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Geothermal Programs

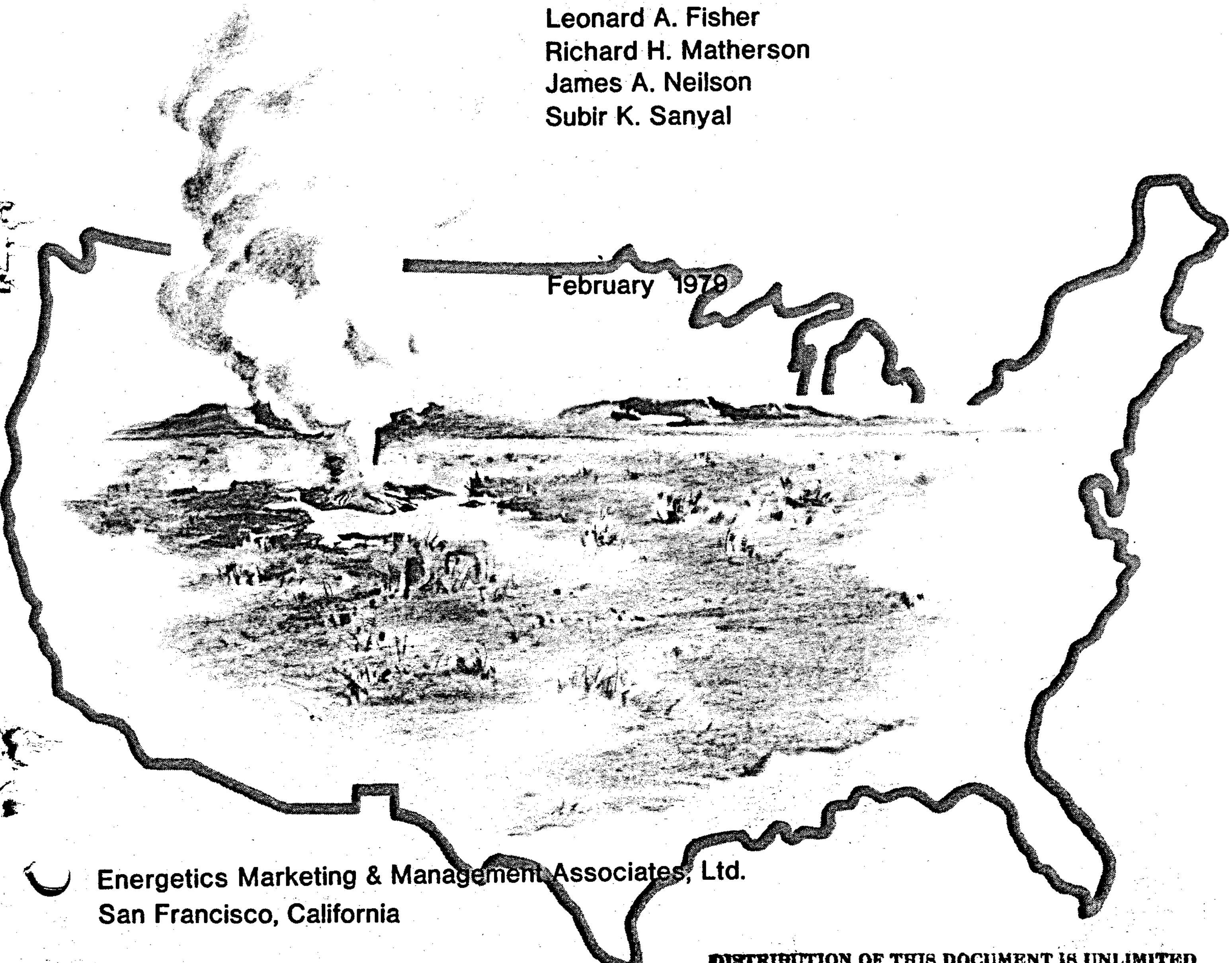
Idaho Operations Office

MOUNTAIN HOME GEOTHERMAL PROJECT

GEOTHERMAL ENERGY APPLICATIONS IN AN INTEGRATED LIVESTOCK MEAT AND FEED PRODUCTION FACILITY AT MOUNTAIN HOME, IDAHO

Final Technical Report

Alfred B. Longyear, Principal Investigator
William R. Brink
Leonard A. Fisher
Richard H. Matherson
James A. Neilson
Subir K. Sanyal



February 1979

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Idaho Operations Office
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ABSTRACT

The Mountain Home Geothermal Project is an engineering and economic study of a vertically integrated livestock meat and feed production facility utilizing direct geothermal energy from the KGRA (Known Geothermal Resource Area) southeast of Mountain Home, Idaho. The study was conducted by a team of industry firms and is supported by an Advisory Board staffed by agricultural and energy specialists in Idaho.

A system of feed production, swine raising, slaughter, potato processing and waste management was selected for study based upon market trends, regional practices, available technology, use of commercial hardware, resource characteristics, thermal cascade and mass flow considerations, and input from the Advisory Board.

The complex covers 160 acres; utilized 115 million Btu per hour, (34 megawatts-thermal), of geothermal heat between 300°F and 70°F; has an installed capital of $35.5 million; produces 150,000 hogs per year, 28 million lbs. of processed potatoes per year, and on the order of 1000 continuous horsepower from methane. The total effluent is 200 gallons per minute (gpm) of irrigation water and 7300 tons per year of saleable high grade fertilizer. The entire facility utilizes 1000 gpm of 350°F geothermal water. The economic analysis indicates that the complex should have a payout of owner-invested capital of just over three years. Total debt at 11% per year interest would be paid out in 12 (twelve) years.

TABLE OF CONTENTS

Description	Page
Abstract	
List of Figures	ii
List of Tables	iv
Chapter 1 - Introduction	1
Chapter 2 - Project Overview	5
Chapter 3 - Geothermal Resource	14
Chapter 4 - System Engineering	37
Chapter 5 - Economics	89
Chapter 6 - Environmental	107
Chapter 7 - Institutional	130
Reference List	138
Glossary	146
Appendix A - Totally Confined Swine Raising	148
Appendix B - Sprouted Grains in Nutrition and Metabolism of Livestock Feed	161
Appendix C - Financing Alternatives for Direct Applications of Geothermal Energy	169

LIST OF FIGURES

Number	Title	Page
2-1	Project Site: Bostic 1-A Well in Potato Field	6
2-2	Schematic of Overall System Studied	8
2-3	Schematic of Selected System	9
2-4	Project Schedule	11
3-1	Sequence of Cenezoic Rocks in Snake River Plain	15
3-2	Depth Contour Map for Water Wells in the Area	17
3-3	Contours of Specific Electrical Conductance	18
3-4	Aeromagnetic Map of the Area	19
3-5	Bostic 1-A, Pressure and Temperature Profiles at 500 gpm	24
3-6	Bostic 1-A, Pressure and Temperature Profiles at 600 gpm	26
3-7	Plot of Production Rate vs. Wellhead Temperature	27
3-8	Plot of Production Rate vs. Water Enthalpy at Wellhead	28
3-9	Plot of Flash Depth vs. Production Rate	30
3-10	Plot of Wellhead Pressure and Temperature vs. Production Rate	31
3-11	Plot of Production Rate vs. Wellhead Steam Quantity and Mixture (Steam & Water) Enthalpy	32
4-1	Schematic of Selected Integrated System	45
4-2	Functional Elements of the Feed Production Subsystem	47
4-3	A Totally Confined Facility Figure Credit: Clay Equipment Corporation	51
4-4	Potato Process Flow Diagram	61
4-5	Schematic of Biogas Generation Subsystem	64
4-6	Approximate Range of Subsystem Temperature Applications	67
4-7	Overall Integrated Site Plan	72
4-8	Site Plan Details	73

LIST OF FIGURES

Number	Title	Page
4-9	Transfer Modes for Heating: Exchange Details	76
4-10	Schematic of Absorption Refrigeration Figure Credit: Arkla Co.	77
4-11	The Thermal Cascade (Including Losses)	78
4-12	Site Hot Water Piping Mains	81
4-13	Building Hot Water Piping Main, Details	82
4-14	Mass Flow Cascade	83
4-15	Product Flows	86
4-16	Product Flow Details	87
5-1	Owner Cash Flow for First Four Years	104
6-1	Precipitation and Temperature: Mountain Home, ID	110
6-2	Deviations of Normal Temperature (By Season)	112
6-3	Monthly Temperature Average (High and Low)	114
6-4	Average Monthly Minimum Temperatures and Frequency of Days Above and Below (Histograms)	115
6-5	Ground Water Movement and Recharge	117
7-1	Flow of Permitting Processes	136

LIST OF TABLES

Number	Title	Page
3-1	Data on Bostic 1-A Well	20
3-2	Geological Column, Bostic 1-A Well	21
3-3	Comparison of Two Production Schemes	33
4-1	Matrix of Subsystems: Selection Summary	39
4-2	Principal Sources of Data	40
4-3	Feed Composition Formula	49
4-4	Baby Pig Losses: Causes and When They Occur	54
4-5	Temperature and Ventilation Requirements	57
4-6	Building Size Guidelines	59
4-7	Actual Pen Space Required Per Animal	59
4-8	Hog Population Guidelines	59
4-9	Average Temperature Targets	68
4-10	Swine Raising Building Areas -7200 Sow Complex	74
4-11	Active Subsystem Areas	74
4-12	Geothermal Heat Applications	75
4-13	Thermal Summary - Peak Loads	79
4-14	Facility Performance Parameters and Footnotes	84 85
4-15	Engineering Estimates and Bases for Capital Costs	88
5-1	Facilities: Construction & Operations Startup	94
5-2	Stock: Operations Startup Schedule	95
5-3	Staffing: Operations Startup Schedule	95
5-4	Feed: Operations Startup Schedule	95
5-5	Financial Projections Through Year Five and Footnotes	97 98
5-6	Financial Projections for Years Six Through Thirty and Footnotes	101 102
6-1	Two Wells Analyzed by Young & Mitchell	119
6-2	Trace Substances in Water Supplies and Footnotes	121 122
6-3	Materials of Interest in Water Quality	123
6-4	Impact Summary	127
7-1	MHGP Institutional Entities	131
7-2	Institutional Impacts and Mitigations	137

CHAPTER 1 - INTRODUCTION

This is the Final Report for the Mountain Home Geothermal Project (MHGP). It covers the technical work performed in the actual period of April 15 through October 31, 1978.

The Project is an engineering and economic study of a vertically integrated livestock meat and feed production facility utilizing direct geothermal energy from a site near Mountain Home, Idaho. The Project is oriented to produce preliminary engineering design information and economic planning data that will contribute directly to implementation of a commercial project at the site. Care has been exercised to assure that the data has a high degree of replicability to other geothermal sites.

Appendix A contains a paper prepared by Randy McMahon, Clay Equipment Company, as his contribution at no cost to the Project. This paper describes modern swine raising practices. Appendix B, prepared by Dr. R. H. Matherson, Agricultural Growth Industries, discusses the importance of fresh grasses(sprouted grains) and their effects upon the nutrition of livestock. Appendix C, prepared by Robert D. Dellas, Energetics Marketing & Management Associates, summarizes the financial planning which has been developed by EMMA as a result of its ongoing financial consulting activities. This paper was furnished at no cost to the Project as part of EMMA's share.

A. MOUNTAIN HOME GEOTHERMAL PROJECT TEAM MEMBERS

The Prime Contractor is a financial consulting firm interested in packaging financing for the implementation of this and similar projects. The firm organized the MHGP Team of specialists to furnish the disciplines and experience needed to conduct the study. The Team Members and their responsibilities are:

1. Energetics Marketing & Management Associates, Ltd. (EMMA), San Francisco, California
   - Charles E. Rynd: Program Manager; Financial Planning and Project Administration
   - Subir K. Sanyal, PhD: Geothermal Reservoir Engineer; leader on Task 1.0 - Geothermal Resource

2. Fred Longyear Co., Sacramento, California
   - Alfred B. Longyear: Principal Investigator; leader on Task 4.0 - Institutional Factors

3. Agricultural Growth Industries, Inc. (AGI), Concord, California
   - Richard H. Matherson, PhD: Agribusiness and Food Process Scientist; leader on Task 2.2 - Agricultural Engineering Factors

4. International Engineering Co. (IECO), San Francisco, California
    - Leonard A. Fisher, P.E.: Systems and Energy Engineer; leader on Task 2.3 - Systems Engineering Factors

5. Ecoview, Napa, California
    - James A. Neilson, PhD: Geothermal Ecologist; leader on Task 3.0 - Environmental Factors

6. Coopers & Lybrand, San Francisco, California
    - William R. Brink: Market and Economic Analyst; leader on Task 5.0 - Economic Factors

B. ADVISORY BOARD

An Advisory Board has been formed to assure consideration of local agricultural practices and needs pertinent to Idaho and the Mountain Home site. This Board of specialists from Idaho has furnished data on livestock, feed and processing practices in the area, made introductions to specific industries and agencies in the state for Team members, and furnished specific advice that was considered in the system selection process. The Board is composed of the following:

1. Roy Taylor, Extension Agricultural Engineer, Idaho Cooperative Extension Service, University of Idaho, Moscow

2. Mark Calnon, Extension Agricultural Agent, Elmore County, Idaho Cooperative Extension Service, Mountain Home

3. Allen Saylor, Executive Vice President, Idaho Cattlemen's Association, Boise

4. Martin Montgomery, Deputy Director, Idaho Office of Energy, Boise

Alternates who have made contributions to the Project include:

1. Tom Hovenden, Secretary-Manager, Idaho Cattle Feeders and Idaho Food Producers Associations, Boise

2. James Worstell, Energy Specialist, Idaho Cooperative Extension Service, Boise

3. David McClain, Oregon Institute of Technology and Idaho Office of Energy, Boise

C. PROJECT BACKGROUND

1. This PRDA study evolved out of consideration for the magnitude of the livestock industry in the West, the urgent need for economic improvements in this industry, its common location with geothermal sites, and the match of energy requirements with known geothermal resources.

Review of prior studies[1-8] and extensive discussion with Idaho (agricultural) Cooperative Extension specialists, and with agronomists and representatives of the USDA and agricultural industry in three states[9-11] has been used to structure the Project and to guide its direction during the study effort. Two major factors affecting the future trends in the livestock industry have been identified:[12-15]

a. The need for more efficient utilization of capital in the livestock industry.

b. The need for a lower-cost, higher-quality livestock feed, preferably from a local source.

2. Results of these earlier studies revealed the degree of benefit that lower-cost heat energy could accrue to subsystems and systems. The focus of **vertical integration, biological cascading** and common-site physical location of major livestock subsystems has resulted from the consideration of:

a. Cost benefits of lower-cost energy (particularly evidenced by earlier studies).[1-8]

b. Logistics/transportation costs and energy required for importing Midwestern and Southeastern processed animal feeds to the Northwest and West.

c. Mortality and high-cost weight-loss associated with long distance transportation of "finished" (fully fed) livestock.

d. Improved capital utilization over that of range operations.

e. Current trends toward vertical integration in the U.S. especially in the production of pork and chicken meats.[16]

f. Higher quality of fresh constituents of livestock feed.

g. Environmental requirements leading to advanced waste management systems.

h. The most efficient utilization of a hydrothermal resource requires a well designed energy cascade between multiple applications--ideally at an integrated site.[17]

D. NATIONAL AND INTERNATIONAL FACTORS

Prior studies have tended to concentrate on the internal engineering and economics of selected subsystems and systems.

From discussions with authorities,[9-11] it has been found that the national and sometimes international impacts on product marketing and feed supply for agricultural applications can overshadow the theoretical advantages of lower-cost energy internal to the system. Consequently, the characterization of feed subsystems and selection of specific animals for this Project have been partially constrained by consideration of national and international impacts on raw material supply (feed constituents) and end-product marketing. These have included recognition of the differences in labor costs for slaughter of cattle in Australia and in the Western states; Russian and Chinese purchases of certain feed grains; Indian, Cuban and other foreign sales of low-priced sugar; as well as the national and regional trends in cattle and swine raising, feeding, slaughter and in livestock feed production.

CHAPTER 2 - PROJECT OVERVIEW

A. PROJECT SUMMARY

1. The Primary Objective of the Project is:

> "To promote early commercialization of geothermal energy in an integrated livestock meat and feed production facility." (Department of Energy Contract ET-78-C-07-1704)

To achieve this objective, the project has been directed to conduct those engineering and economic studies which would result in a preliminary design and economic analysis of a commercially viable livestock operation at the Mountain Home site. In parallel, the Prime Contractor, as a part of other ongoing projects has investigated financing alternatives that might be used in supporting implementation of the complex (see Appendix C).

2. The Site and Geothermal Resource

The Project is an engineering and economic study of a vertically integrated livestock meat and feed production facility utilizing direct energy from the Bostic 1-A well and the underlying geothermal reservoir near Mountain Home, Idaho. The site is in the southwest corner of Sect. 25, T4S, R8E, Boise Meridian, about 13 air miles southeast of Mountain Home. As shown in Figure 2-1, the Bostic well is in a nearly level potato field and about 3/8 mi. northwest of an Intermountain Gas Pumping Station. The Bostic well has been re-entered by Magma-Union for rework.

Based upon available data, the resource is assessed to be a suitable source of hot water (See Chapter 3). The study to date indicates that the resource should be adequate for the project; however, more data is required before the resource assessment can be completed.

3. The Community

The city of Mountain Home and County of Elmore in south central Idaho constitutes the community for this study (see Chapter 7).

4. The Selected System

The core of the system is:

a. An environmentally controlled sprouted grain growing system for production of fresh enzymes and vitamins as a constituent of animal feed

b. A multi-animal livestock feed mill facility

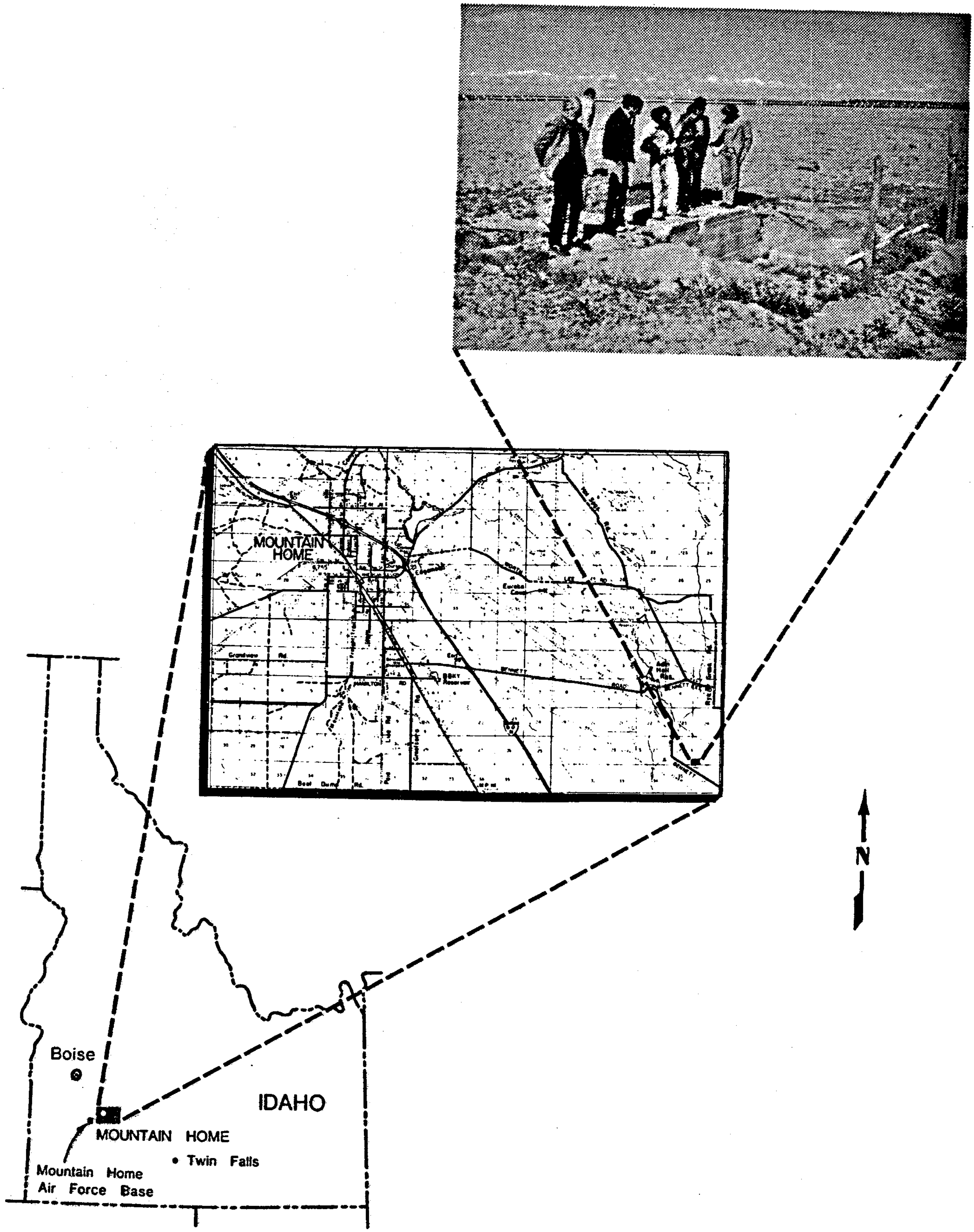


Figure 2-1. Bostic 1-A Well in Potato Field

c. A modular, totally confined swine raising facility
d. A minimum of 60 head per hour hog slaughter and marketing facility
e. A salable animal byproduct processing facility
f. A potato dehydration and processing plant
g. A total waste management facility including methane generation

The overall system concept, as initially evaluated, is schematically shown in Figure 2-2. The small animal, sheep, environmental ponds and secondary processing facility are considered potential growth elements and were not studied in depth in this Project. The system selection and rationale are discussed in Chapter 4. The selected system is shown in Figure 2-3.

5. The Selected System Characteristics

Current practices and trends in commercial slaughter capacity, when applied to a totally vertically integrated facility, result in a site of 100 acres for capital facilities. About 50 acres of common space are used for shared access facilities such as truck parking and loading, animal runways, roadways for material handling, and the like. About 25 acres are used for swine raising in modular commercial hog parlors and the balance is utilized in two- to six-acre facilities for feed growing, feed constituent purchase and storage, feed processing, potato processing, slaughter, biogas production, primary waste treatment, wells and central facilities. Over and above the 100 acres, another 60 acres are used for storage and waste treatment irrigation lands. Through integration and biological cascading, the total effluent from the plant amounts to 200 gpm of irrigation quality water plus salable fertilizer - these are actually products rather than effluents in the common sense.

6. Energy Demand

The facility has a peak geothermal energy demand of 115 million Btu/hr, (34 megawatts-thermal) and through cascading, utilizes temperatures from 300°F* down to 70°F at re-injection. Required peak geothermal fluid flow is nominally 1000 gpm. This energy is equivalent to an average annual consumption of 4,500,000 gallons of oil.

7. Financial Analysis

The entire complex requires $35.5 million in capital improvements. The profitability of the operations returns

*English units are used in order to be consistent with current agribusiness practices.

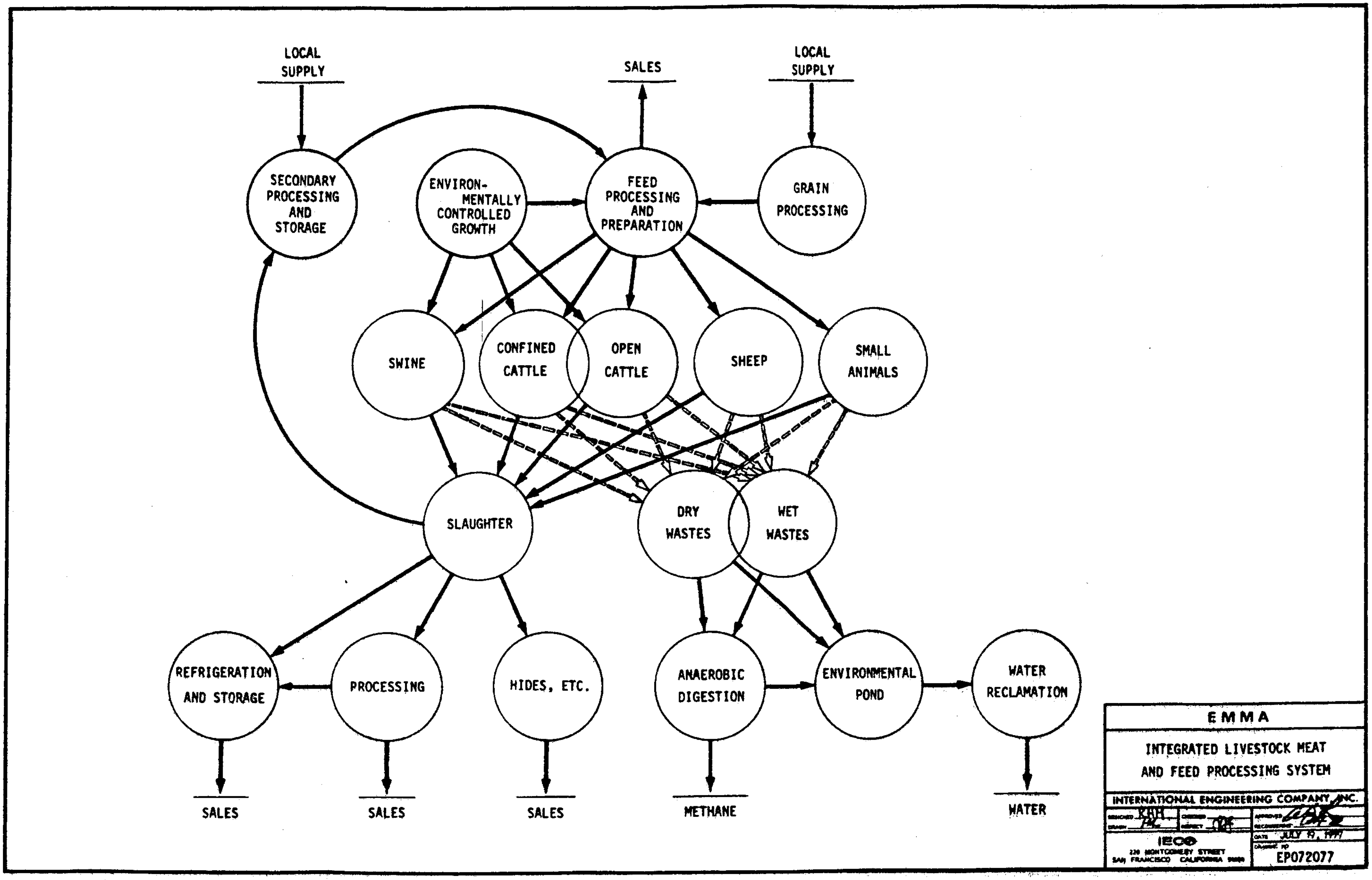


Figure 2-2. Schematic of Overall System Studied

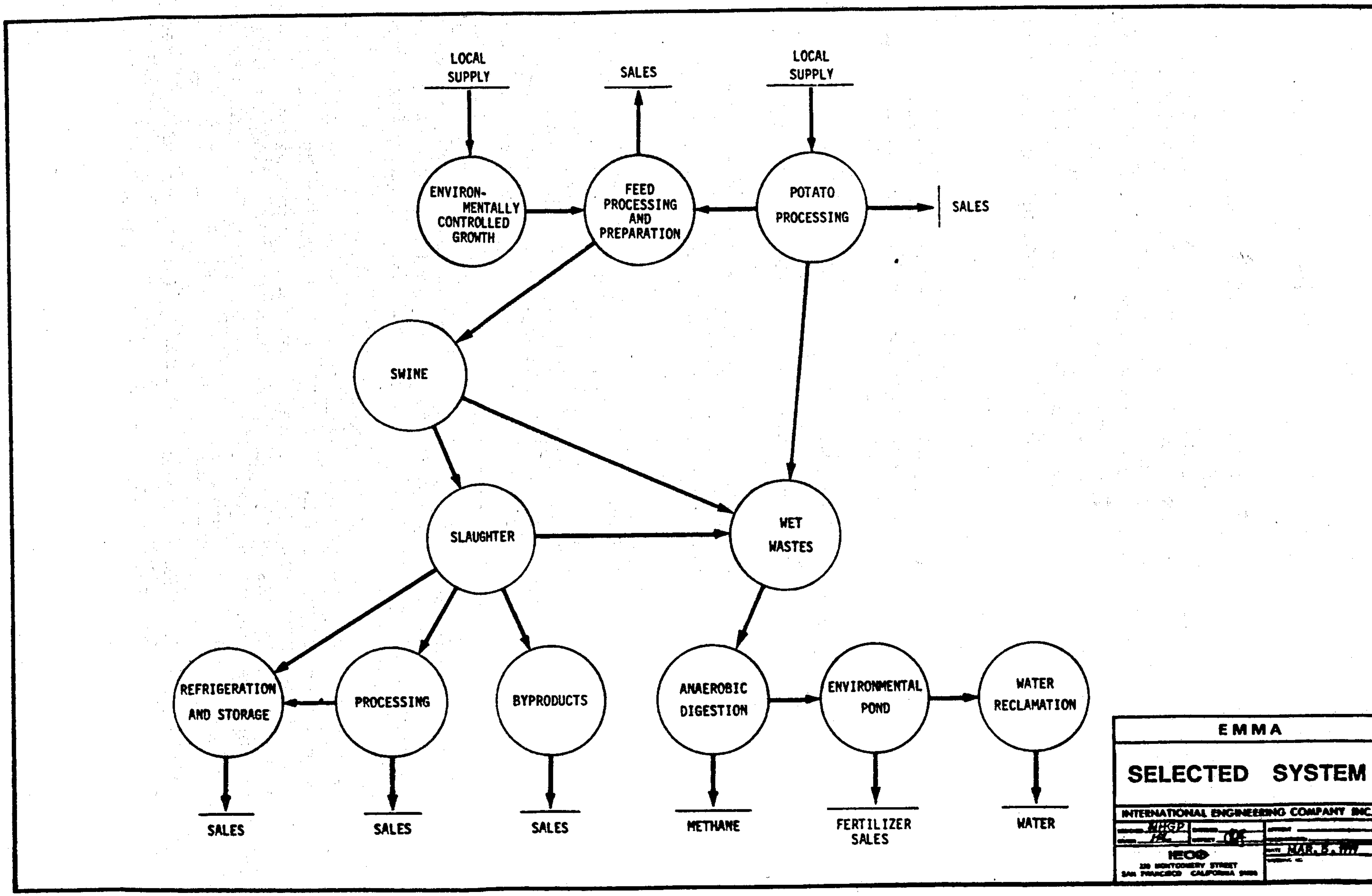


Figure 2-3. Schematic of Selected System

the owners' invested cash in 3.15 years. Total debt at 11% per year interest is paid out in 12 years.

8. Environmental and Institutional Considerations

There are no known environmental or institutional impediments to implementation. However, it should be noted that replication to other sites may require special considerations for site dependent requirements. The magnitude of the facility and its internal fluid flow requirements dictate a concerted approach to design for human, animal and environmental safety. Commercial systems and practices are available for such requirements.

9. System Hardware and Equipment

Although commercial hardware and systems are available for all elements of the complex, unique effort is required to affect the integration and balance of the energy and mass flow streams of the subsystems.

10. Project Scope and Schedule

The Project has been conducted within the following scope:

Task 1.0-<u>Geothermal Resource</u> - An assessment was made of the potential of the Mountain Home geothermal resource based upon data available from the area and the Bostic 1-A well.

Task 2.0-<u>Engineering Factors</u> - An overall system was selected (Task 2.1); the selected subsystems were defined based upon regional practices, the market, and agri-science and engineering analyses (Task 2.2). The integrated system was preliminarily designed with energy and mass flow streams balanced and an energy budget was prepared (Task 2.3).

Task 3.0-<u>Environmental Factors</u> - The area and system were evaluated for environmental impacts and for the determination of mitigating activities to minimize any potential impacts.

Task 4.0-<u>Institutional Factors</u> - The local and State government requirements and attitude toward the Project were assessed to determine potential impediments or adverse socio-economic impacts associated with future implementation and mitigating activities for minimizing such impacts were identified.

Task 5.0-<u>Economic Factors</u> - Considering the market and regional practices, the economics of the Project were analyzed to establish the financing requirement and an economic appraisal of the Project.

The Project Schedule is shown in Figure 2-4.

PROJECT SCHEDULE

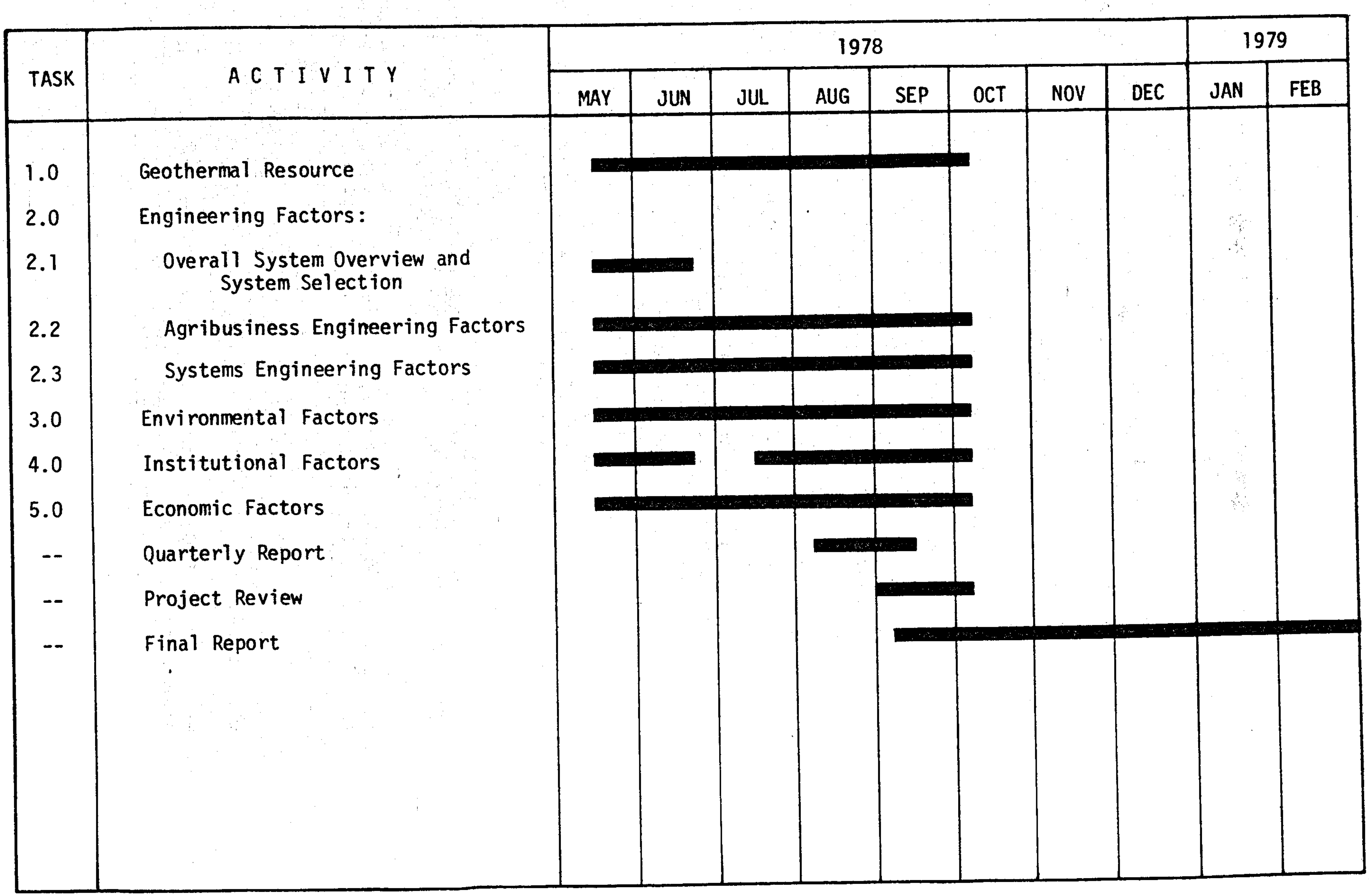


Figure 2-4. Project Schedule

B. CONCLUSIONS

- Swine raising is an ideal application of geothermal direct energy in the livestock industry:

  - It has a long term growth market. (Chapter 5)

  - Existing breeds and technology are available for totally confined raising. (Chapter 4, Appendices A and B)

  - Swine efficiently utilize animal feeds. (Chapter 4)

  - Swine manure provides high yields in methane generation. (Chapter 4)

  - The match of the Application with a hydrothermal resource is excellent. (Chapter 4)

- Environmentally controlled growing of sprouted grains contributes to a locally produced high-quality low-cost feed that aids economically in the production of an improved meat product. The importance of sprouted grains as a <u>constituent</u> of livestock, (including swine) feed is being recognized as a result of genetic and nutrition research on an international basis. However, the basic economics of the MHGP is still sound if other grains, including corn, are utilized. Each site will have different economically optimum feed formulae depending upon the economics of local supplies of feed constituents. The sprouted grains have been utilized in the MHGP as a minor constituent in the feed as a result of the feed trends in Canada and other swine raising areas that have cold climates. (Chapter 4, Appendices A and B)

- Vertical integration of totally confined swine raising and local production of competitive feed are the major factors contributing to the attractive economics of the concept; especially for operations in the Northwest. (Chapter 5)

- Hog slaughter at a minimum commercial scale of 60 head per hour is a key operational sizing criterion for the complex and contributes to the efficiency of the thermal cascade. (Chapter 4)

- Potato processing contributes to the efficiency of the thermal cascade, provides feed constituents and enhances the efficiency of the methane generators. (Chapter 4)

- A well integrated and carefully designed waste management system is the key to eliminating potential environmental or institutional impediments. (Chapters 6 and 7)

- Methane generation is both an economic and an environmental benefit to hog raising facilities of 500 sows or larger and is a major trend in the agricultural industry. (Chapters 4 and 5)

- The complex is large:

  - 100 acres for facilities and common space plus 60 acres for waste handling and disposition.

  - A core system of 7200 breeding sows producing 150,000 hogs per year at 220-240 lbs. live weight each.

  - A geothermal energy demand of 115 million Btu/hr., (34 megawatts-thermal)

  - An installed capital of $35.5 million and an investment payout of 3.15 years to the owners. (Chapters 4 and 5)

- The Mountain Home resource, as known to date, is uniquely suited for the Application. The system can effectively utilize cascaded energy over a temperature range of 300°F down to 70°F at re-injection. (Chapters 3 and 4)

- Geoscientific data on the Mountain Home reservoir is limited. Definition of the reservoir will require additional data. These data are currently being gathered by the developer. (Chapter 3)

- Elements of this Application can be replicated at a number of other hydrothermal sites.

- Though the system is large as a totally integrated entity, each of the subsystems is of an economic size in itself. Limited integrated systems composed of feed production, swine raising and waste management are being planned for two sites in California and one site in Oregon. The system lends itself to a degree of modular dispersion. The economics of slaughter does require the supply of slaughter-ready hogs from the production of at least 7200 sows. The economics of a totally dispersed modular system supplying a regional slaughter facility have yet to be analyzed.

C. RECOMMENDATIONS

It is believed that project implementation can be accelerated through the preparation of a detailed implementation plan.

CHAPTER 3 - GEOTHERMAL RESOURCE

A. RESOURCE CHARACTERISTICS

The major effort in this Task has been the acquisition and evaluation of the available geological, geophysical, geochemical, and engineering data. A number of potential sources of information such as the U.S. Geological Survey, Idaho Department of Water Resources, Idaho National Engineering Laboratory, Boise State University, University of Utah, Gulf Oil and Mineral Company, Magma Power Company, and some private well operators in the area have been contacted. The reference list (numbers 18-30) includes the most relevant geoscientific publications for this project. Unpublished well data on Bostic 1-A well were also collected as discussed later. The main difficulty discovered early in the resource effort has been the lack of readily available accurate data. While significant geoscientific data is available for the Bruneau-Grand View area about ten miles away, data are scanty on the Mountain Home site. Based upon data available to the Project, the important results and conclusions of the resource study to date are discussed below.

The Mountain Home Known Geothermal Resource Area (KGRA) is located in Elmore County in south central Idaho about 50 miles southeast of Boise and about 13 air miles southeast of Mountain Home. The total surface area of the KGRA is 9,250 acres (37.4 square kilometers). The KGRA is located between the central Idaho Tertiary and Cretaceous granitics, and the Tertiary and Quaternary rocks of the Snake River Plain to the west. The KGRA lies on the northwest-southeast trending fault that marks the relatively abrupt transition zone northwest of the Bruneau-Grandview KGRA near Boise. The major hot springs in the area are controlled by faulting. The lithologic types found in the Mountain Home area are Pliocene and Pleistocene sediments, Pleistocene Basalts, and Tertiary silicic volcanics overlying Cretaceous granite. The silicic volcanics are Miocene Rhyolites. Figure 3-1 presents a general stratigraphic sequence of Cenozoic rocks in the western Snake River Plain. In Figure 3-1, those formations that are present in the Mountain Home area are marked with asterisks. The Idavada volcanics underlying the Idaho group is considered to be the most important aquifer and the source of hot water (Young and others, 1975).[28] The Idavada volcanics are lower silicic volcanics, and generally the waters produced from the complex are at significantly higher temperatures than those at nearby wells from overlying units.

