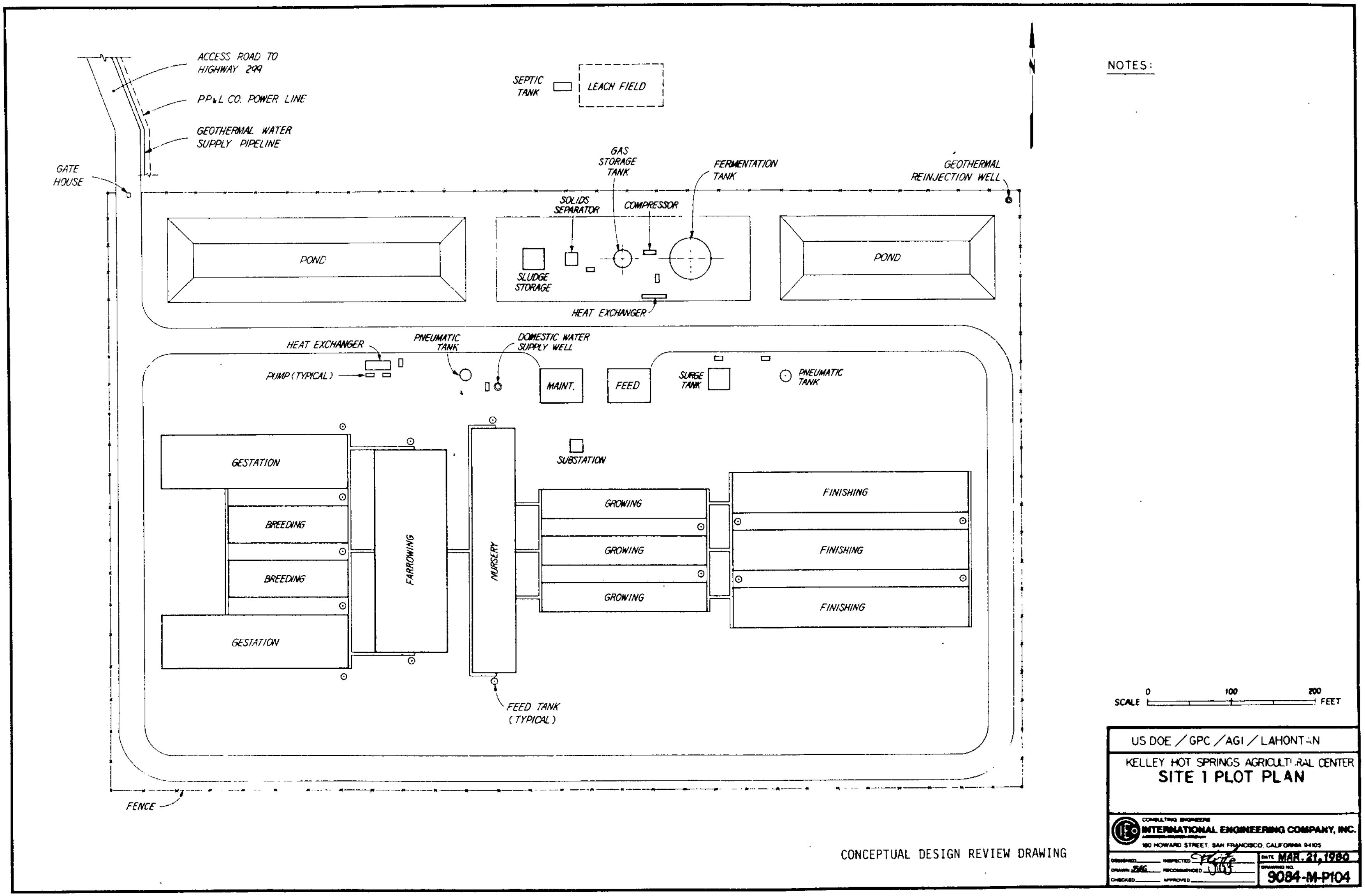


FIGURE 4-3 - SITE 1 PLOT PLAN

TABLE 4-5

AGRISCIENCE CONCEPTUAL DESIGN OPTIONS SELECTED

Paragraph	Trade Study	Design Option Selected	Key Selection Factors
III. A.2.	Gutter Type	flush gutter under slats	health, sanitation, cost
III. A.3.	Slat Material	aligned fiber composites	commercial, sanitation, durability, cost
III. A.4.	Aquaculture	not selected	programmatic
III. A.5.	Feed Source	mill on site	cost
III. A.6.	Growth of Feed Sprouts	not selected	programmatic
III. A.7.	Feed Contents	existing non-proprietary formulations	commercial practice
III. A.8	Alcohol Production Byproduct Use	not selected	unavailable
III. A.9.	Protein Extraction	not selected	no commercial demonstration
III. A.10.	Finish Hog Weight	228 pounds	current practice and facilities
III. A.11.	Water Disposal	field irrigation	environmental, conservation, cost

TABLE 4-6 SHEET 1 OF 2

CIVIL, ELECTRICAL, AND MECHANICAL CONCEPTUAL DESIGN OPTIONS SELECTED

Paragraph	Trade Study	Design Option Selected	Key Selection Factors
III.B.2.	Building Type	pre-engineered metal with steel panels	cost
III.B.3.	Insulation Type	loose fill cellulose, fireproofed	cost, building type
III.B.4.	Insulation Thickness	7-1/2" in walls, 8" in ceilings	R factor, building type, insulation type
III.B.5.	Floor Type	brush and smooth finish concrete	agriscience criteria applications
III.B.6.	Gutters	flat cross section, sloped	efficiency, cost, ease of construction, sanitation and maintenance
III.B.7.	Swine Effluent Ponding	matched cut and fill, film sheet liners	normal practice, cost
III.B.8.	Swine Waste Solids Separation	mechanical separator	cost, ease of operation
III.B.9.	Manure Transport	flush with recycled water	agriscience criteria, cost, conservation
III.B.10	Human Wastes Disposal	septic tank and leach field	cost, local practice
III.B.11.	Pig Carcass Disposal	gas fired incinerator	health, efficiency
III.B.12.	Floor Heating	black steel pipe in concrete	agriscience criteria, thermal design
III.B.13.	Space Heating	fin tube in supply air plenum	cost, compatability
III.B.14.	Wall Heating	not selected	cost
III.B.15.	Exhaust Air Heat Recovery	not selected	cost, "essentially unlimited" heat supply
III.B.16.	Cascade Heating System	space heating, floor heating, methanation	cost, thermal requirements
III.B.17.	Type of Geothermal Piping	uninsulated asbestos cement	cost, experience
III.B.18.	Thermal Storage	not selected	cost
III.B.19.	Primary Heat Exchanger	stainless steel plate type	cost, ease of maintenance
III.B.20.	Deicing of Sidewalks	rock salt	cost
III.B.21.	Geothermal Supply Pump	vertical turbine	engineering experience

TABLE 4-6 SHEET 2 OF 2

CIVIL, ELECTRICAL, AND MECHANICAL CONCEPTUAL DESIGN OPTIONS SELECTED

Paragraph	Trade Study	Design Option Selected	Key Selection Factors
III.B.22.	Geothermal Reinjection Pump	split case horizontal centrifugal	ease of repair and replacement
III.B.23.	Methanation Tank	metal roof, concrete base, metal or concrete walls	cost, design factors
III.B.24.	Methanation Heating	recirculation through heat exchanger	agitation method, existing practice, cost
III.B.25.	Methane Slurry Agitation	recirculation	existing practice, cost
III.B.26.	Methane Storage	steel tank with compressor	cost, end use
III.B.27.	Methane Water Usage	recycling except farrowing and nursery	cost, conservation, agriscience criteria
III.B.28.	Methane Gas Cleaning	compressor aftercooler condensing	cost, end use
III.B.29.	Methane Use	internal combustion engine generators	programmatic goal, existing practice
III.B.30.	Methane Backup system	purchase of electricity	cost, reliability
III.B.31.	Air Handling	ceiling entrance, exhaust fans	agriscience criteria application
III.B.32.	Humidity Control	air changes	cost
III.B.33.	Cooling Method	evaporative	cost, suitability, practice
III.B.34.	Geothermal Backup System	electrical with manual control, backup well and pump	cost, safety
III.B.35.	Site Work	normal agricultural practice	cost, suitability
III.B.36.	Lighting	fluorescent	cost, practice
III.B.37.	Wiring	flexible metallic sheathed cable	cost, agricultural practice
III.B.38.	Power System	480 volt, 3 phase, 60 Hz	loads, standards, utility preference
III.B.39.	Engine Generators	internal combustion	practice
III.B.40.	Transformers	utility provided	cost
III.B.41.	Hazardous Electrical Areas	methane and grain handling	safety
III.B.42.	Outside Wiring	buried	cost, ease of operation