This area has above-normal geothermal gradients. The temperature gradients range from 39°F (22°C) to about 50°F (28°C) per 100 meters. The heat flow in this area is on the order of 1 to 3 heat flow units. The origin of the geothermal water in this area is presumed to be due to deep circulation (Young and others, 1975). The high geothermal gradient in the area has been assumed to be due to a thinning of the upper

SERIES			GROUPS AND FORMATIONS	
QUATERNARY	RECENT		SNAKE RIVER GROUP	Recent lava flows
QUATERNARY	PLEISTOCENE	UPPER	SNAKE RIVER GROUP	Melon Gravel*
QUATERNARY	PLEISTOCENE	UPPER	SNAKE RIVER GROUP	Bancroft Springs Basalt
QUATERNARY	PLEISTOCENE	UPPER	SNAKE RIVER GROUP	Sand Springs Basalt
QUATERNARY	PLEISTOCENE	UPPER	SNAKE RIVER GROUP	Crowsnest Gravel*
QUATERNARY	PLEISTOCENE	UPPER	SNAKE RIVER GROUP	Thousand Springs Basalt
QUATERNARY	PLEISTOCENE	UPPER	SNAKE RIVER GROUP	Sugar Bowl Gravel*
QUATERNARY	PLEISTOCENE	UPPER	SNAKE RIVER GROUP	Madson Basalt
QUATERNARY	PLEISTOCENE	MIDDLE	IDAHO GROUP	Black Mesa Gravel
QUATERNARY	PLEISTOCENE	MIDDLE	IDAHO GROUP	Bruneau Formation*
QUATERNARY	PLEISTOCENE	LOWER	IDAHO GROUP	Tauna Gravel
QUATERNARY / TERTIARY	PLEISTOCENE / PLIOCENE	LOWER / UPPER	IDAHO GROUP	Glenns Ferry Formation*
TERTIARY	PLIOCENE	MIDDLE	IDAHO GROUP	Chalk Hills Formation
TERTIARY	PLIOCENE	MIDDLE / LOWER	IDAHO GROUP	Banbury Basalt*
TERTIARY	PLIOCENE	LOWER	IDAHO GROUP	Poison Creek Formation
TERTIARY	PLIOCENE	LOWER		Idavada Volcanics*

* Formations present in the Mountain Home study area

Figure 3-1. Sequence of Cenozoic Rocks in the Snake River Plain crust in the Snake River Plain. The possibility of a deep seated mafic intrusion underlying the Snake River Plain has also been hypothesized by Brott and others.[31] Although there are many permanent streams, practically all of them have been diverted for agricultural use. Ground water reserves are yet to be defined and are thought to be small.[23] Geothermal development may have a positive effect because of the suitability of the subsurface water for drinking and wild life support. Thermal water is abundant in the area. Temperatures range from 135° to 155°F (57 to 68°C) in springs and irrigation wells, 500 to 1,000 feet (150 to 300 meters) deep. The water has been reported to be relatively fresh with a total dissolved solids (TDS) content of about 300 to 800 parts per million (TRW, 1975). Figure 3-2 presents a depth contour map for the water wells in this area, and Figure 3-3 presents a contour map with the specific electrical conductance in the area of the Mountain Home KGRA.

Hoover and Tippens (1975)[22] have reported the results of the reconnaissance audio magnetotelluric survey over the Bruneau-Grand View area about 10 miles southwest of the Mountain Home area. Their study revealed a northwest-southeast trending, broad conductive anomaly with low resistivities (22 ohm-meters or less) being associated with the highest ground water temperatures (154° to 181°F or 58° to 83°C). Within the conductive area, resistivities are as low as 2 ohm-meters at depth. This may suggest a hot water reservoir, possibly with some rock alterations.

However, this survey did not cover the Mountain Home area proper. Figure 3-4 shows an aeromagnetic map compiled by the U.S. Geologic Survey which shows an elongated pattern that one may expect in a graben structure such as the Snake River Plain. The basic magnetic high in this map appears to parallel the resistivity low in the Bruneau-Grand View area shown by the audio-magnetotelluric survey.

The deep test well reported to be in a fault zone (discovered by remote sensing techniques) and near a shallow intrusive was drilled in August, 1973 (TRW, 1975).[26] The well is known as Bostic 1-A, located approximately 13 air miles (21.2 air kilometers) southeast of Mountain Home. It was an unsuccessful wildcat drilled for oil (or gas). The well was later reworked for geothermal resource production. Table 3-1 gives the pertinent information about this well. The well was originally acquired by the Gulf Energy and Mineral Company but recently the ownership has been transferred to Magma Power and Union Oil Companies. The data from this well, available to the Project, was a drillstem test report (August 27, 1973), a partially complete lithologic log (dated November 14, 1974), and a subsurface temperature survey run on August 14 and 15, 1974. Table 3-2 presents the lithologic column observed in this well. The well was drilled to a total depth of 9,687 feet (2952 meters). The temperature survey taken approximately one year after drilling showed a maximum temperature of 372°F (189°C) at 8,898 feet (2712 meters). The

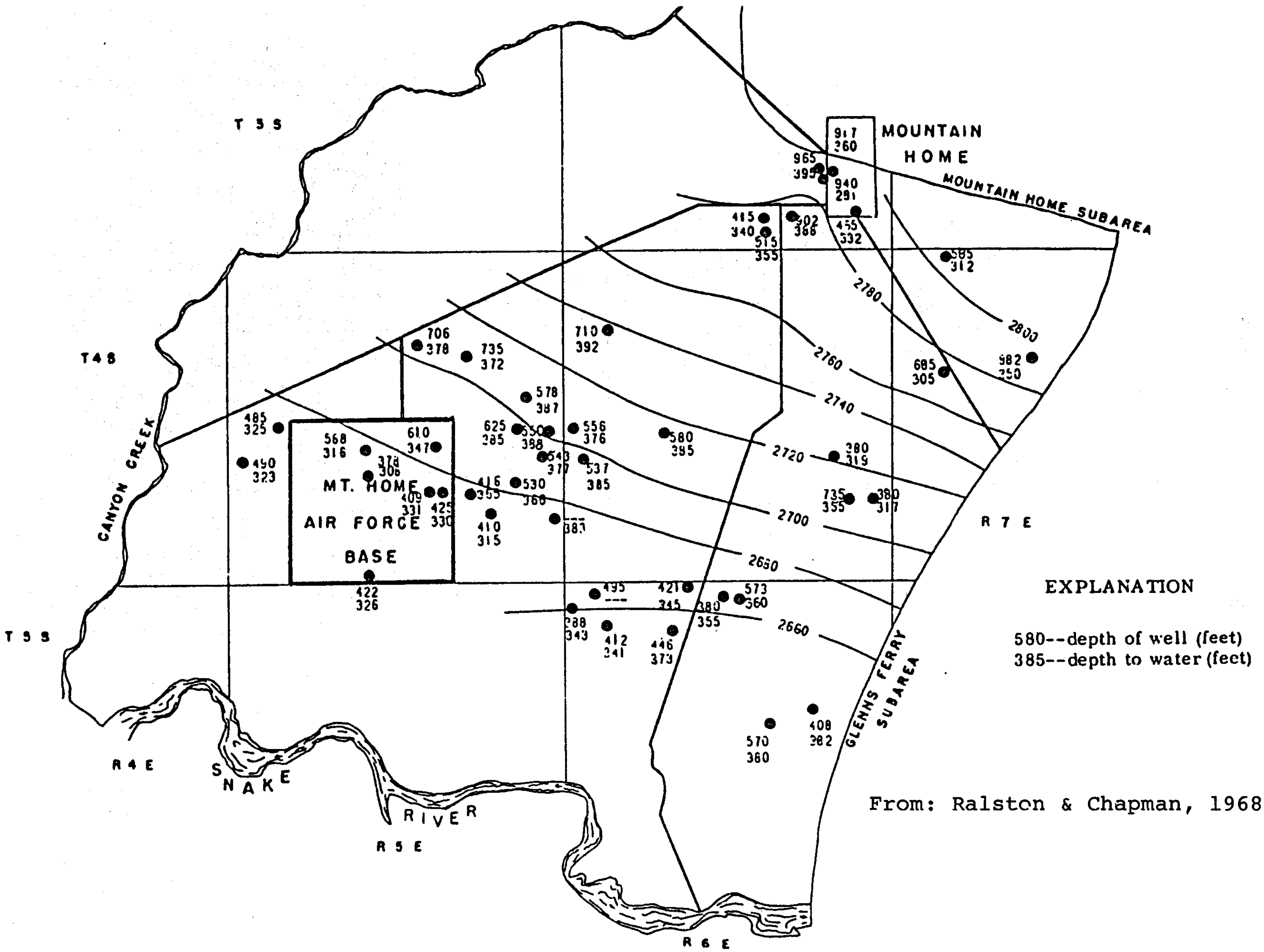


Figure 3-2. Depth Contour Map for Water Wells in Area

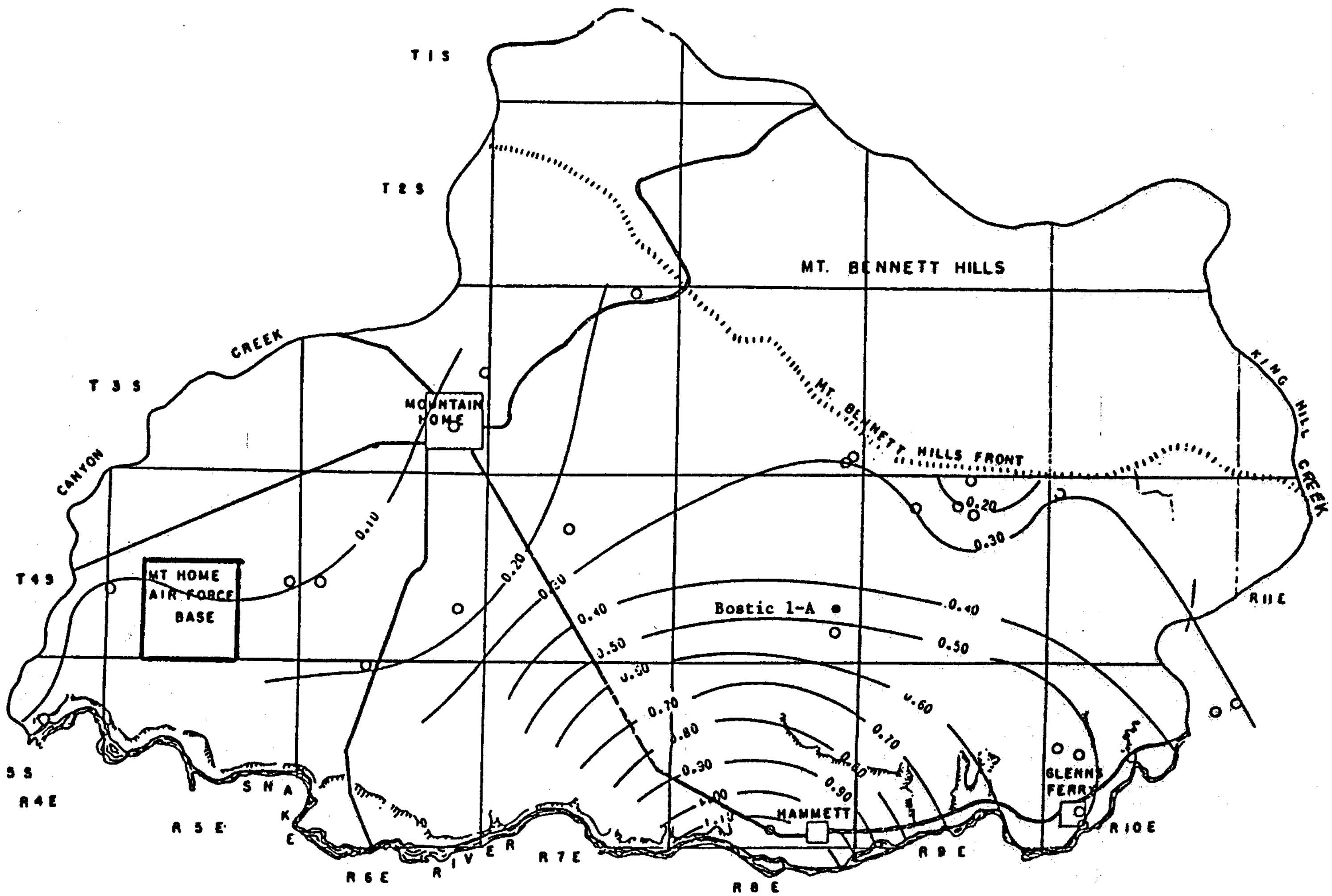
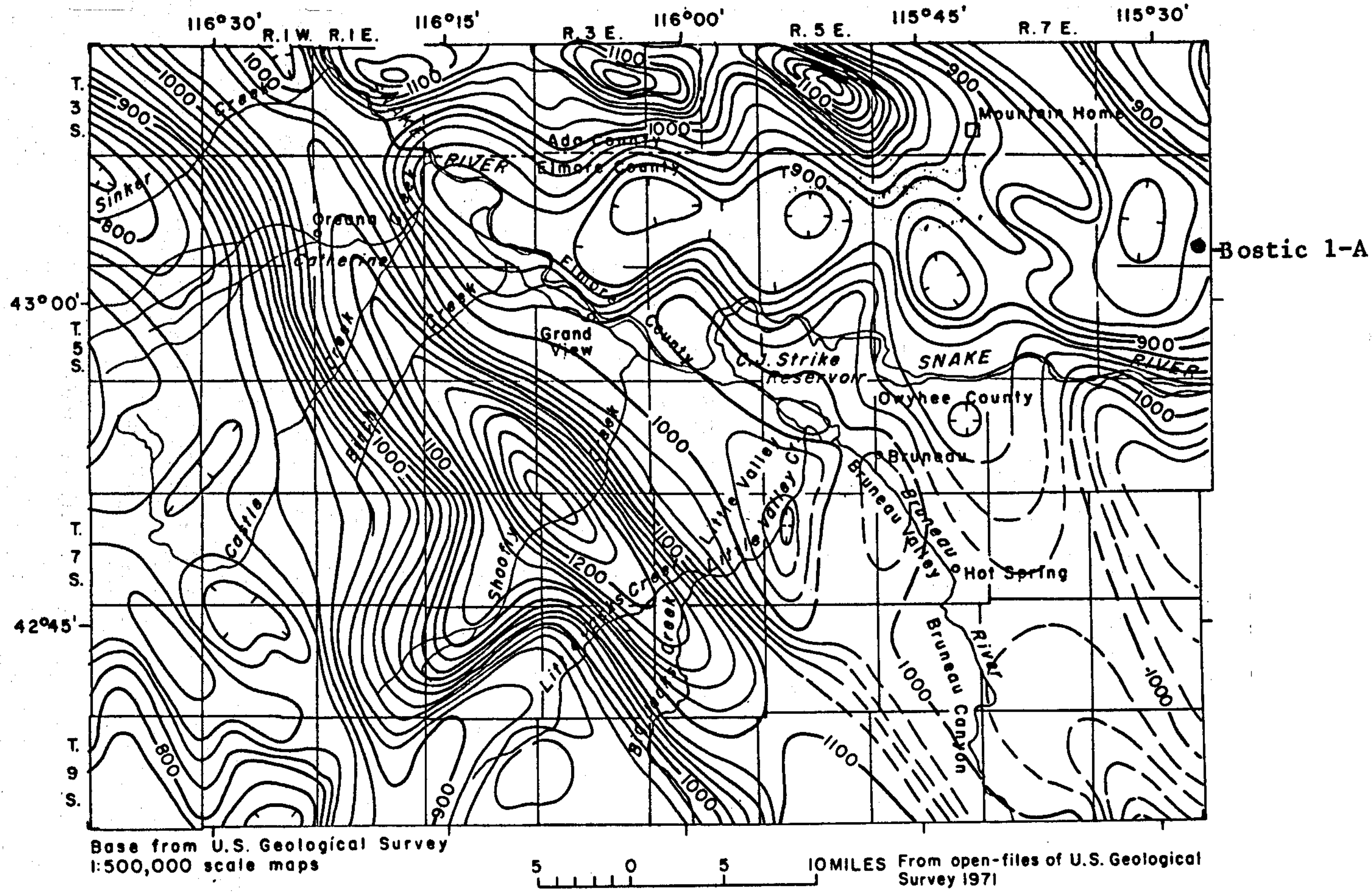


Figure 3-3. Contours of Specific Electrical Conductance



EXPLANATION

LINE OF EQUAL MAGNETIC INTENSITY —— 900 — —

Dashed where data are incomplete. Hachured to indicate closed area of lower magnetic intensity. Interval 20 gammas relative to arbitrary datum.

Figure 3-4. Aeromagnetic Map of the Area

DATA ON WELL BOSTIC 1-A

Location:	SE 1/4 SW 1/4 Sec. 25, T4S, R8E
Elevation:	3,185 feet
Depths Measured From:	Kelly Bushing
Total Depth:	9,678 feet
Main Hole Diameter:	8-3/4 inches
Completion:	Open Hole (10-3/4 inch casing to 1,063 feet)
Date of Drillstem Test:	August 27, 1973
Observed Final Shut-in Pressure (8/27/73):	3,752 psi (Not believed to have reached static reservoir pressure)
Date of Temperature Survey:	August 14-15, 1974
Observed Maximum Temperature:	371.6^{o}F @ 8,898 feet
Observed Flow Rate:	Initially flowed at approximately 1,000 gpm. No significant flow after initial tests. Severe wellbore skin damage suspected.

Table 3-1. Data on Bostic 1-A Well

GEOLOGICAL COLUMN IN WELL BOSTIC 1-A

Depth (Ft)	
700-940	Clay-shale: light gray; slightly silty; very to moderately calcareous; with thin, clayey sandstone and siltstone beds.
940-1090	---
1090-1150	Shale: slightly calcareous; altered volcanic glass content.
1150-1260	Sandstone: altered volcanic glass content.
1260-1430	Basalt with some unconsolidated quartz.
1430-2050	---
2050-2980	Shale: sandy with some basalt; slightly calcareous, tuffaceous
2980-4040	Sandstone: with traces of pyrite, basalt, and carbonates.
4040-4610	Basalt: with volcanic ash, abundant free quartz, and clay.
4610-5740	Shale: argillaceous, with some sandstone and basalt; slightly calcareous, tuffaceous.
5740-5840	Sandstone: layered with dolomite and shale.
5840-7250	Layer of basalt underlain by a layer of tuff (rhyolitic, sith sodic plagioclase and sanidine phenocrysts. Devitrified groundmass composes 95% of the samples.
7250-9440 (Except the section 8800-9000 ft, for which no data is available)	Series of interbedded basalts, salicic tuffs, and rhyolites. Felspars in basalt are clouded with extensive micaceous alteration. Basalts and tuffs show hydrothermal alteration. Tuff is pyritized at places.
9440-9620	Granite; the upper 100 ft. decomposed.

Table 3-2. Geological Column in Well

temperature gradient is very linear starting from a depth of about 2,000 feet (610 meters) above which the temperature gradient is probably influenced by the shallow ground water aquifers. The temperature gradient calculated from this temperature survey is 3.4°F per 100 feet (0.58°C per meter). The temperature profile in this well indicates conduction type heat flow, that is, there is no evidence of a convecting geothermal reservoir.

Initially, the well flowed at about 1,000 gallons per minute (gpm) (5,450 cu. meters per day) but the flow stopped within a few weeks (TRW, 1975).[26] The drill-stem test showed a final shut-in pressure of 3,252 pounds per square inch (psi) (229kg. per sq.cm). The produced water reportedly has a TDS of 300-800 parts per million (TRW, 1975)[26] with a specific conductance of 1.05 ohm-meter at 51°F (10.6°C). It appears that the well was heavily damaged by mud invasion during drilling. It is understood that the well has not flowed again even after attempts at creating pressure drawdown in the well. However, it may be possible to correct the borehole damage and allow the well to flow. Both chemical treatment such as acidizing or fracturing by hydraulic (or explosive) means may be used to improve well productivity and eliminate mud damage. The present operators of the well have recently completed a workover in the well; however the details have not yet been released. (J. Aidlin, personal communication, 1978).[18] This report assumes that the well can be reworked and made to flow at a rate of several hundred gallons per minute.

At this point, it is difficult to provide an accurate model of the Mountain Home geothermal aquifer. However, significant general information about geothermal and small, nongeothermal aquifers in the Snake River Plain are available, and can be used to develop a conceptual geological model at this time. The geothermal aquifers in this area are primarily in the Idavada volcanics recharged by meteoric water from adjoining high lands. The low TDS concentration and high temperature indicate that reservoir recharge is by meteoric water through an extensive circulation system (TRW, 1975).[26] The ground water wells in this area show interference. For example, the Fourth Judicial District Court of the State of Idaho, in settling a water right dispute between Hall and Walker/Lee, established that the Hall and Walker/Lee wells in T3S, R83 location interfered with each other. However, these wells are shallow compared to the deep geothermal well discussed thus far. From the general nature of aquifers and the geological framework in this area, it appears that the geothermal aquifer in Mountain Home is extensive. However, it is possible that the reservoir is subdivided into smaller entities by faults or fracture systems. A recent publication gives the areal extent of the Mountain Home reservoir as 39 square kilometers (Geonomics, 1976)[20], giving a total volume of 11.7 cubic kilometers, a stored heat of 1.3×10^{18} calories, and a gross electrical potential of 35 megawatt-centuries. However, these numbers are crude estimates at best. Considering the relatively low volume production of geothermal water needed (a few hundred gallons per minute) it is reasonable to assume that the reservoir has adequate reserves for the proposed plant. However, whether or not the well can deliver an economical flow rate over the life of the plant will not be known until the well is reworked and flow-tested. The deep ground water wells in this area have high deliverabilities.[28] Hence, the Bostic 1-A well may be expected to be a good producer if the well bore damage can be corrected.

B. WELL BORE HYDRAULICS AND THERMODYNAMICS

Since the utilization plan for the geothermal resource in this project centers around the Bostic 1-A well, it is imperative that a detailed study of the hydraulics of this particular well be undertaken. For the purposes of this study, an existing numerical well bore simulator has been used (Juprasert and Sanyal, 1977).[21] This model takes into account the flow of hot water (or hot water-steam mixture) in a well bore, and calculates the temperature, pressure, enthalpy, and steam quality at any point in the well bore if the pertinent data are given for the downhole condition. For example, given the flow rate, temperature, and pressure at the bottom of the wells and the diameter of the casing, the program can calculate the pressure, temperature, and steam quality at the wellhead and at any point within the well. The program takes into account pressure drop due to change in gravity head, friction, and acceleration, liquid holdup, heat transfer between the liquid and the rock outside the casing, phase change, and the time dependency of heat transfer. For accurate calculations, two other parameters are required in this program. One is a friction factor which can be put into the program; however, if not known this can be approximated. The other parameter is an "overall heat transfer coefficient," which varies from well to well, with depth in the same well, and with flow rate in the same well. If a measured flowing temperature profile in the well is available, the heat transfer coefficient can be calculated. If the coefficient is unavailable, a number for this quantity can be assumed from experience.

Initially, the flowing pressure and temperature profile in the well bore for a given flow rate should be determined. Figure 3-5 shows the calculated temperature and pressure profiles in this well for a flow rate of 500 gpm (2,725 cu. m/day). Also shown in this figure is a static temperature profile in the well bore as obtained from the temperature survey. The bottom hole pressure for this calculation was assumed to be 4,000 psi (281 kg/sq. cm) at 9,000 feet (2,743 meters). The drillstem test showed a final shut-in pressure of 3,750 psi (264 kg/sq. cm); however, the shut-in pressure did not reach the static reservoir pressure. Hence, the static reservoir pressure is probably significantly higher than 3,750 psi (264 kg/sq. cm). Also, during the drillstem test the hydrostatic mud pressure in the well bore was reported to be around 4,109 psi (289 kg/sq. cm). Hence, an upper limit of the reservoir pressure should be around 4,100 psi (288 kg/sq. cm). The flowing

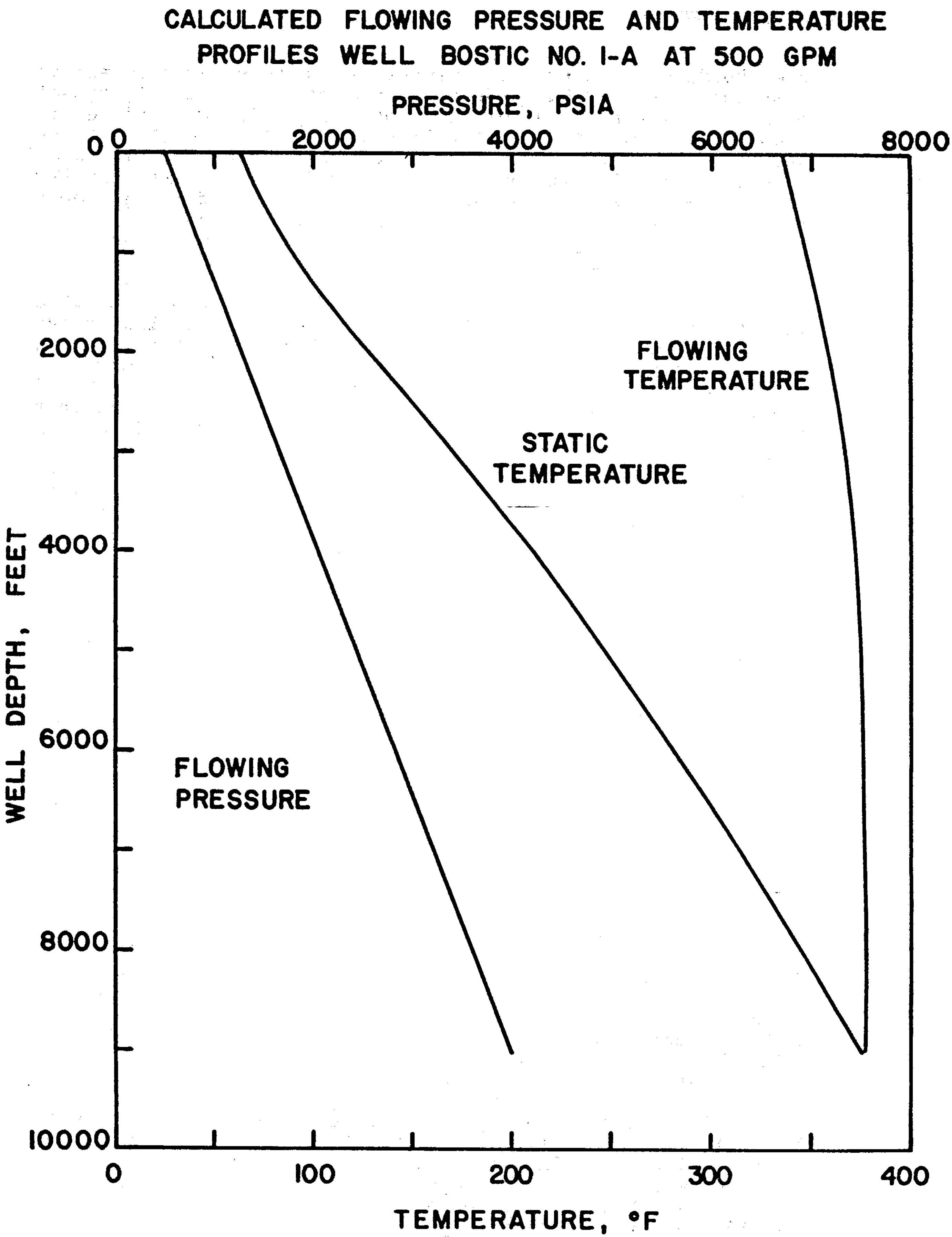

CALCULATED FLOWING PRESSURE AND TEMPERATURE
PROFILES WELL BOSTIC NO. 1-A AT 500 GPM
PRESSURE, PSIA
0
2000
4000
6000
8000
0
2000
4000
6000
8000
10000
WELL DEPTH, FEET
FLOWING
TEMPERATURE
STATIC
TEMPERATURE
FLOWING
PRESSURE
0
100
200
300
400
TEMPERATURE, °F

Figure 3-5.

bottomhole pressure should be substantially smaller than the static reservoir pressure because of the need for pressure drop at the well-reservoir interface. As can be seen on Figure 3-5 the calculated flowing pressure profile is a straight line indicating that the water does not flash into steam. The curvature of the flowing temperature profile toward the upper part of the well is caused by heat transfer between the fluid in the well bore and the rock outside.

Figure 3-6 shows another set of calculated profiles of pressure and temperature in this well at a flow rate of 600 gpm (3,270 cu.m./day). But for this case, a more likely pressure value was assumed 3,500 psi (246 kg/sq. cm) at 9,000 feet (2,743 meters). In this case, the flowing pressure gradient becomes sharply lower at about 400 feet (122 meters) indicating a flashpoint at that depth. The wellhead pressure is much lower and temperature slightly higher than would be seen if the fluid did not flash in the well bore. It is quite likely that the water will flash in the well bore. At this point, it is difficult to evaluate the flowing bottom hole pressure in the well for lack of knowledge of the static reservoir pressure and the permeability around the well bore. The well is scheduled to be reworked by the current operator and it is hoped that an accurate value of the static reservoir pressure will soon be available.

C. SENSITIVITY STUDY

In order to understand the sensitivity of the wellhead fluid condition to the various parameters, the well bore simulation program was run a large number of times with various values of some of the basic parameters. For example, Figure 3-7 shows a plot of the calculated temperature of the fluid at the wellhead versus production rate for the case of a bottomhole pressure of 4,000 (281 kg/sq. cm.) (non-flashing case). In this case, the pressure curve goes through a maximum indicating that there is an optimum production rate which will maximize the wellhead pressure. The temperature curve is monotonocally increasing up to 1,200 gpm (6,540 cu. meters/day), beyond which it practically coincides with the bottomhole temperature. This indicates that for a flow rate higher than 1,200 gpm (6,540 cu.m/day) the rate of heat transfer from the fluid to the rock outside is negligible. Figure 3-8 shows a plot of the calculated water enthalpy at the wellhead versus flow rate for the non-flashing case, the shape of which is very similar to the temperature curve in Figure 3-7.

It appears that beyond a flow rate of about 1,500 gpm (8,175 cu.m/day), the enthalpy of the fluid at the wellhead is essentially the same as the bottomhole fluid enthalpy. Considering enthalpy, it is obvious that the quality of the wellhead water increases rapidly with increasing flow rate up to a flow rate of about 600 gpm (3,270 cu.m/day), beyond which the increase of water enthalpy with increasing flow rate is very slow. Thus, from a thermodynamic standpoint, a flow rate

CALCULATED FLOWING PRESSURE AND TEMPERATURE PROFILES WELL BOSTIC NO. I-A AT 600 GPM

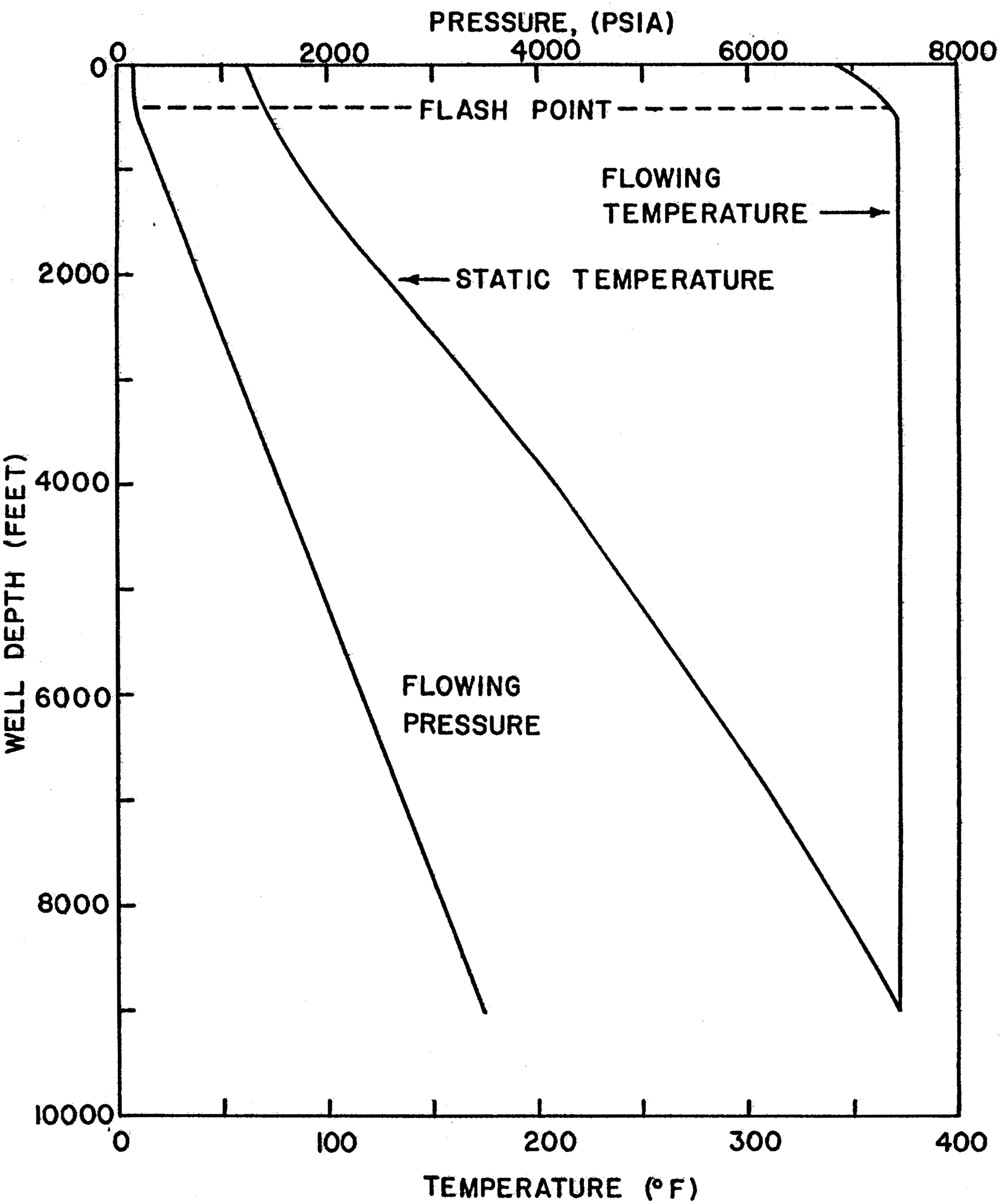


Figure 3-6.

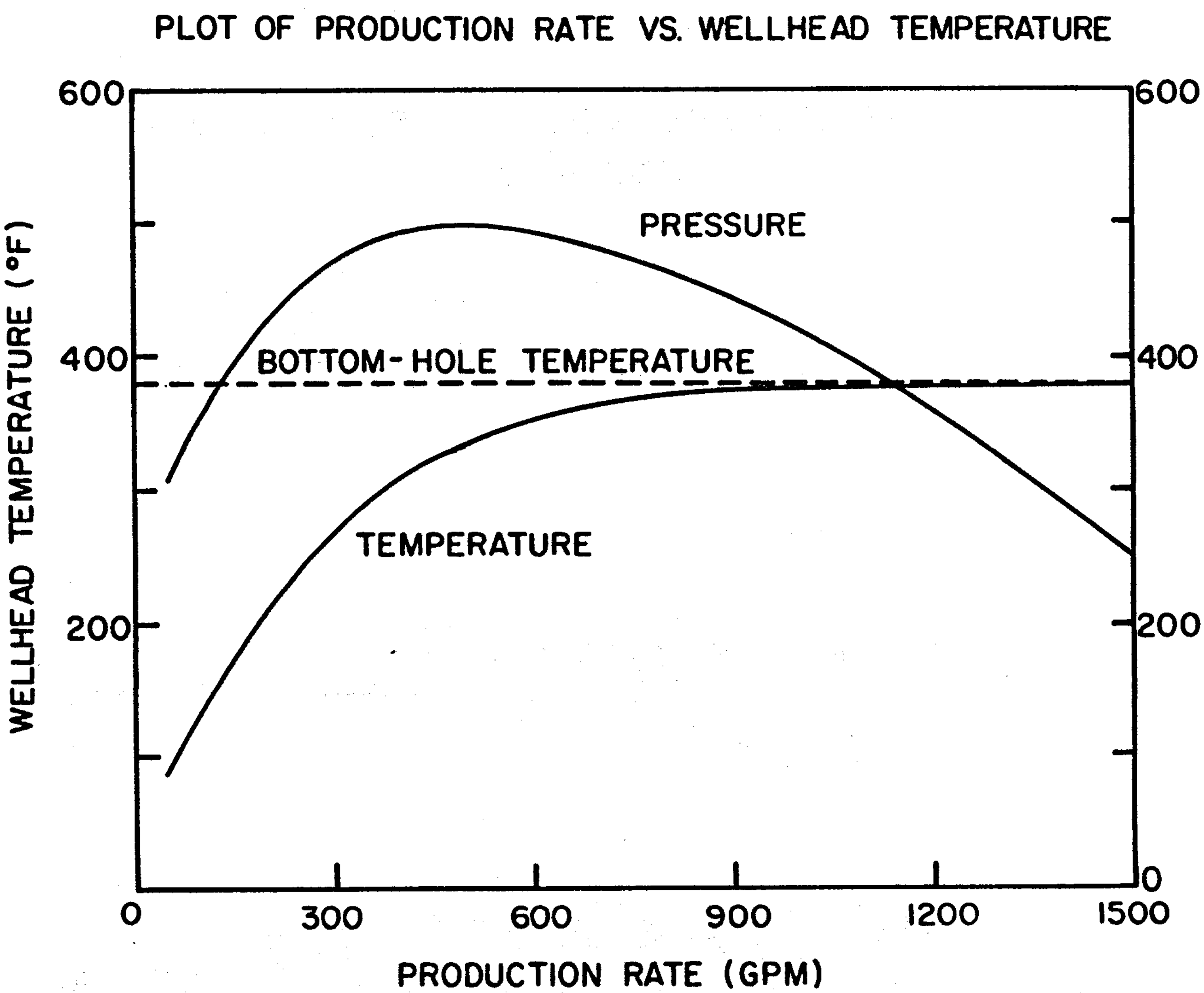

PLOT OF PRODUCTION RATE VS. WELLHEAD TEMPERATURE
600
400
200
WELLHEAD TEMPERATURE (°F)
PRESSURE
BOTTOM-HOLE TEMPERATURE
TEMPERATURE
600
400
200
0
WELLHEAD PRESSURE (PSIA)
0
300
600
900
1200
1500
PRODUCTION RATE (GPM)

Figure 3-7.

PLOT OF PRODUCTION RATE VS. WATER ENTHALPY AT WELLHEAD

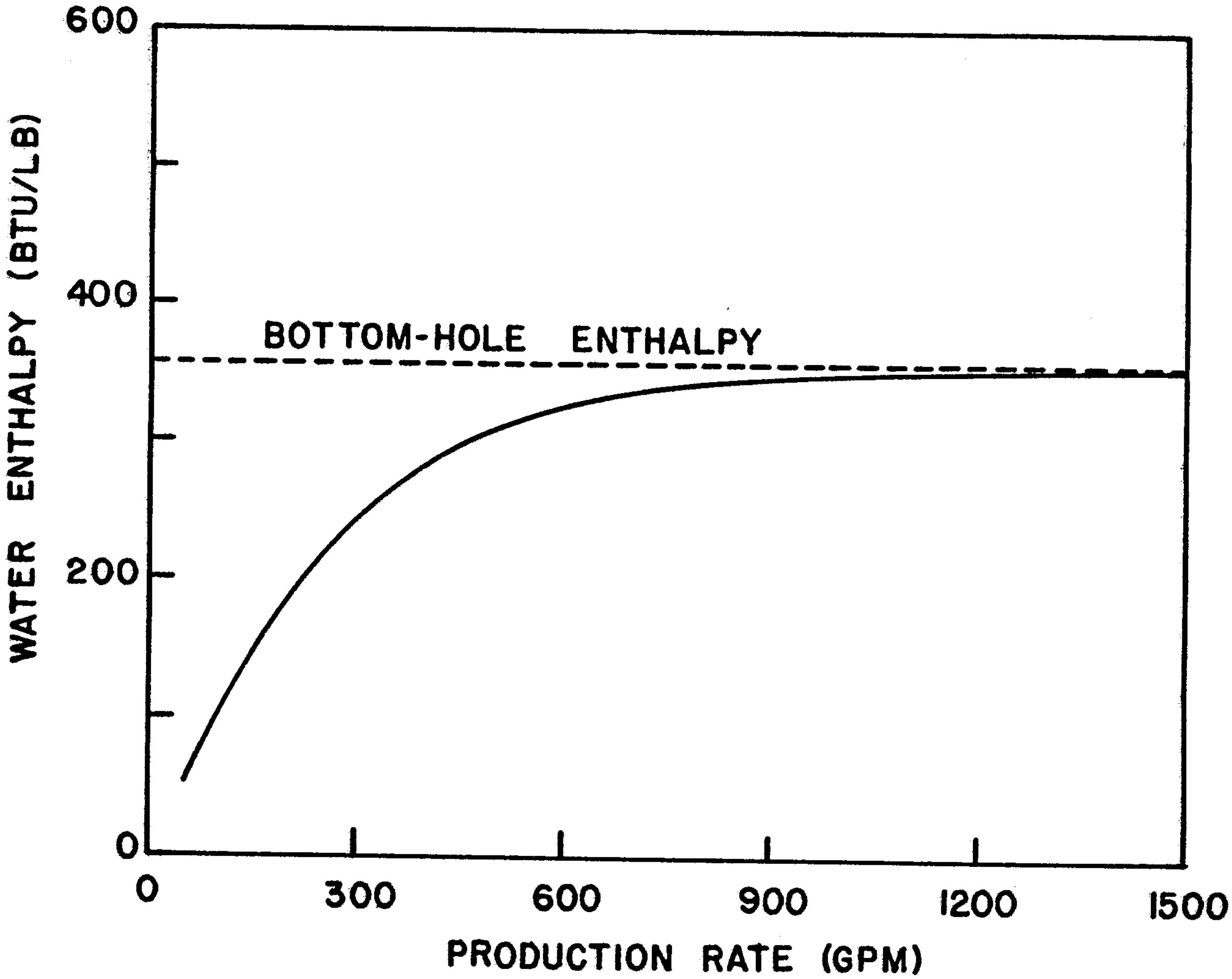


Figure 3-8.

of 600 gpm (3,270 cu.m/day) or higher would be the most efficient means of producing this well; whereas, if maximizing the wellhead pressure is a goal then a flow rate of about 450 gpm (2,453 cu.m/day) is optimum. Figure 3-9 presents the calculated depth at which flashing takes place versus the production rate for the flashing case 3,500 psi (246 kg/sq.cm) bottomhole pressure at 9,000 feet (2,743 meters). The depth of flashing increases rapidly until the flow rate of about 200 gpm (1,090 cu.m/day) is reached. Beyond that the depth of flashing is a linear function of the production rate. Figure 3-10 shows the calculated wellhead pressure and temperature versus flow rate for the flashing case. In this case, both the temperature and pressure curves go through a maximum for the following reason. At lower flow rates, there is more cooling due to heat transfer to the surroundings, but at high flow rates flashing takes place at greater depth and steam flowing up from a greater depth cools down more, creating a declining trend of temperature versus flow rate beyond the maximum. Thus, in this case, considering Figure 3-10, a production rate of 300 gpm (1,635 cu.m/day) is perhaps the most preferable. Figure 3-11 shows the calculated amount of steam in the effluent and enthalpy of steam-water mixture at the wellhead as a function of production rate. As is expected, as the production rate increases, the wellhead steam quantity increases rapidly. However, the mixture enthalpy at the wellhead increases up to a flow rate of little over 200 gpm (1,090 cu.m/day) beyond which the mixture enthalpy reaches the limit (equal to the enthalpy of the bottomhole water). Thus, considering enthalpy, a minimum flow rate of 200 gpm (1,090 cu.m/day) appears desirable.

At this point, it is interesting to compare the flashing versus the non-flashing cases. It should be remembered that the non-flashing case can be considered similar to the situation where a pump may be set up in the well to prevent flashing. From Figures 3-10 and 3-11 it is apparent that a production rate of about 300 gpm (1,635 cu.m/day) is the optimum flow rate for the flashing case. At this flow rate, the mixture enthalpy is practically the same as enthalpy at the bottomhole conditions, namely 345 Btu per pound. For the non-flashing case, for a production rate of 300 gpm, the enthalpy of the wellhead water will be only 243 Btu per pound as shown in Figure 3-8. In Table 3-3 it is clear that at 300 gpm the flashing case provides higher enthalpy than the non-flashing cases. However, the pressure at the wellhead is higher in the non-flashing case. So, if surface pressure is a consideration, then it may be worthwhile installing a downhole pump to prevent flashing in the well bore. It should also be noted that, in the flashing case, the wellhead fluid has higher temperature and that these comparisons are specific to the well conditions chosen. Until an accurate estimate of the static reservoir pressure and the permeability around the well bore are obtained, the exact optimum production condition for the well cannot be provided.

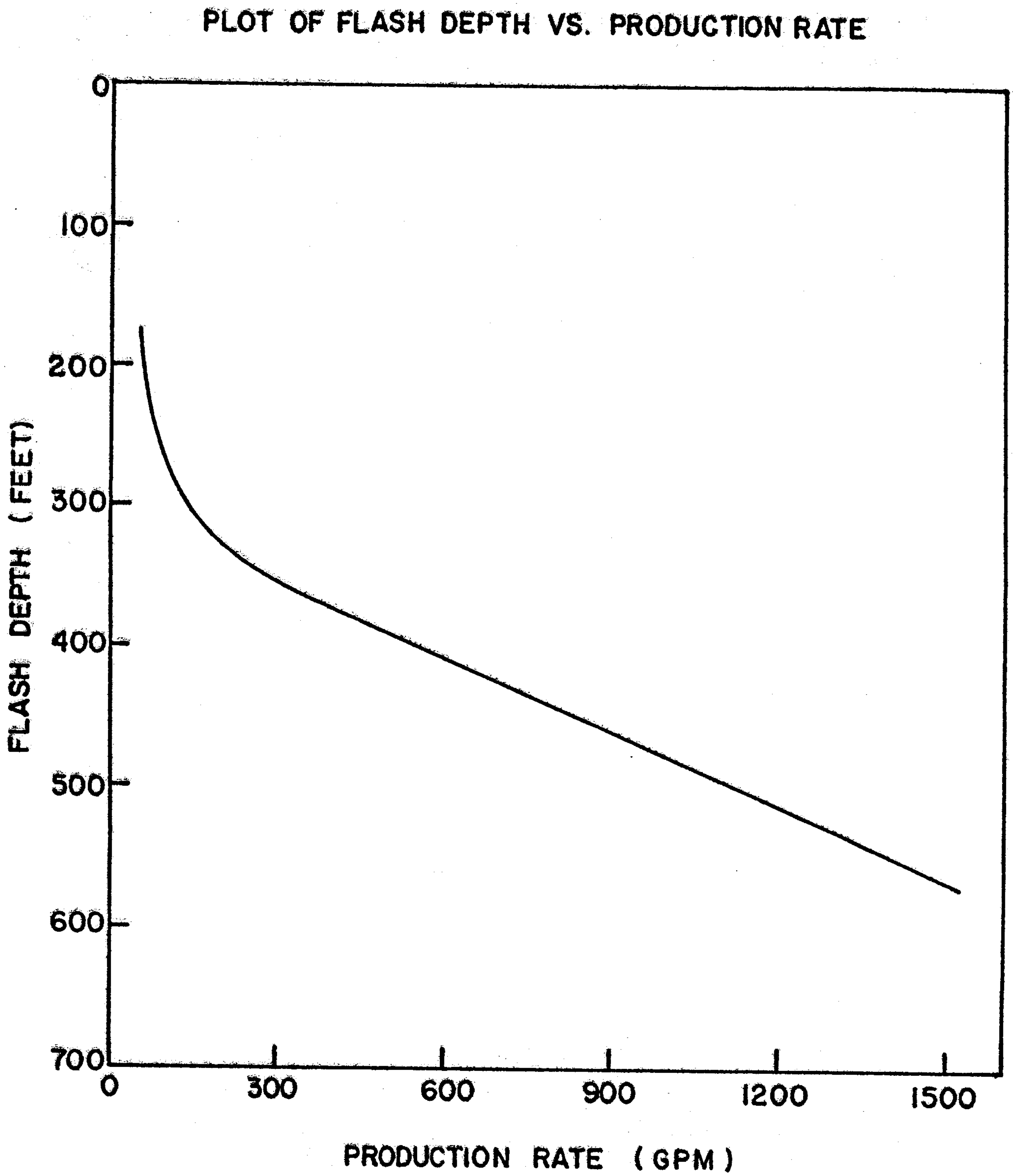

PLOT OF FLASH DEPTH VS. PRODUCTION RATE
0
100
200
300
400
500
600
700
FLASH DEPTH (FEET)
0
300
600
900
1200
1500
PRODUCTION RATE (GPM)

Figure 3-9.

PLOT OF WELLHEAD PRESSURE AND TEMPERATURE VS. PRODUCTION RATE

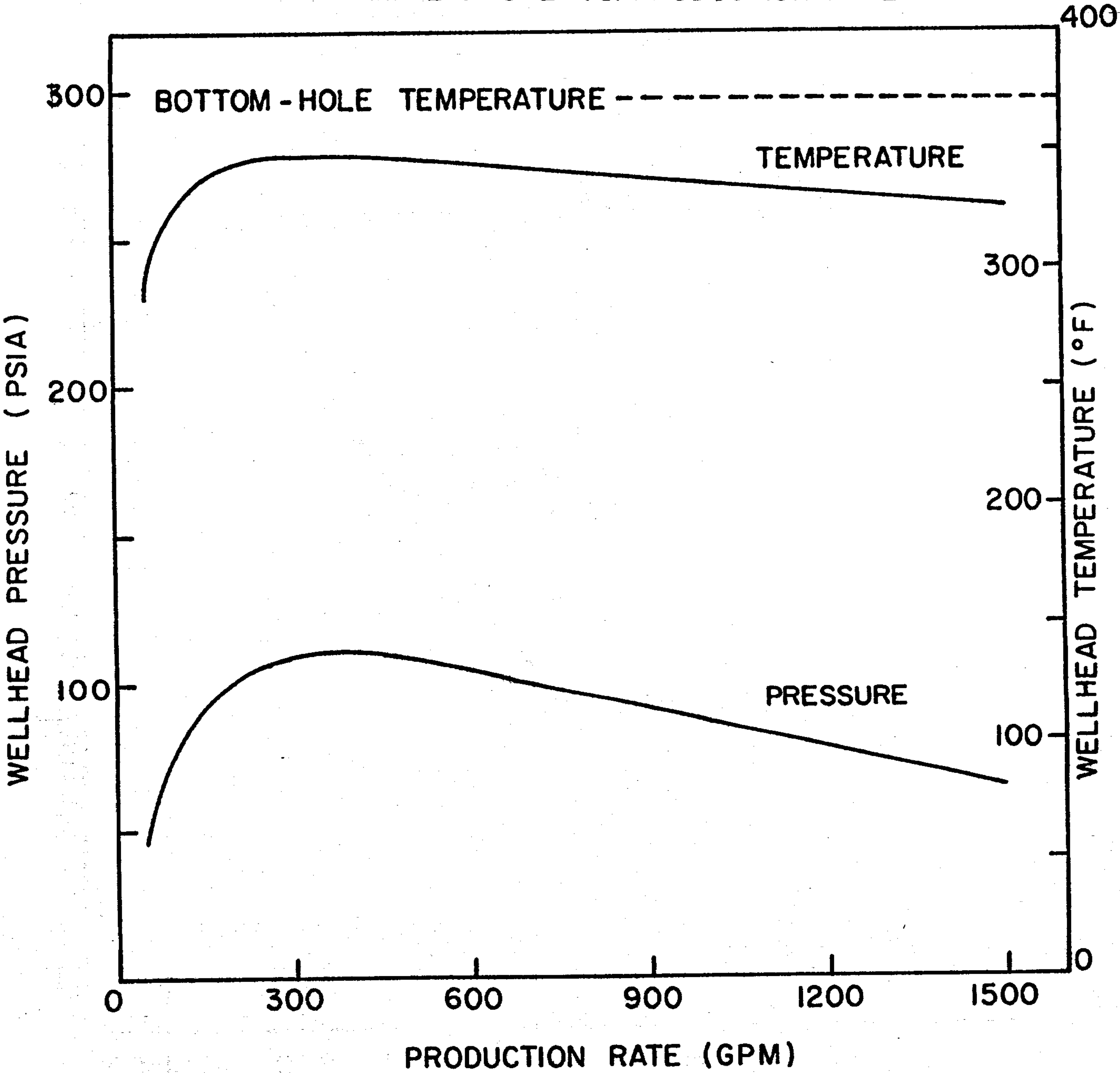


Figure 3-10.

PLOT OF PRODUCTION RATE VS. WELLHEAD STEAM QUANTITY AND MIXTURE (STEAM AND WATER) ENTHALPY

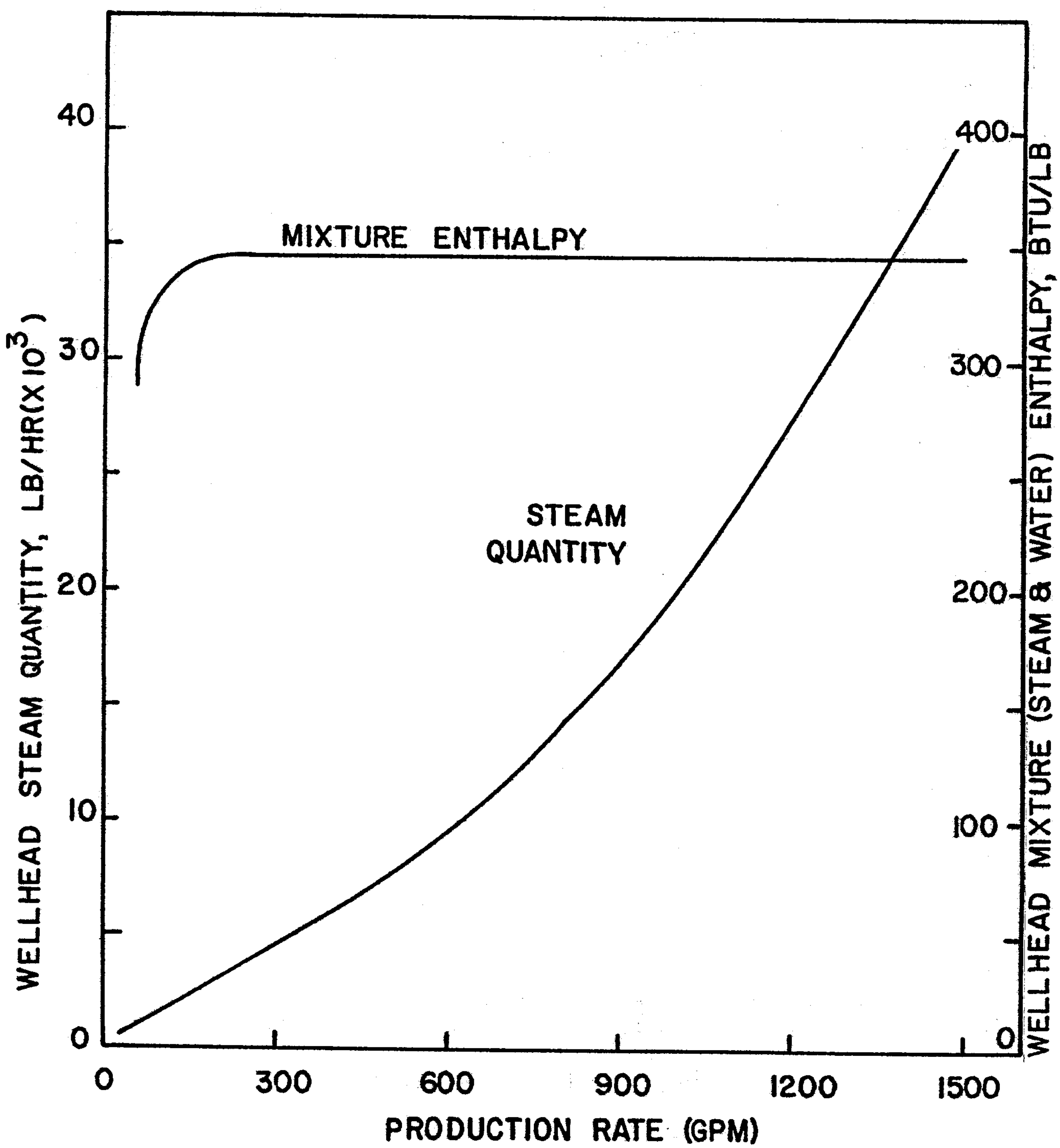


Figure 3-11.

COMPARISON OF TWO PRODUCTION SCHEMES

Flow Rate: 300 gallons/minute

Bottomhole conditions refer to 9,000 Ft depth

	Flashing	Non-Flashing
Bottomhole Pressure (psia)	3,500	4,000
Bottomhole Temperature (°F)	372	372
Bottomhole Enthalpy(Btu/lb)	345	345
Flashing Depth(Ft)	353	-
Steam Quantity at Wellhead (lbs./hour)	4,500	0
Wellhead Pressure(psia)	110 *	480
Wellhead Temperature (°F)	347	270
Wellhead Enthalpy (Btu/lb)	345	239

* less than vapor pressure because already flashed

Table 3-3. Two Production Schemes

D. PROJECTED RESOURCE CAPABILITY

1. The resource is adequate for the proposed project. Recent tests have verified a bottom hole temperature of 372°F and a temperature gradient on the order of 3.5°F per 100 ft. The projected use calls for a maximum flow rate of 1000 gpm which was obtained before the well stopped flowing as a result of damage caused by mud invasion during drilling. The fluid from the well is low in dissolved solids (300-800 ppm) with a specific conductance of 1.05 ohm-meters at 51°F.

2. The well characteristics are appropriate for the Application. The well will be used in the non-flashing mode. The requirement of 1000 gpm can be met by the employment of two wells each flowing at 500 gpm. To prevent flashing at these flow rates, pumps are designed to be set at 500' in each well. The anticipated low concentration of dissolved solids means that the effluent should not contaminate existing ground water providing that it does not contain significant amounts of toxic compounds and elements. Subject to these conditions the geothermal water can be used for irrigation and as drinking water for livestock. Problems such as scaling and corrosion would be avoided.

E. RESERVOIR DEFINITION PLAN

1. The developers, Magma-Union, have re-entered the Bostic 1-A well. The limited flows resulting from this effort indicate that the well damage from the intrusion of mud during the previous operations has not been corrected. However, the bottom hole temperatures have been reconfirmed. In that Magma-Union plans an additional exploration well in the immediate area, specific data cannot be released at this time.

2. An additional exploration well to be drilled in the immediate vicinity is justified on the basis of the high geothermal gradient found in Bostic 1-A and the high flow rate originally obtained. The well should be drilled to a minimum depth of 8500' and should be cased with perforated intervals within the basalts and silicic tuffs below 4000'.

3. It is recommended that a complete suite of well logs be conducted as well as pump testing of the additional well. Geochemical and water quality analyses should be run on the geothermal fluids. Well level monitoring of adjacent geothermal and irrigation wells should be conducted in conjunction with the pump tests. Pump down versus discharge flow and temperature should be measured. Recovery rate of the test well and the monitoring wells should also be measured. Using the data from the well logs and pump tests, the previously conducted numerical well base simulator program should be updated and rerun

using the new data. The reservoir will be engineered to determine flow rate versus temperature, flow rate versus reservoir life and to determine total heat content.

F. RESERVOIR DEVELOPMENT CONSIDERATIONS

Before a reservoir development plan can be drawn up, it is imperative to know the detailed characteristics of the existing well, Bostic 1-A. Information generated as a part of the workover performed by the operator of the well is not available as of this writing. The productivity of the well, the quality and temperature of the produced fluids and the location of the main production zone(s) are, as yet, unknown.

If it is proved that the present well is capable of producing water of 250-300°F temperature at a flow rate in the range of 500-1000 gallons per minute, as originally anticipated, plans should be made for drilling another production well. The exact siting of the second production well is strongly dependent on a detailed evaluation of the characteristics of the existing well and available geotechnical data.

The distance between the two production wells should be great enough to avoid significant interference between the two wells so as to obtain a maximum productivity from both. It is highly speculative to estimate the optimum distance without a knowledge of the permeability, porosity, net pay zone, etc. However, a minimum distance of several hundred feet is reasonable. The completion level in these two wells will again depend on an evaluation of the production characteristics and well bore data obtained from the existing well.

The existence of a major fault through the Mountain Home geothermal area has been suggested by some workers. The relation of this fault to the geothermal potential of the existing well or the area at large is not clearly understood. If and when further geoscientific exploration confirms the existence of the fault and its relation to the geothermal anomaly, the well siting plan should take this into consideration. For example, if the fault is a prime conduit of the geothermal water in the area, it is reasonable to locate the second production well as close to that fault as possible in order to insure maximum productivity. If, on the other hand, the fault is not a major conduit for the geothermal fluid, then it is possible that the fault is an aquiclude or aquitard with respect to the producing zones. In that case, it would be desirable to locate the second production well on the same side of the fault as the existing well. A third possibility exists that the fault is neither a reservoir boundry nor a prime conduit for the fluid. In this case, the location of the fault would not be a major consideration with regard to the siting of the second production well. Geochemical studies and geophysical studies such as temperature gradient and electrical resistivity surveys would help to determine which case applies.

In order to locate the site for an injection well a detailed chemical analysis of the effluent must be obtained. Indeed, if the geothermal water proves to be of a fresh nature and benign from an environmental point of view, the possibility of discharging the effluent into local surface waters should be considered. Alternatively, the water may be injected into shallow ground water aquifers. If, however, the water analysis indicates the presence of harmful constituents or undesirable concentrations of dissolved solids, then the plant effluent must be injected into the subsurface. In that case, a study of the local groundwater characteristics should be undertaken before the injection well is sited.

The injection interval should be below the deepest groundwater aquifer and should be effectively isolated from shallow, potable water aquifers. Because of the relatively low withdrawal rate from the geothermal aquifer, it is probably not necessary, in this use, to inject the plant waste fluids into the geothermal aquifer, which is quite deep compared with the shallow ground water aquifers. If the injection well is located on a fracture system or a fault that may connect either production well, a potential for premature breakthrough of colder injected fluids to the producing wells exists. However, these considerations will become meaningful only after adequate analysis of all the data from the existing well.

G. OTHER OPERATIONAL PROBLEMS

The analysis of the water from the Mountain Home geothermal reservoir has reportedly indicated a TDS of somewhere between 300 to 800 parts per million (TRW, 1975).[26] This range of TDS is considered quite low, in fact the water is potable. It is likely, therefore, that no serious scaling or corrosion should be anticipated for this well. However, it must be pointed out that chemical analysis of the water from this well is not available. Such a chemical analysis is absolutely necessary to estimate the potential for scaling and corrosion from the water. Some minor constituents such as H_2S and carbon dioxide, silica, or carbonate can cause scaling in the well bore. Minor amounts of arsenic or boron can make it toxic, so it is imperative to perform a chemical analysis of the water sample from the reservoir before other operational constraints can be speculated upon. In general, the ground water wells in the area have not shown serious scaling or corrosion problems, though some wells have significant content of dissolved silica. These observations do not necessarily apply to the deep geothermal well.

CHAPTER 4 - SYSTEM ENGINEERING

A. INTRODUCTION - VERTICAL INTEGRATION CONSIDERATIONS

The agricultural industry, in general, has been undergoing major economic review. Efficiencies of operations from the farmer to the point of consumer sales have warranted a close review, and demonstrate needs for improvement of all phases of operations in order to compete for capital funds and consumer dollars.

This Mountain Home Geothermal Project has reviewed problems and trends in the livestock feed production and meat industries. Such a review necessitated the study of each of the agricultural functions separately, namely, breeding, feeding and raising, transportation, slaughter, sales, byproducts, waste management, environmental conditions, and many other factors that are related to each function. At present most of these functions are performed by separate agribusiness entities. In a few cases economic advantage to integration can be observed in present practice. Large scale cattle feed lots and poultry operations usually incorporate a feed mill to ensure meeting nutritional requirements and to ensure a source of supply.[32] The poultry and egg industry has shown a trend for further integration by including feed and slaughter facilities at certain animal production complexes.[32]

The major considerations leading to vertical integration, thermal and biological cascading and common-site physical location of major livestock subsystems were:

1. Cost benefits of lower-cost energy (particularly evidenced by earlier studies).[1,2,4,8,33,34]

2. Logistics/transportation costs and energy required for importing Midwestern and Southeastern U.S. animal feeds to the Northwest and West.

3. Mortality and high-cost weight-loss associated with long distance transportation to market of "finished" (fully fed) livestock.

4. Improved capital utilization over that of range operations.

5. Current trends toward vertical integration in the U.S., especially in the production of pork and chicken meats.[35]

6. Higher quality of fresh elements of livestock feed.[32]

7. Environmental requirements leading to advanced waste management systems.

8. The most efficient utilization of a hydrothermal resource requires a well designed energy cascade between multiple applications, ideally at an integrated site.

The scope and rationale of the study were intended to consider both geothermal energy cascading and biological cascading. The result of this integration lead to defining the entire application as a truly vertically integrated system.

B. SYSTEMS SELECTION

An overall system concept was proposed for study with the purpose of selecting one or more animal types and one or more processes (subsystems), for subsequent engineering and economic analyses.

1. System Concept and Options

Figure 2-2, (Chapter 2, Page 8), Integrated Livestock Meat and Feed Processing System - Overall Concept, indicates subsystem options considered in the overall system selection.

2. Selection Rationale

a. Introduction

It should be noted that considerable proprietary data was collected from very new facilities appropriate to this study. These data provided guidelines in selection; however, the final system and subsystems in this study are based upon use of non-proprietary, commercially available hardware and systems.

Table 4-1, following, shows the matrix of subsystems, the status of their selection for this study, and brief comments impacting their status. These comments are discussed more fully in the following sections.

b. Background Data Collection

Extensive surveys of agricultural practices, agribusiness industrial facilities, systems and hardware were conducted in Idaho and nearby western states. The principal sources of data are listed in Table 4-2.

c. Environmentally Controlled Facility

The results of these surveys and extensive industrial contacts indicate that environmentally controlled growth facilities are the preferred trend in future developments. This is compatible with trends in regional, national and international food production practices.[32, 36, 37] Proper management and technology are the most important factors for such advanced

TABLE 4-1
SELECTION MATRIX SUMMARY

FUNCTION	*	SELECTION FACTORS FOR	AGAINST
ANIMALS:			
Cattle	N	Large Industry	Excess slaughter & feeding capacity in Idaho & surrounding area
Hogs	S	Good Market & Technology	Local bad practices in unconfined raising
Sheep	F	Fair Market	Required more technology
Rabbits	F	Inadequate supply; good pelt demand	Limited national market
Poultry (Chickens)	F	Fair National Market	Limited local practice
SYSTEMS:			
Feed Production	S	Demand for local, high quality,lower cost feed	None
Confined Hog Raising and Feeding	S	Large Market, current trends	Prior local bad practices
Outside Feed Sales, Cattle and Fish	S	Local Demand	None
Slaughter, Hogs	S	Energy Cascade, Animal Health, Product Quality No Transport Impacts	Requires large supply of Animals
Byproduct Process & Sales	S	Economics of Current practices	None
Waste Management & Water Reclamation	S	Regulations Require	None
Methane Production	S	Shaft Power for Facility	Limited economic and operational data
Environmental Aquaculture	F	Potential of protein system performance	Unknown economics
Potato Dehydration	S	Energy & Biological Cascades	Sizing/economics unknown
Potato Byproducts	S	Feed inputs	Feed composition limits sizing

*STATUS: S= Selected
N= Not Selected
F= Future or Growth Option (not studied)

TABLE 4-2
AGRICULTURAL PRACTICES AND PROCESSING DATA SOURCES

Contact	Type of Information
USDA, Western Regional Research Laboratory, Albany California	Meat, food and feed processing
PTE Corporation Santa Clara,California	Hydraulic fluid power systems
Northwest Feeders and Feedlots Association, Boise, Idaho	Feeding practices
Columbia Foods Boise, Idaho	Beef slaughter facility, systems and equipment
Ore-Ida Foods Boise, Idaho	Potato Processing
Amalgamated Sugar Nampa, Idaho	Beet sugar processing facility, systems and equipment, waste management system
Magic West Glenn's Ferry, Idaho	Potato processing facility, systems and equipment
USDA, Snake River Conservation Research Center Twin Falls, Idaho	Waste processing and disposal technology
Fish Breeders of Idaho, Inc., Buhl, Idaho	Fish farming and feed requirements
Clay Equipment Corporation, Iowa	Environmentally controlled (confined) livestock systems and equipment
Industrial Contacts in: California, Colorado, Idaho, Illinois, Iowa, Illinois, Oregon and Canada Contacts prior to study in: Florida, Mexico and Japan	Proprietary information on pork slaughter, rabbit raising equipment, protein extraction, refrigeration equipment, food-drying equipment and vacuum systems. Swine economics, scheduling, feeding, slaughter, processing and facility design

methods as compared with historic open range handling and feeding practices.

Early installations of confined hog raising were established in this country's Midwest section about twenty years ago. These were primarily research and development facilities. A significant increase in this practice has occurred in the United States and Canada over the past five years. In the last two years, feed and labor costs have caused a resurgence of confined facilities on the West Coast. There are several hundred such facilities now operating in the United States.[35]

It has been reported in a number of sources[32,35,38] that the change toward total confinement buildings during the past five years has been steadily increasing. These buildings "offer enhanced feed conversion, higher conception rates, and reduced mortality."[39] Advantages in waste handling attributable to controlled growth parlors are discussed later in this chapter.

d. Animal Selection

As indicated in Proposal EP 072077[40], cattle comprises the largest constituent of agriculture in the West and hence offers the broadest base for replication. However, this study indicates that there is an excess cattle slaughter capacity and several very large cattle feed operations in Idaho. If additional facilities can be economically justified in the future, utilization of geothermal energy could be of interest. On the other hand, the Advisory Board reinforced the real need for a local source of high-quality, competitivly-priced cattle feed. This requirement fits well with the Selected System. The Advisory Board has concurred with the results of the Economic Factors Task 5.0 efforts that indicate swine raising and pork production should be the core of the system.

National distribution of pork flows, in part, through Idaho. Idaho consumes only about one-half the pork being transported through the State. This transshipping is a ready means of market penetration. For instance, California imports 1.3 million carcasses each year, primarily from the Midwest. A major producer in Idaho should be able to supply part of that demand. The regional and national markets for pork are strong and growing.[32,37]

Sheep are in decline (down 277% from 1959 to 1974)[41] in the County for reasons of shortage of qualified herders and predator damage. Lastly, further genetic development is required for confined raising of sheep.

e. Feed Production and Processing

Cattle, sheep, hog, (and fish) feeding costs and quality have been reviewed with livestock raisers and feeders. There is a sound need for lower-cost and higher-quality feeds for all these animals (and fish) in the region.

Appendix B discusses nutritional and metabolic trends in animal feeds.

f. Slaughter

The mortality and expensive live weight loss, associated with the shipment of slaughter-ready ("finish fed") animals, combined with the costs and energy requirements of transportation and handling, serve to support the vertical integration of slaughter and animal raising facilities at a single site. Current practices and economic trends in the United States indicate the advantages of such a plan.[42]

g. Potato Processing

A significant portion of the livestock feed is constituted of locally available products. In the Mountain Home area two readily available crops stand out as candidates for feed constituents:

- potatoes
- sugar beets

Besides fitting well in the energy cascade of the system, potato byproducts, amounting to roughly one-fifth of the green potato in dehydration processes, can constitute on the order of 10%-60% of livestock feed, depending on the type of animal. Cattle feeds in the area contain up to 60% potato byproducts. Swine feeds can range from 10% to 30% depending upon the metabolic energy balance of the final feed product. For this study, utilizing byproducts from the dehydration process, 10% of the swine feed will be composed of potato byproducts.

A further plus for the selection of potato processing is the synergistic increase in methane production from combined inputs of potato waste and swine manure as compared to the total output of both elements alone.

As an alternate to potatoes, sugar beet processing was considered. Other than possible use of locally purchased byproducts for the livestock feed process, sugar beets was ruled out for the following reasons:

1) Sugar beet processing requires higher temperatures than potato processing[17, 43], cascades the heat

energy within its own process, and does not fit in the overall selected system thermal cascade.

2) A large sugar industry is already present in the area.

3) The sugar market is quite unstable and is vulnerable to impacts from foreign supply.

4) National process capacity is presently considered to be excessive.[43]

h. Waste Management

Nearly half of the field grown crop energy consumed by animals eventually ends up as manure.[39] In line with the previously discussed trend towards large confinement buildings for livestock, automated waste gathering and handling systems will also be utilized. Such highly mechanized systems, designed with environmental quality as a concern, would be consistent with this trend, would provide fertilizer and would capture otherwise wasted energy in the bioconversion processes utilized in waste treatment.[39]

The biological processes involved in energy and nutrient recovery from animal wastes are, for the most part, optimal in production rates at the low temperatures of a geothermal cascade (roughly 120°F and lower). Such optimal production rates result in smaller equipment sizes.

The final effluent water quality will be suitable for field irrigation.

3. Selected System

The core of the geothermally enhanced selected system consists of:

a. An environmentally controlled sprouted grain growing system.

b. A multi-animal feed mill facility.

c. A modular, totally confined swine raising facility.

d. A minimum of 60 head per hour hog slaughter and marketing facility.

e. A potato dehydration plant.

f. A total waste management facility including methane generation.

The selected integrated system is shown schematically as Figure 4-1.

C. REQUIREMENTS AND CRITERIA

1. Environmentally Controlled Feed Growing Facility

Environmentally Controlled Growing Systems (known as ECGS) are a modern form of a phase of hydroponic culture.

Farmers and researchers acknowledge that fresh, green grass in the spring is the most nutritious feed you can give livestock, as it provides most of the known vitamins, minerals, protein, and enzymes necessary for excellent health. The grass is produced wet, therefore it provides the animal with vitally important "grass juice factors".[44,45] However, Nature allows us only one spring every year.

Normal irrigated Mid-California hay raising acreage will yield 18 tons of green chop per acre per year.[32] Environmentally controlled hydroponic growth systems can produce the equivalent of over 80,000 tons per acre per year.

Growth is accelerated by automatically and precisely controlled environmental factors such as temperature, humidity, aeration, and light. One pound of proper quality seed produces seven to eight pounds of grass in seven days.[44,46,47]

Environmentally Controlled Growing Systems are available in various modular sizes.[47] Small modular units have a higher labor factor. However, equipment sized for the Mountain Home Geothermal Project is automated. Seed handling equipment and storage facilities are those generally used in the seed processing industry.[32,35,47] Pre-treatment, washing, soaking and metering equipment is the same as that used in the vegetable dehydration and freezing industry.[48] Processing equipment for handling the grains after being sprouted is the same as that used in malting, and the wine and vegetable freezing industries.[33,38,48] Hydraulic shaft power is suggested for these items to improve efficiencies, reduce maintenance, improve sanitation conditions and comply with OSHA standards.

The equipment requires a minimum of a ten foot ceiling, and a floor space of sixty-four working square feet for eleven tons per month of sprouted grain production. Additional space is required for service areas. Ambient temperatures surrounding the equipment should be maintained between 70°F and a maximum temperature of 90°F must not be exceeded in the ECGS equipment. Refrigeration to maintain internal operating conditions will amount to a minimum of one ton per 64 square feet of floor space <u>within</u> the sprout production equipment itself.

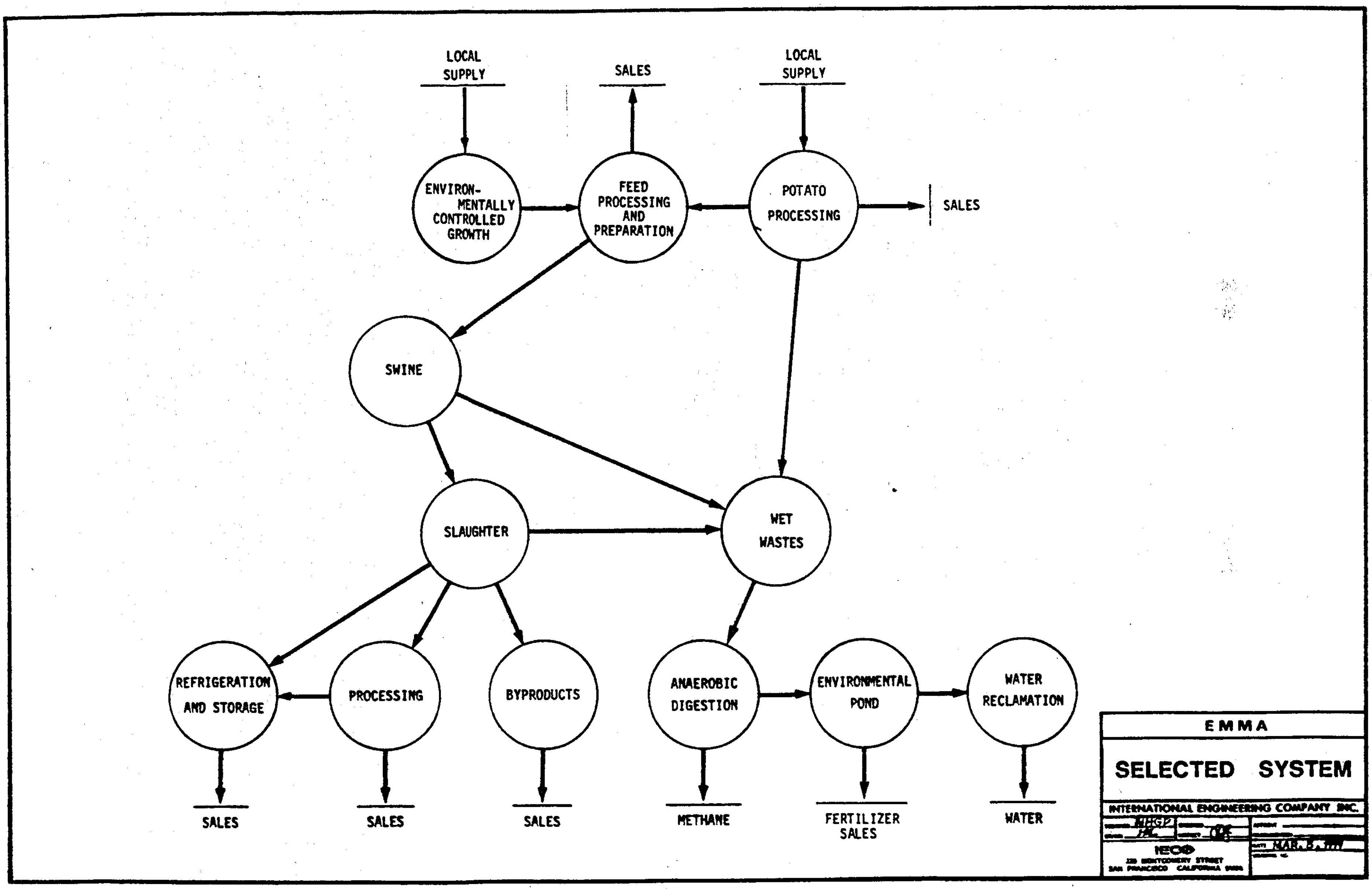


Figure 4-1. Selected Integrated System

Electric light power requirements are about 1000 watts per eleven ton per month unit. Fresh water requirements are about 75 gallons per day for such units, most of which becomes moisture within the sprouted grains.

Water drainage from ECGS system can be fed to animals.

2. Animal Feed Production

An economic sizing of the feed mill will furnish capacity for both feeding swine within the system as well as for sale for feeding other livestock in the region. Local production of feed, utilizing geothermal energy, for consumption within the system is important to lower cash flow requirements within the system and improve the financial balance of the complex. Current commercial high quality feeds composed of environmentally grown sprouted grains plus locally produced agricultural byproducts processed within the system should cost significantly less than purchased commercial feeds. Additional significant savings in cost and energy consumed by transportation are to be realized.

The material is either bulk stored in a non-pelletized mash type condition for immediate use, or transferred to a pelletizing system using a cold process for outside sales. Since quality of the feed is emphasized, the pelletizing of the feed is not employed for internal use. Frictional heat reduces certain heat sensitive elements of the ingredients. Any pelletizing of the product for sales is accomplished with immediate cooling and temperature control of the product to ensure higher quality.

Cattle, sheep, hog and fish feeding costs and quality have been reviewed with livestock raisers and feeders in the Idaho area. The upward trend on feed costs is prevalent throughout the United States, with slightly higher costs of corn and similar products in the Western States region.[33]

It is efficient to raise swine and produce their feed at the same location. For example, many successful small family farms produce feed and raise livestock. Furthermore, a feed mill system compatible to the needs of the area is important. Rather than using an expensive multiphase feed mill, a cold process system can be employed, thereby improving upon certain quality factors.

Referring to Figure 4-2, one can review the functional elements of the feed production subsystem. In addition to the refrigeration for the ECGS, the cold process in the grind/surge plus the mixer blender (the mill) require cooling of liquified sprout concentrates. This liquid is the primary moisture control media for the blended feed. Product temperature in process should not exceed 80°F.

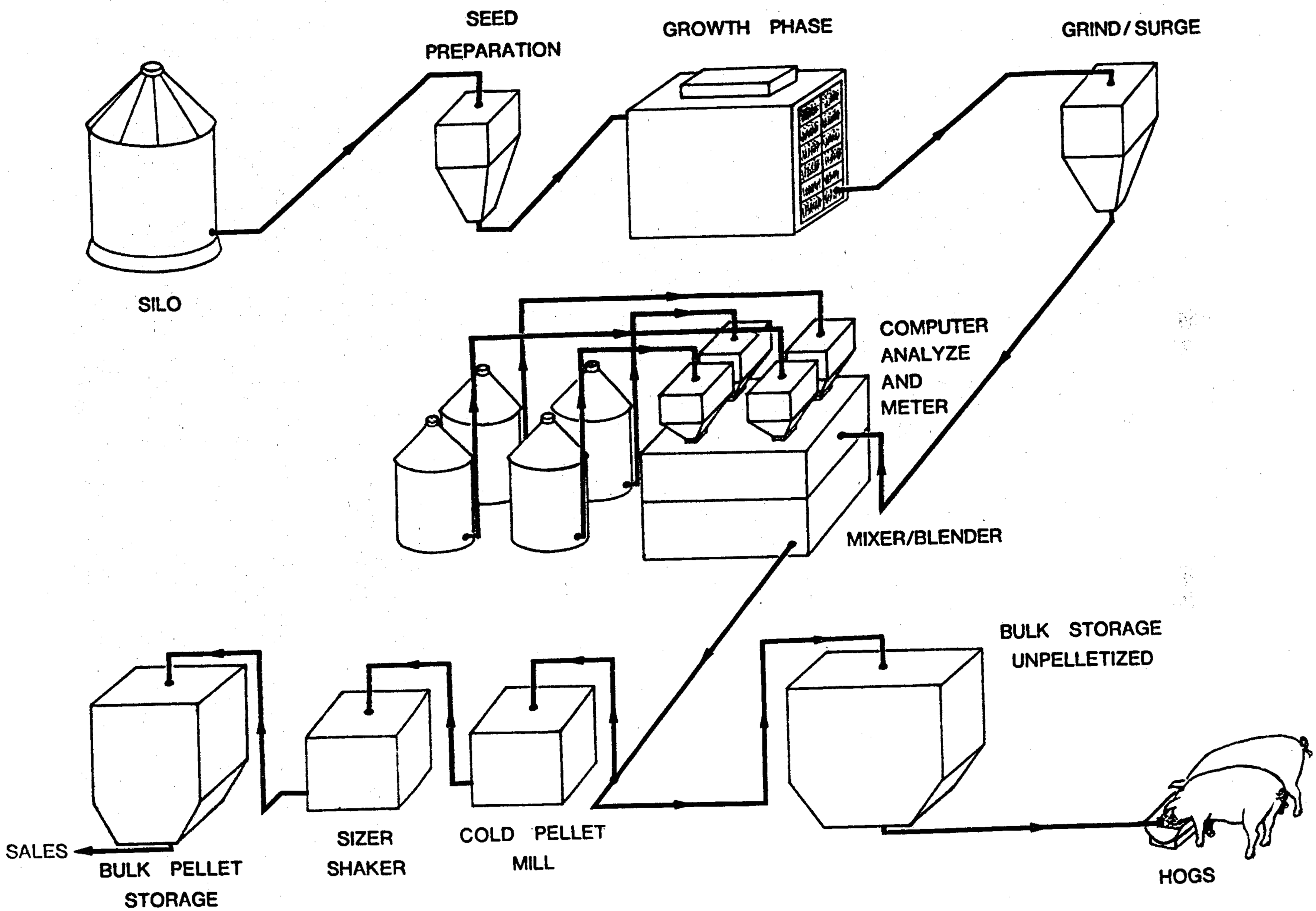


Figure 4-2. Feed Production Subsystem

Engineering design criteria for the internal feed mill are based upon commercially available equipment, although the processing technique itself does have some unique features.[35] Adequately sized storage facilities are required for raw ingredient needs. A mini-computer-operated scale system is used to properly meter the various ingredients into several ribbon blenders. A refrigerated liquid spray and pump system is integrated with the blenders to facilitate proper blending and mositure content using the environmentally grown grass.[47] Elevator transfer equipment is standard. The material is either bulk stored as a non-pelletized mash for immediate use, or transferred to a pelletizing system, using a cold process, for outside sales. Since quality of the feed is emphasized, the pelletizing of the feed is not employed for internal use. Frictional heat does reduce certain heat-sensitive elements of the ingredients. Any pelletizing of the product for sales is accomplished with immediate cooling and temperature control of the product to ensure highest quality.

Bulk storage for internal use is handled by surge hoppers at each of the swine facility buildings. A variation in the formula is essential for the various stages of swine growth. This can be more readily controlled when an internal mill facility is present. Moisture of the product is critical for feed stability, quality and material handling characteristics in the feed system. Moisture is controlled by proper blending of liquified sprouted grains with the dry ingredients. Geothermal energy is used for both refrigeration and heat in the mill and processing complex.

The feed formula for the economic analyses of this study is shown in Table 4-3.