TABLE 4-7

AGRISCIENCE CONCEPTUAL DESIGN SUMMARY

Building	Number of Buildings	Building Dimensions	Building Population	Pen Dimensions	Square Feet per Animal	Animal Weight pounds	Water Use gallons per day Drink	Water Use gallons per day Flush	Feed pounds per day	Manure per day pounds*	Manure per day gallons
Breeding	2	44' x 142'	200	22" x 7'	12.8	140,000	1,400	3,460	2,464	10,977	1,400
Gestation	2	64' x 220'	472	14' x 25'	25	306,800	4,648	3,460	5,664	24,053	3,068
Farrowing	1	86' x 240'	252 sows (2016 piglets)	5' x 7'	35	80,640 (18,144)	2,061	2,070	2,128 (956)	6,322 (1,422)	807 (181)
Nursery	1	52'-7" x 290'-3"	4224	6' x 7'	2.3-2.6	75,000	2,500	1,800	5,246	5,880	750
Growing	3	35'-3" x 196'-3"	1364	6' x 16'	4.4-4.8	296,480	4,709	7,800	18,086	23,244	2,965
Finishing	3	43'-3" x 282'-3"	1360	8' x 20'	7.3	610,400	13,952	7,800	27,952	47,855	6,104
TOTALS	12	-	16,008	-	-	1,527,464	29,270	26,390	62,496	119,753	15,275

* 75 percent water.

Established agricultural practice dictated natural vegetation for unoccupied areas with cleared surfaces for small trucks to deliver feed from the feedmill to the feed tanks at each building.

Power will be provided to the project from two sources: local utility power stepped down to 480 V and multiple, on-site, methane powered engine generators producing power at 480 V. Both sources of power will be brought to a common bus which feeds a main distribution panel. On-site generators located at the substation will be provided with automatic synchronizing equipment to coordinate with the power line frequency and phasing. The incoming power line, transformers, and protective equipment will be provided by the utility except for the 480-V protective equipment. Power will be distributed by radial direct buried cables to each building at 480 V from where it will be stepped down to 220 or 110 V as required.

The facilities depicted in Figure 4-3 are designed per the conceptual design options selected as a result of the previously described trade studies.

C. Process Flows

1. Agricultural Materials Flow - Figure 4-3 depicts the concrete swine walkways are surrounded by movable rails and provide for the following flow:

- sows circulate continually through breeding to gestation to farrowing and to breeding again.
- piglets are born in farrowing and progress through nursery, growing, and finishing to pickup for slaughter at the end of finishing.
- replacement gilts and boars are held in finishing or breeding, depending on operational practice.
- animals at any particular stage may be moved directly to any building of the next developmental stage.

Feed constituents are transferred from incoming trucks to bulk storage tanks adjacent to the feed mill by conveying equipment. In the mill, a mini-computer operated scale system is used to properly meter the various ingredients into several ribbon type blenders. The blended feed is conveyed to trucks from which it is distributed to building feed tanks shown in Figure 4-3. Distribution of the 31.25 daily tons of feed to and throughout the buildings is by automatic conveying equipment.

2. Geothermal System - Figure 4-4 presents a schematic diagram of the Site 1 geothermal system mains.

Geothermal fluids at a wellhead temperature of 208°F flows at 325 gpm from a well off site through buried 6-inch diameter Transite (asbestos cement) Class 150 pipe to a stainless steel plate type heat exchanger where it raises the temperature of the clean hot water in the circulating loop by 60°F. Following heat exchange, the geo fluids are pumped to a reinjection well, through the same type and size pipe. The hot water heating loop also uses variously sized buried asbestos cement pipe.

All asbestos cement pipe is buried at least 3 feet below the surface, depending on traffic, and is surrounded by sand.

Inside building hot water distribution piping is insulated (where exposed to human contact) Schedule 40 black steel.

Space heating is via exposed 1¼ inch diameter steel fin tube piping in each building supply plenum, each building requiring roughly two lengthwise runs of fin tube. Water enters the runs at about 180°F.

The methane fermentation tank is heated by heat exchange from the hot water loop at 180°F to recirculating manure slurry to maintain the tank at an optimum 131°F. The heat exchanger is a tube-in-shell type, (slurry in tubes).

Piglet areas in the farrowing and nursery areas have systems for heating the floor to 80°F. This is accomplished by circulating 115°F hot water through 1-inch diameter Schedule 40 black steel pipe embedded in the floor concrete on 12-inch centers.

3. Potable and Recycled Water System - Figure 4-5 shows

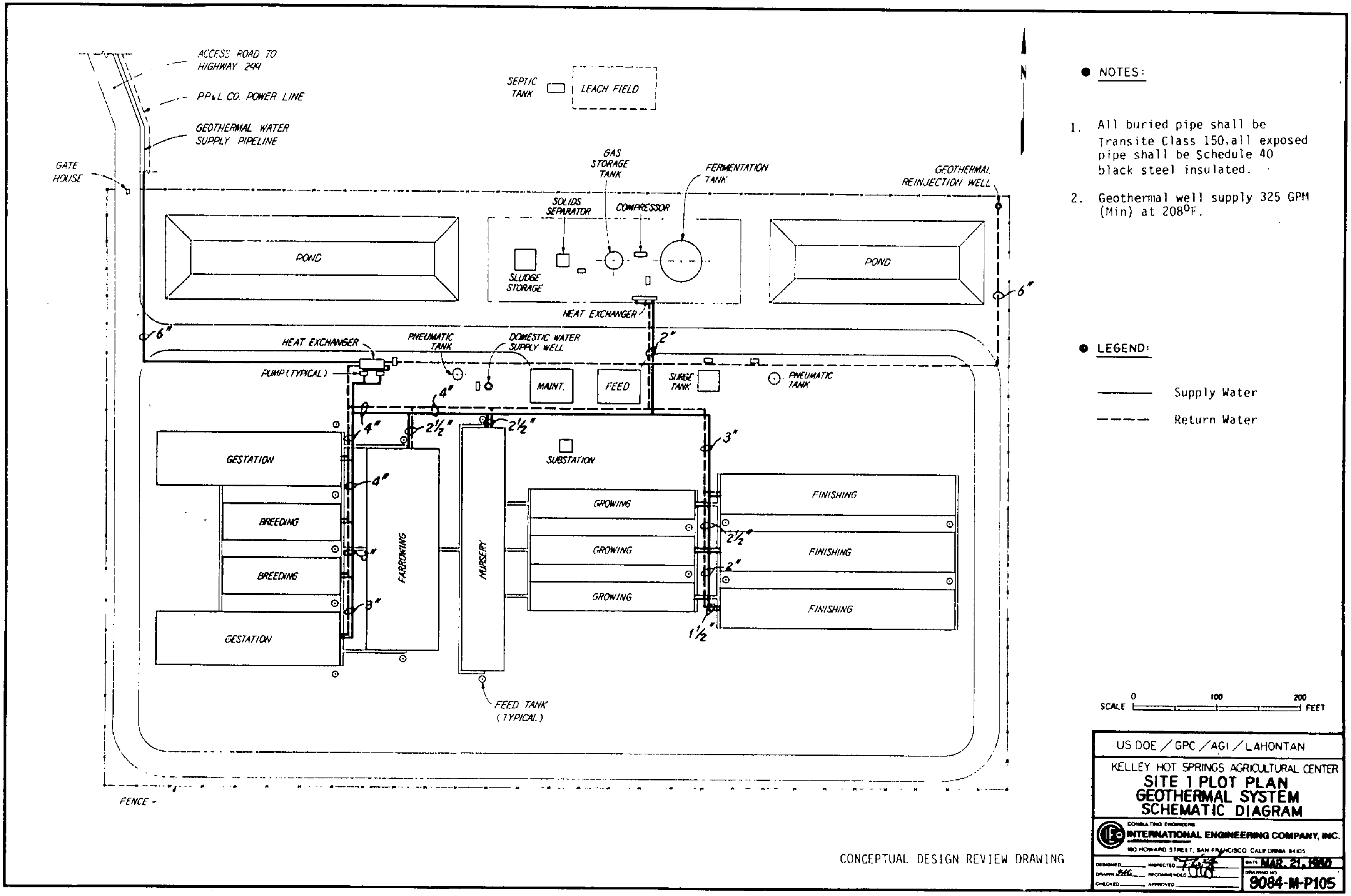
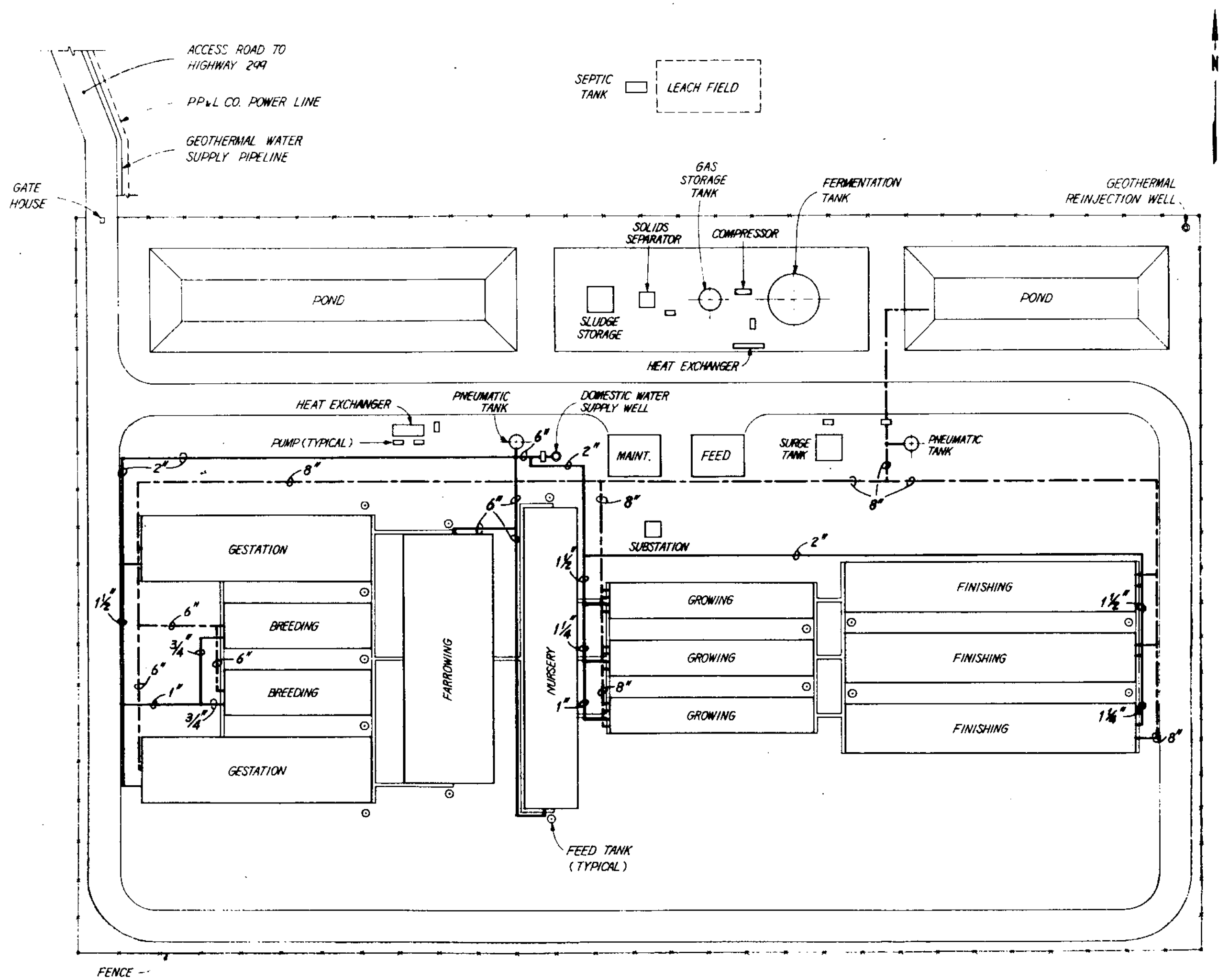