The daily production of the mixer blender in the feed system is 165 ton/day for the swine complex. External sales would require either extra capacity or multiple shift operation. The mixer blender is a duplex system for redundancy.

Silo storage on site for purchased feed materials will be a minimum of 550 tons for a five day supply, following which externally warehoused storage supplies will be utilized.

Barley (or equivalent) seed storage on site should be 360 tons for a 60 day supply.

Ceiling height in the mill is at least 30 feet. Transfer elevators will be located in the building. Hydraulic drive is recommended for OSHA standards, explosion protection and economics.

TABLE 4-3
FEED COMPOSITION*

Item	Percent of Total by Weight
Environmentally Controlled Sprouted Grains	25
Potato Byproducts	10
Locally Purchased Products**	65
TOTAL	100

*Formulas will vary for animal age groups as well as for adjustment of proper TDN, DP, CP, NFE, calories, mineral and moisture. (See Appendix B.)

**Locally Purchased Products consist of a variable and proprietary balance of ingredients.

Storage of feed constituents within the building is designed for protection against extreme weather conditions.

The mill area requires about 5,000 square feet.

Mill processing area space conditioning should be designed to maintain human comfort conditions. Air filtering must meet OSHA conditions.

3. Swine Raising

a. Introduction

Swine raising systems in the United States are becoming highly technical enterprises.[32,36,37] Farm raised hogs are greatly influenced by climatic elements. Confinement units provide greater protection from wind, rain, snow, cold, heat, and excessive humidity from the outdoor environment.

The climate of many eastern hog raising areas is too severe for successful swine production in open feedlots or inexpensive, open-front buildings as sometimes is the custom in areas of moderate climate. Winter temperatures in a considerable part of the swine producing agricultural areas can drop to -20°F or colder, and in summer hot periods the temperature may rise to a humid 90°F.

Similar climatic conditions can be noted for the Mountain Home area.[36] The pig, a non-sweating animal, has no way of coping with climatic extremes. Hence, an obvious necessity for the future of swine raising is environmentally controlled confinement which includes control of temperature, humidity, airflow, light intensity, sound, sanitation, water and feed elements.

In recent years many farmers have improved their operations by going to partial confinement, which usually begins by giving the sow protective shelter (open front sheds) during farrowing (birthing).

A totally confined facility (such as that shown in Figure 4-3) is ideal for the farmer who believes in a management-intensive rather than a labor-intensive operation. Proper design will reduce labor requirements so that the operator may apply technology to proper animal management. This requires considerable capital investment. The apparently high capital cost of the facility is relatively low when depreciation is considered.[35, 37] Management, facility and equipment design, feed handling and animal feed conversions, and environmental technology are necessary for a totally confined swine operation.

To understand a total confinement, environmentally controlled swine operation, one should be familiar with four major areas; breeding and gestation; farrowing (birthing); nursery (weaning); and growing-finishing.

b. Breeding and Gestation

Maximum production from a sow means giving birth to more, larger, and healthier pigs. The general swine producer (non-confined) is not accomplishing this. Presently, the average sixteen eggs fertilized during conception usually yields only 35% to 40% of the potential litter. Literature shows that these losses result from environmental stresses during gestation.[36, 37] In the Eastern farm and open feed lots, the gestating sow has not had the protection needed for proper production. This, as well as increased feed requirements during severe winters such as 1976, 1977, and 1978 have shown reduced U.S. hog production.[49,50]

The following scientific and biological factors, which apply not only to breeding and gestation but to all areas of hog raising in confinement, should be considered in engineering design:

- Social/environmental factors and animal group size to control pecking order

Photo Credit:
Clay Equipment Corporation

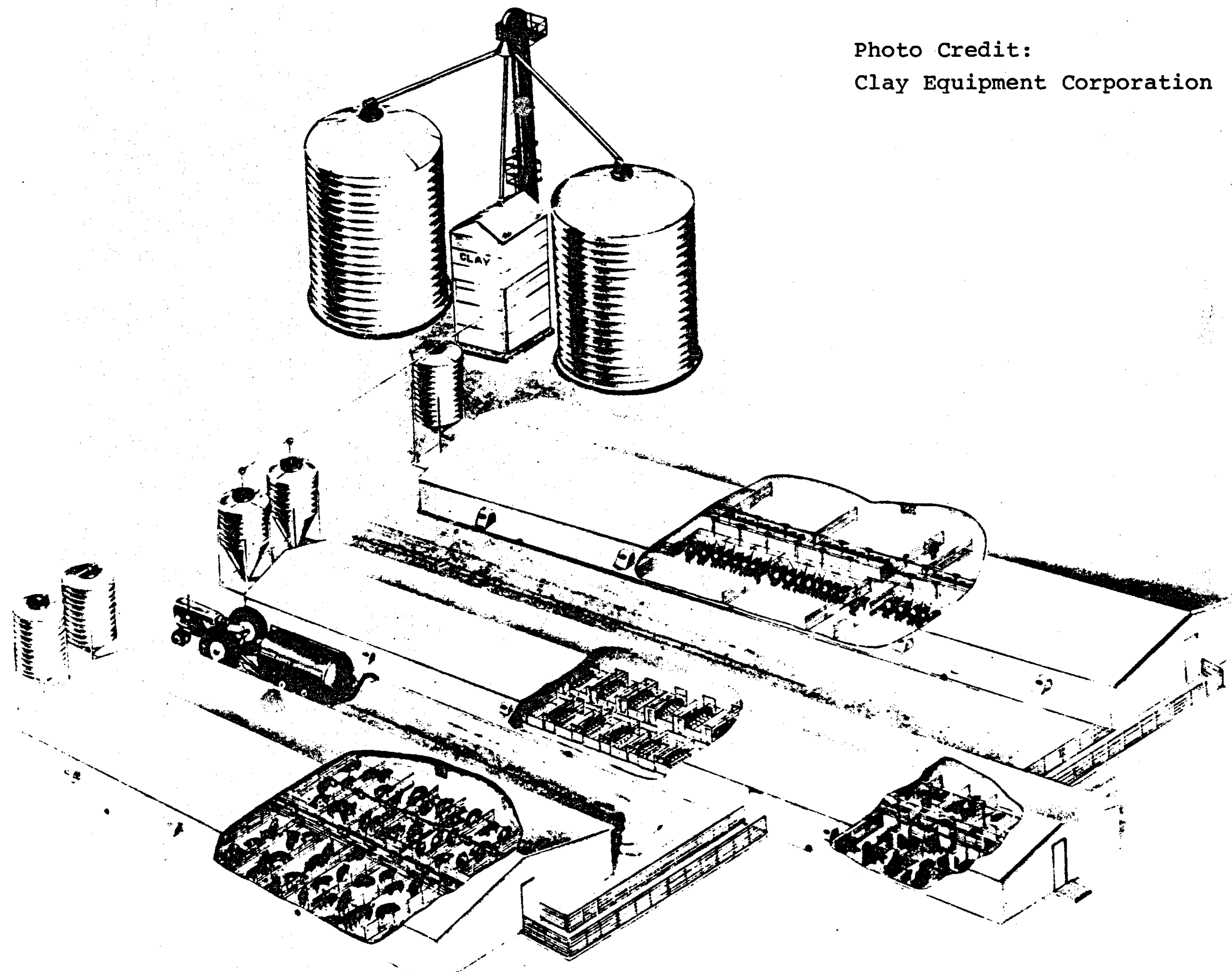


Figure 4-3. A Totally Confined Facility

- Smaller pen sizes to control fighting between animals
- Uniform animal size grouping for better feeding control
- Feed system for proper metering and ration
- Building design for optimum air flow, odor control and air plenum capacity
- Insulation of building for proper temperature control
- Pen design for boar holding and gilt social adjustment
- Breeding pens for maximum effect and footing for animals to prolong animal health
- Artificial insemination criteria for larger operations
- Geothermally heated water used in building design to replace conventional heat sources
- Interior wall construction and floor design for maximum waste removal and general sanitation
- Pen design for optimum animal movement from one location to another, as well as management and equipment movement within the buildings
- Gutter treatment for manure handling or grated floor with flush, scrape collection and drainage
- Fresh water to animals (preferably an automated watering system)
- Minimal external traffic influence for minimal stress to animals
- Prevent access to building interiors for vermin, birds and insects

c. Farrowing (Birth) Area

This birth facility should actually be considered just that! - a HOSPITAL MATERNITY AREA. Emphasis on grouping of animals into common birth periods is very important in order to maintain proper sanitation throughout the animals' stay in this area. The building should be cleaned and sanitized to control disease transmission between birth groups. Separate sewage lines should be considered for separate buildings as an additional means of disease control.

Advanced design of a farrowing facility must allow for separately controlled temperature areas so that the piglets may creep away from the sow after nursing and stay in a warmer environment than that required by the sow. (60-70°F for sow and 90°F for piglets). Geothermal floor heating is applicable for the piglets. Air flow and lack of drafts on the piglets is critical as piglet mortality is a dominating factor during this period as shown in Table 4-4.

Special farrowing pens are necessary to optimize these factors. Manufacturers of swine equipment supply similar specially designed equipment for these areas.[37] Size of farrowing building is dependent on the management schedule for animal groups and the size of the modular groups within the swine operation. The basic design criterion is usually related to the number of producing sows in the operation. As noted later, we have used design criteria of 600 breeding sow-units in a spatial arrangement combining two of these units into a module of 1200 breeding sows. Special farrowing equipment will reduce the number of pigs crushed. Chill factors to the young are also more easily controlled when combined with proper heating and air flow movement design. This special equipment also reduces labor in areas of feeding, automatic water system, bedding and manure handling. Bedding can be thereby eliminated, thus improving sanitation and eliminating bedding-related labor costs.

Partially slotted floors and liquid manure handling improve sanitation, health and reduce labor, thus allowing the operator to control these on a more timely schedule. As this is the center of the swine raising complex, the major emphasis should be placed on design factors that reduce labor thus allowing the swine manager to concentrate his effort on the farrowing operation. Manure and waste handling as mentioned in the discussion on gestation is equally important in this and all other areas. Automatically regulated temperature control is essential.

d. Nursery Area

Stress to the pig in confinement is one of the key factors in all of the areas of discussion. The nursery area is often under emphasized in confined raising. Important biological factors in this area will reduce stress to the young pigs.

The small nursing pig (25 to 50 pounds) requires temperatures of 70° to 80°F. Heat in the floor where the pigs sleep helps to secure a clean dry area for the nursery pig. It also assists in training the pigs to maintain cleanliness in a certain area. One half

Table 4-4
BABY PIG LOSSES[37]

CAUSES OF BABY PIG LOSSES	% OF LOSSES
CRUSHED BY SOW	49.3%
FARROWED DEAD	16.3%
CHILL (DRAFTS)	9.0%
STARVATION	6.0%
EATEN	4.7%
TOO WEAK (LIGHT BIRTHWEIGHT)	4.3%
SCOURS	1.0%
OTHER	9.4%
	100.0%

WHEN LOSSES TAKE PLACE	% OF LOSSES
FIRST WEEK	56.2%
SECOND WEEK	15.1%
THIRD WEEK	8.3%
FOURTH WEEK	6.3%
FIFTH WEEK	4.4%
SIXTH WEEK	3.4%
SEVENTH WEEK	2.9%
EIGHTH WEEK	2.4%
AFTER EIGHTH WEEK	1.0%
	100.0%

of the pen area should be designed for slotted floors. Manure handling with such a system can be automated thus reducing labor in this area.

Small pens of five by ten feet in size will allow for sizing separation to reduce the potential loss from the natural pecking order of the animals. Fourteen to twenty pigs per pen affords 2.5 to 3.6 square feet per medium-sized animal.

The small pigs are easier to watch in smaller groups of equal litter size. Scheduling from the farrowing litters to this area is also easier to maintain with smaller units.

More efficient and greater weight gains are observed in confined nursery areas as a result of temperature and humidity control and less stress. Soil-borne infestations are not present and disease control is more adequate. Properly designed nursery facilities mean greater flexibility in the farrowing and finishing aras. The small size of the pig at this stage allows greater flexibility at lower capital costs per square foot. Traffic pattern for the pigs is essential to reduce excess passage space. Pen design and constuction is important at this point to facilitate maximum utilization of space and movement.

Ventilation exhaust fans should be placed in positions to optimize circulation, maintain adequate temperature control, and reduce or eliminate drafts.

Automatic watering bowls are the same type used in the farrowing area; thus eliminating stress from any change of watering method.

e. Finishing Area

Full grown hogs of uniform size and weight are becoming more important in the market. Uniform size hogs with less back fat bring premium prices at slaughterhouses. This can be accomplished more easily when the animals are controlled in confined systems. As discussed previously, stress and pecking order of the animals can be more readily handled, as social groups have been established in the nursery. The finishing area is designed to allow the hog to gain weight at the optimum rate. Confinement reduces the stress caused by traffic, heat, cold, wind, snow, and rain. Hence, feed conversion efficiencies are improved.[36,37,43,51,52]

The comfort zone for confined swine is between 60° and 70°F.[37] Statistics show that under average conditions, at these temperatures, animal gain is 2.0 pounds per day. Temperatures of 20 degrees lower (40°-50°F) alter this conversion ratio to 1.8 pounds per day. A drop to 30°F lowers this ratio even further to 1.6 pounds per day.[37] Similar decreases in feed conversion efficiencies can be seen when the temperature of the animal increases from excess heat. It is obvious, therefore that feed conversion efficiency as affected by temperature and humidity control is a critical factor with swine. Such controls can economically be justified with a few basic calculations of feed comsumption and conversion (see Appendix A).

The necessity for good traffic flow in the nursery area has been mentioned. It is equally important in the finishing area. The size of the animals in this area also define the optimum pen configuration. The social nature of the animal can be exploited by designing a long narrow pen. By providing a slotted floor area that occupies at least one-third of the pen floor, the animal will dung in this area. A hog is a clean animal when conditions allow. The animal's social nature will compel it to feed in the unslotted area and eliminate in the slotted area, away from his feed area. Such a slotted area with proper manure handling equipment again permits the operator to minimize his labor requirements.

The Iowa State University has studied alternative feeding methods.[37] Self-feeding and floor feeding methods have been reviewed. On the basis of literature review and Appendix A, self-feeding equipment is not recommended here. There appears to be too much feed lost into the manure system and wasted.

Use of a time release feed system in the clean area of the pen has several advantages. The operator can more readily observe a sick animal that does not rise when the feed is released. Quantity amounts can be adjusted for optimum consumption. These feed systems optimally time feed releases four to six times each day. By feeding on such an interval the pecking order of the animals is compensated. During one feeding one animal may eat more than another. However, this is self adjusting as at the next feeding that animal is not as hungry and allows others to eat their required amounts. An operator can observe the feeding habits of an area and optimize the utilization of feed by adjusting the quantity dropped at each cycle.

4. Ventilation

Ventilation is particularly important in confined livestock raising. Swine, like other livestock, have a "comfort zone" of humidity, air flow, and temperature at which feed conversion efficiency and rate of weight gain are optimized. Temperature and ventilation requirements used as bases for system designs are summarized in Table 4-5 following.

TABLE 4-5
TEMPERATURE AND VENTILATION REQUIREMENTS

Animal Unit	Temperature (°F)	Ventilation: Winter Normal (cfm/Animal Unit)	Ventilation: Summer Normal (Building air changes per min)
Sow & Litter	60-70 (Sow) 90 (Litter)	50	1
Nursery	70-80	10	1
Finishing	60-70	25	1

5. Building Type

The general type of building is common to all hog areas. New swine complexes are generally one story with insulated frame or metal construction, the lowest-cost method of providing a well insulated structure necessary for any phase of the above subsystems. Surfaces of interior walls and floors must be designed for ease of cleaning and required sanitation.

Several multi-story swine complexes have been designed,[32, 46] but, after reviewing, this method is not recommended. Too many problems arise from the need for support posts, manure handling systems, and slopes to the floors.

The following is a review list of questions to consider during planning and construction of a modern confined swine raising facility. It provides the design criteria utilized in the facility design and costing of the Mountain Home Geothermal Project.

- Is there proximity to energy sources and water?
- Are buildings and modules designed for expansion?
- Does design ensure that exhaust air from one building does not interfere with intake air of another building?
- Will the master sewer system meet immediate needs and expansion requirements?

- Has a modular size been established which can be used as the basis for calculation of other areas?

- Has the essential manure handling and storage or secondary treatment been fully considered?

- Does the system assure that the movement of animals, manure, vehicle traffic and feed do not interfere with each other?

- Have building structures been selected that do not require internal posts which interfere with pen and equipment placement?

- Do building roof and ceiling designs allow for proper air movement and ventilation?

- Has allowance been made for proper fire separation from highly combustible surroundings such as feed or ingredient storage?

- Will selected heating and ventilation equipment optimize temperature and humidity comfort conditions without drafts to the animals? This requires separate design criteria for summer and winter conditions.

- Have all plans been reviewed by qualified engineers and approved by local authorities?

Facility sizing is based upon animal residence time, pen space required per animal and animal populations. The following three tables give the criteria used in this study.

6. Swine Slaughter

The sizing of the standard economic slaughter facility begins at about sixty hogs per hour. Geothermal applications are numerous in the heated water requirements for processing as well as phases of absorption refrigeration in the chilling and cold storage areas.

Swine slaughter facilities are relatively small when compared with those required for cattle. Sizing criteria is basically established by the internal equipment and flow pattern. A smaller, abattoir type of slaughter facility is not suggested. Such a smaller complex becomes questionable when the capital requirements and volume are evaluated. The sizing of the modern economic slaughter facility begins at about 60 hogs per hour.[53,54]

Design criteria are based on current commercial practices. In summary, the principal processes are as follows:

TABLE 4-6
BUILDING SIZE GUIDELINES

Area	Animal Residence Time
Breeding	28 days
Gestation	86 days
Farrowing	28 days
Nursery	35 days
Finishing	105 days

TABLE 4-7
ACTUAL PEN SPACE REQUIRED PER ANIMAL

Area	Square Feet Per Animal
Breeding	14.0
Gestation	23.0
Farrowing (includes sow and litter)	35.0
Nursery	2.8
Finishing	7.1

TABLE 4-8
HOG POPULATION GUIDELINES

Area	Potential Pen Capacity (Animals)
Breeding (includes boars, sows, and gilts)	1700
Gestation	6050
Farrowing (includes sow and litter)	1200
Nursery	14,400
Finishing	31,200

- The hogs are herded from the finishing section of the parlors to the hold area for inspection for disease and sanitation.

- The hogs are stunned and bled, shackled, dipped in a hot water bath to set the hair folicles, sent through a drag and spinning hair remover, and a fast flame singe for residual hair removal and then continue on a conveyor.

- The carcasses are opened, eviscerated, split, and the carcass and offal are inspected by USDA/Meat Inspection Division (MID) personnel.

- Carcasses are cut and split for sales, washed, fast chilled, and precooled in the "Hot Box" for temperature draw down.

- Carcasses are transferred to the "sales cooler" for final grading, storage, and holding for market at a maximum of 35°F.

The design criteria and processes for operation are defined in detail in the USDA/MID manual.[55]

Equipment designed for the slaughter of 60 hogs per hour can also be designed for speed control and additional labor stations to increase this capacity to about 160 hogs per hour. The auxiliary refrigeration holding and storage facilities will then become limiting. Duration of time held after kill and prior to shipment naturally has to be coordinated with sales and transportation factors. The production output can be further expanded by operating two work shifts.

Standby refrigeration may be considered in the final design. A tank of liquid carbon dioxide could fulfill the requirement.

A minimum of 180°F is required by MID. for wash down water.

7. Potato Processing

A significant portion of the livestock feed is constituted of locally available products. In the Mountain Home area potatoes stand out as one of the best candidates for feed constituents. Potato processing facilities are relatively standard installations. Washing, peeling, and blanching are common to both freezing and dehydration operations.[56]

A process flow diagram, Figure 4-4, describes the functions in the potato process as base lined for this study.[57] Rather than duplicate, an interpolation of a previous study was "black boxed" for this study.[57] The Mountain Home Geothermal Project sizing was based upon the

POTATO PROCESS FLOW DIAGRAM

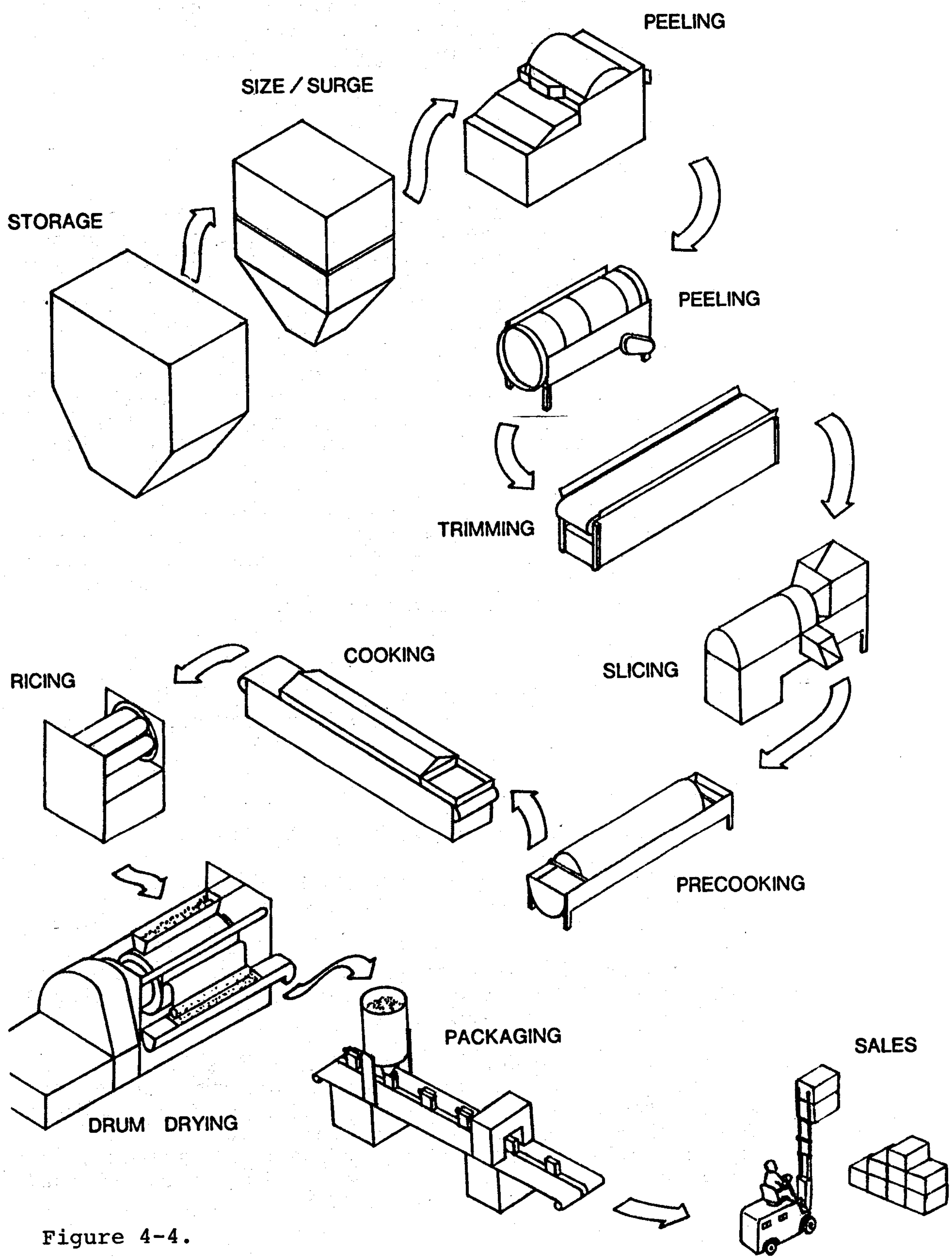


Figure 4-4.

potato byproduct needs in the basic feed formula, Table 4-3, optimized for economics within the potato process itself and iterated to integrate in the heat balance of the overall system.

8. Waste Management and Methane Generation

a. Introduction

In line with the previously discussed trend towards large confinement buildings for livestock, automated waste gathering and handling systems are also utilized. Such mechanized systems, designed with environmental quality as a concern, are consistent with this trend, provide fertilizer and provide a means of capture of the energy otherwise lost in manure. The biological process involved in energy and nutrient recovery from animal wastes are, for the most part, optimal in production rates at the low temperatures of a geothermal cascade (roughly 120°F and lower).[59]

Methane generation is the unique feature of the waste management system in this report. By incorporating methane generation equipment, the swine manure handling system becomes a closed system, eliminating odor and insect management problems.

b. Waste Handling

Proper waste management is a key element of the Mountain Home Geothermal Project for many reasons, among the most important of which are:

- animal health
- avoidance of air and water pollution
- compliance with applicable regulations
- economic advantage.

In line with trends in confined livestock raising and suitability for biogas generation processes, liquid manure handling is recommended.

Swine manure, the dominant portion of the waste being handled, is collected in pits below the slatted hog parlor floors. This waste is scraped from storage pits below the slats into waste mains where an approximately equal volume of water is added to facilitate transport and anaerobic decomposition. Following the anaerobic process, which also is used for other non-human organic wastes, the remaining waste slurry, reduced about fifty percent in volatile solids,[38] is allowed to settle in open ponds and the liquid portion is reused for waste transport while solid portion is sold for or used as fertilizer for cropped fields.

In order to maintain high levels of disease control, the waste system is designed to prevent flow of waste from one room of a parlor to the next - backflow is prevented.

The manure handling must be designed to handle 600,000 pounds of manure slurry per day from the fully stocked 7200 sow complex.

A holding capacity downstream of the digesters is required for 120 days production during the winter.

It should be noted that waste management also involves a separate septic system for human wastes, pyrolytic incineration for dead animals, and a solid waste holding area for storage prior to transport to a separate local waste facility.

c. Biogas Generation

In the biogas generation subsystem, geothermal heat is used to promote elevated temperature anaerobic bacterial digestive action of organic material. The decomposition of organic matter in the absence of oxygen is called anaerobic fermentation. Anaerobic fermentation of organic products results in methane, carbon dioxide, hydrogen, traces of other gases, and the production of some heat. The residue remaining is hygienic, rich in nutrients, and high in nitrogen. Weed seeds and potentially damaging germs are killed by the absence of oxygen during the fermentation process, rather than by the higher heat generated by the aerobic process.[60,61]

The biogas producing digestive activities are optimal in two temperature ranges: 85° - 105° and 120° - 140°F, although digestion will occur from freezing to 156°F. Fermentation, however, is less stable in the higher of these two ranges[60] and, consequently, the biogas units are to be designed to be maintained in the lower optimal range.

The Mountain Home Geothermal Project biogas generation subsystem is designed with the following features:

- The key element in the biogas process is the enclosed biomass digester tank. These tanks are sealed off from the atmosphere (particularly oxygen) and have provisions for raw material inflow, gas outflow, and organic residue outflow. (See Figure 4-5).

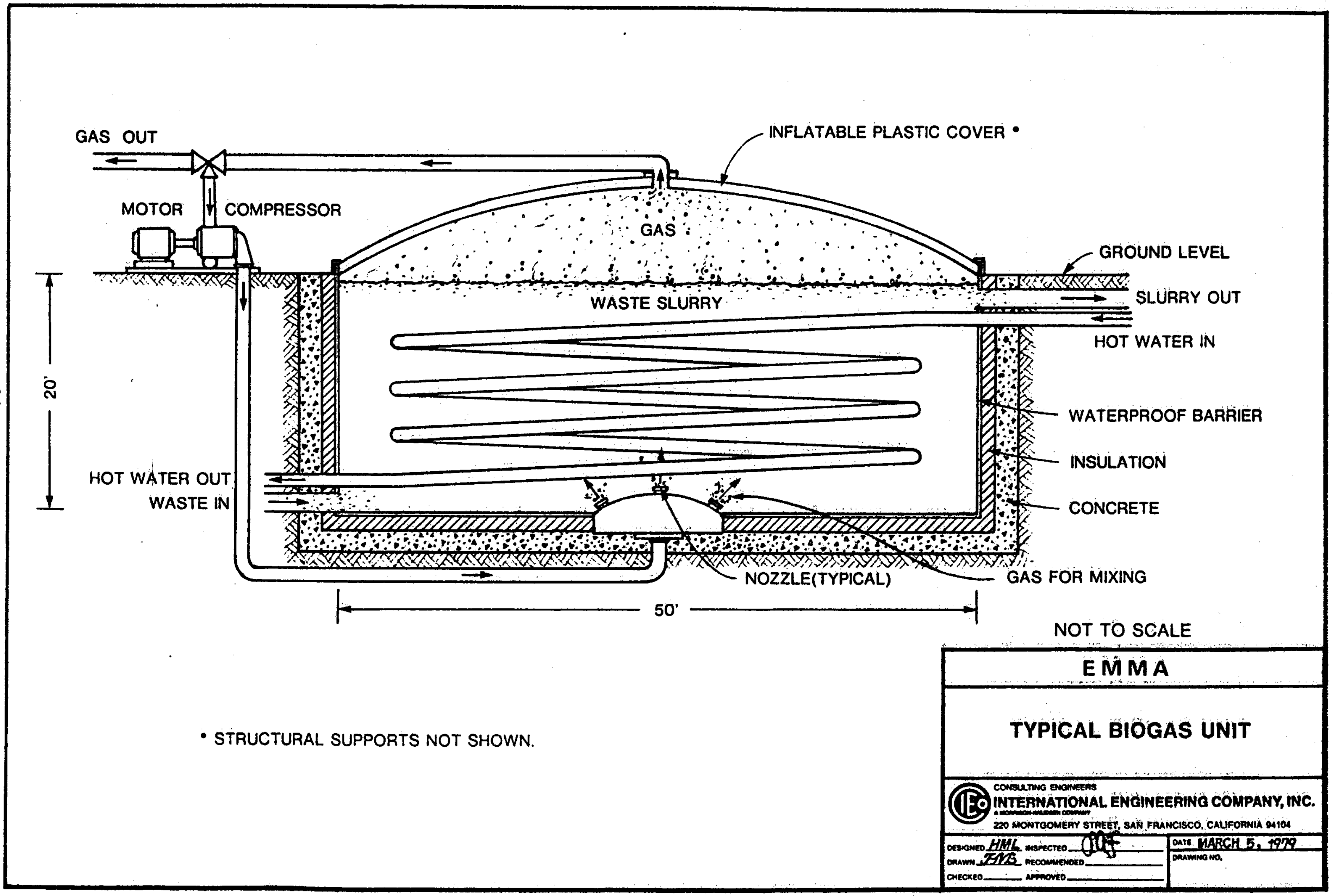


Figure 4-5. Biogas Generation Subsystem (Digester Tank)

- Continuous, rather than batch, material supply to the biogas units is utilized here. This supply method not only affords a more definite and regular output of biogas, but is also well suited to the types of organic waste utilized.

- Mountain Home Geothermal Project inputs to the biogas process are of such a size that relatively large volume tanks are required. For production, storage, and standby design requirements, 16 tanks twenty feet high by fifty feet in diameter are nominally required. It should be noted that biogas production at the high end of the reported production range would require an increase in total tankage.

- The temperature of the digesters is controlled by the addition of heat to maintain the desired 85°-105°F temperature range. This heating is accomplished by circulating clean hot water through coils built into the digesters. Insulation for the digesters is provided to minimize this heating requirement.

- Slurry particle size range is controlled by comminuters prior to the tanks.

- Slurry agitation in the digesters is provided by bubbling a portion of the biogas through the digester.

- The carbon:nitrogen ratio of swine manure is enhanced for biogas production by the synergistic addition of potato processing waste.[38,60,62]

- The biogas is stripped of carbon dioxide and other deleterious elements and is burned directly as methane (without pressurization) in engine-generator sets to produce electricity for use as required by subsystem components and for shaft power. Storage is provided for surge requirements. Furthermore, a growth element in this system would be the possible combustion of methane to increase peak temperature available to the system.

- Systems designed to date indicate that a single unit is not advisable. Multiple units are designed for economic size of construction as well as for biological factors that occur during collection of ingredients, generation, and utilization. It appears to be better to have multiple units in case one system may undergo a biological malfunction of operations which would generally only occur if some foreign agents were introduced to in activate the system as has occured in trial industrial applications where unknown wastes are introduced. This would probably not occur in a properly managed system at this complex. However, a multiple system would provide safety and would surely be more advantageous for modular expansion as required.[38,62]

L. Boersma of the Oregon State University presents some of the most current and functional design data seen to date. Design criteria for the proportionate amount of added water and other detailed important factors to increase final yields are presented.[38]

9. Integrated System Criteria

Integrating factors for the Mountain Home Geothermal Project are:

- thermal cascade considerations
- mass flow cascade considerations
- space requirements
- economic considerations

The integration must be carried on simultaneously for these considerations, as each is a function of the others.

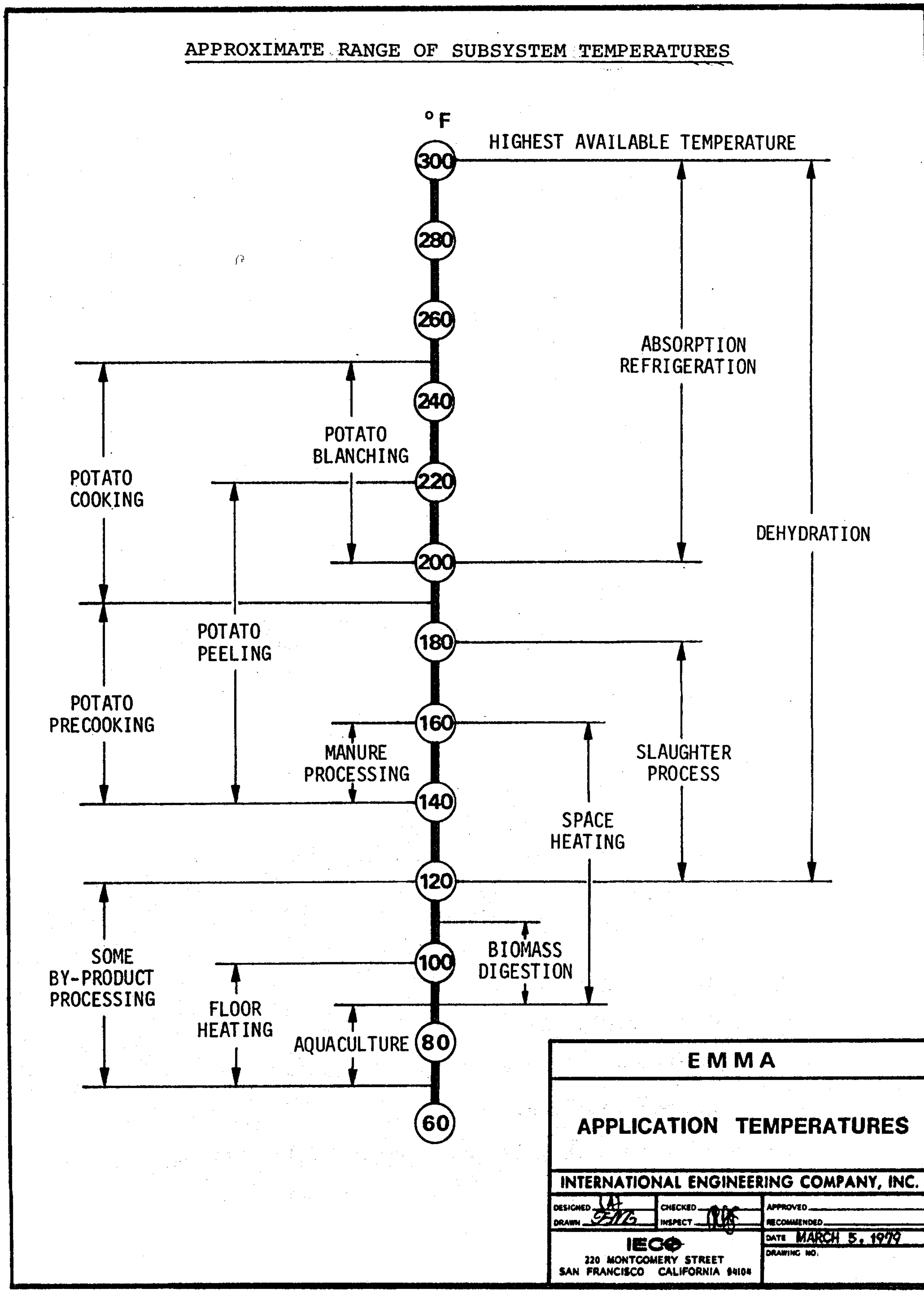
10. Temperature Cascade Considerations

Figure 4-6 shows the approximate range of subsystem temperature applications which could be provided by the geothermal fluids of the Mountain Home Geothermal Project.

Table 4-9 lists the process and environmental temperature targets by subsystem.

11. Mass Flow Cascade Considerations

The totally confined swine operation is the focal element of the system from a qualitative internal mass flow balancing viewpoint; the commercially dictated slaughter operation sizing controls the quantitative aspects of the cascade. The reader should note biological (qualitative) flow requirements were balanced between themselves prior to application of quantitative sizing based upon economic considerations.



APPROXIMATE RANGE OF SUBSYSTEM TEMPERATURES
°F
HIGHEST AVAILABLE TEMPERATURE
300
280
260
240
220
200
180
160
140
120
100
80
60
ABSORPTION REFRIGERATION
DEHYDRATION
POTATO COOKING
POTATO BLANCHING
POTATO PEELING
POTATO PRECOOKING
MANURE PROCESSING
SLAUGHTER PROCESS
SPACE HEATING
BIOMASS DIGESTION
SOME BY-PRODUCT PROCESSING
FLOOR HEATING
AQUACULTURE
EMMA
APPLICATION TEMPERATURES
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Figure 4-6.

TABLE 4-9
AVERAGE TEMPERATURE TARGETS

Environmentally Controlled Growth System	70°F
Mill	70°F
Swine Raising	60°F - 90°F
Slaughter - absorption refrigeration	28°F
- compression refrigeration	-10°F
- process heat	120°F - 180°F
Potato Dehydration	130°F - 300°F
Methane Generation	100°F

12. Space Requirements

Each of the subsystem activities has service, preparation, and handling space associated with its own environmentally controlled area. Examples of such associated space requirements are:

- wells
- heat exchangers
- hog travel runways between buildings
- vehicle access for feed distribution
- waste systems
- equipment servicing
- office space
- employee facilities
- agriculturally dictated space requirements
- area for expansion.

The physical facility is based on the following factors:

- Minimum commercial slaughter at 60 head per hour dictates hog populations and results in a 7200 sow complex.

- The average feed formulation and the quantity per hog dictate the mill sizing. In actual practice there are five or more formulations that are mixed for feeding to the different stages of hog raising.

- The feed formula and hog population also size the potato process facility.

- Based on known ratios of meat-to-animal byproducts and animal waste and of feed-to-manure production, one can size the meat production/ sales facilities and the waste management facilities.

- Operating characteristics of the methane generation system combined with waste from the hog and potato operations determine the size of the waste management system.

In addition to the sizing based upon throughput of the systems, spacing for maintenance, sanitation and health and special limitations in traffic flow are required. For instance, hog travel ways between raising facilities and slaughter are not to be crossed by vehicular travel.

All combustible, non-edible wastes, especially dead animals and offal must be pyrolitically incinerated at the site. Incineration is required to meet health requirements and pyrolitic incineration is required to meet odor control for environmental requirements.

Hydraulic power using the methane directly in diesel fueled engines will be used for the major shaft power requirements. Hydraulic shaft power is industry practice for modern slaughter and food processing facilities. Such systems are safer, more economic and more reliable than electric motor drives in these applications. Additional preliminary design would be required to determine the economics of electric generation for in-plant use.

13. Economic Considerations

Subsystem activity sizes were initially predicated upon commercially successful independent individual enterprises. The economic sizing of slaughter operations based upon existing commercial practice has resulted in defining an inherently large overall system. The slaughter facility capacity for hogs should not be less than sixty animals per hour for an eight hour working day.

The design criteria for animal raising facilities must take into account the cost tradeoffs in facility construction, animal feed conversion factors, feed costs, traffic movements, and expansion plans. The selected system is modular with each single module supporting 600 breeding sows. Six duplex modules (1200 sows each) are required to fully supply the minimum slaughter capacity.

As subsystem integrations progressed, commercial sizes were adjusted to obtain a balance of thermal, energy, mass, and space considerations, which in turn, modified the commercial subsystem sizes; in other words, iterations between the engineering and economic analyses were required to optimize the system.

D. ALTERNATE AND GROWTH ELEMENTS

The following alternate and growth elements have been considered for future development at the Mountain Home Geothermal Project Site:

- Providing there is an economic benefit through biological and energy cascading, a small animal raising and feeding element could be included. Rex rabbits are the prime animal candidate with chickens as an alternate.

- Small animal slaughter and meat packaging processes would be considered. In the case of Rex rabbits, pelts would also be tanned and sold.

- Hog slaughter operations could be extended to include meat processing and a box ready packaging facility.

- Regional practices indicate the need for a high quality, lower cost feed for cattle and fish.

- Providing sheep can be further genetically developed for confined raising in Idaho, sheep raising is a future potential.

- Hogs from outside the Mountain Home Geothermal Project could be purchased, slaughtered, and processed. Other animal slaughter would require separate slaughter lines. A common central refrigeration plant would be economic.

- Numerous slaughter byproduct processing subsystems would be considered: hog hides for burn victims (limited market), blood drying, frozen pancreas, tallow, and others.

- Environmental aquaculture, internal to the system (not fish for sales), may be of benefit to the system and is considered as an alternative and future growth element.

- Residual biological cascade flows may indicate a capacity for growth elements of aquaculture and greenhouses in an industrial park complex. These have not been elements of the study and would require additional energy considerations.

The small animal operations have an insignificant impact upon the 7200 sow operation. The relatively small inputs/outputs also have an insignificant impact on the entire system operation, but may have a significant socioeconomic impact on the area due to employment factors.

DESIGN AND PERFORMANCE

The subsystems of this study were designed to the depth required to estimate the costs for use in the economic analyses in Chapter 5.

1. Size and Space

Figure 4-7 depicts the overall integrated site plan and Figure 4-8 shows site plan details. Based on current agricultural practices and trends in commercial slaughter, the entire integrated facility, exclusive of land for waste treatment irrigation, will encompass approximately one hundred acres. About fifty acres of common space are used for shared access facilities such as truck parking and loading, animal runways, and roadways for material handling. About 25 acres are used for hog raising in modular commercial hog parlors and the balance is utilized in two- to six-acre facilities for feed growing, feed processing, potato processing, slaughter, biogas production, primary waste treatment, wells and central facilities. Over and above the one hundred acres, another sixty acres are used as a surge for potential waste storage. The waste treatment effluent, though of agricultural quality, if disposed of through land application,[63,64] must be accomplished on land under the control of the waste management system operator. The buildings are all one story, insulated metal construction. Interior surfaces in animal raising and slaughter are as specified by USDA/MID for sanitation processes.