Figure 4-4 - GEOTHERMAL SYSTEM SCHEMATIC DIAGRAM



- NOTES:

1. Recycled effluent pipe shall be Transite Class 150 for buried, and fiberglass reinforced PVC for exposed piping.

2. Potable water pipe shall be Transite Class 150 for buried 4" diameter and larger, Type L copper for less than 4" diameter pipe. Exposed pipe shall be Type L copper pipe 2" diameter and smaller, Schedule 40 black steel for 2½" diameter and larger. All exposed piping shall be insulated.

- **LEGEND:**

———	Potable Water
—·—·—	Recycled Water

SCALE 0 100 200 FEET

US DOE / GPC / AGI / LAHONTAN

KELLEY HOT SPRINGS AGRICULTURAL CENTER

SITE 1 PLOT PLAN
POTABLE & RECYCLED WATER SCHEMATIC DIAGRAM

CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
180 HOWARD STREET, SAN FRANCISCO, CALIFORNIA 94105

DATE MAR. 21, 1980
DRAWING NO. 9084-M-P107

CONCEPTUAL DESIGN REVIEW DRAWING

Figure 4-5 - POTABLE AND RECYCLED WATER SCHEMATIC DIAGRAM a schematic diagram of the main external-to-building features of the potable and recycled water systems.

Potable water is provided through buried piping to each building for animal consumption and washdown and, additionally, to the farrowing and nursery buildings for flush after pressurization in a pneumatic tank.

Recycled water from the methane system is pumped from a holding pond to a pneumatic pressurization tank from which it is distributed to all but the nursery and farrowing buildings for gutter flushing.

Buried potable water pipe 4 inches in diameter and larger and buried recycled effluent pipe is Class 150 Transite. Buried potable water pipe less than 4 inches in diameter is Type L copper.

Exposed piping for potable water is Schedule 40 black steel for diameters of 2½ to 4 inches and Type L copper for diameters of 2 inches and smaller. Exposed recycled water pipe will be fiberglass reinforced polyvinyl chloride (PVC). All exposed piping in these systems outside of buildings will be insulated.

Method of water provision to animals is by animal controlled "automatic" water bowls to minimize flesh damage and tail biting associated with water nipple type systems.

4. Animal Waste System - Figure 4-6 schematically shows the animal waste water collection and distribution system from the swine houses through the biogas generation process.

From the flush gutters, animal sewage will flow by gravity through buried pipe to the one-day surge holding tank and then into the fermentation tank. The tank will provide for thermophilic anaerobic digestion at 131^{O}F from geothermal heat. The fluid retention time in the tanks is six days, which produces biogas and a sterile liquid effluent, the solids of which may be utilized as a fertilizer or animal feed supplement. The roughly 60 tons per day of animal sewage inflow can produce a daily methane production of 105,000 cubic feet at atmospheric pressure.

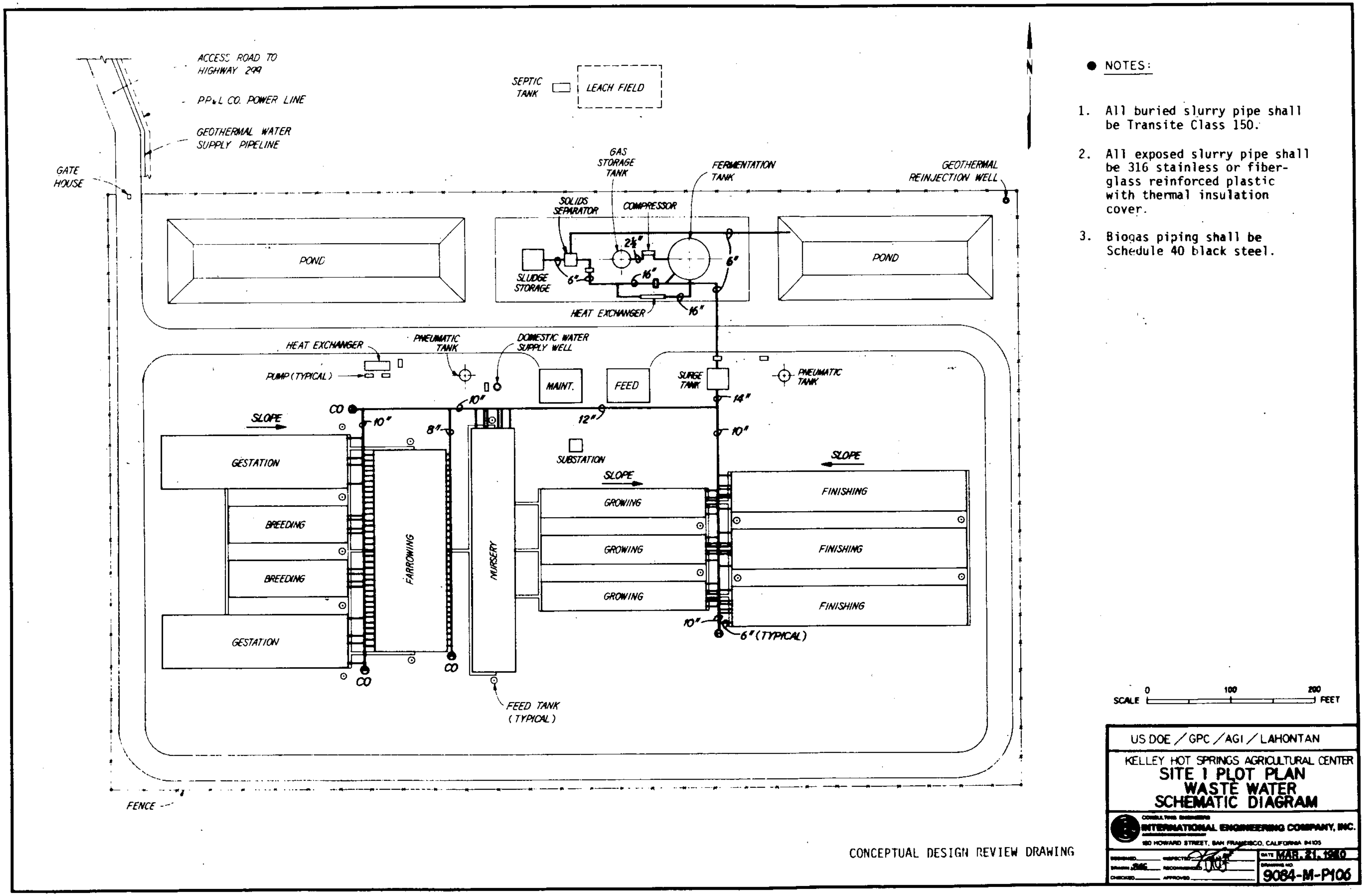


Figure 4-6 - WASTE WATER SCHEMATIC DIAGRAM

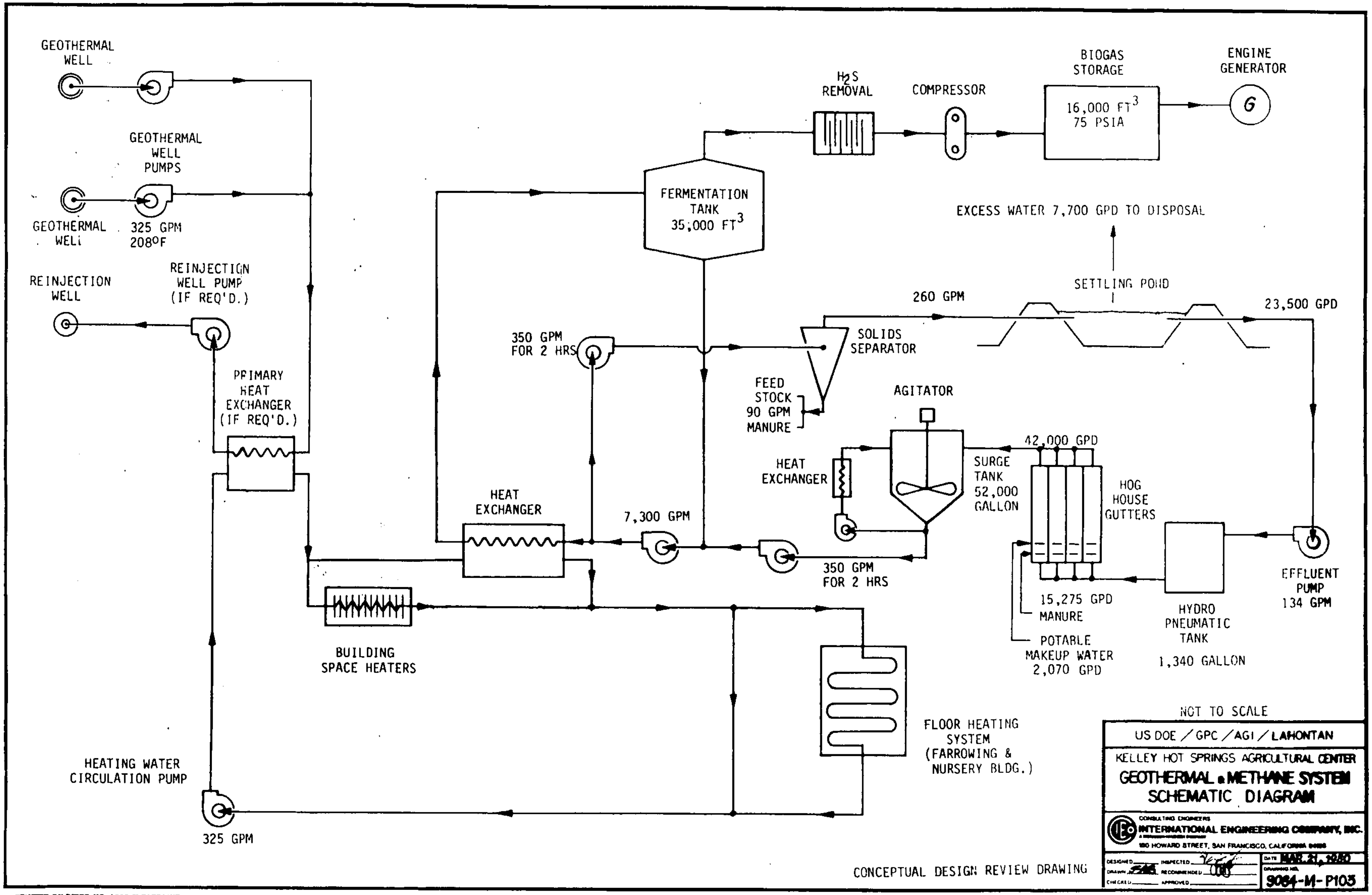


Figure 4-7 - FLOW SYSTEMS SUMMARY

Before compression, a scrubber will remove most of the carbon dioxide and hydrogen sulfide from the biogas, with the remaining gas nearly all methane. The compressed methane can be injected as fuel into internal combustion engine-generator units.

The combustion of gases will convert the remaining traces of hydrogen sulphide and will burn off most odors - eliminating the need for a gas treatment plant. An equivalent continuous 24 hours per day power generation of about 400 kW can be provided by the methane fuel. This is a major impact on the project electric power requirements as the equivalent total project continuous power requirements are roughly 560 kW.

Conservative estimates were used for the methane produced so that after the plant start-up period, methane gas production may be increased above the conservative estimates used, and the methane fueled generators could supply power back into the utility's lines for credit.

Piping is as follows: Class 150 Transite for buried pipe; Type 316 stainless steel or fiberglass reinforced PVC for exposed slurry piping (with thermal insulation cover) and Schedule 40 black steel for biogas.

5. Flow Systems Summary - Figure 4-7 schematically summarizes the major flow systems' flows and equipment for the Kelley Hot Springs Agricultural Center conceptual design.

6. Energy Summary - The use of geothermal energy in the KHSAC displaces nearly 700,000 gallons of fuel oil yearly; use of biogas displaces about 300,000 gallons of fuel oil per year. Total yearly fossil fuel savings, then, are approximately 1,000,000 gallons of fuel oil equivalent.

D. Costing

1. Capital Costs - Capital costs were estimated on an early 1980 basis without any contingency factors or inflationary multipliers. Costs were estimated by a variety of ways as appropriate:

- engineering estimating manuals including those of Means, Dodge, and Trade Service Publications; (References 28, 70, 71, 90).
- actual catalog prices; (References 2, 18, 67).
- manufacturers' budget estimates for major cost items; (References 49*, 50*, 83*, 105*, 99).
- similar experience of the agriscience and engineering firms;

and

- recent published similar experience. (References 27, 92, 93, 94, 95, 65, 72, 81).

Capital costs developed are summarized in Chapter 5, following.

2. Operating Costs - Operating costs are also estimated on an early 1980 basis without contingency factors or inflationary multipliers. Cost estimating bases included:

- recent experience of private operators (including some proprietary data used for guidance); (References 12*, 38*, 80*, 85*, 87*).
- published feed and supply costs; (References 15, 24, 53, 69, 91A).
- comparable labor rate classifications;
- costs estimated by the electrical utility; and
- agriscience and engineering experience.

The key cost operating areas of feed and labor merit brief further explanation. Feed costs vary from $7.75 to $12.15 per hundredweight (cwt) with an average of $8.32/cwt for the 31.25 tons of feed utilized daily at the KHSAC. Labor staffing (with annual salaries) is as follows: 1 feed production foreman ($13,800) with 3 assistants ($10,400 each); 4 swine production supervisors ($13,800 each) with 4 assistants ($11,400 each); 1 energy systems technician ($12,000); 1 maintenance foreman ($14,400) with 1 assistant ($12,000); 1 general business and sales manager ($19,000); and 1 bookkeeper ($10,800).

Operating costs developed are summarized in Chapter 6.

CHAPTER 5 -- CONSTRUCTION PLAN

I. FACILITIES CONSTRUCTION COSTING

Construction costing has been based upon the Conceptual Design as designated in Chapter 4. For conceptual cost estimating, it has been assumed that the facility will be located south of the reservoir in Site 1 and it will be connected to the supply well by a one mile pipeline. The access road would run south from U.S. 299 to the site gate for one-half mile.