The swine raising building areas are summarized in Table 4-10. The overall summary of all principal buildings are summarized in Table 4-11.

2. Geothermal Energy Application

The application of geothermal energy is extensive throughout the entire system as indicated in Table 4-12.

Transfer modes for heating are represented in Figure 4-9. Absorption refrigeration is schematically shown in Figure 4-10.[65]

The thermal cascade (including losses) is illustrated graphically in Figure 4-11. Of the 1000 gpm circulating at peak, 800 gpm at the highest temperature (300°F) are used for absorption refrigeration for slaughter. The slaughter system considered for the Project could be designed for faster product throughput by utilizing a blast chilling tunnel. This lower temperature operation is typically accomplished with compression refrigeration. Consequently, absorption refrigeration will be used for

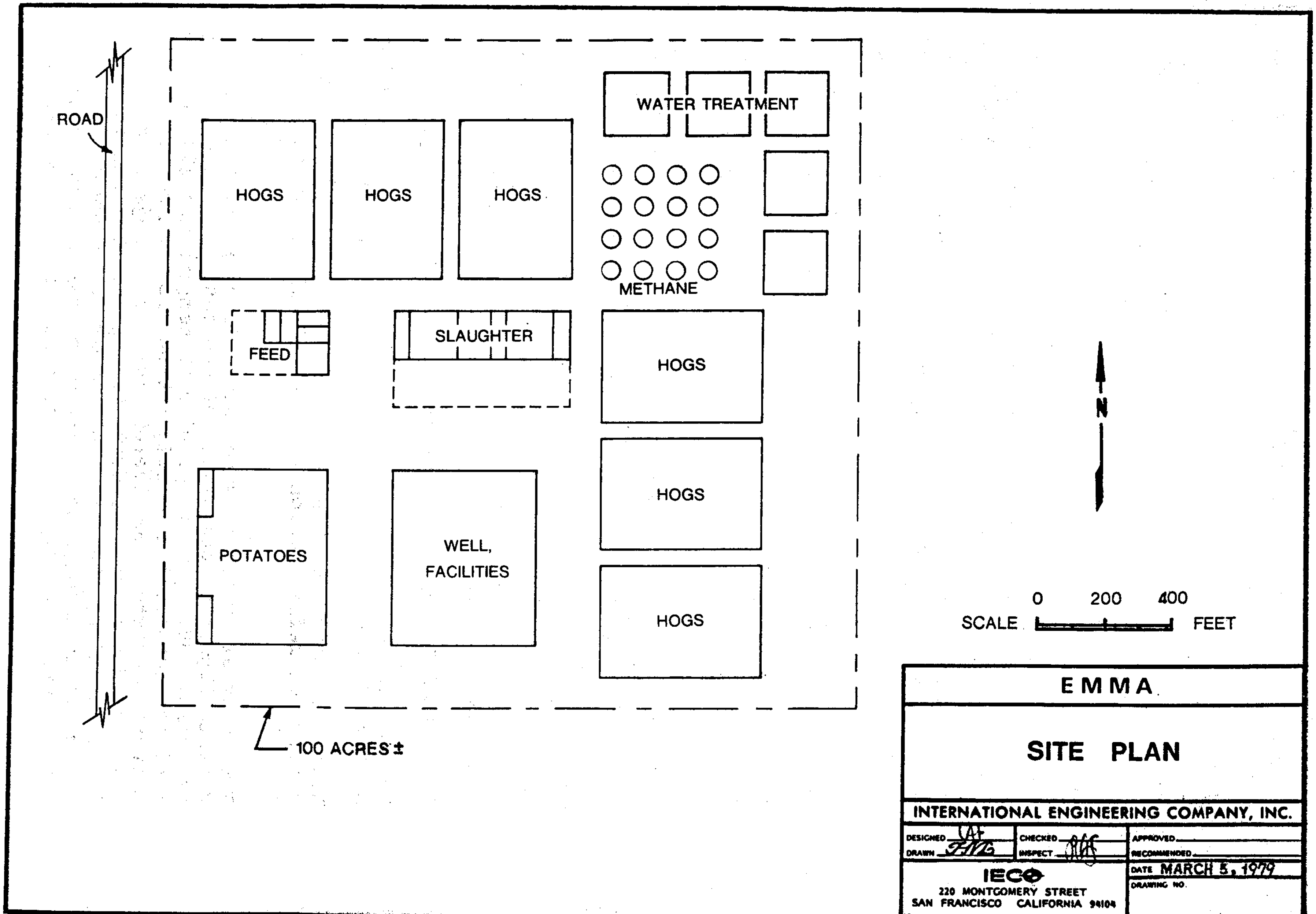
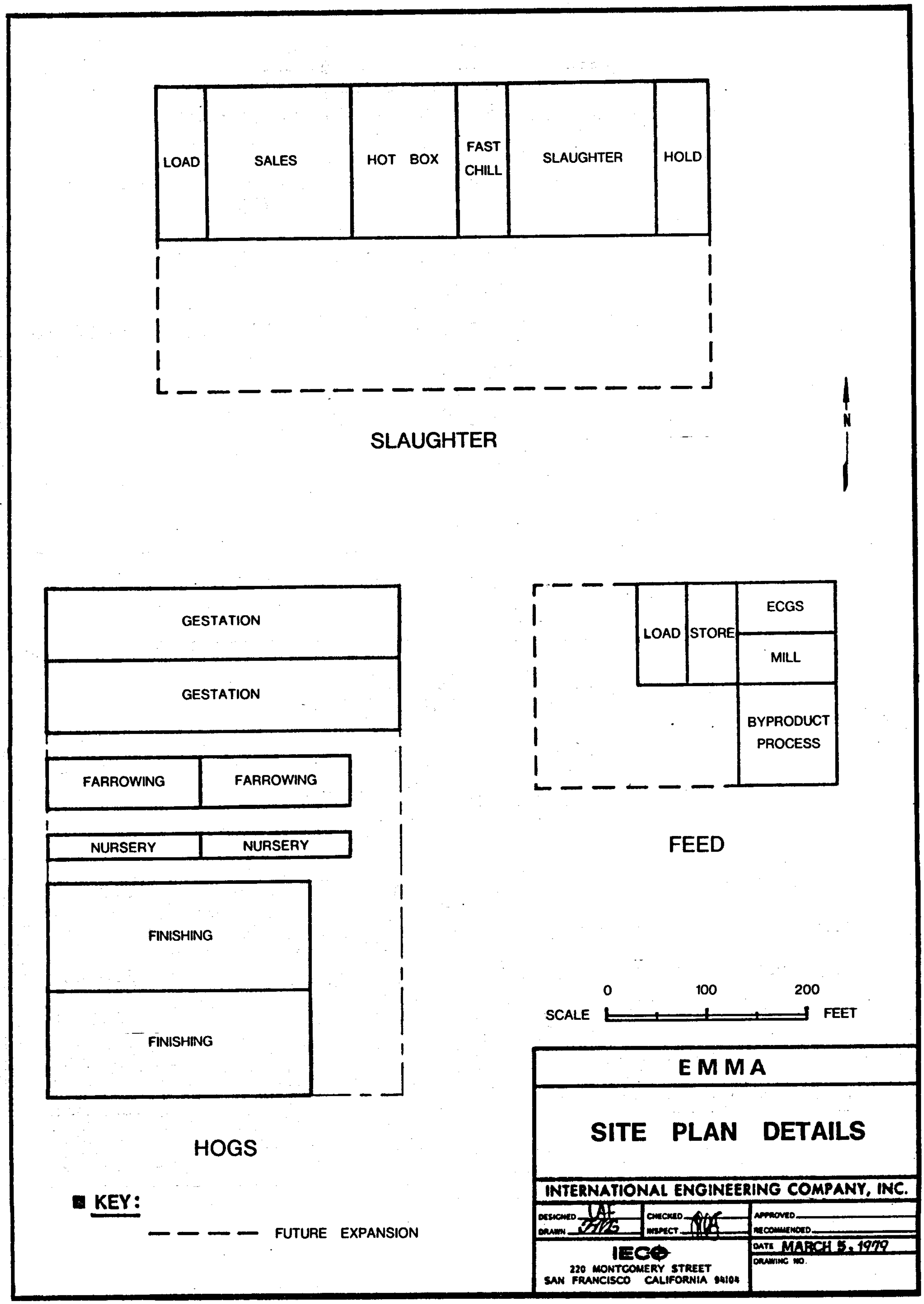


Figure 4-7. Overall Integrated Site Plan



LOAD
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FUTURE EXPANSION
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SITE PLAN DETAILS
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Figure 4-8.

TABLE 4-10
SWINE RAISING BUILDING AREAS--7200 SOW COMPLEX

Building Function	Area (ft^2)	Average Area*/Animal (ft^2)
Breeding	23,400	13.8
Gestation	204,300	33.8
Farrowing	102,000	85.0 (Sow and Litter)
Nursery	52,200	3.6
Finishing	307,200	9.8
Total	689,100	

*Includes aisles and working areas

TABLE 4-11
ACTIVE SUBSYSTEM AREAS

Subsystem	Area (ft^2)
Environmentally Controlled Growth System	5,000
Mill and Storage	25,000
Swine Raising	689,100
Slaughter	82,500
Potato Processing	220,000
Waste and Methane Generation	31,400
Waste Ponds (Internal)	217,800
Wells and Support Operations	130,000
Total	1,400,800

TABLE 4-12
GEOTHERMAL HEAT APPLICATIONS

Subsystem	Heat Transfer Mode
Environmentally Controlled Growth System	
Space Heating	Fan Coils
Space Cooling	Absorption Refrigeration
Mill and Storage	
Space Heating	Fan Coils
Space and Liquid Cooling	Absorption Refrigeration
Swine Raising	
Space Heating	Fan Coils
Floor Heating	Radiant Floor Area
Space Cooling	Evaporative Cooling
Slaughter	
Space Heating	Fan Coils
Space Cooling	Absorption Refrigeration
Coolers	Absorption Refrigeration
Cold Rooms	Mechanical Refrigeration
Hot Water Washes	Heat Exchangers
Potato Processing	Heat Exchangers
Waste Management	
Digester Heating	Coils in Tanks
Pond Heating	Piping in Ponds
Geothermal Supply	Primary Heat Exchanger

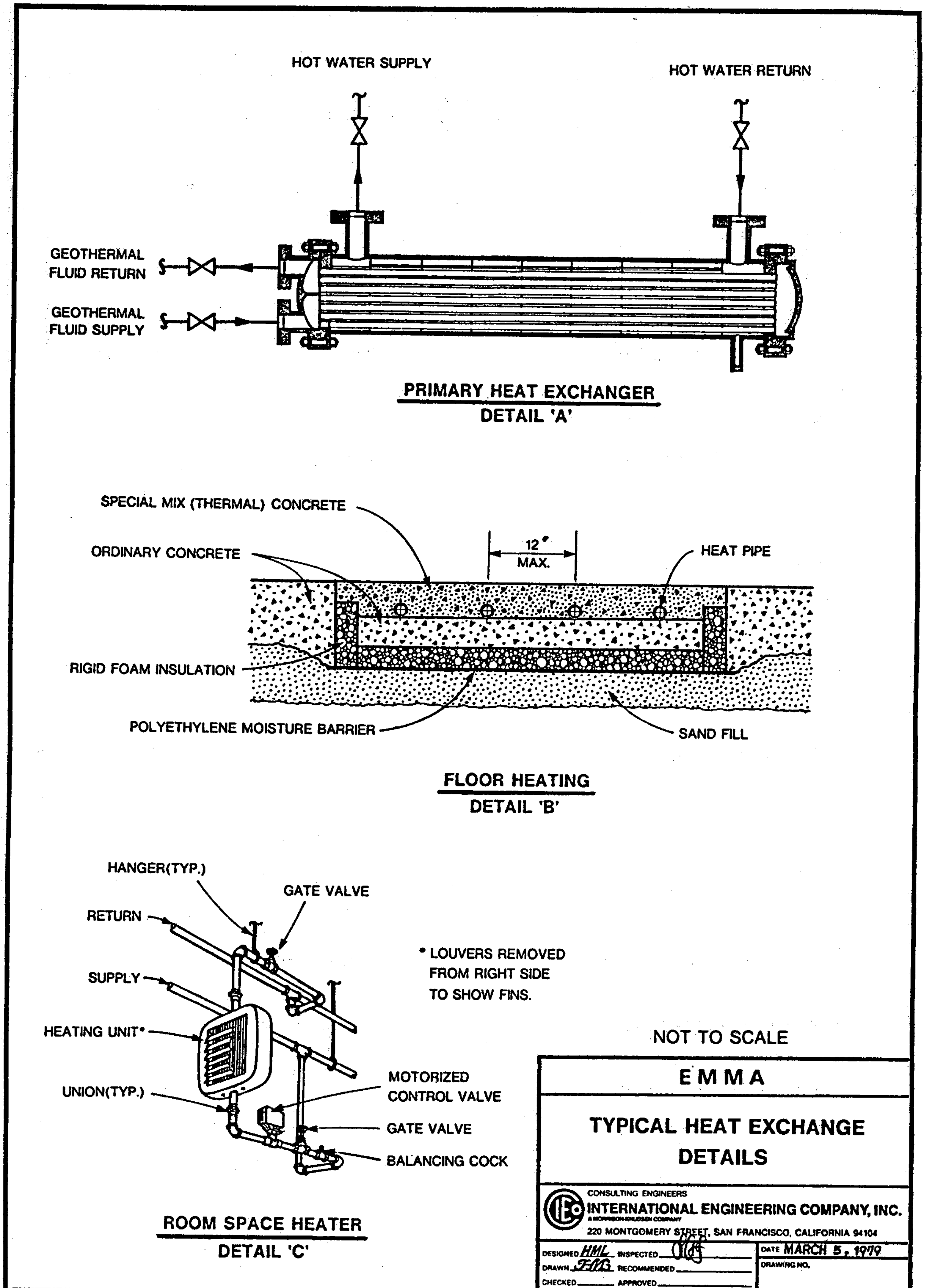
HOT WATER SUPPLY
HOT WATER RETURN
GEOTHERMAL FLUID RETURN
GEOTHERMAL FLUID SUPPLY
PRIMARY HEAT EXCHANGER
DETAIL 'A'
SPECIAL MIX (THERMAL) CONCRETE
ORDINARY CONCRETE
12" MAX.
HEAT PIPE
RIGID FOAM INSULATION
POLYETHYLENE MOISTURE BARRIER
SAND FILL
FLOOR HEATING
DETAIL 'B'
HANGER(TYP.)
GATE VALVE
RETURN
SUPPLY
HEATING UNIT*
UNION(TYP.)
MOTORIZED CONTROL VALVE
GATE VALVE
BALANCING COCK
* LOUVERS REMOVED FROM RIGHT SIDE TO SHOW FINS.
ROOM SPACE HEATER
DETAIL 'C'
NOT TO SCALE
EMMA
TYPICAL HEAT EXCHANGE DETAILS
CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
220 MONTGOMERY STREET, SAN FRANCISCO, CALIFORNIA 94104
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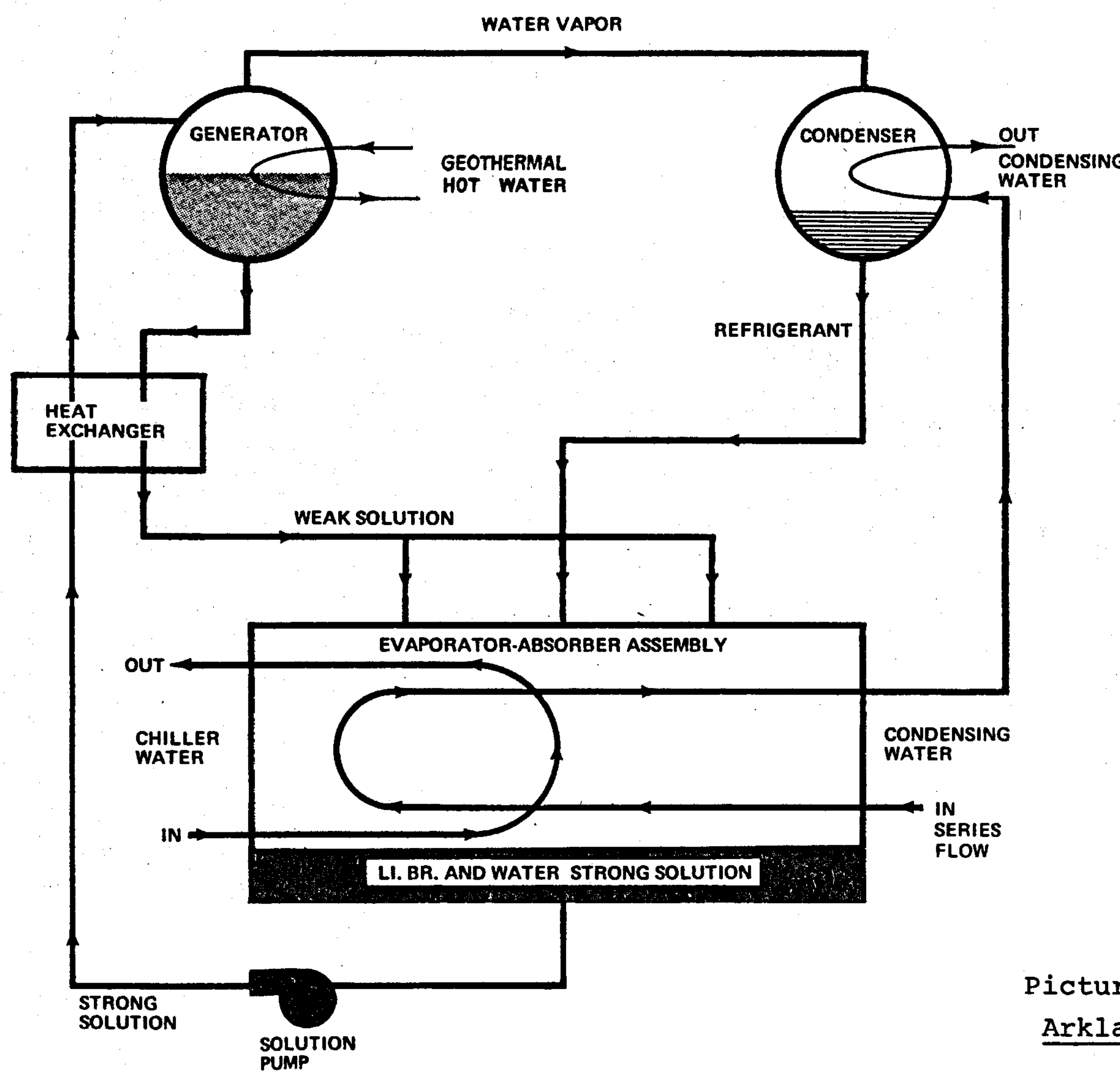
Figure 4-9.



Picture Credit:
Arkla Company

Figure 4-10. Schematic of Absorption Refrigeration

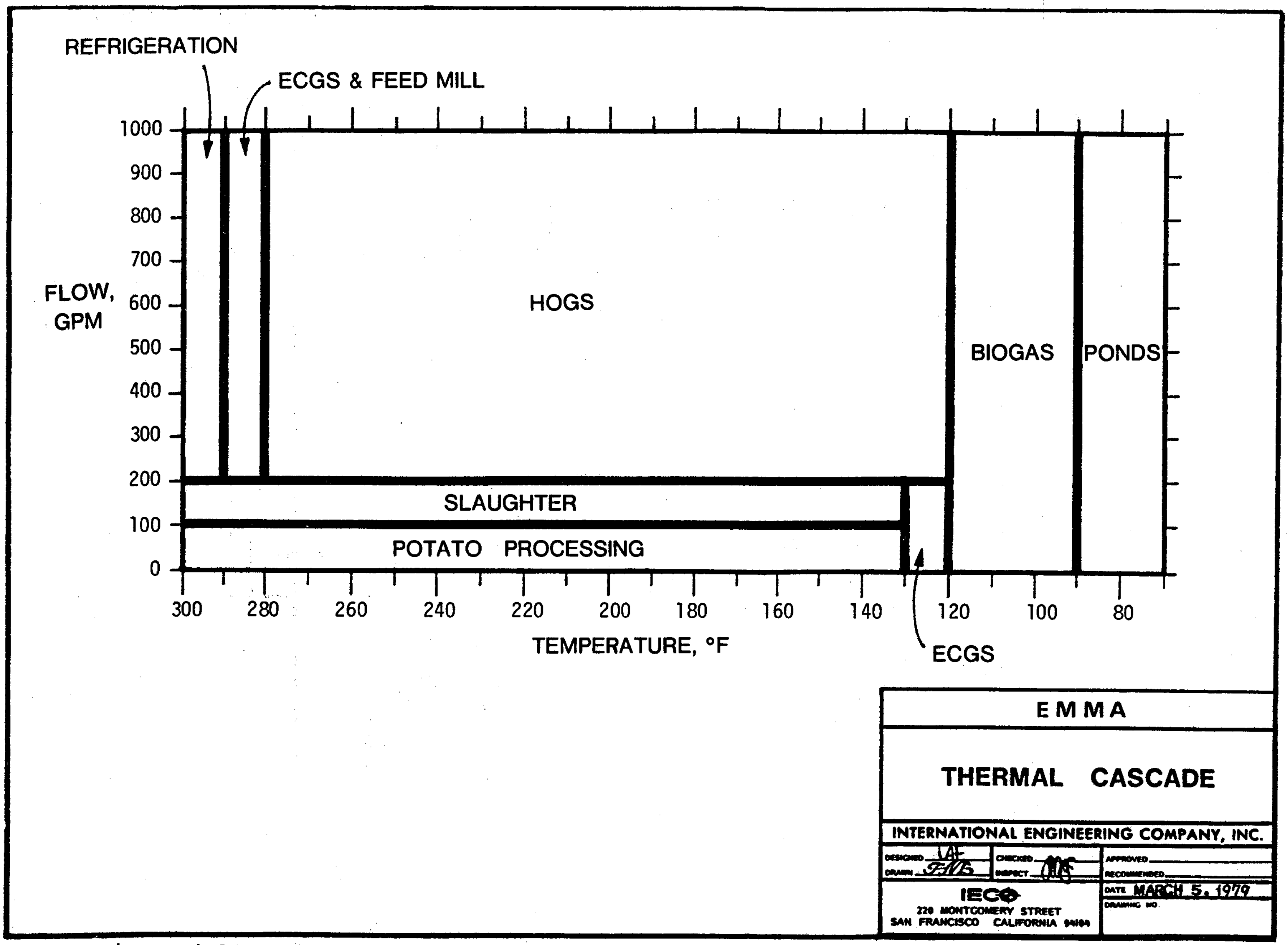


Figure 4-11. Thermal Cascade (Including Losses)

moderate cooling. Mechancial systems will be used to achieve the low freezing temperatures in the range of +10 to -10°F in the slaughter subsystem.

The slaughter processes themselves require 100 gpm of water over the temperature range of 300°F to 130°F. The highest temperature water is used for sterilization and cleanup operations while lower temperature water is used for carcass hair removal.

The potato operation cascades 100 gpm from 300°F down to 130°F through dehydration, blanching, cooking, precooking, and peeling.

Space and process conditioning for mill and ECGS utilizes 800 gpm dropping from 290°F to 280°F and 200 gpm from 130°F to 120°F. Hog raising space heating takes 800 gpm from 280°F to 120°F. Biogas operations cascade the entire flow of 1000 gpm from 120°F down to 90°F, and the ponds utilize the remaining heat.

The peak heat energy loads are summarized in Table 4-13.

TABLE 4-13
THERMAL SUMMARY--PEAK LOADS

Activity	Heat Used (Million Btu/Hr)
Absorption Refrigeration	4.0
Feed Production	5.0
Slaughter Processes	8.5
Potato Processes	8.5
Hog Raising	64.0
Biogas Generation	15.0
Water Treatment	10.0
Total	115.0

This is equivalent to 34 million watts-thermal total peak load.

The geothermal fluids are maintained at pressure sufficiently high to prevent flashing through the primary heat exchangers. The fresh water heat transfer fluid is also pressurized in a closed circuit to prevent flashing. This water is treated to prevent scaling and corrosion as required. Consumptive hot water for wash in slaughter and for the potato process is accomplished at the appropriate subsystem through heat exchange with the hot fresh water loop. The primary distribution of the geothermal fluid and geothermally heated primary loop is illustrated in Figures 4-12 and 4-13. Pipe sizing was generally based upon fluid velocities in the range of seven to ten feet per second.

3. Mass Flow Cascade and Principal Inputs/Outputs

Figure 4-14 depicts the mass flow cascade. Paced by the flow through the slaughter operation of sixty head per hour, mass flows are derived from the interface relationships and are numerically summarized in Table 4-14.

Figure 4-15 and 4-16 depict the material flows. The reader should note that the hogs move in confined channels that prohibit truck cross traffic for reasons of sanitation, health, and efficiency. All hog parlor feed storage areas are conveniently accessible by truck. Traffic in and out of the facility is kept at the periphery. Waste flows are underground and designed for maximum health, sanitation and disease control.

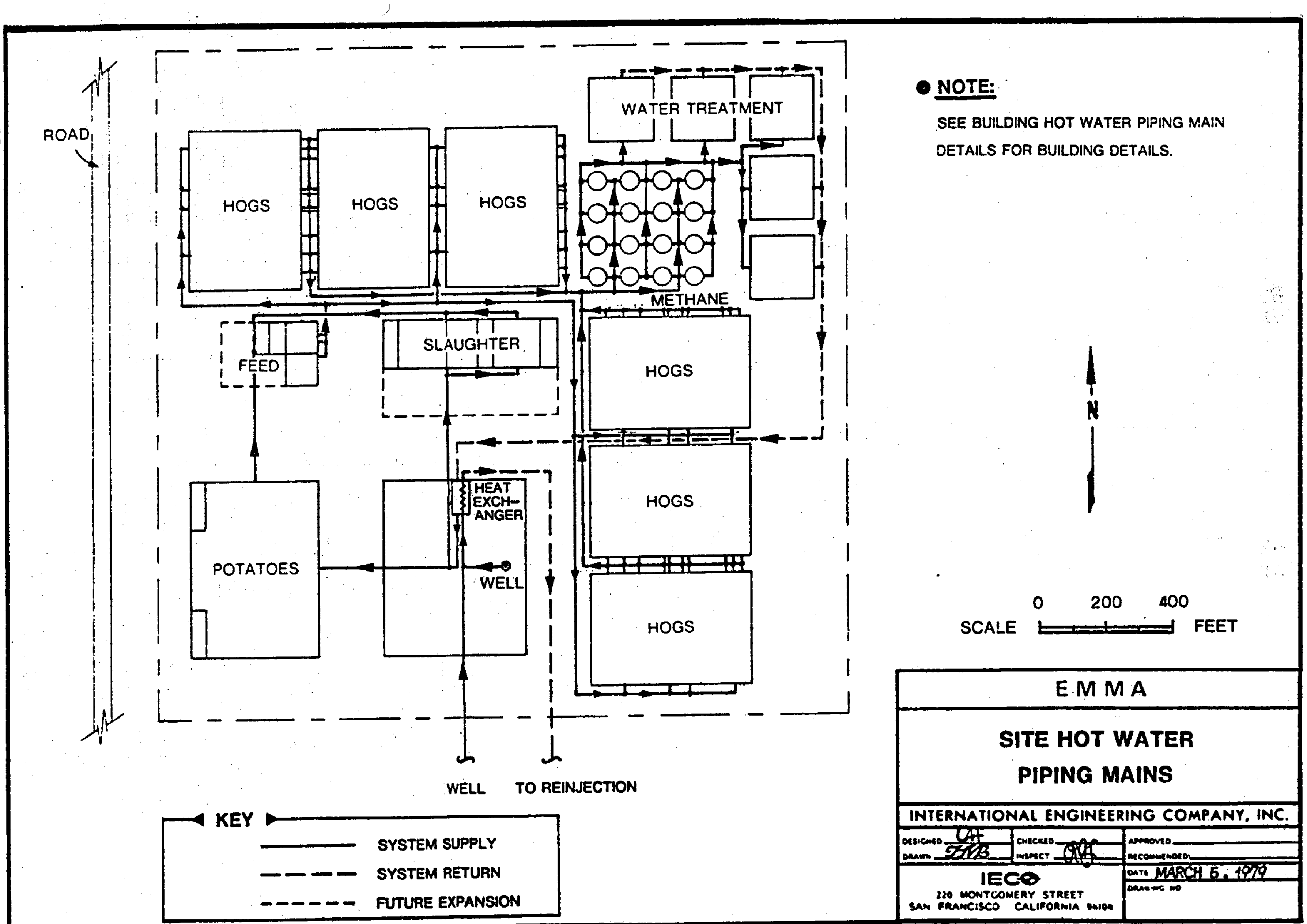
4. Engineering Cost Estimates

Cost estimates and their bases were prepared for the economic analyses. They are summarized in Table 4-15.

5. Energy Budget

It should be noted that of the approximately 1000 shaft horsepower resulting from the biogas process, about half the horsepower will suffice to drive the geothermal supply pumps and hot water circulating pumps; the remaining power can be utilized for subsystem requirements.

As indicated earlier, the system has a peak geothermal energy demand of 115 million Btu/hr, (34 MWt) and through cascading utilizes temperatures from 300°F down to 70°F. Required peak geothermal fluid flow is nominally 1000 gallons per minute. This energy is equivalent to an average annual consumption of over 4,500,000 gallons of oil.


ROAD
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POTATOES
HEAT EXCH-ANGER
WELL
WELL
TO REINJECTION
KEY
SYSTEM SUPPLY
SYSTEM RETURN
FUTURE EXPANSION
NOTE:
SEE BUILDING HOT WATER PIPING MAIN DETAILS FOR BUILDING DETAILS.
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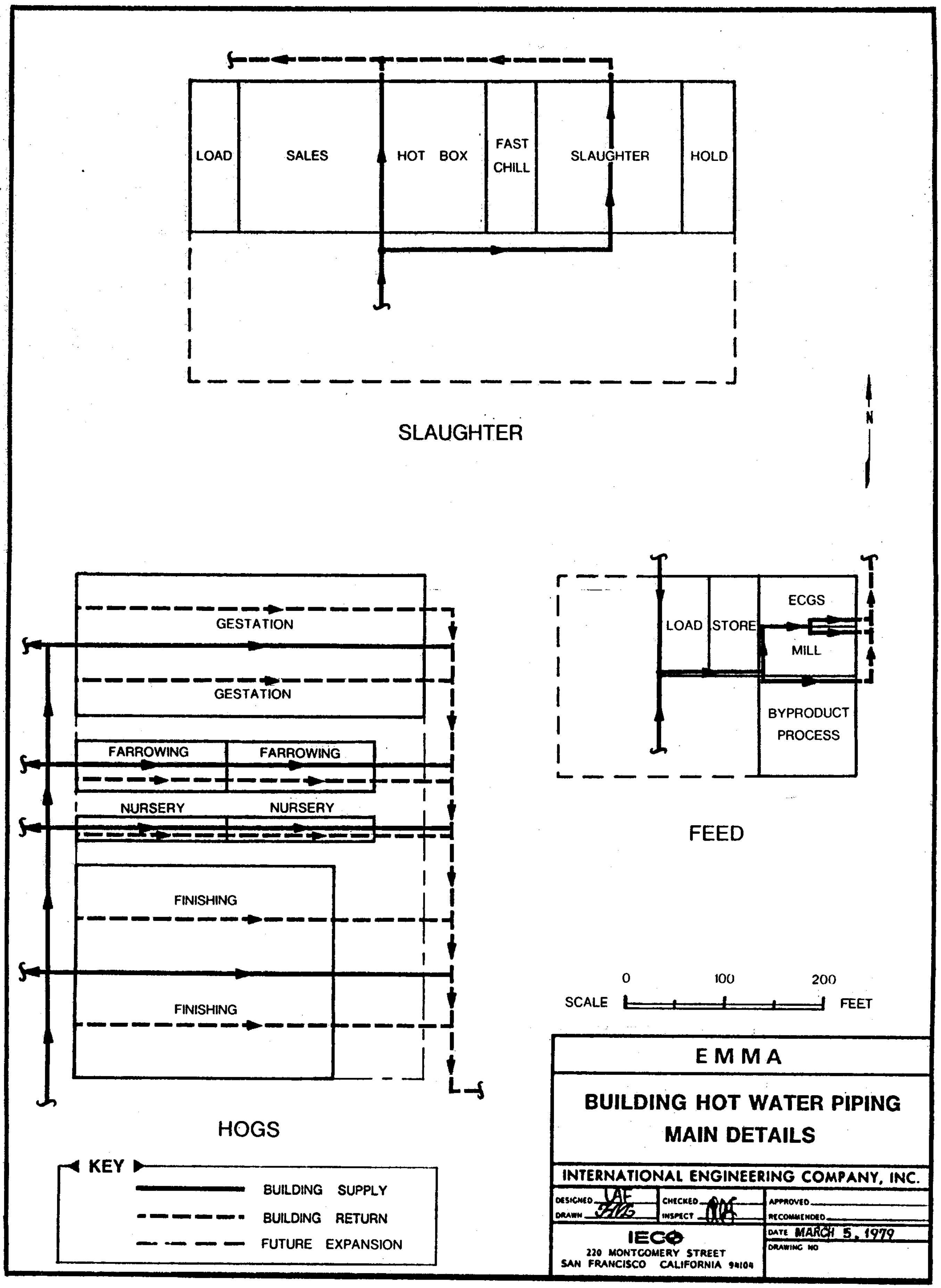
Figure 4-12.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FUTURE EXPANSION
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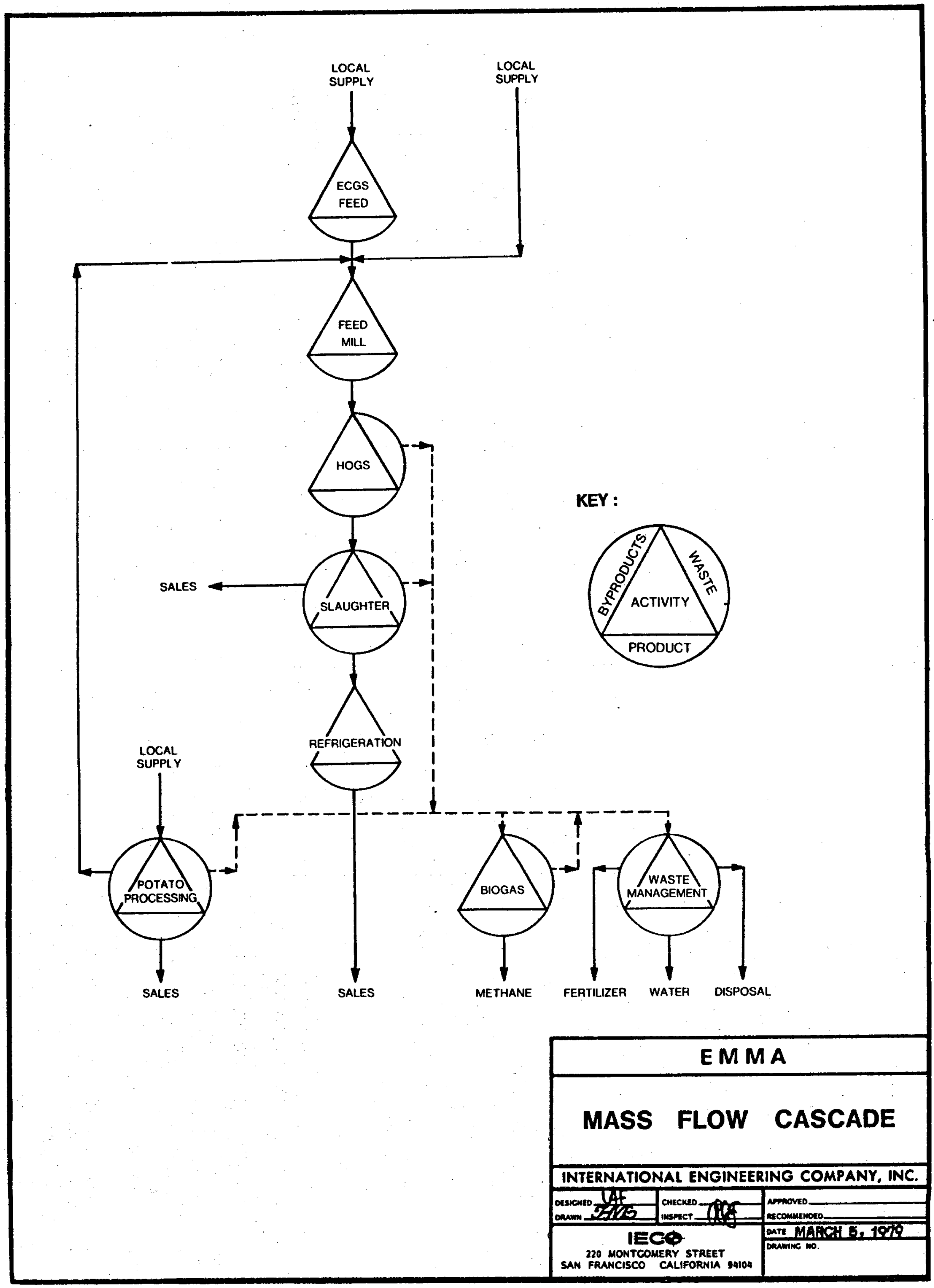
Figure 4-13.


LOCAL SUPPLY
LOCAL SUPPLY
ECGS FEED
FEED MILL
HOGS
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BYPRODUCTS
WASTE
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POTATO PROCESSING
BIOGAS
WASTE MANAGEMENT
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MASS FLOW CASCADE
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Figure 4-14.

TABLE 4-14
FACILITY PERFORMANCE PARAMETERS

FACILITY	UNITS	ECONOMIC MINIMUM 1/	DESIGN PEAK 2/	FACILITY MAXIMUM 3/
ECGS				
Barley Seed Purchased	Ton/Day 4/	N.A.	5.9	5.9
Barley Sprout Plants Harvested	Ton/Day 4/		41.25	41.25
MILL				
Purchased Supplies	Ton/Day 4/	N.A.	107.25	214
Total Output	Ton/Day 4/	N.A.	165	330
SWINE PARLORS				
Average Litter Size/Sow	Piglets/Litter	7.0 6/	9.25 7/	11.0
Average Litter Rate/Sow	Litters/Year	2.0 6/	2.25 7/	2.5
Slaughter Weight	Lbs/Hog	220	240	240 10/
Total Production	Hogs/Year	100,800	150,000	157,500
SLAUGHTER				
Process Rate	Hogs/Hr 5/	60	60	160 11/
Dressed Weight	Lbs/Hog	165	180	180
Total Production	Ton/Day	39.6	43.2	115.2
POTATO PROCESS				
Green Potato Purchase	Ton/Day 5/	N.A.	100	133
Byproducts For Feed Mill	Ton/Day	N.A.	16.5	22.0
Processed Potatoes Sold	Ton/Day	N.A.	66.7	88.7
WASTE MANAGEMENT AND METHANE				
Manure (Wet)	Ton/Day	N.A.	300	315
Potato Wastes	Ton/Day	N.A.	16.8	22.3
Water Effluent (Agri-Quality)	Gal/Min	N.A.	100	105
Methane	$10^3 ft^3$/Day 4/	N.A.	400 9/	420 9/
Fertilizer (Dry)	Ton/Day	N.A.	20	21
GEOTHERMAL FLUID				
Supply	Gal/Min	500 8/	1000	1000
Reinjection	Gal/Min	500 8/	1000	1500

FOOTNOTES TO TABLE 4-14:

N.A. Not Applicable.

1/ Economic minimum capacity of facility at base line design. This facility is large enough in size of all subsystems, except slaughter, so that all subsystems are at or above minimum economic size. Operation below level (when indicated) here will reduce overall economics to a point of concern.

2/ Design baseline for this study.

3/ Unless indicated otherwise, this rate is achieved by operating at two shifts and/or utilizing standby equipment (digesters, wells, etc.)

4/ 365 days/year.

5/ 250 days/year.

6/ Proper management should achieve thise rates in order to assure minimum economic operations of totally confined systems.

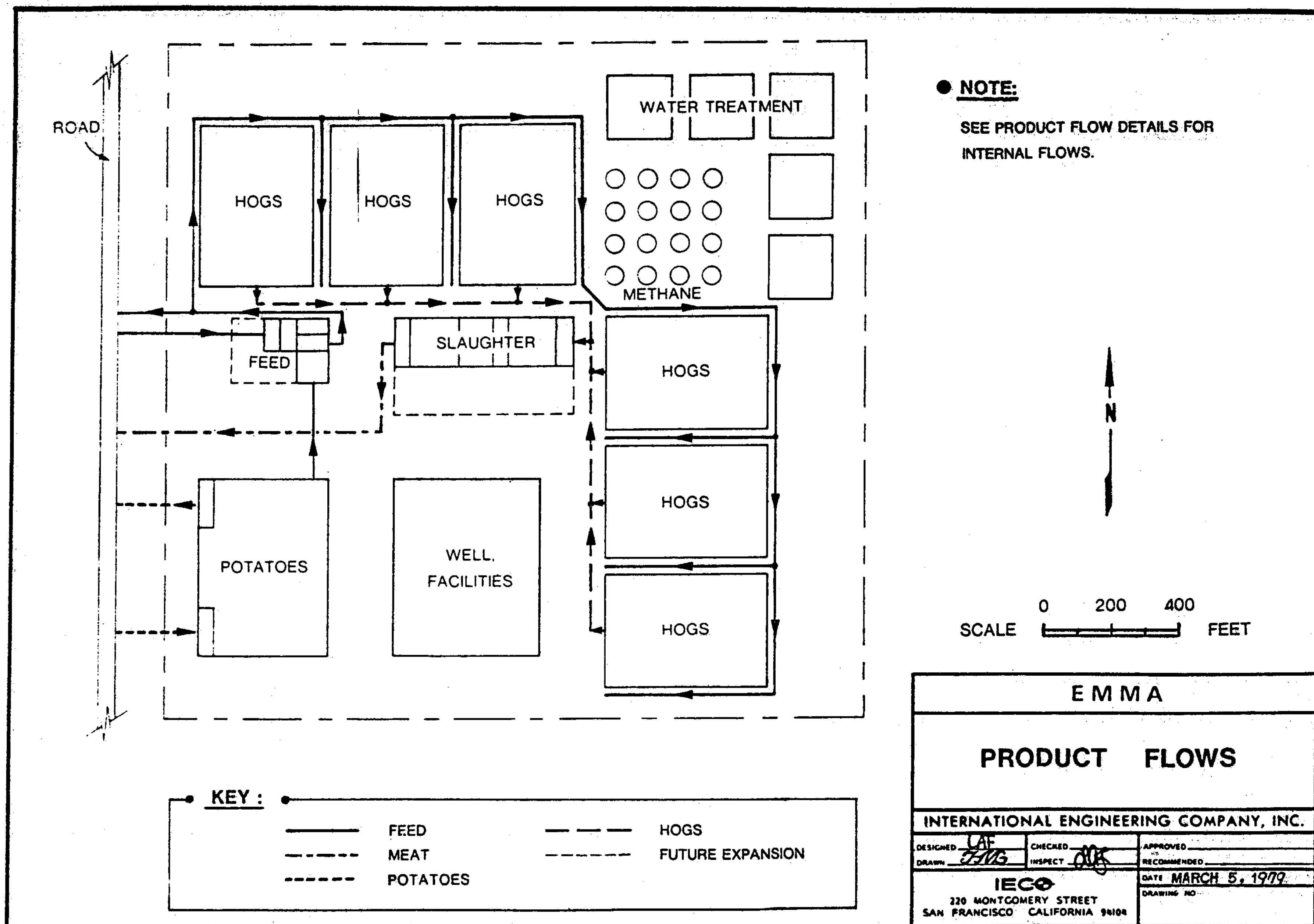
7/ Farmers using totally confined systems with qualified management are achieving 9 to 10 piglets per litter and 2.3 to 2.5 litters per sow per year on a national average.