A. Installed costs - Installed costs as of early 1980 have been used with nominal contractor mark-up without any contingency or inflationary multipliers. Unit costs were determined by a combination of factors as follows:

- A fully contracted turnkey job at prevailing rates has been assumed.
- Engineering costs have been based upon the experience of the engineering firm with backup estimates derived from estimating documentation[70, 71]. On large equipment items, quotes have been obtained directly from manufacturers.
- Agricultural equipment was estimated, utilizing quotes from equipment manufacturers, and catalog data.
- Building construction and erection figures were obtained directly from Melco Steel Buildings and from the experience of John F. Otto, Inc., General Contractor, and Carson Development Co, Sacramento, CA.
- Site work estimates were based upon Carson Development Co.'s experience plus consulting with Teichert Construction, Sacramento, Excavating and Engineering Constractors.

It should be noted in all cases the suppliers, subcontractors and construction firms were requested to consider the specific site in southern Modoc County when making their estimates.

The Conceptual Construction Costs are shown in Table 5-1. The first sheet summarizes the costs and delineates the software costs of engineering and management. The allocation of geothermal related effort has been delineated. The following sheets give the breakdown of the costs and identifies the units and unit costs associated with the hardware elements. These are installed costs. The percentage of the elements that are geothermal related have been estimated in these detailed sheets. In the summary, sheet 1, the geothermal-related software has been estimated on the same basis as the overall installed capital costs have been allocated; i.e. 32.4% of total software. The software has been estimated on the basis of the total construction plan and the specific elements and tasks required for the construction design, construction and checkout and test of all systems.

II. CONCEPTUAL CONSTRUCTION SCHEDULE

The Construction Schedule has been greatly affected by two major constraints. The first is the expected requirement that the geothermal resource must be proven by thoroughly testing a production well before any other construction work may proceed. With a projected drilling start date of September, 1980, and an interval of two months allotted for drilling, casing and testing, it is expected that little in the way of site work and essentially no construction can be accomplished before the spring of 1981. The second constraint is the severe winters of the Canby region of southern Modoc County in northeastern California. While heavy snow is not normal for the area, quite low temperatures are experienced from November through March, and early spring thawing results in muddy conditions.

If, however, resource development could commence in July and/or site work be initiated by September 1, it would be possible to lay down foundations and slabs of perhaps four buildings (gestation and farrowing) before winter temperatures would preclude further concrete work. Since the metal buildings can be erected at virtually any time and the interior work then proceed under shelter throughout the winter season, a considerable head start can be obtained in the overall schedule that could make substantial completion possible by late 1981. This could accelerate the start of swine production by several

TABLE 5-1. -- CONCEPTUAL CONSTRUCTION COSTS

CONCEPTUAL COST SUMMARY

		TOTAL COST	GEOTHERMAL RELATED
I.	HARDWARE COST		
	A. GEOTHERMAL RESOURCE	$ 551,000	$ 551,000
	B. SITEWORK	123,400	0
	C. BUILDING STRUCTURES	1,493,100	179,900
	D. BUILDING MECHANICAL	540,300	240,300
	E. BUILDING ELECTRICAL	435,200	52,800
	F. BUILDING AGRICULTURAL EQUIPMENT	967,400	0
	G. SPECIALIZED AGRICULTURAL EQUIPMENT	194,500	0
	H. SWINE WASTE SYSTEM	601,000	565,000
	I. SITE UTILITIES	191,600	60,200
	TOTAL HARDWARE COSTS	$5,097,500	$1,649,200
II.	SOFTWARE COST		
	A. DESIGN AND ENGINEERING	$ 408,000	$ 132,000
	B. CONSTRUCTION MANAGEMENT AND CONTROLS	377,000	122,000
	C. PROGRAM MANAGEMENT SERVICES	250,000	81,000
	TOTAL SOFTWARE COST	$1,035,000	$ 335,000
III.	TOTAL CONCEPTUAL COST	$6,132,500	$1,984,200

TABLE 5-1. -- CONCEPTUAL CONSTRUCTION COSTS

CONCEPTUAL COST DETAIL

HARDWARE COST	UNIT	COST OF UNIT	NO. OF UNITS	TOTAL COST	GEOTHERMAL RELATED
A. Geothermal Resource Development					
1. Production Wells - Drill, Case, Test	Ea	$350,000	1	$350,000	100%
2. Production Pumps, Tanks, Equipment	Ea	$ 24,000	2	$ 48,000	100%
3. Primary Heat Exchangers	Ea	$ 12,500	2	$ 25,000	100%
4. Injection Well	Ea	$ 50,000	1	$ 50,000	100%
5. Injection Pump	Ea	$ 4,500	1	$ 4,500	100%
6. Production Piping - 6" Transite to Site - Assume 1.0 mi.	LF	$ 14	5280	$ 73,500	100%
Subtotal				$551,000	$551,000
B. Sitework					
1. Land	AC	$ 750	16	$ 12,000	0
2. Soils Testing and Surveying	LS			$ 5,000	0
3. Grading and Site Preparation	AC	$ 2,500	16	$ 40,000	0
4. Roads (30' width) - Within Site	SF	$ .33	30,000	$ 10,000	0
Access -- assume 0.5 mi.	SF	$ .33	72,200	$ 26,400	0
5. Fencing, Security	LF	$ 10	3,000	$ 30,000	0
Subtotal				$123,400	0
C. Building Structures					
1. Concrete Foundation and Slabs	CY	$ 170	2,800	$476,000	20%
2. Metal Buildings - Shell	LS			$597,200	0
Doors and Windows	LS			$ 35,000	0

TABLE 5-1. -- CONCEPTUAL CONSTRUCTION COSTS

CONCEPTUAL COST DETAIL (CONT.)

	UNIT	COST OF UNIT	NO. OF UNITS	TOTAL COST	GEOTHERMAL RELATED
C. 3. Building Erection	SF	$ .80	141,000	$112,800	0
4. Interior Walls and Epoxy	SF	$ 1.20	56,000	$ 67,000	0
5. Interior Ceilings and Epoxy	SF	$ .75	141,000	$100,000	0
6. Insulation - BlownCellulose	SF	$ .43	197,000	$ 84,700	100%
7. Walkways - 4 X 1200 LF	CY	$ 150	64	$ 9,600	0
8. Railings	LF	$ 4	1,200	$ 4,800	0
Subtotal				$1,493,100	$179,900
D. Building Mechanical					
1. Secondary Heat Exchangers	LF	$ 12	2,400	$ 28,800	100%
2. Exhaust Fans	LS			$ 60,000	
3. Evap. Coolers and Ducting	LS			$100,000	
4. Cold Water Piping	LS			$140,000	
5. Hot Water Piping (Incl. Floor)	LF	$ 7.50	28,200	$211,500	100%
Subtotal				$540,300	$240,300
E. Building Electrical					
1. Distribution Panels	Ea	$ 5,000	29	$145,000	0
2. Buried Cable	LF	$ 9.50	5,000	$ 47,500	0
3. Transformers (30 KVA)	Ea	$ 1,500	14	$ 21,000	0
4. Fluorescent Fixtures	Ea	40	770	$ 30,800	0
5. Wiring (Romex)	LF	$ 2.25	50,000	$112,500	0
6. Duplex Receptacles	Ea	15	270	$ 4,100	0
7. Motor Starters	LS			$ 21,500	0
8. Thermostats and Fittings	LS			$ 52,800	100%
Subtotal				$435,200	$ 52,800

TABLE 5-1. -- CONCEPTUAL CONSTRUCTION COSTS

CONCEPTUAL COST DETAIL (CONT.)

	UNIT	COST OF UNIT	NO. OF UNITS	TOTAL COST	GEOTHERMAL RELATED
F. Building Agricultural Equipment					
1. Pens, Gates, Waterers, etc.	LS			$617,100	0
2. Slats (Plastic)	LS			$145,300	0
3. Automated Feed System(Internal)	LS			$135,000	0
4. Feed Storage (External)	LS			$ 40,000	0
5. Special Areas (Lab, Office, Rest)	SF	$ 15	2,000	$ 30,000	0
Subtotal				$967,400	0
G. Specialized Agricultural Equipment					
1. Feed Mill, Equipment and Storage	LS			$149,500	0
2. Maintenance Equipment (Shop, Veh.)	LS			$ 30,000	0
3. Incinerator	LS			$ 15,000	0
Subtotal				$194,500	0
H. Swine Waste System					
1. Methane Tanks and Foundations	LS			$240,000	100%
2. Methane Equipment (Pumps, Heat Exchange, Separation, Piping, Valves, Controls)	LS			$100,000	100%
3. Waste Flushing System	LS			$225,000	100%
4. Ponds and Liners	LS			$ 31,000	0
5. Temporary Manure Storage	LS			$ 5,000	0
Subtotal				$601,000	$565,000

TABLE 5-1. -- CONCEPTUAL CONSTRUCTION COSTS

CONCEPTUAL COST DETAIL (CONT.)

	UNIT	COST OF UNIT	NO. OF UNITS	TOTAL COST	GEOTHERMAL RELATED
I. Site Utilities					
1. Domestic Water Well	LS			$ 20,000	0
2. Domestic Water Pump	Ea	$ 4,000	2	$ 8,000	0
3. Septic System (Human Waste)	LS			$ 8,400	0
4. Hot Water Distribution Piping	LF	$ 17	2,600	$ 44,200	100%
5. Hot Water Booster Pumps	Ea	$ 8,000	2	$ 16,000	100%
6. 300 KW Generator and Switch Gear	Ea	$95,000	1	$ 95,000	0
Subtotal				$191,600	$ 60,200
TOTAL HARDWARE COST				$5,097,500	$1,649,200

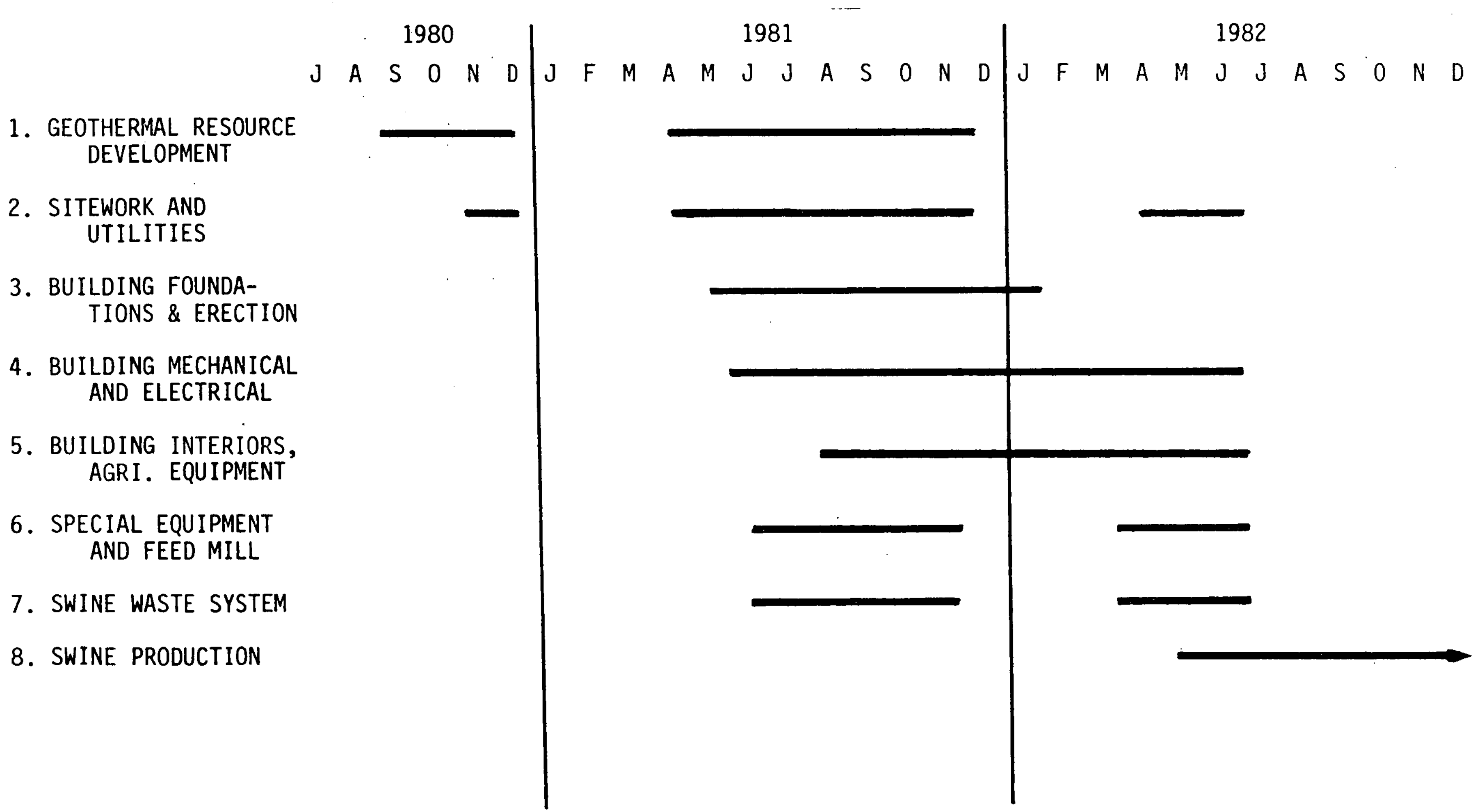


Figure 5-1. Conceptual Construction Schedule

months from the schedule projected in Figure 5-1. Highlights of the schedule are as follows:

- It is assumed that a production geothermal well must be drilled, cased and proven out by stringent testing before further construction work will be permitted. With a late summer, 1980, start on this well, it is assumed that only minor site work and construction improvements (mainly access and drainage) would commence before mid-spring of 1981. As soon as the resource is proven, long-lead items may be ordered for later delivery.
- The building season of 1981 would be spent on site work, underground utilities, concrete foundation work and erecting the building shells, with these buildings closed in by December of 1981.
- Winter and spring of 1982 will be devoted to completing the buildings and preparing for the major equipment items, which will be installed during the late winter and spring of 1982, with startup of facilities planned for the late spring of 1982 -- a 20 month schedule from start to animal operations.

III. MANAGEMENT PLAN

The construction project will be managed through a Construction Management Agreement between the construction management firm, Lahontan, Inc. and Geothermal Power Corporation, the designated owner-operator. It is proposed that the well would be drilled by a subcontractor that would be selected through a qualifications process and competitive bid. The final contract would be arrived at through negotiation. All trades would be furnished through a competitive bidding process.

As is common practice in agricultural complexes, the owner would reserve the right to complete the interior of buildings and install equipment using his operational personnel. Technical advice for this activity would be obtained from equipment suppliers. Through management planning and project scheduling, the construction would be sequenced to permit the completion of the gestation and farrowing buildings early in the project. The nursery, growing and finishing buildings and breeding facilities would follow in a logical sequence. This would permit bringing pregnant sows on board as early as practical in the construction program. Detailed planning would have to be conducted to minimize stress on the animals and to maintain health conditions.

CHAPTER 6 -- ECONOMIC ANALYSIS

I. MARKET CONSIDERATIONS

In 1978, California slaughtered over 1,600,000 hogs and pigs. Of these, California imported 1,337,000 head[13], up 37,000 from 1977. The proposed KHSAC output of 25,920 head is only 2% of the 1978 import figure and is less than the increase from 1977 to 1978. Therefore, the KHSAC impact on the import competition should be negligible. The KHSAC output represents only 1.6% of the hogs slaughtered in California.

Over 60% of the stock imported into California comes from Missouri and Nebraska. As transportation costs continue to rise faster than general inflation, these distant competitors will experience a greater profit squeeze on shipments to California.

Hog market economics revolve around feed cost conversion into revenue dollars. While KHSAC is close to a large pork market, it is also distant from traditional low cost feed. The facility is designed to efficiently convert feed to meat, thus somewhat less feed is required to produce a given hog weight relative to most competitors. But feed may still be relatively high. KHSAC is designed to counter potentially higher feed costs in the following ways:

a) More efficient conversion of feed to prime, quality hogs (better environment).
b) Higher financial leverage through geothermally related tax advantages and DOE support.
c) Less marketing transportation costs.
d) Reduced dependency on energy inflation.
e) An integrated feed production facility.