8/ Average flow is nominally half of peak flow.

9/ Methane yield is a strong function of carbon:nitrogen ratio, actual ingredients and operating conditions.

10/ Feed efficiencies and market acceptance are peaked at 240 pounds per pig.

11/ Would require expansion of animal supply.


ROAD
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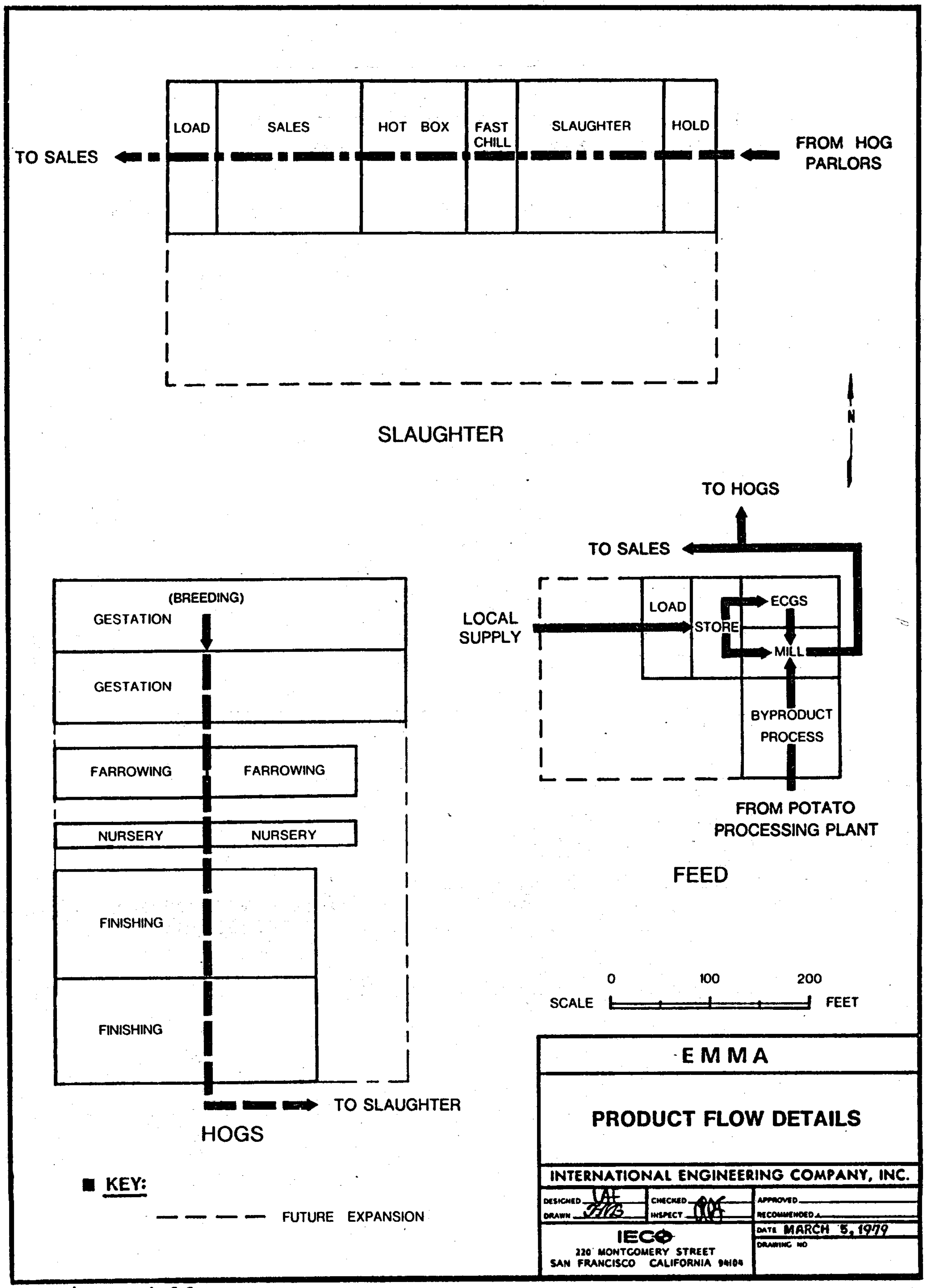
WATER TREATMENT
METHANE
FEED
SLAUGHTER
HOGS
HOGS
HOGS
POTATOES
WELL, FACILITIES
NOTE:
SEE PRODUCT FLOW DETAILS FOR INTERNAL FLOWS.
N
SCALE 0 200 400 FEET
KEY:
FEED
MEAT
POTATOES
HOGS
FUTURE EXPANSION
EMMA
PRODUCT FLOWS
INTERNATIONAL ENGINEERING COMPANY, INC.
DESIGNED
DRAWN
CHECKED
INSPECT
APPROVED
RECOMMENDED
DATE MARCH 5, 1979
DRAWING NO
IECO
220 MONTGOMERY STREET
SAN FRANCISCO CALIFORNIA 94104

Figure 4-15.



LOAD
SALES
HOT BOX
FAST CHILL
SLAUGHTER
HOLD
TO SALES
FROM HOG PARLORS
SLAUGHTER
N
TO HOGS
TO SALES
LOCAL SUPPLY
LOAD
STORE
EGGS
MILL
BYPRODUCT PROCESS
FROM POTATO PROCESSING PLANT
FEED
(BREEDING)
GESTATION
GESTATION
FARROWING
FARROWING
NURSERY
NURSERY
FINISHING
FINISHING
TO SLAUGHTER
HOGS
KEY:
FUTURE EXPANSION
SCALE
0
100
200
FEET
EMMA
PRODUCT FLOW DETAILS
INTERNATIONAL ENGINEERING COMPANY, INC.
DESIGNED
DRAWN
CHECKED
INSPECT
APPROVED
RECOMMENDED
DATE MARCH 5, 1979
DRAWING NO
IECO
220 MONTGOMERY STREET
SAN FRANCISCO CALIFORNIA 94104

Figure 4-16.

TABLE 4-15
ENGINEERING ESTIMATES AND BASES FOR CAPITAL COSTS

Item	Quantity	Basis		Total $1,000
Site Work	1	6.3% of $27,000,000	1,2/	1,700
Fresh Water Supply	1		3/	600
and Septic Sewage	1		3/	600
Geothermal				
Rework Bostic 1-A	1		4/	150
Standby Well	1		4/	600
Reinjection Well	1		4/	400
Equipment	5/		3/	300
Swine Buildings	689,100 Ft²	$14.66/Ft²	1,3/	10,100
Swine Equipment	Lump Sum		6/	4,200
ECGS	Lump Sum		6/	1,700
Mill	Lump Sum		6/	1,150
Potato Process	Lump Sum		7/	2,000
Slaughter	Lump Sum		8/	3,000
Methane Digester	16	$100,000 ea		1,600
Methane Equipment	Lump Sum		3/	400
Utilities	Lump Sum		1/	800
Contingency	1	20%		5,740
TOTAL				$34,440

FOOTNOTES:

1/ Means Cost Data, 1978
2/ Subtotal of capital costs less site work
3/ Engineering Estimate
4/ Geoscientific Estimate, Task 1.0
5/ Two pumps @ $40,000 ea; Four Heat exchangers @ $20,000 ea; One and 3/4 miles of A/C pipe, insulated, @ $80,000/mi.
6/ Manufacturer's Quote
7/ Interpolation of OIT study
8/ Scaled from existing commercial facility

CHAPTER 5 - ECONOMICS

Using documented or reported data sources, a general economic appraisal of the site dependent livestock alternatives was performed with emphasis on the future economic potential of the selected local livestock industry, the potential marketing of by-products from the system and economics of geothermal versus other energy sources. The final effort covered an appraisal of the assumptions and techniques used in developing projections of revenues, construction capital, operating costs and resulting cash flows which were merged for estimating payback, internal rate of return and present value.

A. LIVESTOCK ALTERNATIVES

Cattle, swine, sheep and small animals were the four livestock alternatives considered as core systems for the Mountain Home site. Contacts with regional and local U.S. Department of Agriculture (USDA) and Extension Service offices and inputs from varied private and government interests in Idaho and neighboring states led to a preference for a swine-oriented project. Summaries of key findings and considerations for each livestock system candidate are presented below.

1. Cattle System

Although a cattle core system would provide a substantial long term opportunity on a national level, local slaughter excess capacity and the recent entry of Iowa beef and U.S. Justice Department interests into the area would likely jeopardize the success of a new cattle venture.[66-68] A new cattle production facility would be likely to fail or succeed as a function of exogenous factors well outside the geothermally based, integrated livestock system factors of interest to this project. However, selected cattle-related activities appear to be ideal subsystem candidates.

2. Swine System

As with the cattle option, a swine core system would provide long term opportunity but with fewer local disadvantages. Swine parlor technology is adequately developed to support a closed environment system and hog breeds suitable to parlor operations are available.[37] Additionally, energy requirements for a swine operation present a full range of applications for maximizing anticipated geothermal advantages. USDA statistics indicate that Idaho, Nevada, Oregon and Washington collectively import approximately 500,000 swine per year and that California imports just over 1.3 million head per year.[69-72] Presently, this significant demand is being filled primarily by imports from the Midwest.[69-72] Approximately 20,000 head per year are transshipped through Idaho; of this, about half are sold to local packing operations. A swine core system would thus be competing against distant producers for a fairly large local market.

3. Sheep System

A less stable but significant western market exists for sheep and lambs; California imports over half a million head per year.[69,72] However, a breed of sheep which is conducive to completely confined parlor systems is not available and integrated system operations technology for sheep is still evolving. To use sheep as the core system could introduce high levels of uncertainty in agriculture technology which could easily overshadow the factors of concern in this study.

4. Small Animal Systems

In general, small animal livestock markets are less stable than is deemed desirable as a core system for this project. USDA statistics reflect that total chickens in Idaho increased 7.8% from 1974 to 1975 and dropped 5.9% from 1975 to 1976. National changes were in the reverse directions for the same periods, -1.2% and +0.2% respectively. There has also been a gradual decline of U.S. produced chickens over the last few years.[72]

There are several proven small animal systems available of which poultry is the most highly developed. Rabbit and mink production systems and breeds are also developed to an acceptable level; however, available documentation is for small scale production operations. While appropriate for subsystem operations, the small animal option does not appear to be acceptable as a core system for the project.

B. THE SWINE MARKET

Swine production has not changed significantly from 20,000,000,000 liveweight pounds per year over the last decade. However, the national gross income value of slaughtered hogs has risen from four billion dollars to eight billion dollars[72,73] and the number of producers has dropped from above 1,000,000 to below 700,000 and will likely drop to 300,000 producers by 1985.[74]

In general, animal agriculture over the next decade will be operating in an increasingly complex and competitive market place.[74]

- Non-agricultural people are increasingly formulating agricultural policy.

- Future policy will place an even stronger emphasis on securing abundant and diversified products for consumers at reasonable prices.

- There will be growing public concern about the beneficial and potentially harmful effects of agricultural products (this concern may be one of agriculture's greatest challenges in the decade ahead); beneficial and harmful effects will be related to total environment and all human senses and physiology.

- Increasing specialization and efficiency of crop and livestock operations will be sought to remain competitive for consumer markets and investor capital.

- Small scale agricultural operations will continue to give way to large operations; the 2% of total farms which now provide 36% of farm sales is the fastest growing segment of the farm economy.[74,75]

- Agricultural operations, especially intensive energy users, must adjust to increasing costs; labor, materials and produce prices which will continue to rise at about 8% per year,[74,76] but key feed and energy resources may climb at double that rate.

In addition to the general animal agriculture market pressures noted above, the swine producing industry will continue to face feed sensitive profits, swine disease risks, the hog cycle phenomenon and dramatic reduction in numbers of small-scale operations. Since 1965, there has been over a one-third drop in hog producer numbers and the current numbers of hog producers is expected to be halved by 1985.[74] Along with an increasing role of larger scale operations is a growing use of confinement systems. Presently, better than three fourths of U.S. sow herds and better than one-half of the finishing stock are involved in some type of confinement system.[74, 77] Within the next decade it is expected that 80% of finished marketed hogs will come from large scale confined system operations.[77] This approximately 25% increase could involve four billion liveweight pounds per year of hogs.

Stated in very simple and general terms, the hog cycle phenomenon noted above refers to the following cycle of events:

- Hog prices are high due to shortages.

- If reasonably priced feed is available, opportunists enter swine production with little capital and inefficient operations.

- Opportunists dump high numbers of hogs on the market.

- Prices drop due to abundant supply.

- Opportunists drop out of production due to reduced profit and disease pressures.

- Cycle starts again when hog shortages occur and feed is available.

The feed sensitive profits are a fundamental economic reality of a critical resource (pounds of feed) required for conversion to marketable output (pounds of pork). The labor, land and capital inputs are significant resources but they are relatively predictable costs and none are as significant or as volatile as feed costs. Profitable hog production demands minimized feed cost and maximized feed conversion to marketable meat pounds.

Swine diseases, environmental concerns, and production quality problems and hazards are discussed elsewhere in this report.

C. ECONOMIC OBJECTIVES

Our economic objective in this MHGP investigation has been to assess the selected system's profitability and, within the assigned level of effort, to optimize the profitability through integration of commercially available technology.

For enhanced hog production profitability, this meant that at a minimum we sought to:

- provide adequate low cost, sufficiently high quality feed;
- maximize feed-to-hog conversion for greater profits;
- minimize handling, processing and shipping of input resources, work-in-process, and output products;
- minimize waste disposal costs through beneficial recycling integration, conversion and byproduct sales;
- minimize disease risk;
- verify existing technology;
- price out subsystem alternatives;
- assess the existence of a near and future market, and;
- quantify our findings into overall operational and cash flow projections.

All items above, except the last two, are discussed in detail in other sections of this report. The existence of a near and future market has been indicated earlier in this section but needs to be directly related to the MHGP operation.

It has been pointed out that the western market demand of more than 1-1/2 million hogs per year is being met by inshipments from midwestern states. The MHGP would produce 150,000 hogs per year or approximately 10% of the current regional demand level. A 10% inroad on the inshipments is a reasonable objective if MHGP production is competitive in price. If the West Coast demand should climb 10%, MHGP could satisfy the new demand without directly impacting inshipment competitors.

It has also been pointed out that over the next decade, approximately four billion liveweight pounds per year of hog production will move to large scale confinement production facilities. As MHGP will produce less than forty million pounds per year, it will seek to be less than 0.2% (.002) of the target operational market, certainly a reasonable objective.

With market and operational posture targets within reason, the basic concerns focus on technological practicality, competitive production, and financial feasibility.

Technological practicality is discussed in the Resource, Engineering, Environmental and Institutional sections of this report. Competitive production and financial feasibility are discussed in following sections which cover the implementation schedule, cash flow projection and investment review.

D. IMPLEMENTATION SCHEDULES

The implementation schedules developed for the MHGP study assume that the project owners can secure full financing from the start, i.e., financing is not a constraint on implementation schedules. The key constraints to implementation schedules are engineering preparation, construction duration, logical sequencing of operational system startups, and minimum-maximum system loading factors.

1. Facility Capital Requirements

Table 5-1 lists the estimated requirements for capital and presents the proposed facility construction schedule in funds required per quarter year to completion. The total capital required is estimated to be $35.5 million dollars expressed in 1/1/78 values.

Refering to Table 5-1, construction has been scheduled over a nine quarter period starting in the first quarter with initial site excavation, geothermal resource development and engineering for the hog parlors and anaerobic digesters. Construction of the hog parlors, feed mill plant, digesters and utility building is begun in the second quarter. The potato processing and slaughter plants are begun in the fourth and seventh quarters respectively. Most systems are engineered and constructed in three or less quarters except the hog parlors and anaerobic digesters which are constructed simultaneously and take seven months to engineer and construct.

2. Operations Startup

Tables 5-2, 5-3 and 5-4 present the fundamental operations startup schedule covering management, personnel, labor, herd buildings, and feed processing startup. The first sows are scheduled to be on site during the third quarter

TABLE 5-1
FACILITY CONSTRUCTION AND OPERATIONS STARTUP SCHEDULE

DESCRIPTION	(1/1/78 dollars) Line Total	FIRST YEAR 1	2	3	4	SECOND YEAR 1	2	3	4	THIRD YEAR 1	2	3	4
FACILITIES:													
Site work & Land (including ponds but not irrigation fields)	1700	300	200	200	200	200	200	200	200				
Fresh water wells & septic tank systems	600	100	200	100		100		100					
Central Support Facilities:													
Well Rework	150	150											
Standby Well	600		600										
Re-injection Well	400	400											
Wellhead Equip. & Mains	300	100	200										
Maintenance-Utility Bldg. & Equipment	800		300	300		100		100					
Hog Parlors:													
No. 1	4085	1021	1021	2043									
2	2043				1532	511							
3	2043				511	1532							
4	2043					1021	1022						
5	2043						1532	511					
6	2043						511	1532					
Feed Facilities:													
Mill	1150		500	650									
E.C.G.S.	1700		700	1000									
Potato Processing	2000				800	600	600						
Waste Management:													
Digester No. 1	800	500	200	100									
2	400			100	100	200							
3	400					200	200						
4	400						200	200					
Slaughter Plant	3000							1000	1000	1000			
	28699	2571	3921	4493	3143	4464	4264	3643	1200	1000			
Contingency (20% of above total)	5740	514	784	899	629	893	853	729	240	200			
Construction Management Fee (3% of all above)	1033	93	141	162	113	161	154	131	43	36			
	35472	3178	4846	5553	3885	5518	5270	4503	1483	1236			

FOOTNOTES to Table 5-1

a. 1/1/78 dollars are used throughout the exhibits. Depending upon when actual design and construction might be proposed, escalation (inflation) should be applied to all dollar amounts. Applying escalation will shorten the payback slightly and have a negligible favorable effect on the internal rate of return (all costs and revenues will increase except depreciation allowance, interest expense, and principal payments). Consideration should be given to using higher inflation factors for feed and external energy requirements.

b. During detailed design, individually determined equivalent contingencies would be allocated to each capital building and equipment estimate.

c. Hog parlors were stocked per a universal 6 month stocking, breeding and growth cycle. Detailed design would likely refine this to a 5 month cycle and would provide a quicker startup phase with more favorable startup cash flows. The parlors were also only loaded to 1200 sows; refined operations could reduce livestock production variances and increase parlor utilization and throughout by 5%.

TABLE 5-2
LIVESTOCK OPERATIONS STARTUP SCHEDULE

DESCRIPTION	Line Total	FIRST YEAR 1	FIRST YEAR 2	FIRST YEAR 3	FIRST YEAR 4	SECOND YEAR 1	SECOND YEAR 2	SECOND YEAR 3	SECOND YEAR 4	THIRD YEAR 1	THIRD YEAR 2	THIRD YEAR 3	THIRD YEAR 4
STOCK:													
Gilts selected for stock							1000	1500	1400	400			
Sows on hand at end of period				400	1000	2000	3600	5400	6800	7200			
Sows added during period				400	600	1000	1600	1800	1400	400			
Weanling pigs (12 wk) on feed						6000	10000	16000	30000	38000	44000	44000	42000
Shotes (22 wk) on feed						2000	6000	12000	20000	34000	42000	42000	44000
Hogs available for market & stock							4000	6000	16000	26000	34000	44000	42000
Hogs marketed live							3000	4500	14600	15600			
Hogs slaughtered for market										10000	34000	39600	39600

TABLE 5-3
STAFFING OPERATIONS STARTUP SCHEDULE

DESCRIPTION	Line Total	FIRST YEAR 1	FIRST YEAR 2	FIRST YEAR 3	FIRST YEAR 4	SECOND YEAR 1	SECOND YEAR 2	SECOND YEAR 3	SECOND YEAR 4	THIRD YEAR 1	THIRD YEAR 2	THIRD YEAR 3	THIRD YEAR 4
STAFFING:													
FTE @ $35,000, $42,000 W/OH		1											
$30,000, $36,000 W/OH		1											
$20,000, $24,000 W/OH		1		1			1						
$15,000, $18,000 W/OH		1											
$12,000, $14,400 W/OH		1					1						
$ 9/hr., $18,720 W/OH		5	1	5	4	3	5	5	20				
$ 6/hr., $12,480 W/OH		1	4	9	12	13	9						
$ 5/hr., $10,400 W/OH		2	3	2									

TABLE 5-4
FEED PRODUCTION OPERATIONS STARTUP SCHEDULE

DESCRIPTION	Line Total	FIRST YEAR 1	FIRST YEAR 2	FIRST YEAR 3	FIRST YEAR 4	SECOND YEAR 1	SECOND YEAR 2	SECOND YEAR 3	SECOND YEAR 4	THIRD YEAR 1	THIRD YEAR 2	THIRD YEAR 3	THIRD YEAR 4
FEED:													
Tons of feed consumed/day				1	3	15	30	55	90	130	150	165	165
Tons of feed produced/day				50	100	150	165	165	165	165	165	165	165
Tons of potato substitute purchased/day				5	10	15							
Tons of mill supplement purchased/day				33	65	98	107	107	107	107	107	107	107
Tons of sprout seed purchased/day				2	4	5	6	6	6	6	6	6	6
Tons of raw potato processed/day							100	100	100	100	100	100	100
Tons of processed potatoes sold/day							16	17	17	17	17	17	17
Tons of milled feed sold/day				49	97	135	135	110	75	30	15		

and would occupy the nearly completed first hog parlor (Table 5-2). The full complement of sows would be installed by the ninth quarter. The management and labor personnel (Table 5-3) and the feed material processing (Table 5-4) were scheduled (added) according to the herd building and facility construction schedules.

E. FINANCIAL PROJECTIONS

Financial projections required a number of operational and financial assumptions which are presented in conjunction with the projections, subsequent calculations and analyses. This subsection is divided into (1) Financial Projection Through Year Five, (2) Financial Projection For Years 6-30, and (3) Financial Assessment.

1. Financial Projection Through Year Five

Using the assumed facility construction and operations startup schedules presented in Tables 5-1 through 5-4, Table 5-5 was developed to estimate owner cash flow projections for the first five years. The footnotes to Table 5-5 itemize the many assumptions required to develop the cash flows and the numbers in Table 5-5 are only financial conjectures based upon the footnoted assumptions. However, the assumptions are founded upon the MHGP team's investigations of comparable commercial operations, published literature, personal contacts and third-party unpublished documents.

As Table 5-5 shows, the heavy cash outflows are projected to be over by the end of the second year. Third year inflows are boosted by tax loss carry forward and an investment tax credit allowance yielding an estimated owner cash payback period of 3.15 years as calculated at the bottom of Table 5-5. By the end of the fifth year of the projection, net owner cash inflow after business tax (but before personal tax) is estimated to be slightly over ten million dollars.

2. Financial Projection For Years 6-30

Continuing the format of Table 5-5, "Financial Projection Through Year Five", Table 5-6 was developed, "Financial Projection For Years 6-30." Again, the footnotes to Table 5-5 itemize the many assumptions required to extrapolate the cash flow estimates to the end of the thirtieth year. The financial conjectures of Table 5-6 are generally based on extensions of Table 5-5's assumptions with added assumptions about equipment replacement and terminal value.

The last loan payback payment is shown to occur at the end of year twelve. However, the expected jump in owner cash inflow does not materialize until the fourteenth year because an allowance was made in the thirteenth year for

TABLE 5-5
FINANCIAL PROJECTIONS THROUGH YEAR FIVE

Years	FIRST					SECOND					THIRD	FOURTH	FIFTH
Quarters	1	2	3	4	T	1	2	3	4	T			
(a) Revenue			132	786	918	1093	2404	2448	3427	9372	23174	23174	23174
(b) Feed Materials			70	411	481	603	1170	1170	1170	4113	4287	4287	4287
(c) Utilities & Maintenance	50	100	150	200	500	250	300	400	500	1450	1774	1774	1774
(d) Direct Labor		32	57	113	202	170	224	276	299	969	1508	1508	1508
(e) Salaries & Office O/H	41	41	48	48	178	48	59	59	59	225	236	236	236
(f) Livestock Replacement													540
(g) Depreciation						511	511	511	511	2044	2044	2044	2044
(h) Interest									3335	3335	2927	2754	2561
Taxable Income					(443)					(2764)	(7191)	10571	10224
Tax @ 48%											(3452)	5074	4908
(i) Tax Credit					873					901	(1774)		
Tax											1678		
Earnings After Tax					(443)					(2764)	5513	5497	5316
Add Depreciation						511	511	511	511	2044	2044	2044	2044
(j) Less Principal Payment											1573	1746	1939
Less Capital Share	795	1212	1388	971	4366	1380	1318	1126	680	4504			
(k) Cash to owner	(886)	(1385)	(1581)	(957)	(4809)	(1358)	(667)	(583)	(2661)	(5224)	9191	5795*	5421
Cum owner cash	(886)	(2271)	(3852)	(4809)		(6167)	(6834)	(7417)	(10078)		(887)	*4908	10329
(j) Capital Outlay	3178	4846	5553	3885		5518	5270	4503	2719				
25% Owner	795	1212	1388	971		1380	1318	1126	680				
75% Debt	2384	3635	4165	2914		4139	3953	3377	2039				
Cum debt	2384	6019	10184	13098		17237	21190	24567	26606				

*Payback Calculation: $3 + \frac{887}{5795} = 3.15$ yrs.

FOOTNOTES to Table 5-5

a. • Live 240 lb. hogs @ $.52/lb.
The live weight at slaughter of 240 lbs is based upon U.S. averages for hogs per USDA data.[71] The sales price of $.52/lb is based upon mathematical trend lines of USDA data as follows:

  - Mathematic trend lines from 1972 to 1977 extended to 1979 for California statistics projects sales price in 1979 at $52.76/cwt.[69]

  - Mathematic trend lines from 1972 to 1977 extended to 1979 for Idaho statistics projects sales prices in 1979 at $49.61/cw.[70]

  - Mathematic trend lines from 1971 to 1976 extended to 1979 for U.S. national statistics projects sales price in 1979 at $61.40/cwt.

• Slaughtered 240 lb. hogs dressed to 180 lbs. @ 76.44-/lcwt.

• Human consumption potato sales @ $650.00/tn.

• Surplus feed sales @ $90.00/tn

b. • Potato waste substitute (pre-potato plant operations) @ $56.00/tn.

• Feed Mill Supplement @ $50.00/tn.

• Barley sprout seed @ $152.40/tn + $39.60/tn supplies.

• Raw potatoes @ $65.00/tn.

c. Builds to 5% of capital to provide maintenance crews, supplies, modifications, minor replacements and repairs, basic property tax and external utilities for operations.

d. Cost with overhead applied to wage earners on hand per Table 5-3 schedule.

e. Salaried people with overhead plus an additional 20% office overhead.

f. Sows are replaced each 3 years per IRS guideline. Allowance is for foregone market revenue, added veterinary processing and testing, special handling of old and new sow, less allowance for sale of replaced sow. Net allowance is $225 per sow and 2400 sows per year.

FOOTNOTES to Table 5-5 (continued)

g. General assumptions for initial depreciation and investment tax credit allowance:

	Total	Buildings and Non-Equipment	Specialty Items and Equipment	Investment Tax Credit Estimate
Site Work & Land	1700	1700	-	-
Fresh Water Wells & Septic Tanks	600	600	-	-
Well Rework	150	-	150	15
Standby Well	600	-	600	60
Re-injection Well	400	-	400	40
Well Head Equip & Utility-Maintenance Support	300	-	300	30
	800	400	400	40
Hog Parlors	14300	10100	4200	941
Feed Mill	1150	767	383	38
ECGS	1700	1133	567	57
Potato Plant	2000	1333	667	67
Digester-Waste Systems	2000	500	1500	150
Slaughter Plant	3000	2000	1000	100
Contingency	5740	3740	2000	200
Construction Mgmt	1033	670	363	36
	35473	22943	12530	1774
Life	-	29 years	10 years	-
Annual Depreciation	2044	791	1253	-

h. Schedule used for interest and principal:

YR NO	Begin Balance	Interest 11%/YR on Begin Bal	Principal Reduction
3	26606	2927	1573
4	25033	2754	1746
5	23286	2561	1939
6	21348	2348	2152
7	19196	2112	2388
8	16808	1849	2651
9	14156	1557	2943
10	11214	1233	3267
11	7947	874	3626
12*	4321	475	4321*

*Final Payment is $4,796.

FOOTNOTES to Table 5-5 (continued)

i. Cash to owner is Earnings After Tax adjusted for depreciation (a non-cash expense), principal payments (a non-earnings outflow), and owner's share of capital outlay (a non-earnings outflow).

j. For the purposes of this projection, it was assumed that the owner would put up 25% of capital outlays and all operating expenses during startup. In actuality, the owner should be able to include much of the startup operating expenses within the loan calculation and reduce startup owner cash requirements. Depending upon the owner's loan negotiating posture, lenders may also provide more than 75% of required funds.

k.	Taxable income	=	$10,398
	Loss carry forward	=	(3,207)
	Effective taxable income	=	$ 7,191
l.	Tax @ 48%	=	$ 3,452
	Tax Credit carry forward	=	1,774
	Tax paid	=	$ 1,678
m.	Taxable income	=	$10,398
	Less Tax paid	=	(1,678)
	Add depreciation	=	2,044
	Less Principal Payment	=	(1,573)
	Cash to owner	=	$ 9,191

n. Non-cash impact.

TABLE 5-6
FINANCIAL PROJECTION FOR YEARS SIX THROUGH THIRTY

YEARS	6	7	8	9	10	11	12	13	14-16	17, 19-22, 24-27, 29-30	18,23 28	(d) Terminal Value
Revenue	23174											
Feed Materials	4287											
Utilities & Maintenance	1774											
Direct Labor	1508											
Salaries & Office O/H	236											
Livestock Replacement	540											
Depreciation	2044						791	1209	1209	1627	1627	
Interest	2348	2112	1849	1557	1233	874	475					
Taxable Income	10437	10673	10936	11228	11552	11911	13563	13620	13620	13202	13202	
(a) Tax @ 48%	5010	5123	5249	5389	5545	5717	6510	6538	6538	6337	6337	
EAT	5427	5550	5687	5839	6007	6194	7053	7082	7082	6865	6865	
Add Depreciation (b)	2044	2044	2044	2044	2044	2044	791	1209	1209	1627	1627	
Less Principal Payment	2152	2388	2651	2943	3267	3626	4321					
Less Capital Share (c)								4180			4180	
Cash to Owner	5319	5206	5080	4940	4784	4612	3523	4111	8291	8492	4312	1500

FOOTNOTES to Table 5-6

NOTE: Footnotes a. through i. of Table 5-5 also apply to Table 5-6.

a. Investment Tax credit may be discontinued in the near future. If it is not, livestock replacement and other investments could provide an additional tax credit.

b. Depreciation Schedule (Linear) (Also review footnote g of Table 5-2):

Inclusive Years	Bldg(1)	Equip	Total
1	0	0	0
2 - 11	791	1253(2)	2044
12	791	0	791
13 - 16	791	418(3)	1209
17 - 30	791	836(4)	1627

(1) Bldg: $22,943 ÷ 29 years = $ 791
(2) Eq: $12,530 ÷ 10 years = $1,253
(3) Eq: 4,180 ÷ 10 years = $ 418
(4) Eq: $8,360 ÷ 10 years = $ 836

c. 1/3 of equipment replaced in years 12, 18, 23, 28 to allow for special refabrication-replacements and geothermal equipment-wells modification-rework-enhancement, no loans used, only internal cash.
$12,530 ÷ 3 = $4,180

d. For financial analyses, a 30 year life was chosen to allow development of a reasonable projection of future cash flows without exceeding a reasonable life expectancy for the buildings and geothermal resource. In actuality, the buildings and geothermal resource should remain productive for more than 30 years and improved technology should not only extend the project's life but may also allow advantageous modifications and changes during the 30 year period being projected.

major equipment overhaul-replacement and geothermal rework expenditures. The same allowance is also made in years 18, 23 and 28. In determining the internal rate of return, a terminal value of $1,500,000 was assumed as a cash inflow in the thirtieth year. The owner's estimated cashflow this far distant in the future has relatively little impact on internal rate of return calculations but an arbitrary termination date and value must be assigned in order to perform the mathematics.

F. ECONOMIC ASSESSMENT

The conjectured owner cash flows from Tables 5-5 and 5-6 were analyzed using a General Electric computer program (DISCT$) to calculate an internal rate of return, verify the 3.15 year payback period calculation of Table 5-5, and generate present worth values for different owner cost of capital levels. The first two years of data were input by quarters and years 3-30 by years. Interest and principal payments were input as end-of-year payments as was the terminal value for year 30. All other flows were assumed to occur linearly through each quarter or year as appropriate.

The payback was verified as 3.15 years and the internal rate of return on owner cash flows was calculated to be 62.4%. Present worth results were:

Cost of Cash (Owner Capital)	Discounted Present Worth
6%	$70 million
8%	54 million
10%	43 million
12%	34 million
15%	25 million
20%	16 million
25%	11 million

The maximum owner cash investment required, just over $10 million, occurred at the end of the second year. Figure 5-1 is a diagram of the owner cash flow for the first four years. As can be seen from the diagram, if the first interest payment is postponed until the end of the ninth quarter or beyond, the maximum owner cash investment could be reduced to $7.5 million occurring at the end of the seventh quarter.

Due to the limited scope of this study, many financial factors were not explored in detail. While these would not have materially affected the results of this study, they should be fully explored by those contemplating implementation of such a project.

Advantageous financial factors not included:

- Investment tax credit on breeding stock

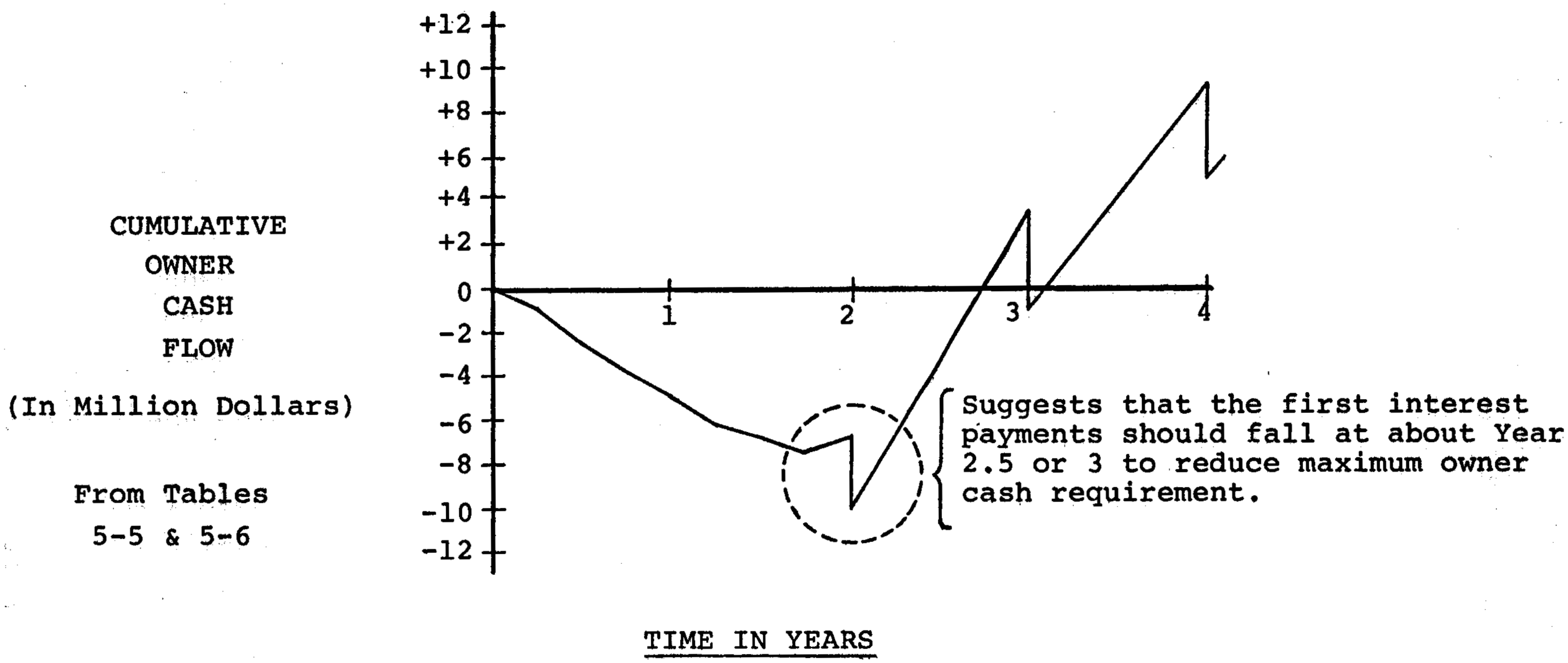


Figure 5-1. Owner Investment Cash Flow Diagram (For First Four Years)

- Business investment credit
- Geothermal reservoir depletion
- First year depreciation bonus
- Intangible drilling cost allowance
- Accelerated depreciation
- Leasing alternatives
- Pollution control allowances

Disadvantageous financial factors not included:

- State taxes
- Legal & tax counsel
- Direct operations taxes
- Conservation taxes
- Property taxes (beyond basic allowance in "Utilities and Maintenance" line of projections)
- License taxes & fees

The economics of the proposed market, capital and operations plan are subject to many significant risks, noted throughout this report. Key high risk factors to be considered in a detailed feasibility and design effort would include:

- Market outlets for production
- Geothermal development uncertainty
- Equipment and material lead time
- Government regulation changes
- Wellhead lease negotiations
- Equipment replacement schedules and costs
- Tax law changes
- Technological uncertainties
- Project construction and management qualifications

As with all new ventures, potential investors are responsible for their own investigations and conclusions. This study has not been a detailed engineering or marketing effort. In accordance with PRDA guidelines, this has been an engineering and economic study.

Our findings and conclusions represent our good faith assessment of potential future performance of an actual system provided that the noted assumptions hold and that our information sources have been reliable. We have no reasonable grounds to believe, and do not believe at the time of writing this 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 understanding or use of the material by a reasonably qualified investor, designer, manager or operator.

CHAPTER 6 - ENVIRONMENTAL

A. ENVIRONMENTAL APPROACH

1. Scope

Environmental factors have been identified and evaluated within the scope of this Task. Potential impacts of the project on the landscape have been identified The recommendations for mitigation of impacts are subject to modification should new data so dictate. Consideration has been given to internal environmental, health and safety factors that occur within the system as designed. These findings should be reviewed and modified during the design and construction phases of the Project.

2. Data Collection

On-site inspection and regional surveys were conducted in Idaho. Inspections of local industries and agricultural production facilities that might involve geothermal applications were conducted to evaluate environmental implications if used as a component in the project. These investigations extended to processing plants outside Idaho. Emphasis has been placed on the analysis of environmental factors that are external to the systems. The development of the environmental matrix analysis system is based upon the engineering information in Chapter 4.

B. GENERAL ENVIRONMENTAL SETTING

1. Topography

The Bostic 1-A site is located on the Snake River Plain in the Bennett Creek drainage, on the 3190 foot contour, which is midway between Bennett and Ryegrass Creeks. Land fall is gentle but undulating to the south and southwest. The area is largely free of the ravines and deep stream dissections that occur closer to the Snake River some 12 miles distant.

The plain continues to the north some 6 miles before the topography rises sharply into the Mt. Bennett Hills.

2. Geology and Soils

The underlying geology is discussed in detail in Chapter 3, but the soil parent material is largely basaltic. This portion of the plain is made up of large alluvial out washes from the Mt. Bennett Hills overlaying substantial thicknesses of extensive basalt flows that form the substructure of the plain.

Soils are deep alluviums with a caliche layer occurring at dephts of 1 to 4 feet, apparently depending on the nature of local surface configurations of swales, hummocks and other small land form anomalies.

3. Vegetation

The natural vegetation in this area of the Snake River Plain is treeless brushland with small interspersed grasslands.

The vicinity of Mountain Home, Bruneau, and Grand View includes major blocks of agricultural land as well as high desert shrub communities dominated by big sagebrush, shadscale, and greasewood.

Anthropogenic communities predominate in the general area. These communities are cultivated crops such as feed grain, winter and spring wheat, potatoes and sugar beets.

4. Fauna

The most important wildlife habitat type in the general area of the Snake River itself, where cliffs provide nesting places for one of the world's largest breeding concentrations of raptorial birds. The Bureau of Land Management has established the Snake River Birds of Prey Study Area near Grand View, about 12 to 15 miles southwest of the site, and research is being conducted on many aspects of the biology of these raptor populations. The most numerous species of nesting raptors are prairie falcons, golden eagles and red-tailed hawks. Other raptors found in the area are the kestrel, ferruginous hawk, marsh hawk, great horned owl, barn owl, and raven. These birds of prey hunt widely over the surrounding plains, including the well site area, with lizards, snakes, small birds and rodents forming most of their food.

Mammalian predators include coyotes, bobcats, and badgers. rodents are abundant in the desert shrub communities of the Snake River Plains, with black-tailed jack rabbits, desert cottontail rabbits, Townsend's ground squirrels and Least chipmunks among the most important prey items for mammalian predators and raptors alike. Deer mice and voles are common in agricultural areas, as are Townsend's pocket gophers and Ord's kangaroo rats.