From a marketing perspective, KHSAC output will not have a major impact on the market, and tradeoffs available to the agriculture complex indicate that it has the potential to be a viable project. Formal negotiations for feed purchase and transportation when compared to formal

GPC - KHSAC

CALIFORNIA HOG PRICES AT STOCKTON

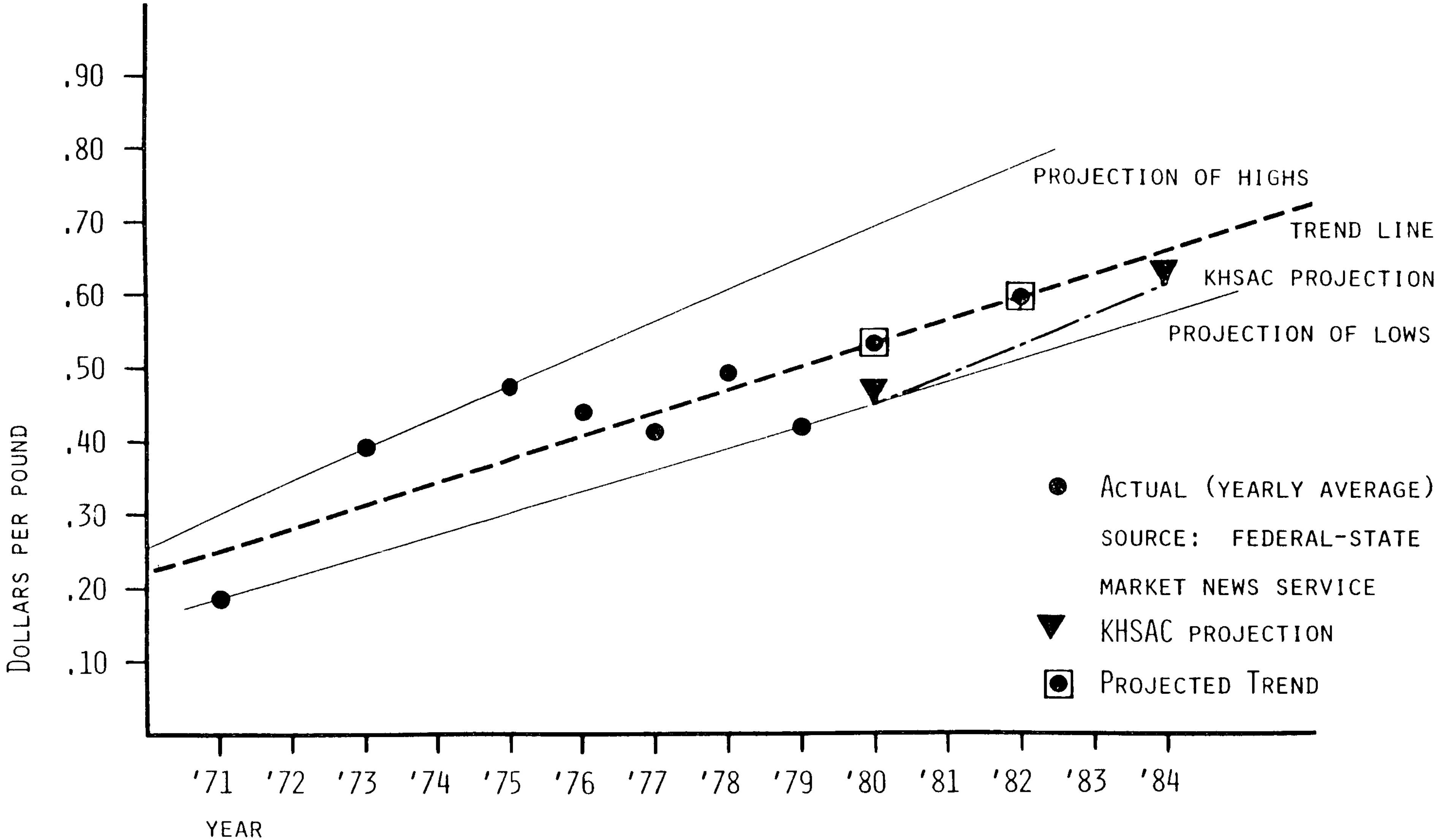


Figure 6-1 - HOG PRICE REVIEW

negotiations for hog sales and transportation will control the future economics of the project. Conceptual level information, as reflected in the operating economics, is promising.

II. OPERATING ECONOMICS

A. Revenue - At the conceptual design level, revenue was calculated as design pounds of liveweight animals produced times anticipated revenue per pound. Chapter 4, "Engineering", provides the derivation of pounds produced. The revenue per pound projections were based on a long range assessment of historical hog prices and current expectations for hog prices over the next couple of years. Figure 6-1. "Hog Price Review", provides an overview relating projected hog prices with historical (trend line) events.

The hog price projection used for conceptual economic assessment is a series of prices escalating at 8% per year, shown in Figure 6-1. The first price used in the economic projection is 51.3¢ per pound in 1982. Published material and conversation sourced during this phase considered this projection conservative, especially for prime quality pork[37].

B. Operating Costs - At the conceptual level, operating costs were projected in seven categories:

Feed - materials and additives
Labor - labor and management
Utilities - electrical, fuels
Materials - production supplies
Services - legal, audit, veterinarian
Depreciation - buildings, equipment, capitalized costs
Interest - 20 year loan at 18%

Cost Estimates provided for each category were escalated through 1987 to provide a payback analysis. These are presented in Table 6-1 Feed, labor, materials, and services were escalated at 8%. Utilities, including fuels, were escalated at 15%. Depreciation was calculated as straight line 10-year for equipment and 30-year for buildings. Interest

TABLE 6-1

OPERATING SUMMARY - FIRST SIX YEARS

	1982	1983	1984	1985	1986	1987
Revenues						
Market Pounds	1,477,440	5,909,760	5,909,760	5,909,760	5,909,760	5,909,760
Price per pound	.513	.554	.599	.647	.698	.754
Pork Sales	$ 757,927	$3,274,007	$3,539,946	$3,823,615	$4,125,012	$4,455,960
Operating Costs:						
Feed (Note 1)	454,896	1,965,151	2,122,363	2,292,152	2,475,524	2,673,566
Labor (Note 2)	76,131	328,886	355,196	383,612	414,301	447,446
Utilities	6,480	29,809	34,281	39,423	45,336	52,136
Materials	3,500	15,117	16,326	17,632	19,042	20,567
Services	7,000	30,233	32,652	35,264	38,084	41,132
Depreciation	544,555	544,555	544,555	544,555	544,555	544,555
Interest	560,021	556,201	551,694	546,376	540,101	532,696
	$1,652,583	$3,469,952	$3,657,067	$3,859,014	$4,076,943	$4,312,098
Taxable Earnings	(894,656)	(195,945)	(117,121)	(35,399)	48,069	143,862
50% Tax Allowance					24,035	71,931
Earnings	$(894,656)	$(195,945)	$(117,121)	$(35,399)	$ 24,034	$ 71,931

Notes:

1. According to the Pork Industry Handbook[82], large scale feed mills have an economic breakeven between 300-600 sows. Such a mill is designed into KHSAC.

2. Standard labor requirements seem to be well below 1 hr/cwt above 2,500 head produced per year,[96]. Published references ranged from .35 hr/cwt [96] to 1 hr/cwt [98] KHSAC has .50 hr/cwt (15 labor people X 49 work weeks X 40 hrs/59,098 cwt).

was calculated using a 20-year loan at 18% on required borrowed funds.

The 18% interest rate on the borrowed funds was used to peg debt service at a worst-case, high level to reflect difficult financing, financing fees, and cover concerns about possible exceptionally high finance charges. Actual interest rates and fees should be well below 18%. At 18%, debt service is $581,239 per year (principal and interest). At 12% the annual service would be $416,527 ($164,712 less cash needed per year).

Operating cost estimates were compared to several published references to test for major variations. A summary of the comparisons is shown in Table 6-2. Costs were expected to be relatively higher because of current high construction costs and exaggerated interest costs. However, because the facility has been efficiently designed, uses energy-efficient practices, and has energy supplied from geothermal, the facility operating costs are expected to be increasingly competitive over time.

Increasing competitiveness is expected to be a result of:

- Less dependence on energy inflation.
- Higher feed conversion than other operations which will be forced to conserve energy.
- Increasingly lower hog transportation costs relative to midwest shippers.
- Lower construction costs relative to those who must build or rebuild in future years.
- Tax advantages, especially until business tax credits, depletion, and intangible writeoffs have been taken.

C. <u>Sources and Uses of Cash</u> - A conceptual summary of major sources and uses of cash was prepared to determine the resulting payback period, see Table 6 -3. The typical (ongoing) sources and uses consider after tax earnings as the major source. Depreciation and tax credits and allowances used are also sources to correct the non-cash expenses used in calculating after tax earnings. For the conceptual summary, uses of cash are principal payments and owner cash draws to repay owner equity.

TABLE 6-2

Comparison of Operating Costs

	Basic Operating Costs					
	Feed	Labor	Other	Total	Fixed	Total
KHSAC (1979)	22.63	3.78	7.28	33.69	6.56	40.25
A. (1978)	24.15	3.97	5.95	34.07	4.04	38.12
B. (1978)	18.42	2.76	3.84	25.02	5.78	30.81
C. (1979)	23.95	4.45	4.20	32.60	8.40	41.00
D. (1978)	20.08*	7.93*	1.28*	29.29*	5.83*	35.12

*Arrived at by using assumptions in the text of the material.