Common game birds include ring-necked pheasant (primarily in agricultural areas), chukar (in rocky canyons), mourning dove, and quail. Small birds characteristic of the region are western meadowlarks, horned larks, various sparrows, sage thrasher, loggerhead shrike, and black-billed magpie. Western rattlesnake, gopher snake, and striped whipsnake occur in good numbers. The most abundant lizards are side-blotched lizard, western fence lizard, leopard lizard and desert horned lizard. Various species of frogs and toads are found, especially along creeks and near ponds.

5. Archaeology and History

These aspects of environmental concern were not investigated in any detail. Current agricultural land use and tillage would have largely destroyed any sites in the area: hence archaeolgoical remains can largely be discounted on the site should construction take place.

6. General Geothermal Factors

Because the resource is hot water, environmntal hazards are minimal compared to noise, air pollution and other factors in live steam. Since the water is superheated and water quality is not documented, project operation will involve heat exchangers and the maintenance of pressure in the system including re-injection.

Such a system eliminates concern that might arise from subsidence through liquid removal, noise from escaping steam, and/or induced seismicity.

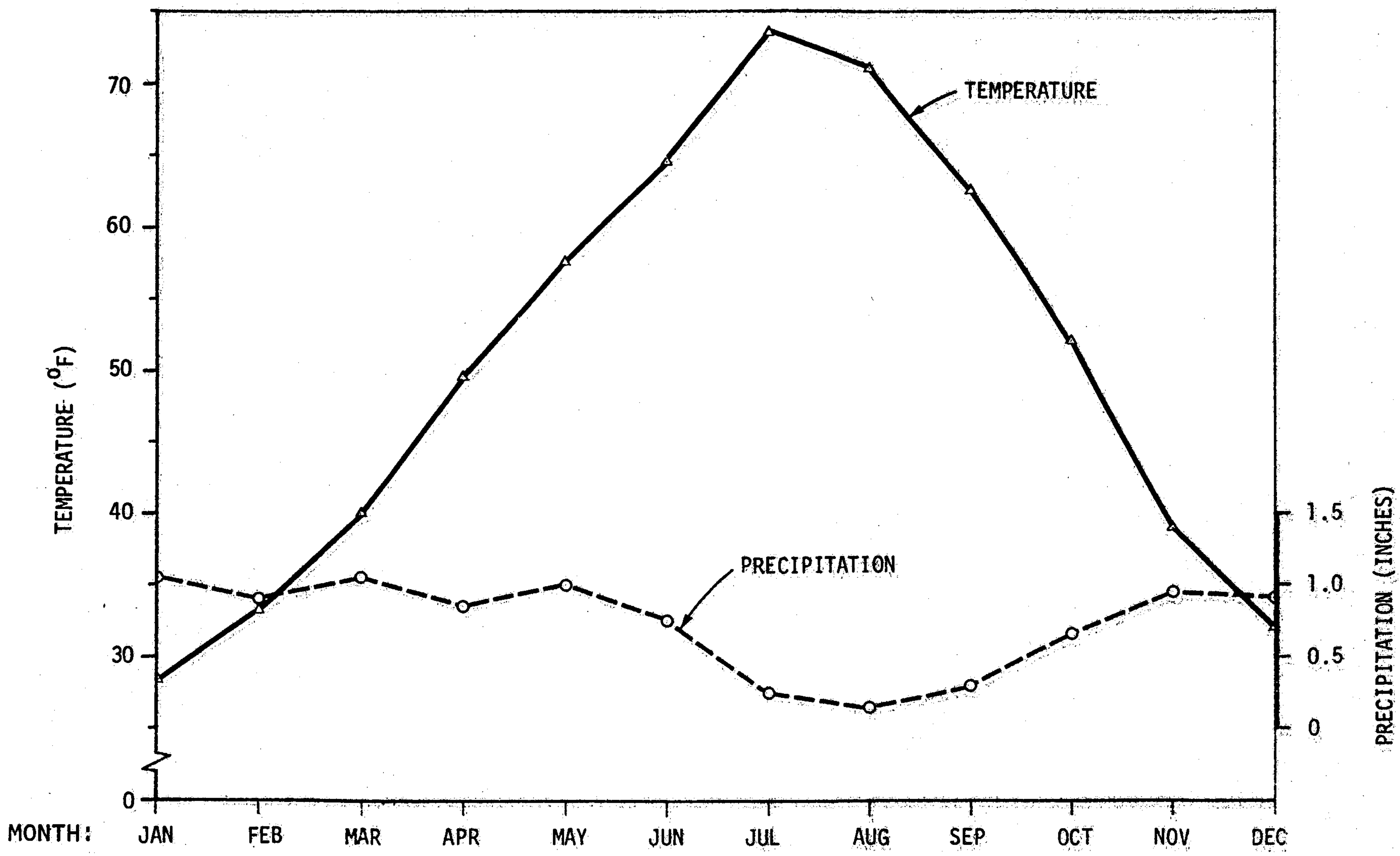
Whether or not such a system will involve problems with resource cooling or modification cannot be determined in advance. An examination of the integrity of the rock, (basalts and volcanics), the depth of withdrawal (6000-9000 feet), and the relatively low demand of extraction (1000± gallons/min) support above contentions and suggest that no resource modification is probable.

7. General Climatic Aspects

The Great Basin, to which this region of Southern Idaho belongs, is classed as a cool-desert. Some precipitation occurs every month, but 50% occurs between February and June, (See Figure 6-1). At Mountain Home the annual precipitation average is 9.5 inches. Precipitation from late November to the end of March is nearly always in the form of snow or sleet. Average snow depth is 13.6 inches for the season. Rarely does snow depth on the ground exceed 3 inches.

Over a 71 year temperature record an average 63 days per year have temperatures exceeding 90°F but only four days on an average will be below 0°F. The extreme recorded temperature range is 110°F to -36°F. May 16 to September 22 is the average frost-free period but frosts have occurred as late as June 27 and as early as August 30, (See Figure 6-1.)

Because of the potential for dispersed operations in the three KGRA's (Bruneau, Grand View and Mountain Home), temperature variations were investigated between Grand



Source: "Climatography of the U.S., No.81-4, Decennial of U.S. Climate"

Figure 6-1. Temperature and Precipitation Regime at Mountain Home, Idaho based on Monthly Normals (60 Years of Record)

View, Boise and Mountain Home. Figure 6-2 shows the deviation of monthly normal temperatures by seasons. These data indicate that both stations are warmer than Mountain Home and the Grand View spring and summer temperatures are significantly so. Winter and late fall temperatures are higher, but only by less than 1.5°F.

Wind speeds at Mountain Home average 6 miles or less, 39% of the time and 7 to 15 miles/hour 41% of the time. Northwest and east or southeast winds are most frequent but the strongest winds are from the west and northwest. These are usually associated with thundershower activity and winds 22 miles/hr or greater occur from July through September 1% of the time. Such winds occur 4% of the time during February, March, and April.

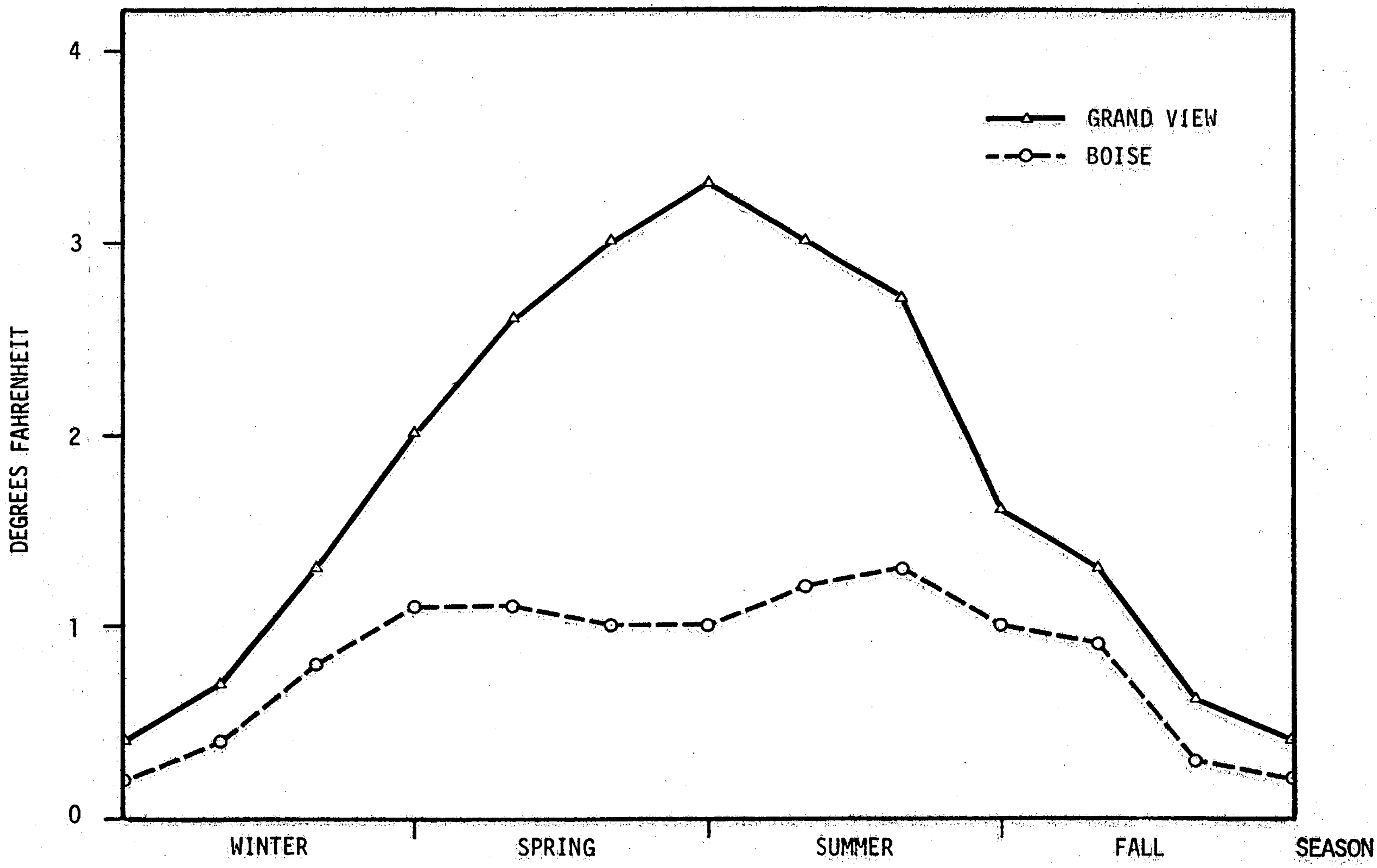
C. WELL SITE ENVIRONMENTAL CHARACTERISTICS

1. Local Topography and Current Land Use

The Bostic 1-A well site is in the SE/4 of a half section potato field. Local land surface configuration is being modified as lands are being brought under cultivation. Canals for irrigation have been or are being constructed and in some areas fields are graded and shaped into rectangular blocks to accommodate "Wheel rain" sprinkler systems. This is the case in the well site area. Nearby areas are irrigated from well-connected pivotal sprinkler systems with extensions or separate systems to accommodate rectangular areas. Land surface configuration under this type of system is usually not so severely modified. In either case, however, local natural drainage is often severely modified and redirected for agricultural purposes.

2. Vegetation

Land at the well site has been cleared and graded for cultivation within the last 24 months. Large areas to the west and north of similar terrain have been under cultivation for longer periods. Some areas to the east have been cleared, are being cleared, or are in native vegetation. Immediately to the south and southeast are large areas of "modified" sagebrush-grass community that is now typical of the uncultivated portions of the Snake River Plains. The native community in the immediate vicinity consists of sagebrush (Artemisia tridentata), annual grasses,- most commonly Western cheat grass (Bromus tectorum), filaree (Erodium cicutarium), and Nuttall's balsamroot (Balsamorhiza hookeri var. hispidula) as principal dominants. Weedy species such as Russian thistle (Salsola kali) and tansy mustard (Descurina sophia) are abundant in overgrazed and disturbed areas. They also are among the principal weedy species in new fields.



Source: "Climatography of the U.S., No. 81-4, Decennial of the U.S."
Based on 3 months moving mean of monthly normal temperatures

Figure 6-2. Normal Temperature Differences between Mountain Home, Boise and Grand View.

3. Temperature

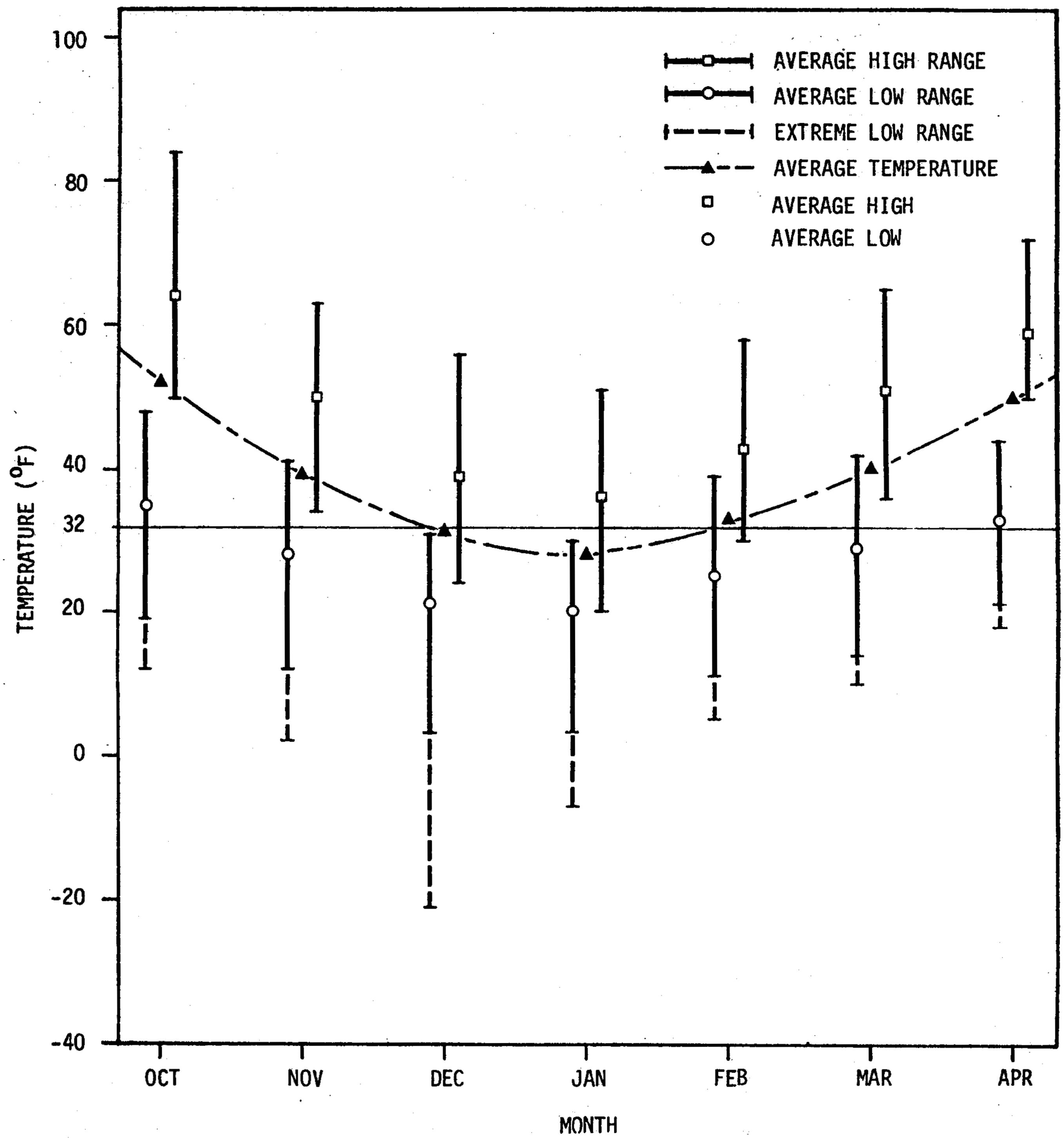
Climatic factors affect various aspects of project design and operation. Those critical to key production systems chosen for initial installation in this project are minimum temperatures and wind direction. Adequate data for the latter were not available for analysis during the course of this study; however, the temperature regime was analyzed.

Range and periodicity of low temperatures during winter are of particular interest because of stress on livestock and demands on the resource. Figure 6-3 illustrates the monthly average, minimum and maximum ranges and extreme lows that are to be expected (data analyzed for years 1971 - 1976). Design criteria for environmental control need to cover the extreme lows, however, the probability of occurrence and its probable duration are elements that may not need complete design criteria. In particular, temperature stress on hogs for short durations can be covered in part by natural homostatic characteristics of the hogs themselves and heat re-allocation within the Project.

Figure 6-4 compares the average monthly minimums (vertical lines) the frequency of days below the average minimum in 5 degree intervals (right histogram) and the frequency of periods above and below average minimums in 2 day intervals (left histograms). The most severe departures of extreme lows (more than minus 30 degrees below average minimum) for the five year period 1971 - 1976 occur in December and January and their occurrences total 29 days. With one of exception, the duration extreme lows (more than 25°F below average minimum) was of only 1 or 2 days. However, the low period may last up to 10 days. Durations of cold periods below average minimums are usually longer in December, January and February than in the the fall and spring months. There is a greater frequency of long duration (up to 14 days) low periods followed by long periods above the average minimum in winter but rarely do such periods average above freezing, (See Figure 6-3).

These data indicate that outside design temperature criteria for maintaining non-stress conditions for swine, should be in the range of 5°F to 8°F for periods of up to 14 days. Such a design criterion would permit building temperatures of 50°F to 55°F for several hours each day during an extended low period except in hog farrowing and nursery buildings, where temperatures would be held to at least 65°F.

While the summer normal high temperatures for Mountain Home fall within the ideal range the extremes do not. Maximum daily temperatures can exceed 85°F at any time during the months of April through September.



Source: U.S. Weather Bureau Monthly Climatic Data
Based on Years 1971 through 1976, Mountain Home, Idaho

Figure 6-3. Monthly Average Temperature Ranges showing Minimums, Maximums and Extreme Lows

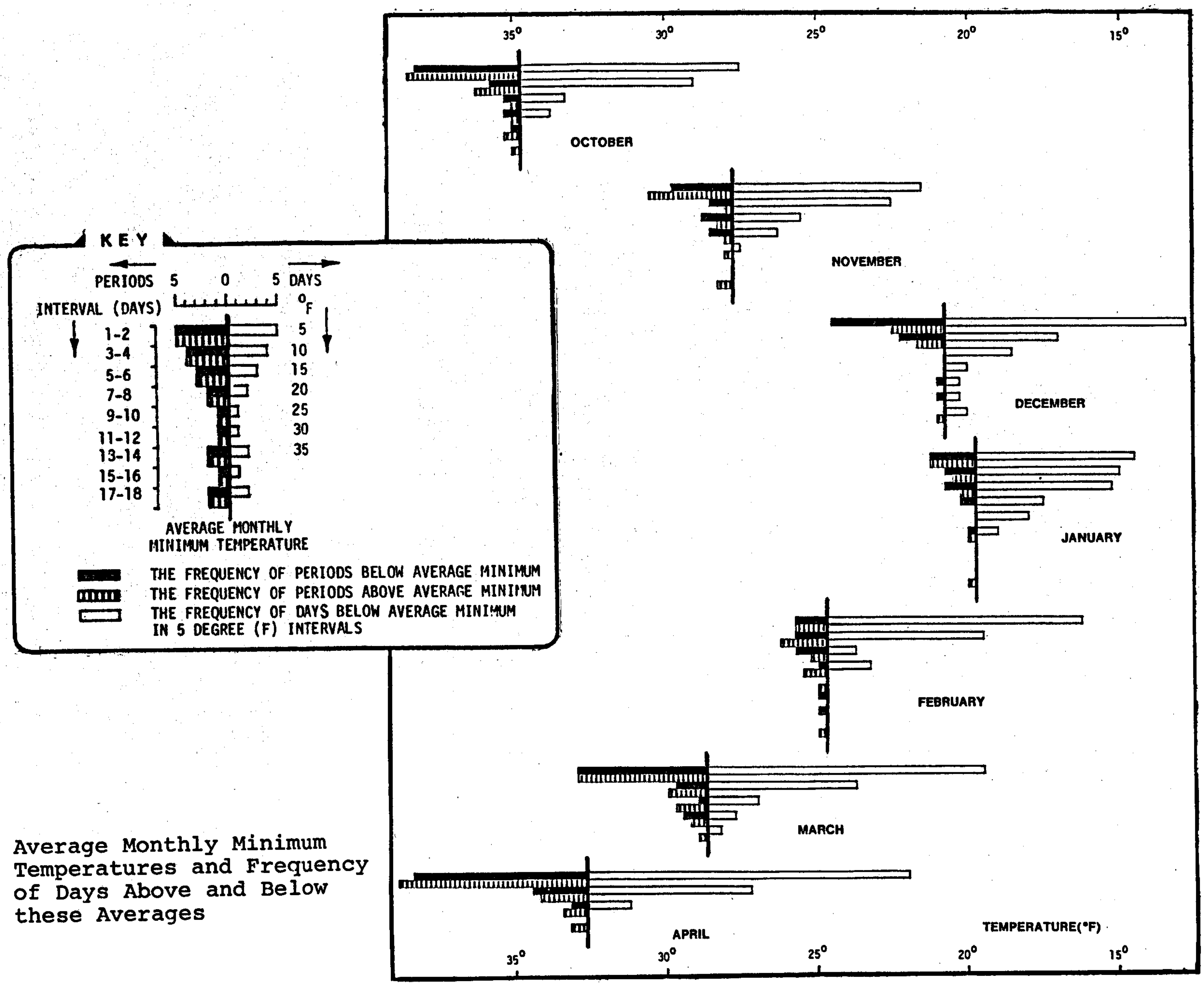


Figure 6-4. Average Monthly Minimum Temperatures and Frequency of Days Above and Below these Averages

4. Air Quality

Good air quality is a valued local resource; and in general air quality of the area is very high. Particulates are present sometimes at certain seasons in high quantities. These are mostly soil and dust particles of a large range of sizes. Agricultural soils are fallowed and open especially during the fall, winter and early spring. Tillage in fall and spring generate a source of fines that are picked up by winds. Much of such movement preceeds thundershower activity. There is no local source of man-made air pollution within a ten mile radius.

5. Water Quality

Data on which to base sound environmental water quality judgements is very limited for the Bostic 1-A site. We have however, compared this area to the Bruneau-Grand View KGRA on the assumption that the geothermal reservoirs are similar.

According to Young and Whitehead [28] meteoric water recharge areas occur in the Owyhee Mountains North of the project area and flow through permeable layers between denser confining layers into the Snake River valley. This pattern is modified by faults forcing water to higher layers or to the surface (See Figure 6-5). Apparently, heating occurs along the fractures. The hotter waters most often occur in the fractures closest to the Owyhee uplift or on the high plateau (Personal communication, Mr. Joseph Beale, Geologist, Phillips Oil Company, Salt Lake City, Utah 1978).

If this particular pattern includes the Mountain Home KGRA, and to date there is no evidence to counter it, water quality data developed for Bruneau-Grand View can serve as an indication of water quality potential at the Bostic 1-A site.

In reviewing the table of chemical analyses in Young and Whitehead [28] the following are apparent for deep (2500+ feet), hot (140°F-167°F) wells:

- Boron concentrations range between 150 and 850 mg/1.
- Arsenic concentrations range between 2 and 44 mg/l.
- Fluoride concentrations range between 11 and 21 mg/l.
- All wells tend to be carbonaceous.
- Mercury can be discounted as an important factor but does occur as traces in some wells.

- 117 -

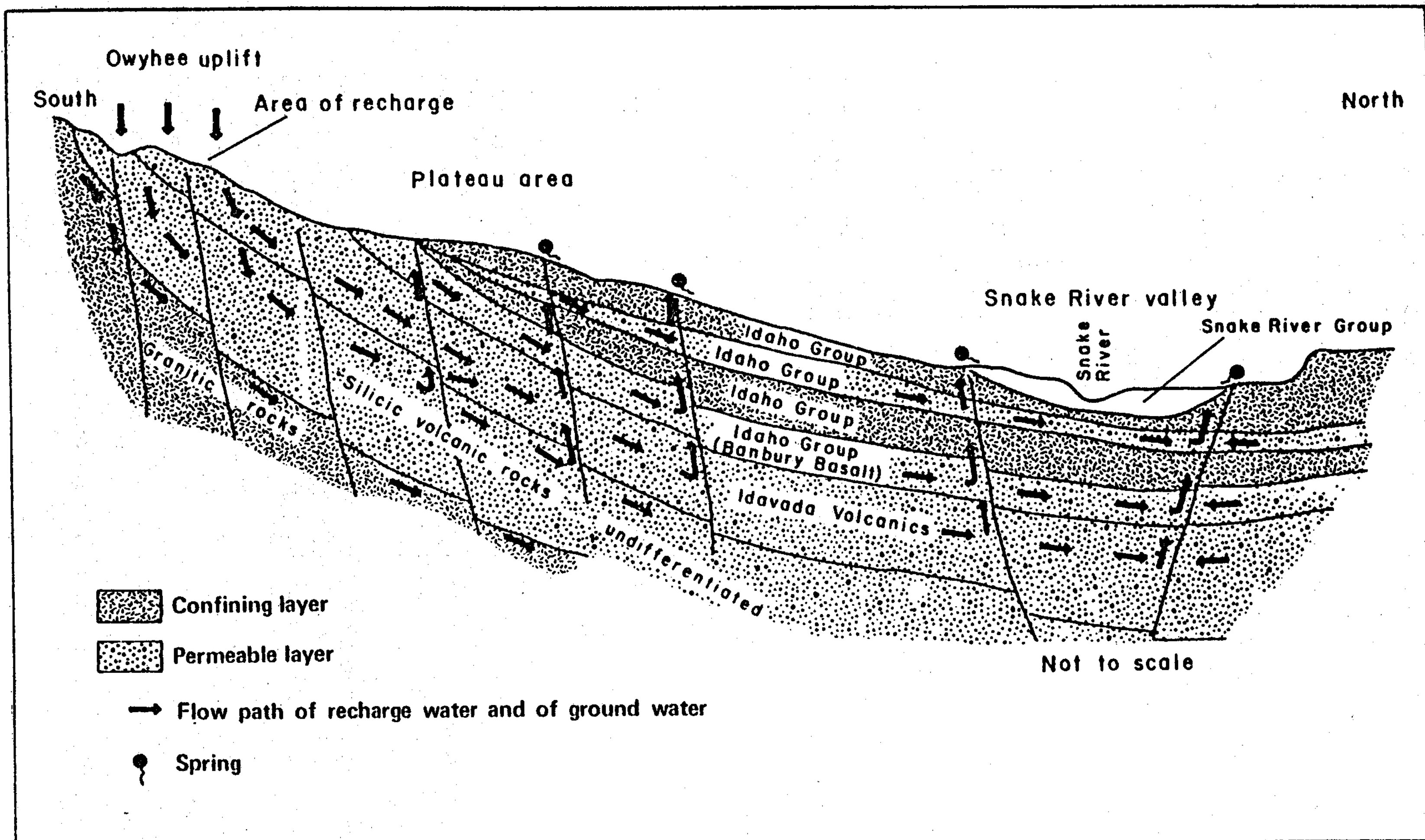


Figure 6-5. Idealized Hydrogeologic Section Showing General Relation of Geologic Units, Recharge, and Ground-Water Movement

- Boron concentrations are highest from sedimentary aquifers.

- Hydrogen sulfide does not appear to occur. However, methane in low volumes occurs in sedimentary aquifers.

As will be pointed out in subsequent discussions, these levels exceed recommended values for domestic, livestock and irrigation uses. However, relatively simple extraction techniques for tertiary water treatment can remove enough of these elements to attain acceptable levels, if consumption is desired or required.

Existing water sources, both surface and shallow underground, have a high degree of purity and are largely free of growth-inhibiting salts. Several irrigation wells are located in the vicinity and are used for raising potatoes, a crop which is intolerant of both saline conditions and boron. The geothermal well water is reported[26] to be less than 800 ppm total dissolved salts (TDS) and hence meets discharge requirements for agricultural irrigiation or surface disposal. This quality limits environmental concerns to intrasystem operations and the level of subsystem contamination, and accidental releases of contaminated water.

Two geothermal wells in the general area, used for irrigation, were analyzed by Young and Mitchell in 1973.[27] Their data is presented in Table 6-1.

These relatively shallow thermal wells and springs are low in total dissolved solids ranging from 14 to 13,700 mg/l, averaging 812mg/l (Young and Mitchell, 1973).

The recorded data from Bostic 1-A well indicates a TDS concentration of about 800 mg/l; however, according to Mr. Vane Suter, Geothermal Operations Manager of Union Oil Company, (personal communication) those results can be misleading because of possible dilution from waters used in drilling.

Since no detailed analysis of geothermal water from the well is available, or definitive data on which to make judgements, the design of this project assumes removal of heat through a heat exchanger and re-injection of these waters to depths to be specified by State permit.

Table 6-2 compares maximum trace substances in public water supply sources. Referring to the foregoing Table 6-2, recommendations for minimum raw water quality for public supplies are intended to assure that the water will be potable. For waters zoned for public supply but not meeting water quality requirements in all respects, recommendations can be considered to be a minimum target toward which efforts at upgrading quality should be

A COMPARISON OF VOLCANIC-ROCK AQUIFERS VERSUS IDAHO BATHOLITH THERMAL WATERS

	VOLCANIC-ROCK AQUIFERS		IDAHO BATHOLITH	
	WELL 4S-1E-34BAD1	WELL 5S-3E-26BCB1	SUNBEAM HOT SPRINGS 11N-15E-19C1S	VULCAN HOT SPRINGS 14N-6E-11BDA1S
TEMPERATURE (°F)	167.9	181.4	168.8	188.6
SILICA (MG/1)	91	110	91	120
CALCIUM (MG/1)	1.0	2.1	1.5	1.8
MAGNESIUM (MG/1)	0	0	0	.1
SODIUM (MG/1)	99	110	85	94
POTASSIUM (MG/1)	.8	1.7	2.4	3
SULFATE (MG/1)	40	62	54	43
CHLORIDE (MG/1)	13	15	12	17
FLUORIDE (MG/1)	13	15	15	24

Table 6-1. Two Wells in Area Analyzed by Young & Mitchell, 1973 [27]

directed. The following remarks apply to the Project as standards of performance.

a. Livestock Water Supply

Domestic animals represent an important segment of agriculture and are a vital source of food. Consideration of the quantity of water an animal consumes per day and the concentration of mineral elements in such water are important factors in establishing practical water quality criteria for livestock enterprises. Many substances dissolved or suspended in water may be potentially toxic. These include inorganic elements and their salts, certain organic wastes from man's activities, pathogens, parasitic organisms, herbicides and pesticide residues. Adverse reactions of livestock to any of these concentrations is subject to a number of variables, which include: age, sex, species, physiological state of the animals, water intake, diet, chemical form of the impurity, and temperature of the environment. The EPA water quality criteria, listed in Table 6-2, have taken these factors into account. Margins of safety are unusually large and are well below toxic limits for domestic animals.

b. Irrigation Water Supplies

There are two levels of consideration for use of geothermal or surface water for irrigation purposes maximum concentrations and long term maximum concentration.

Trace elements normally occur in waters or soil solutions in concentrations of less than a few mg/l with usual concentrations less than 100 mg/l. Some may be essential for plant growth, while others are nonessential. Build-up of trace elements may adversely affect plants directly by either the development of high osmotic conditions in the plant substrate or by the presence of a phytotoxic constituent in the water. Effects of undesirable constituents may be manifested in suppressed vegetative growth, reduced fruit development, impaired quality or a combination of these factors.

Recommended maximum trace element concentrations for irrigation waters compared with waters of the study area are shown in Table 6-2. Suggested maximum concentrations for continuous use on soils are set for sandy soils that have low capacities to react with the element in question. They are generally set at levels less than toxic concentrations for the most sensitive plants grown in nutrient solutions or sand cultures. This level recognizes that soil concentrations increase as water is lost through evapotranspiration,

RECOMMENDED MAXIMUM CONCENTRATIONS OF TRACE SUBSTANCES IN WATER

ENVIRONMENTAL PROTECTION AGENCY, 1972

CONSTITUENT	WATER SUPPLY			
	PUBLIC	LIVESTOCK	IRRIGATION	
			FOR CONTINUOUS USE ON SOIL	FOR USE UP TO 20 YRS.-FINE SOIL*
ALKALINITY	None	--	--	--
ALUMINUM	--	5.0 mg/l	5.0 mg/l	20.0 mg/l
AMMONIA	0.5 mg/l	--	--	--
ARSENIC TOT.COLI.	20,000 MPN/100 ml	--	--	--
BORON	--	5.0 mg/l	0.75 mg/l	2.0 mg/l
CADMIUM	10 μg/l	50 μg/l	--	--
CHLORIDE #	250 mg/l	--	--	--
CHROMIUM	50 μg/l	1.0 mg/l	0.1 mg/l	1.0 mg/l
COLOR	75 ALPHA	--	--	--
COPPER	1.0 mg/l	0.5 mg/l	0.2 mg/l	5.0 mg/l
CYANIDE	0.2 mg/l	--	--	--
FLUORIDE #	**	--	--	--
IRON	0.3 mg/l	--	5.0 mg/l	20.0 mg/l
LEAD	50 μg/l	0.1 mg/l	5.0 mg/l	10.0 mg/l
MANGANESE	50 μg/l	--	0.2 mg/l	10.0 mg/l
MERCURY	2 μg/l	10 μg/l	5.0 mg/l	10.0 mg/l
NICKEL	--	--	0.2 mg/l	2.0 mg/l
NITRATE	10 mg/l	100 ppm	--	--
NITRITE	10 mg/l	10 ppm	--	--
pH	5.0 to 9.0	--	--	--
SELENIUM	10 μg/l	0.05 mg/l	--	--
SULFATE #	250 mg/l	--	--	--
ZINC	5 mg/l	25 mg/l	2.0 mg/l	10.0 mg/l

Table 6-2. Maximum Concentrations for Water Supplies

FOOTNOTES TO TABLE 6-2:

-- Not Applicable

mg/l -milligrams per liter

µg/l -micrograms per liter

one µg = 1/1000 mg (a µg is a much lower concentration)

* Fine Textured Soils of pH 6.0 to 8.5

** In the United States, the primary source of fluoride is the drinking water supply. Thus, the amount of fluoride ingested is determined largely by the temperature since water intake is higher in hot weather. For this reason, fluoride limits in raw drinking water are established on the basis of air temperature:

°F	mg/l of fluoride
80-91	1.4
72-79	1.6
65-71	1.8
59-64	2.0
55-58	2.2
50-54	2.4

The following were the only verifiable data for geothermal wells within the Mountain Home study area which exceed the recommended maximum concentrations (apparently all other chemical species have not been examined):

Public Water Supply	Average Values
Chloride	14
Fluoride	18
Sulfate	50

> and that the effective concentration in the soil solution, at near steady state, is higher than in irrigation water. The criteria for short-term use are suggested for soils having high capacities to remove from solution the element being considered.

The only criteria we have to go on as far as application of non-geothermal Project water to be used as irrigation water is that nearly all irrigation in the vicinity of the Project site is from wells. However, Project water to be released into surface runoff systems may not be equal to the waters in local creeks. Testing will be necessary to:

- determine the level of trace constituents found in natural waters of the area.
- determine the levels accumulated in the final storage ponds.

Constituents of particular interest that are suspected either in geothermal water, surface water supplied to the Project or materials concentrated in the course of Project operation are shown in Table 6-3.

TABLE 6-3
MATERIALS OF INTEREST IN
WATER QUALITY AND THEIR POTENTIAL SOURCES

MATERIAL	PROBABLE SOURCE
Copper	hog feed additives
Zinc	hog feed and galvanized iron equipment
Arsenic	geothermal water and shallow aquifers
Boron	geothermal water
Lead	geothermal water
Mercury	geothermal water
Hydrogen sulfide	geothermal water
Flouride	geothermal shallow aquifer and surface waters

Hydrogen sulfide may be more significant in shallow wells or springs or in early flow measurements from deep wells. Experience in other KGRA's indicate H_2S levels drop over time and are considerably more concentrated in shallow wells 0-3000 feet than in deep wells (6-10,000 feet). Note that Young and Whitehead[28] made no mention of H_2S in their report on gaseous constituents, but visits to two hot springs in the area indicated its presence in low concentrations.

6. Land Use

The aspect of the area is open space and agriculture. Principal use of land is large scale agriculture. As indicated above much of the area in the vicinity of the well site is already under cultivation. The nature of these operations appear to be large scale, well capitalized, corporate farming ventures. Very few rural residences are found in the area, but several large corporation farm headquarters dot the countryside. These consist of several large steel buildings housing equipment and agricultural products, particularly potatoes and grain.

Two pipelines cross the countryside near the well site. These move natural gas. A pumping way station is located within one half mile of the site.

At one time the area was heavily grazed but since the advent of irrigation and the decline in the sheep industry, this land use is limited to higher, hilly undeveloped ground.

Access to the site is via a county road which is classed as light duty surfaced. This road connects to the Interstate Highway 80 about ten miles to the northwest near Mountain Home. The site is about 50 miles from Boise and about 75 miles from Twin Falls.

About one mile of new road would have to be built and surface improvements over perhaps five miles of road will have to be made. No traffic or unusual load problems would be created by the development as currently envisioned.

7. Scenic Quality

No concentrations of people nor heavily travelled roads occur in the immediate vicinity, hence the rural atmosphere and open space atmosphere dominate. Vistas toward distant mountains toward the north and the Snake River Plain to the south and east are afforded from the property. Whether or not the site could be seen from Interstate 80 is not known by us, but low rolling hills probably intervene.

Possible geothermal development of the type suggested in this report would appear very similar to the existing corporate farming headquarters already on the landscape.

8. Odors

This aesthetic factor should be of little concern because of the type of waste management systems being considered. The solids and semi-solids will be collected and processed immediately in methane generators. Waste water treatment will follow several pathways, none of which is expected to generate odors.

9. Noise Generation

Noise generation is expected to be well within suburban residential limits. As far as is currently known the loudest single noise source will be large trucks making deliveries and removing products. These are expected to be on the order of 10 per day at full operation. Smaller trucks and autos will generate some noise but the rural atmosphere and open space will dissipate any objectional impact.

D. INTERNAL SYSTEMS

Development of design and plans have been carried to the point where preliminary examination for details of health, safety and environmental flaws are possible. Some of the factors that have been examined are:

1. Methane Generation

The potential for explosion or asphyxiation hazards are minimal. The methane generators operate at very low pressures. And accumulations of methane are kept at low levels since the gas is used very soon after generation. Generators and storage tanks are to be installed in the open air and laid out so that the transfer from generator to use is proximal and contained in a single area devoted to that single purpose.

2. Project Generation and Accumulation of Toxic Materials

Toxic materials can be generated from long term use of feed stuffs or as byproducts produced in the systems at several points. Copper and zinc could be accumulated in waters and sediments over a period of years in a closed system.

These ions will arise most probably from hog wastes because these elements replace iron in the bile salts of hogs. Their occurrence will be most likely in wash water and sediments deposited in waste water treatment ponds.

Uncooked potato wastes often contain high levels of cyanic acid and alkaloids. Cooking eliminates cyanic acid but has little or no effect on the alkaloids. The tolerance level to potato alkaloids is apparently high in hogs, however, and current industry practice indicates that this is not a significant problem.

3. Pathogen Transfer

Pathogens are potentially transferred through aerosols, water, feed, physical transport via contaminated clothing, vehicles, bedding, wastes, manures and direct animal contact. Intraproject transmission of diseases is reduced in every way possible through habitat cleanliness, strict control of feed materials, isolation in environmentally controlled building systems, reduction of stress in animals, and separation of wastes from each production unit. Transfer of pathogens from outside sources must be limited by controlled access and on-site incineration of dead animals and non-byproduct wastes. Manures must be moved directly into methane digestors which generate acids and heat that preclude the survival of pathogens. Non-fecal waste waters from the slaughter house and feed production units etc. must be transferred to aerated ponds and, depending on their contaminates, treated through standard tertiary treatment methods . These built-in mitigations reduce normal pathogen transport into and out of the Project to acceptable limits.

The remoteness of the Project site, low incidence of hog populations on the Snake River Plain, and the distance from the Project to other livestock operations of the same class reduce the export or induction of aerosol-borne pathogens to a minimum. The die-off rate of pathogens is affected by time and exposure to ultraviolet which reduces their viability for spore formation. This buffer zone between other possible livestock operations reduces these concerns to a minimum.

4. Critical Potential Impacts and Mitigations

The isolation and identification of major impacts is presented in Table 6-4 together with the system to which each is associated.

Particulate matter generated in preparing certain types of agricultural wastes such as straw, cardboard, dried fruit pumice or beet pulp may require mitigations such as cyclonic arrestors, vacuum or ionic absorbtion equipment, etc. The total magnitude of the problem will be restricted to the amount of material processed and prevailing wind direction. The sensitivity will be most important for feed mill personnel and for personnel and livestock down wind within the Project.

Environmental consequences are most important within the waste disposal system. Previously we have alluded to odor, pathogen dissemination, and water quality

TABLE 6-4
SUMMARY OF IMPACTS OF LIVESTOCK PRODUCTION MODULE FOR MT. HOME IDAHO

System	Impact Type	Probability of Occurence	Magnitude of Impact	Sensitivity of Impact
ECGS	None	N.A.	N.A.	N.A.
Feed Mill	1. Dust and particulate matter generation 2. Worker safety	1. High but partially discounted because of wet feed source 2. Moderate to low, depends on effectiveness of safety design and application	1. Moderate 2. Low	1. Low because of rural area 2. Could be high
Hog Parlor Module	1. Odors 2. Noise 3. Waste accumulation	1. Low 2. Low to none, confined to buildings 3. Very low	1. Very low 2. Very low 3. Very low	1. Very low 2. Very low 3. Very low
Potato Processing Module	1. Noise 2. Traffic	1. Very low, confined to buildings 2. Seasonally moderate	1. Very low 2. Low	1. Very low 2. Very low
Methane Generation	1. Spontaneous combustion 2. Residue disposal 3. Carbon monoxide (hydraulic motor drives)	1. Low 2. High 3. High	1. Moderate 2. Moderate 3. Low	1. Low 2. Low 3. Very low
Slaughter	1. Odors 2. Noise 3. Waste disposal 4. Safety hazard	1. Low 2. Low 3. High 4. Moderate	1. Low 2. Low 3. Low to moderate 4. Low to high	1. Very low 2. Very low 3. Variable 4. Variable
Refrigeration and Storage	None	None	None	None
Water Reclamation & Aquaculture	1. Odors 2. Toxic residues 3. Substandard water quality discharge 4. Accidental spills of untreated water	1. Low 2. Low to moderate 3. Moderate 4. Low	1. Very low 2. Moderate 3. Moderate 4. Moderate	1. Very low 2. Variable 3. Moderate 4. Moderate to high

maintenance. Generation of odors throughout the system are minor because of the concept of constant manure removal and methane generation. Residue waters will be cleaned sufficiently for recycling within the Project using simple aeration ponding. Discharge of Project waters to natural environments in Idaho requires that water quality will not deteriorate. This restriction can be complied with through standard tertiary water treatment facilities.