A. Missouri Cooperative Extension Service [84]

B. University of Minnesota[41] ($3.50/hr. labor charge added)

C. Government Statistics[96]

D. Iowa Coop. Ext. Service[34]

TABLE 6-3

SOURCES AND USES SUMMARY - FIRST SEVEN YEARS

	1981	1982	1983	1984	1985	1986	1987
CASH SOURCES/USES							
Earnings	0	$(894,656)	$(195,945)	$(117,121)	$(35,399)	$ 24,034	$ 71,931
Depreciation Allowance	0	544,555	544,555	544,555	544,555	544,555	544,555
Tax Credits*	0	0	0	0	0	24,034	71,931
Working Capital	0	(548,004)	0	0	0	0	0
Assets	(3,066,250)	(3,066,250)	0	0	0	0	0
D.O.E.	992,100	992,100	0	0	0	0	0
Loan Principal	1,037,075	2,052,932**	(25,038)	(29,545)	(34,863)	(41,138)	(48,543)
Equity	1,037,075	919,323	0	0	0	0	0
Cash Draw	0	0	(323,572)	(397,889)	(474,293)	(551,485)	(639,874)
	0	0	0	0	0	0	0
Equity Cash Balance	$(1,037,075)	$(1,956,398)	$(1,632,826)	$(1,234,937)	$(760,644)	$(209,159)	$430,715

*Loss Carryforward, ITC, Business Tax Credits, etc.; effect on payback analysis is that no income tax will be paid until after owner cash payback.

**2,074,150 New
(21,218) Payment
2,052,932 Net

Table 6 -3 covers the sources and uses through 1987. The equity cash balance is shown at the bottom of the table and reflects an owner cash payback in 1987, a payback in less than five operating years, and six years from start of construction. A payback of six to seven years was considered an upper limit[41].

During construction and startup, sources and uses of cash are atypical. For example, earnings are negative and are shown as a use of cash (a loss). D.O.E. funds are shown as an initial source of cash as are loan principal and equity. The major uses of initial cash are for assets and working capital. In each year, the algebraic sum of sources and uses is always zero.

D. Conceptual Economic Assessment - The conceptual level revenue and cost projections indicate that the project is viable with an expected owner cash payback within five years operation. However, the actual outcome is very sensitive to revenue per pound, feed costs, and full production marketing.

Revenue per pound was projected conservatively over the projected period per Figure 6 -1. Feed costs are at expected costs (neither optimistic nor pessimistic) and full production marketing is expected to be realized in the California market. Because optimistic projections were not used on any of the key variables and overall costs were inline with available comparisons, the conceptual economic projection appears reasonable.

The conceptual projections lack many details which will become available in the next phases of the project. Cogeneration revenues, increased throughput, and lower interest rates are changes which may significantly improve operating earnings and payback. Once building and equipment lists are complete, accelerated depreciation schedules can also be run to delay tax payments even further (an improvement in the long term but not within the owner cash payback period). Firm equity structure will also allow more detailed scheduling and costing of the debt service and may even introduce favorable debt terms such as FMHA guarantees, delayed payments, and interest coverage until income is realized.

A number of less material considerations will also be clarified in the next phases as specific details and agreements become available. Some of these other enhancements to the economic assessment are listed in Chapter 7, Section III.

Given the conceptual status of the project as covered here, the economic assessment of the project appears favorable based on available information. Coopers and Lybrand have no reasonable grounds to believe, and do not believe at the time of preparing this conceptual design report, that any of our assumptions or information sources are unreasonable, unreliable, or untrue or that there has been an omission of any material fact important to the continuation of the project into preliminary design and Phase II, where many of the costs and parameters will be further identified and evaluated. Some future considerations have been mentioned in this chapter, others are discussed in Chapter 7, "Considerations for Preliminary Design."

CHAPTER 7 --CONSIDERATIONS FOR PRELIMINARY DESIGN

I. OBJECTIVE FOR PRELIMINARY DESIGN ACTIVITY

The Preliminary Design is being directed to optimize the economics of the Kelley Hot Springs Agricultural Center. In light of the current high cost of financing and cyclical pork prices, the effort is being focused in the areas of:

- Increasing pork production in the basic 1,200 sow configured facility
- Reducing the feed costs and improving the effectivity of feed constituents
- Review of design concepts to reduce the capital cost of the facility
- Construction planning to reduce construction time and accelerate time for admission of the production herd into the facility
- Review of the economics and business planning to maximize the rate of pay back of investor capital and increase tax shelter.

II. SELECTED CRITERIA AND GUIDELINES

Based upon the review of the Conceptual Design and the Summary Economic Analysis, it was determined that it was desirable to reduce the capital cost of the facility and to increase the productivity and to reduce the cost of feed to maximum extent practical and still maintain an acceptable level of health and quality for the animals. The design was reviewed for the purpose of identifying areas that warranted consideration of changes in order to enhance the economics of the overall concept. These considerations will be evaluated through the Preliminary Design activity. The principal changes are as defined below:

1. Based upon the quality of water from Kelley Hot Spring as measured to date, the primary heat exchanger has been deleted. The radiant

heating in the floor is the only area in which a fresh water loop and heat exchanger will be utilized.

2. The reinjection well has been eliminated. The unconsumed geothermal fluids will be released through natural drainage on the surface or sprayed through an irrigation system. Primary use of the geothermal fluids will be for makeup water in the manure flush and in the methane generation system. Waste waters that have been purified by the methane generation process will be used for manure flushing in the breeding and gestation and growing and finishing buildings. Fresh and or uncontaminated geothermal water flush will be utilized in the farrowing and nursery buildings.

3. The site for the facility for this effort is Site 6. Both the supply well and the facility will be located at Site 6. As an alternative, the supply well will be located on Site 6, and this will be connected by buried, uninsulated transite pipeline to the facility through an existing culvert under US 299. The facility for this alternative configuration will be located in the archeologically cleared area in Site 3.

4. By using the operator's crew for finishing the interior of the buildings and installing equipment, a certain magnitude of savings in labor may be achieved.

5. The lineal footage of fin tube heat exchangers in the ceilings of the swine raising buildings are to be reevaluated.

6. Sprouted grain growing equipment is to be added to produce sprouted barley. The sprouted barley will displace about 20 percent of the commercial feed in the breeding, gestation, and farrowing buildings. International research and certain commercial growing practices incorporate sprouts and/or green grass chop in their feed in order to improve breeding, gestation and lactation.

7. The incinerator is to be deleted and a caustic tank for disposal of dead piglets up through nursery size is to be incorporated. Adult swine dead carcasses will be disposed of through hauling to a solid waste or rendering facility in the county.

8. Gravity tanks will be used for waste flusing in lieu of the

previously considered high-flow pumping system.

9. The 300 KW electric generating system is to be deleted and replaced by a 100 KW emergency standby power supply system. The biogas storage tank is to be deleted and low pressure methane is to be furnished at the facility boundary to the Surprise Rural Electric Cooperative Company for generating electricity with their own motor generator set. Additional discussions are to be held with the utility to refine and pursue this cogeneration concept. The methane will be scrubbed in order to remove H_2S, CO_2 and any other harmful materials.

10. By rearranging the animal pen layouts in the farrowing building and reshaping but not increasing the size of this building, two additional pens can be included in each of the 18 rooms. This will permit impregnating additional gilts to increase the production herd to 1,360 pregnant and farrowing sows. This increases the pork production by over 13 percent.

III. PRELIMINARY ECONOMIC IMPACTS

With the addition of biogas sales and increased throughput (up 13% to 66,925 cwt/yr), owner cash payback could be brought back from 1987 (4½ years) into 1986 (4 years). Better financing terms could reduce the payback as much as another half year. Minor fluctuations in capital costs would be absorbed over the life of the debt, so their impact on costs would be small.

Other significant favorable or unfavorable impacts will most likely occur in formal negotiations for feed materials costs (including transportation), formal marketing arrangements (including price per pound, transportation, and commissions or fees), and outside services. The level of outside services will be inverse to the caliber of inhouse people, that is, strong inhouse bookkeeping, animal husbandry, marketing, and purchasing capabilities will significantly reduce use of outside services and enhance operating profits. Inhouse weaknesses in these areas will reduce operating margins and increase needed outside services, a double penalty. Outside services include tax counsel, legal counsel, audit, and veterinarian services.

Other details which will be identified during the next phase are:

- Verified costs by category
- Investment Tax Credit
- Business Tax Credit (Energy Tax Credit)
- Depletion qualification
- First-year depreciation bonuses
- Accelerated depreciation schedules
- Inventory, personal property, and real estate taxes
- Separate state and federal tax calculations
- Licensing and insurance requirements
- Marketing agreement specifics
- Feed procurement specifics
- Hog and feed transportation costs
- Equipment and facility overhaul and replacement costs
- More firm construction schedules
- More firm operations startup schedules
- More definite equity structure
- More clear financing requirements, fees, and rates
- Appropriate working capital levels and growth (Accounts Receivable, Accounts Payable, Inventory and Cash)
- Production throughput levels

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