The Project will operate adjacent waste disposal lands for irrigated field crop production (non-edible) in order to utilize Project water and to lessen any potential impact from accumulation of toxic substances in localized water supplies.

Noise and odors do not appear to be generated in significant amounts to require mitigations other than those that are built into the Project, i.e.; methane generation, environmentally controlled buildings and waste water treatment systems.

Safety hazards are present but can be mitigated to affect minimal impact. Human error and carelessness are really the major sources of hazard and these are best controlled by personnel quality, management and operation procedures and constant vigilance.

For future implementation, the following should be obtained:

a. Full spectrum analysis of all ions to be found in geothermal water.

b. Full spectrum analysis of surface waters and irrigation wells in the vicinity.

c. A pilot full spectrum analysis monitoring of wastes generated in the Project and residues and water status throughout the Project over a period of 5 years, to supplement monthly monitoring as required by State permit.

d. A periodic monitoring of any discharged water either for irrigation or surface drainage in accordance with State regulations.

Items a. and b. will be concluded prior to construction and final design completion in order to:

a. Establish the requirements and criteria for re-injection of geothermal water.

b. Modify Project design details.

c. Establish pre-Project base line data for performance standards.

In summary - there are no known impediments to maintenance of environmental quality as identified herein.

CHAPTER 7 - INSTITUTIONAL

The institutional assessment for the Project assumes Federal permitting will occur in accordance with currently established regulations for activities funded and/or controlled by cognizant Federal agencies. The institutional activities for this Project have been directed to assess attitudes, conditions and permitting and other requirements at the State and local levels.

Institutional entities that have been contacted for advice, regulatory/permitting requirements and informal reviews of the project's interim results are listed in Table 7-1.

A. SOCIO-ECONOMIC CHARACTERISTICS OF THE AREA

Mountain Home is the County seat and the major trade and financial center for Elmore County.[78,79] The greatest single socio-economic factor in the area is Mountain Home Air Force Base (MHAFB) located about 11 air miles southwest of Mountain Home.[78-84] City residential population grew from 1193 in 1940 to 6,811 in 1975, a 466% increase. MHAFB has a population of about 11,000 and the County has a total population of about 20,000. The economic base of the city is composed of agriculture in the private sector and MHAFB in the public sector. Factors related to the Project are as follows:

1. MHAFB is a crucial but not locally-controlled factor in the socio-economic future of the community. The Base employs 46% of the civilian employment in the County. An increase in the private sector employment is being encouraged.[80,81] The total County employment in 1975 was approximately 8000.

2. A strengthened agricultural-based economy is essential to the self-determined future of the community.[80]

3. Clean air is one of the primary environmental concerns of the community.[85]

4. There is an out-migration of youth due to lack of private sector job opportunities.[85]

5. Unemployment is under 6%.[80-82]

6. Median income is 13.4% below that of the state.[80]

7. In 1970 there were 5200 occupied housing units; only 80 of these were crowded; the average occupancy was 3.4/unit. There has been an inadequate supply of better quality units.

8. Industrial park planning is a current activity of the community. Emphasis is on agribusiness and light industry enterprises. Sites under consideration are in the immediate vicinity of the City of Mountain Home.[85,86]

TABLE 7-1
MHGP INSTITUTIONAL ENTITIES

Entity	Contacts	Institutional Activities
City of Mountain Home	Mayor, Administrative Assistant, City Engineer, Chairman of Planning Commission, Chamber of Commerce	Community needs identification, Agri-industrial park planning, Community services definition, Statistics, Community attitudes.
County of Elmore, ID	County Commissioner, Administrative Assistant to Board of Commissioners, County Clerk, Administrator and Director of Planning, County Extension Agent	Comprehensive Plan compliance, County zoning, Building Permits, County needs and services, Agricultural practices, Statistics, County attitude.
Idaho Dept of Water Resources	Regulatory & Permitting	Geothermal and water rights permitting, (drilling, abandonment, re-entering and re-injection), Waste disposition at depths greater than 18 feet.
Idaho Dept of Health & Welfare, Division of Environment	Headquarters, Boise, Region 2 Offices, Central District Health Department (Mountain Home)	Solid, liquid and gaseous waste disposition permitting.
Idaho Office of Energy	Director, Assistant Director (Advisory Board Member)	Coordination with other Projects in the State, State Energy Data, State attitude.
Idaho Div. of Tourism & Industrial Development	Administrator	State attitude for Project, State programs supporting economic development projects.
Idaho Office of Uniform Building Safety	Building Permits Dept.	Building permitting (in cooperation with County).

TABLE 7-1
MHGP INSTITUTIONAL ENTITIES

Entity	Contacts	Institutional Activities
Idaho (Ag) Cooperative Extension Service	Agricultural Engineer, Energy Specialist (Advisory Board Member), County Extension Agent (Advisory Board Member)	Agricultural practices and technology, Experiment Station and Ag Research Planning, Agricultural Data, Extension Service attitude.
Idaho Cattlemen's Association, Idaho Cattle Feeders and Food Producers Associations	Executive V.P. (Advisory Board Member) Secretary-Manager (Associate Advisory Board Member)	Agricultural Practices, trends, Technical Advice, Data, Industry Contacts, Industry attitude.
U.S. Geological Survey	Geologist	Water and geothermal resources.
U.S. Bureau of Reclamation	Project Planning	Geothermal Resource exploration for local governments under PL94-156.
Regional Offices of U.S. Congressmen and Senators	Regional Representatives	Support for any required enabling legislation, political support.
U.S. Economic Development Administration	Regional Office	EDA requirements and support for economic projects.
U.S. Farmers Home Administration	Regional Office - Farmer, Community, and Business & Industry Programs	FmHA requirements and support for rural development projects.

9. 23% of the county lands are farms.[78,79]

10. Over 50% of the County lands are in private, State and Federal range land.[78,79]

11. Major crops are alfalfa, barley, wheat, sugar beets, and potatoes.[78,79]

12. Major livestock operations are cattle and declining herds of sheep.[78,79,85-90]

13. Agriproduct sales increased from $4.2 million in 1959 to $44.6 million in 1975, half of which is livestock.[78,79]

14. The City of Mountain Home and Elmore County, as expressed by local officials, are in favor of agricultural and geothermal development.[80-82]

The community has excellent highway transportation over east-west U.S. 80, plus U.S. 20 and 30 and state 51, 67, and 68. Union Pacific Railroad has service through Mountain Home. Air freight is handled out of Boise, 40 miles west of Mountain Home.

B. STATE AND COMMUNITY ATTITUDES

All State agencies contacted have been helpful and constructive in their advice and in their offers of assistance in ultimate implementation. The officials and staffs in both the City of Mountain Home and Elmore County have indicated the desirability of strengthening their agricultural base and they encourage the development of geothermal resources in the area.[80, 81, 88] The Idaho Department of Water Resources has an official position in favor of the development of geothermal resources.[89]

It should be noted that all advice and comments received from State and local governmental entities have been informal, based upon the conceptual and preliminary design data from the Project. They all will require an official review before an official position can be defined. We have mutually appreciated the informal preliminary process which has permitted informal data exchange during the formation of the Project. The contacts to date have been made to determine basic guidelines and policy and to review and understand the pertinent regulations and practices.

C. STATE AND LOCAL PERMITTING

Extensive documentation has been collected in support of the institutional activities. The following summaries of the community and the State and local regulations are based upon this documentation and personal contacts.[29,30,78-92]

No geothermal ordinance or permitting occurs at the county level. All permitting for geothermal development, utilization and shut down or abandonment is controlled through the Idaho Department of Water Resources. Geothermal fluid disposition, if re-injected at depths greater than 18 feet, is also controlled by Water Resources. Disposition of geothermal fluids on the surface and to a depth of 18 feet and disposition of all other waste liquids, solids and gases are under the control of the Environmental Division, Idaho Department of Health and Welfare. Review and approval of systems engineering and plant design is required.[89,90]

In Idaho, geothermal is sui generis -- a discrete resource that is only relatable to water and mineral resources. For direct energy applications, such as "space heating, green house operations", etc., geothermal drilling may be permitted either under the (Geothermal) Rules and Regulations and Minimum Well Construction Standards of the Department of Water Resources, April 12, 1978, or under a water right permit from the Department of Water Resources.[88] In that the Bostic 1-A well was permitted for geothermal-electric and in that re-entering permitting has been obtained by the developers for geothermal-electric exploration, and in that such activity is progressing satsifactorily, but outside of this Project, permitting for geothermal development is not an issue for this Project.[85] However, utilization of hot water from 300°F aquifers will be controlled by the department to regulate potential well interferences. This is of particular concern since, historically, well interferences have occurred in the Tea Pot Dome area, about 5 to 9 air miles north of the Project site,[83] and since the interaction occurred over only a 7 mile distance. It should be noted that the Hall vs. Walker and Lee resources are shallow aquifers -- a hot spring and irrigation wells. The Hall vs. Walker and Lee water rights were settled by decree -- one of three ways of obtaining water rights in Idaho. The other two have been through permit (primary) or claim (prior to 1971).[87] Hence, well interference testing will be an important aspect of implementation.[85]

Disposition by re-injection is permitted based upon approval of overall system performance and engineering data presented to the department. The basic criteria is to prevent any degradation of surface and ground water reservoirs. Re-injection must be at a depth significantly below that which can be expected to be developed in the future for potable water supplies. One criteria is to re-inject into aquifers that have a TDS of 3000 mg/l (equivalent to PPM on unit volume basis) or greater. If the fluid to be injected has less than 3000mg/l it need not be injected in aquifers of higher TDS.

The engineering design of waste disposition systems must be approved by the Environmental Division, Region 2, Idaho Department of Health and Welfare. It has been suggested that even the preliminary design be reviewed for comment by the Central District Health Department (Environmental Division), Mountain Home.[85] If the waste fluids generated, even through rain water runoff, can possibly contaminate ground water resources, observation wells will be required to be included in the Project. These must be monitored on a prescribed basis during operations. Informal comment by division personnel indicates the probability that enough irrigation wells already exist in the Project area for observation when and if such observation is required.[85]

The high degree of concentration and inter-connection of system elements is both advantageous and disadvantageous. On the positive side, the biological cascading of material (waste/byproducts) flows within the complex can minimize or eliminate potential pollution problems. On the other hand the concentration of such large streams of waste requires a well designed waste management and safety system. The waste handling, animal life support, feed production and refrigeration subsystems must be designed with backup systems and surge capacities to assure successful operation during the repair of physical breakdowns. Design review for permitting will concentrate on these areas.

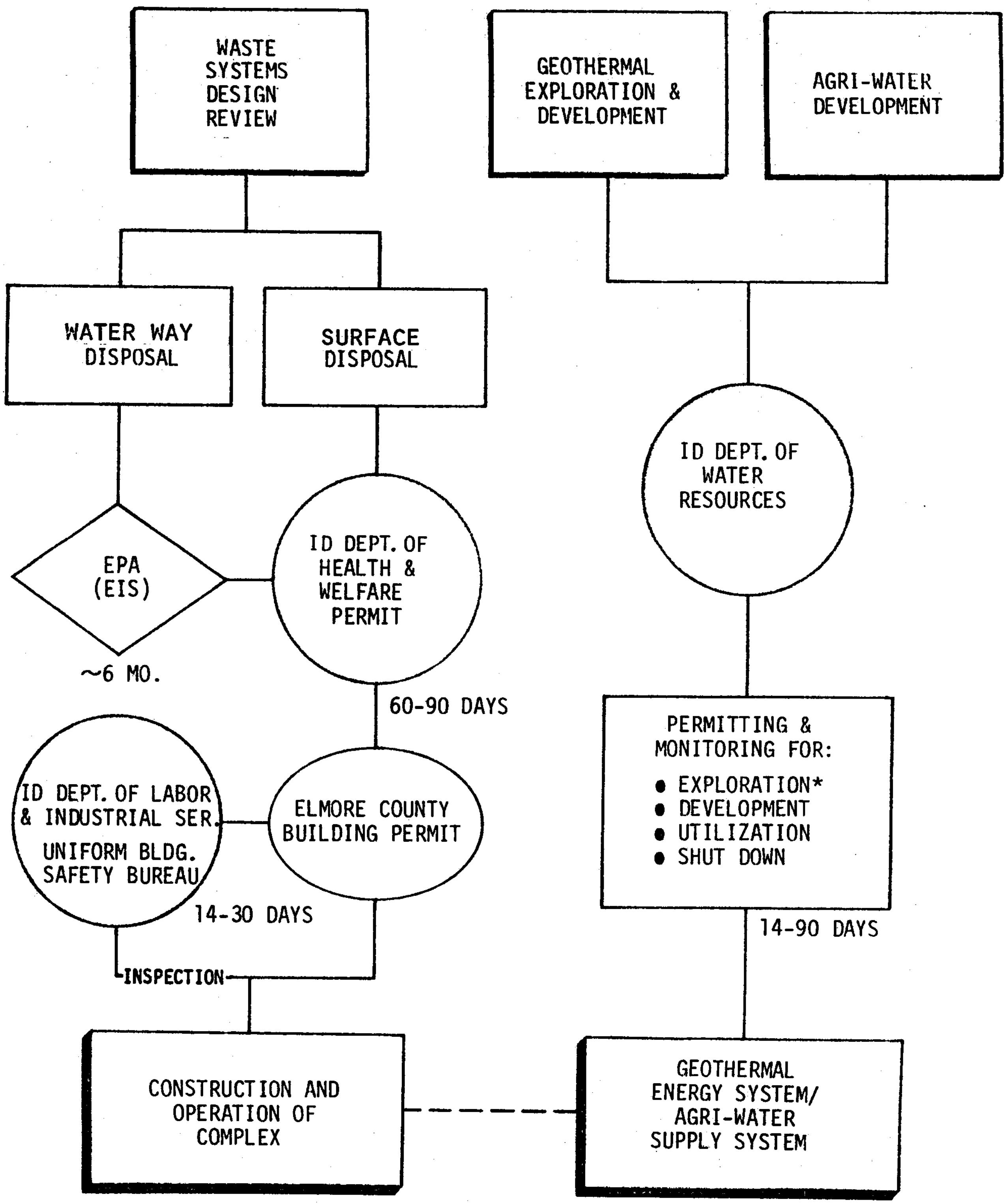
The permitting process is conducted primarily at the State level with cooperative participation on the part of the County. Building permits are processed after all environmental and water/geothermal permits are in hand. The building permits are initiated at the County level but processed and administered at the State level. Figure 7-1 describes the flow of permit processes. The span times for particular permitting is shown in this figure. Exploratory well permitting normally requires two weeks or less. Field development will require public hearings and hence about 60-90 days for the total permit, (not including rejections and resubmission, if required). The waste systems review (plant design) for the system as designed will require 60 to 90 days, (not including rejection and resubmission). If disposition of fluids will include flow into surface waters, a new requirement calls for a full Environmental Impact Statement (EIS) under EPA regulations. Depending upon the magnitude of the operation and degree of public participation, it is estimated that such EIS process may require approximately 6 months.

D. COMMUNITY IMPACTS

The relatively remote location of the facility results in minimum foreseeable impacts upon the community. The project is designed with its own fire fighting capability. Police protection would be available through the county sheriff, supplemented by normal plant security. Assuming employee residences will be located at Mountain Home and Glenns Ferry, a summary of impacts and mitigations is presented in Table 7-2.

E. IMPEDIMENTS AND MITIGATIONS

In summary, there are no known institutional impediments to implementation of the selected system at the Mountain Home site. Policies and regulations pertinent primarily to disposition of geothermal fluids and other waste flows can be



* EXISTING, ACTIVE PERMIT FOR BOSTIC 1-A WELL

Figure 7-1. Permitting Process Flow Diagram complied with through normal engineering practices and commercial hardware. It should be noted that institutional factors are quite site-specific for local and state permitting. Replication at other sites will require appropriate reassessment. At Mountain Home, geothermal developments have already been permitted and further work has been additionally permitted for the current developer. The livestock and feed production practices in this facility are common. The degree of concentration and magnitude of the operation is unique; however, the relatively remote location of the site plus conventional design procedure and commercial practices can mitigate any impacts during normal operations.

TABLE 7-2
COMMUNITY IMPACTS AND MITIGATIONS

IMPACTS	MITIGATIONS
100 Direct, 370 Total New Jobs	-None
$35.5 Million Added Assessed Value	-None
244 Additional Housing Units	-Housing Developers Currently Active in Mountain Home Area
Road Improvement for Trucking	-Mountain Home and Glenns Ferry Highway Districts' Activity
Employee Transportation	-Leased Van Fleet
New Solid Waste Load	-Coordinate with Glenns Ferry Land Fill; Inedible Livestock Byproducts and Dead Animals are Incinerated at Site
300,000 GPD (200 gpm) Irrigation Water Effluent	-Facility-Controlled Irrigation of Crops

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GLOSSARY

alluvial adj. -found in or made up of sand, clay, etc., gradually deposited by moving water, as along a river bed or the shore of a lake.

aerobic adj. -able to live or grow only in the presence of oxygen.

anaerobic adj. -a microorganism that can live and grow where there is no free oxygen, as certain bacteria.

anthropogenic adj. -has been affected by man.

Application n. -in this report refers to the total concept of a vertically integrated swine raising and meat processing complex.

aquifer n. -an underground layer of porous rock, sand, etc., containing water, into which wells can be sunk.

basalt n. -a dark, tough, fine-grained to dense, extrusive volcanic rock commonly occurring in sheetlike lava flows.

biogas n. -methane produced by anaerobic digestion of hydrocarbon materials, i.e. manure, plant and animal wastes, etc.

biological cascade n. -outputs of manure, animal offal, potato by-products and wastes, virgin cellulose, nutrients, methane production which are used as inputs for other elements of the system.

BTU n. -British Thermal Unit (a measure of heat).

caliche n. -soil containing a whitish accumulation of calcium carbonate.

cascading v. -flowing or stepping down to decreasing levels.

Conversion Factor n. -lbs. of feed required to produce 1 lb. of meat on a live animal.

enthalpy n. -a measure of the energy content of a system per unit mass.

Environmentally Controlled Growing System (ECGS) n. -growing of sprouted grains (in this Project) in an enclosed container wherein temperature, moisture, light and nutrients are controlled on a regular schedule to achieve maximum growth rates and maximum food values in the end product.

evapotranspiration n. -the total water loss from the soil, including that by direct evaporation and that by transpiration from the surfaces of plants.

farrow n. -a litter of pigs; vt.,vi. -to give birth to a litter of pigs.

flash n. -the conversion of high temperature water (liquid) to steam (gas).

geothermal adj. -having to do with the heat of the earth's interior.

gpm n. -gallons per minute

graben n. -a relatively long narrow area of the earth's crust that has subsided between two bordering faults.

H_2S -chemical symbol for Hydrogen sulfide (gas).

KGRA n. -Known Geothermal Resource Area

lysine n. -an amino acid, $C_6H_{14}N_2O_2$, obtained synthetically or by the hydrolysis of certain proteins in digestion; enzyme critical for good digestion of food.

mafic adj. -of or pertaining to igneous rocks rich in magnesium and iron and comparatively low in silica.

methane n. -a colorless, odorless, flammable gaseous hydrocarbon, CH_4, present in natural gas and formed by the decomposition of vegetable matter, as in marshes and mines, or produced artificially by heating carbon monoxide and hydrogen over a nickel catalyst; it is used as fuels, a source of carbon black, etc.

osmotic adj. -pertaining to the tendency of a solvent to pass through a semipermeable membrane, as the wall of a living cell, into a solution of higher concentration, so as to equalize concentrations on both sides of the membrane.

pH n. -symbol for degree of acidity or alkalinity of a solution.

phytotoxic adj. -toxic to plants.

plenum n.,pl. -space filled with matter; opposed to Vacuum; an enclosed volume of gas under greater pressure than that surrounding the container.

ppm n. -parts per million.

PRDA n. -Program Research and Development Announcement

rhyolite n. -a kind of volcanic rock, commonly occurring as a lava flow, containing much silica, granite-like composition but with a fine-grained texture.

slurry n. -a thin watery mixture of a fine, insoluble material, as clay, cement, soil, etc.

sui generis adj. -altogether unique; unduplicated.

TDN n. -Total Digested Nutrients.

TDS n. -Total Dissolved Solids.

triticale n. -a grain; a hybrid cross between rye and wheat, possessing high protein levels and nutrition values.

vertically integrated system n. -more than one interrelated livestock operation integrated into a single operation; i.e., feed production plus breeding, raising of livestock plus slaughter for production of meat.

APPENDIX A

TOTALLY CONFINED SWINE RAISING

By Randy McMahon
Clay Equipment Corporation
Cedar Falls, Iowa 50613

INTRODUCTION

Confinement housing, as we know it today, had its beginning in the 50's and early 60's. In an effort to become more efficient in the number of animals produced and methods used, numerous "systems" and ideas were employed, tested, rejected, and accepted. The total confinement enterprise, as we know it today, is the result of the "experiments" of the late 50's and early 60's. We will attempt to review the reason the trends to confinement and also, specific design criteria that have evolved which are critical to the individual segments of swine production, i.e., gestation, farrowing, nursery, and finishing.

REASONS FOR CONFINEMENT

Heritability, as it relates to reasons for confinement, is a function of how many of those characteristics that affect the performance and profitability of the animal are determined by his genetic makeup or his environment. The following table lists by characteristics those items that affect the animal's carcass quality and performance. It also lists the "average percent" which is controlled by heritability.

TABLE I. HERITABILITY ESTIMATES

LEVEL OF HERITABILITY	CHARACTERISTICS	AVERAGE PERCENT
High	Carcass Length	60
	% Ham (based on carcass weight)	60
	% Fat Cuts (based on carcass weight)	60
	Backfat Thickness	50
	Loin Eye Area	50
Medium	% Lean Cuts (based on carcass weight)	35
	Feed Efficiency	30
	Growth Rate (weaning to market)	30
	Five Month Weight	25
Low	Weaning Weight	15
	Number Farrowed	10
	Number Weaned	10
	Butt Weight	5

The amount of ham, percent lean cuts, back fat thickness, and loin eye area are those items that the packer is most concerned about in his purchases of animals from producers. They are so important that nearly all packers today offer premiums for animals whose percent of meat cuts is greater than the average animal produced. (While these characteristics are highly affected by their genetic makeup, 40 percent of the end results is a function of its environment.) These premiums range from $1.00 to $3.00 per hundred pounds of body weight. This means an average of $2.25 to $7.00 per animal premium. Even though these unit returns are small, when compounded by total animals marketed during the year, the total return becomes obvious.

A proper environment is extremely important at all levels of heritability. At the low levels, it is the only meaningful way to improve these characteristics. At the medium and high levels, it becomes important in reducing variables which would alter maximum genetic potential.

UNIFORMITY OF SIZE

Swine, like every other animal, develop certain social structures. As early as one to two days after birth, baby pigs develop a hierarchy of social structure. Approximately 30 percent of the animals have a dominating characteristic and approximately 60 percent have a passive social characteristic. The dominating animals soon become the animals that control the eating and sleeping habits of the rest of the group.

Since early days of confinement, the trend has changed from grouping animals in groups of 75 to 100 down to groups of 16 to 20. Also the change has taken place in grouping animals by size, weight, and age, as opposed to grouping by litter. This practice has helped the producer get more uniformity out of his animals. It is not uncommon to see producers who will change the configuration of animals three to four times during the first six month life cycle. This changing of the "pecking order" evens out growth rates and enables the producer to have a larger number of his animals ready for market (approximately 200 to 225 pounds) at the same time. This is important for the producer so that he can: 1.) capitalize on the best market with more animals if that market requires extensive transportation and, 2.) ease his scheduling through his system by bringing the timid, more docile animals to market at the same rate as the aggressive animals. This has been made possible by the general nature of confinement, in that, the animals are controlled in pens that allow for the transfer of animals from one group to another.

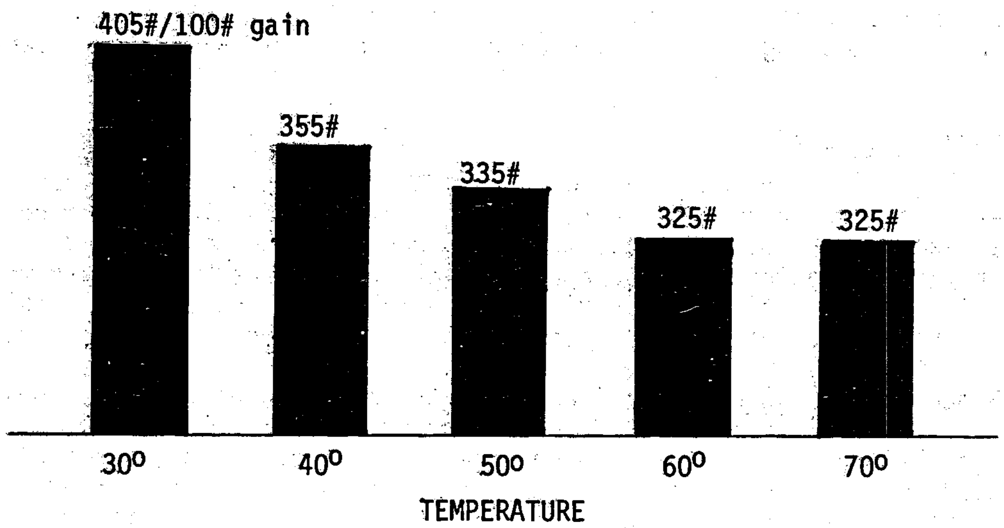
Open-lot or non-confined housing does not adapt itself to such movement. The lot is, for economic reasons, sized to handle larger groups of animals. Perimeter fencing is used rather than small group pens. Labor in sorting, handling, and moving animals housed in non-confined pens exceeds the value returned. For the above two reasons, the end profitability is reduced because the uniformity and time needed to get animals to market is extended by as much as one month. *Producers using confinement are now able to market 85 to 90 percent of their animals within 5½ months as compared to 6½ months, which is the national average for all animals sold in 1977.

FEED COST

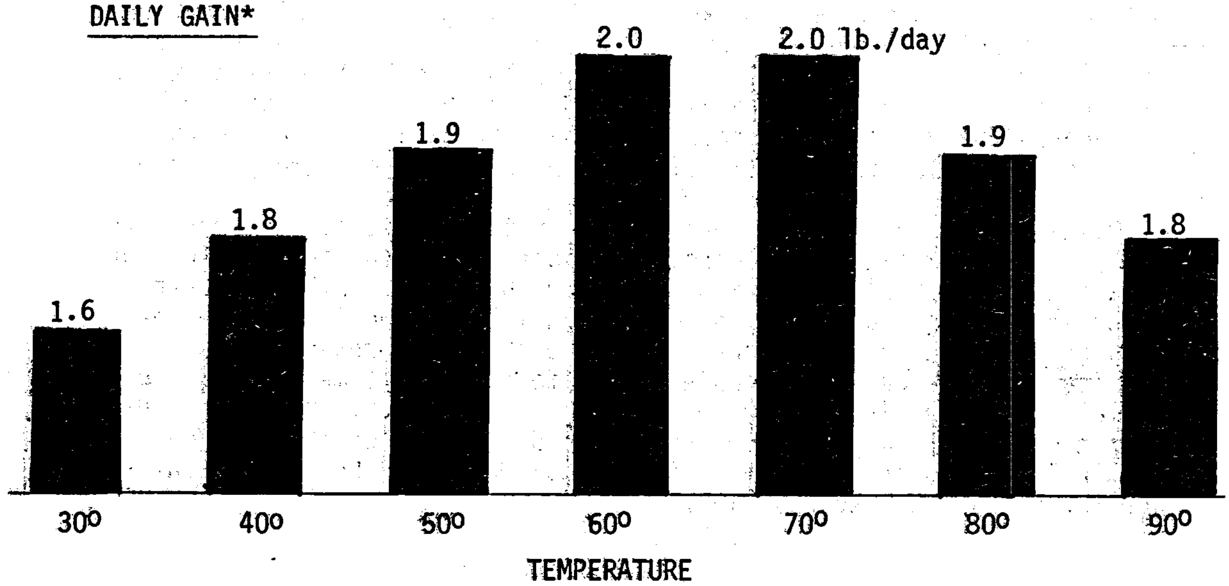
One of the paramount reasons for total confinement must be the feed cost factor. The total feed cost represents 60 to 70 percent of the total production cost. As the following graph visually points out, the amount of feed necessary to produce 100 pounds of gain is a function of temperature.

*National Pork Producers Statistic
J. Marvin Garner, Secretary

FEED EFFICIENCY*



DAILY GAIN*



*For Swine, from American Society of Agricultural Engineer's Yearbook

As we see a decrease in temperature, we see an increase in feed necessary to produce body weight due to the fact that more feed is required to maintain body function. As we increase the temperature above 70°, the daily gain begins to decline because of the temperature effect on swine. The swine animal's physical characteristics prevent him from dispensing body heat by sweating. The animal, therefore, does not do any activity that would increase his body temperature, including getting up and eating. If, however,an environment can be created that will take steps to control both the effects of extended cold to prevent the loss of feed used for the purpose of maintaining body heat and the effect of heat and the animal's discomfort, we can reduce time to market and amount of feed necessary. This is critically important when we see feed costs of 3.5 to 4 cents per pound as few as eight years ago to 6.5 to 7 cents today. This has necessitated a change in building design, as well as original confinement

To illustrate the feed cost savings that can be accomplished, take a typical gestation example. Iowa State University recommendations for feeding during gestation saves eight pounds of feed per animal per day; yet this is to maintain the sow, provide for enough energy to produce a litter and allow for the fact that certain aggressive animals will eat more than the timid animals. At the same time, research has projected that four pounds per day per animal is adequate to take care of maintaining the sow and producing pigs, if the enviromental and social problems can be eliminated. If we take a group of 600 sows as an example, assume a 114 day gestation cycle, we see a feed cost difference of $2736 per gestation cycle.

Facilities that had little or no insulation were little more than windbreaks and shades. Today's systems have ceiling insulation with "R" factors of 25 to 30 and side wall insulation with "R" factors of 12 to 18 to control the heat loss in winter and prevent heat buildup in the summer.

DISEASE CONTROL

The swine animal has a very low disease resistance factor. Such common swine diseases as T.G.E.,Pseudorabies, and bloody scours have, in many cases, killed nearly the entire herd or youngstock population. Cures and vaccines are possible when an outbreak is first detected; this, however, is costly (in some cases as much as $1.50 to $2.00 per treatment per head) and very time consuming. This also slows down the growth cycle of the animals, thus increasing the feed necessary to get animals to market and time required to do so. Since many of these diseases can and are transmitted by rodents (such as field mice, rats, skunks, squirrels), as well as by birds (such as sparrows, pigeons, etc.), it is nearly impossible to halt a disease outbreak once it occurs.

Total confinement, however, helps eliminate some of the dangers of disease outbreaks by confining the animals into enviromentally controlled buildings those rodents, birds, and even human visitors are controlled and isolated from the animals. Many such confinement buildings are locked to outside guests unless they are willing to shower and change clothes before entering. Facilities are also designed to that segments of the total facility can be isolated and separated from the rest should an outbreak occur.

Total confinement also helps accelerate a treatment program should a disease outbreak occur. This is done two ways. 1.) By confining the animals, it becomes much easier to facilitate treatment. Nearly 70 percent of the labor in treating animals is getting the animal penned so they can be treated. This is eliminated by having the animals already confined. 2.) Because of the nature and design of confined housing, once the disease has been controlled, it is much easier to clean and disinfect this type of housing and restock.

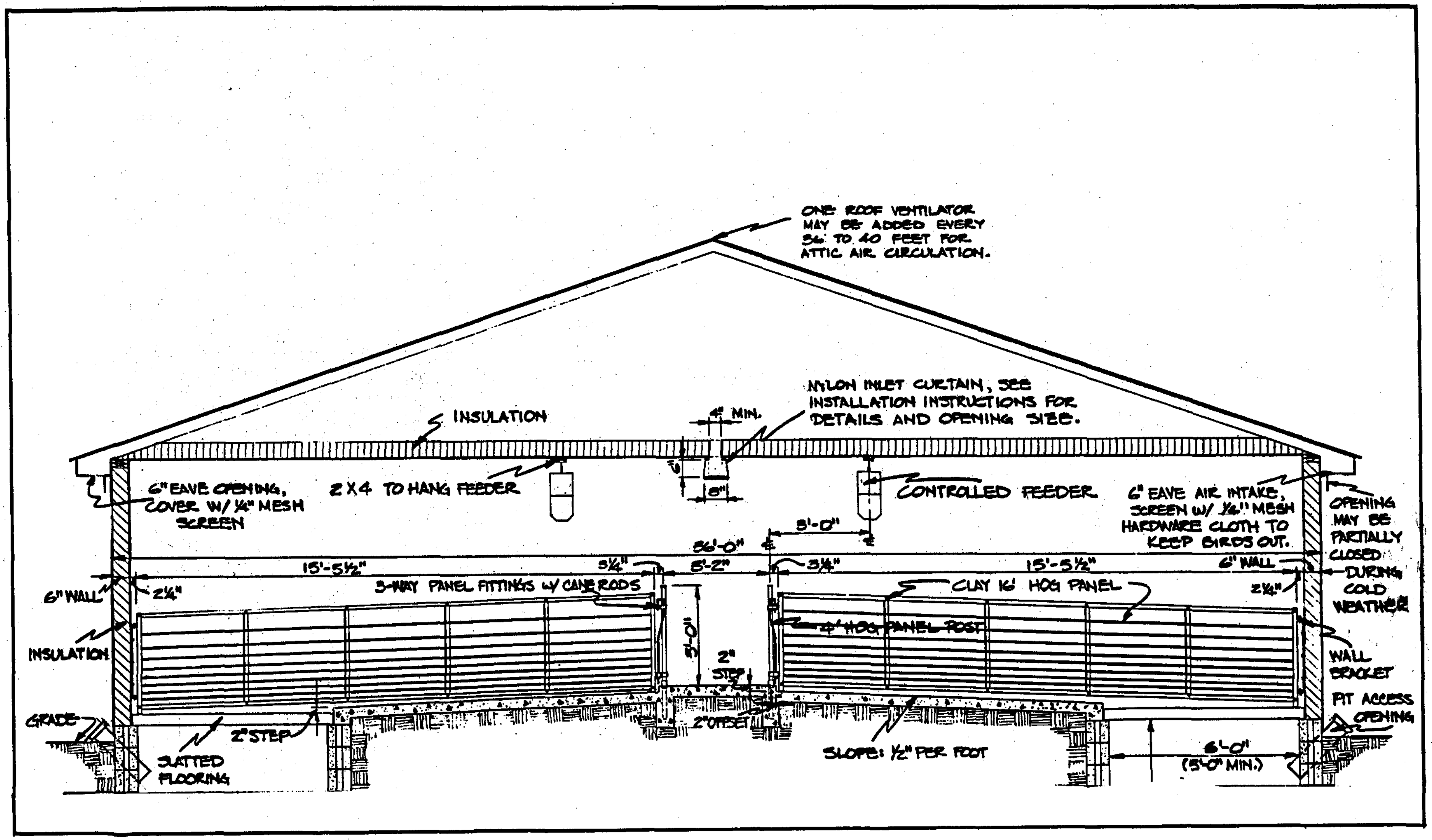
Open-lot facilities sometimes cannot be restocked for a period of up to one year because viruses are capable of laying dormant in the soil for long periods of time, thus requiring either a new facility or abandonment of the building for a long period of time.

BUILDING DESIGN - SPECIFIC LAYOUT (State of Art)

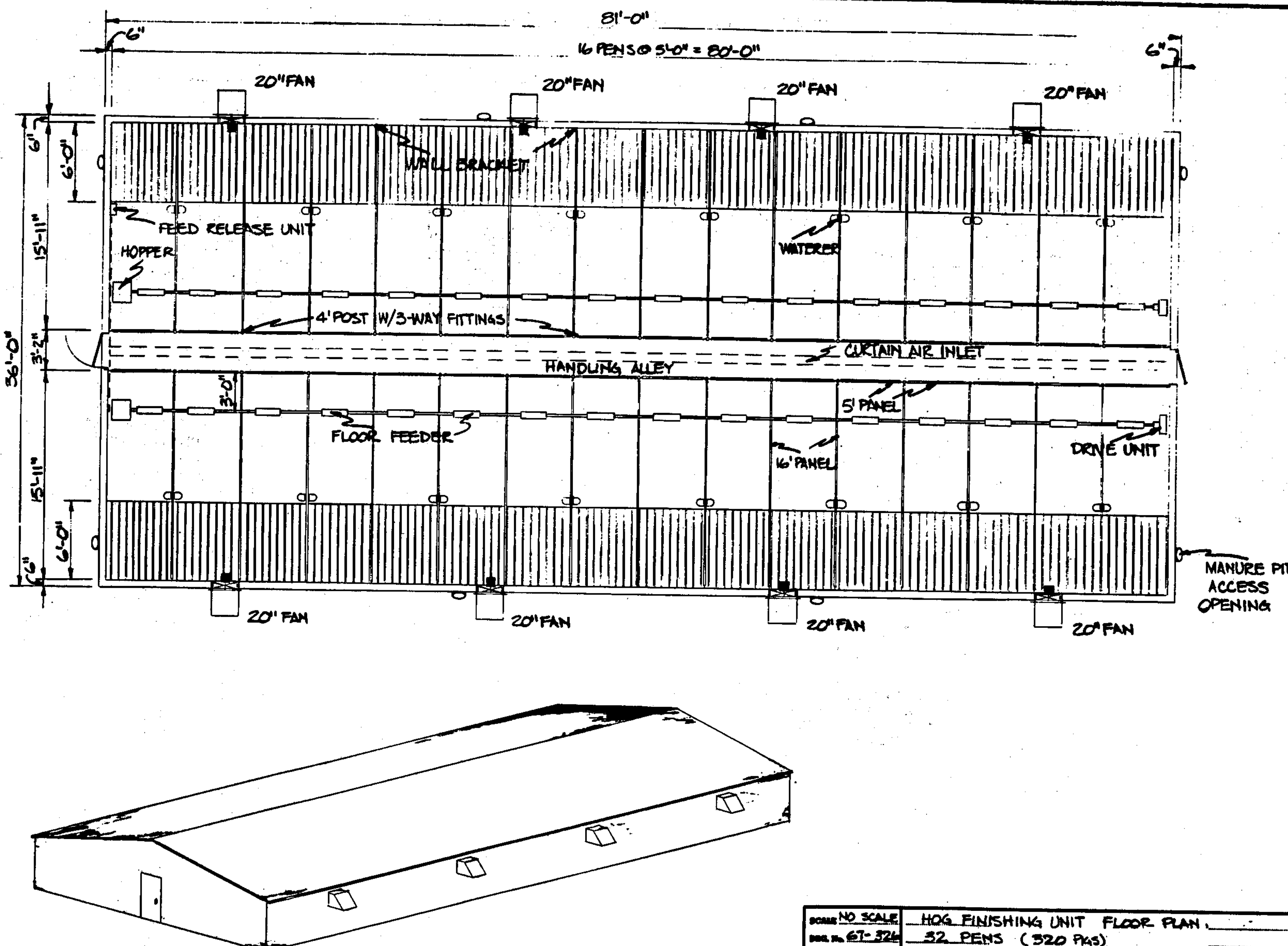
Since the beginning of confinement, the state of art has drastically changed. In the early stages of confinement facilities, we planned with provisions made for approximately 18 to 20 square feet; today facilities are planned for around 7.5 to 8 square feet. This represents a vast technological change, as well as a considerable cost savings in overall building costs, i.e., less than one half the number of square feet needed for same animal.

The social interaction and animal habits make the design of the building critical. If we are going to: 1.) reduce labor and, 2.) maintain or improve animal growth performance, then the animal characteristics are very important.

The following is a general floor plan and layout of a typical finishing unit.



GENERAL FLOOR PLAN, TYPICAL FINISHING UNIT LAYOUT



SCALE NO SCALE	HOG FINISHING UNIT FLOOR PLAN
DWG. No. 67-326	32 PENS (320 PIGS)
DRAWN BY BAST	CENTER HANDLING ALLEY (OUTSIDE PITS)
CLAY	CLAY EQUIPMENT CORPORATION, Cedar Falls, Iowa FORT WAYNE, IND. BINGHAMTON, N.Y. MORTON, ILL.

DATE 6-12-67
REVISED 8-29-67
11-6-67, 7-11-68
12-6-71, 10-15-?

Confinement design changes aid in labor and clean up time. The designs of buildings such as the one pictured have advanced to the point that the feeding system is included in the critical design criteria. The drop feeding system eliminates space requirements of conventional feeding systems and also helps eliminate clean up time in the pens. It is just one example of a technological change that is critical to building design.

The extent of specialization has even been recognized by the Federal Tax officials and Congress in the Investment Credit Law that just passed. This provides for investment credit of 10 percent for the entire facility because this facility is so designed that the building could not be used for any other purpose than the confined housing of swine.

These are then some of the background reasons and the trends that have led to total confinement. As the trends and reasons developed, different segments of the life cycle of animals were viewed separately and the confinement buildings were designed with the critical problems and goals of each segment in mind. What follows is a brief look at these individual segments - gestation, farrowing, nursery, finishing and a review of why the design is the way it is.

GESTATION

The goals of the gestation system are to produce the maximum number of large healthy pigs, with a minimum of labor and a minimum of feed cost (not underfeeding).

In order for the sow to farrow the maximum number of large, healthy pigs, the facility must provide the proper environment for the sow, so she will reach her genetic potential. The phrase "proper environment" should include nutritional management in order for her to realize this goal. However, this discussion will only deal with the buildings and equipment, not the ration fed.

The total confinement gestation system is designed to maximize sow production. Total confinement reduces the stress put on sows caused by mud, extremes of cold and heat, wind, rain, and snow. The sow herd is cleared of soil-borne parasites. Confinement reduces handling and feeding labor. The system makes it easier to observe the animals for heat detection and disease control. The pasture is freed from sow grazing and can be utilized for crop production.

The environmentally controlled building helps control the temperature and humidity in the building to provide a comfortable environment for the sows and operator. The feed requirements of the sow is reduced by controlling the temperature. Proper ventilation prevents any large heat buildup above outside shade temperature. Proper insulation will reduce condensation, control heat loss in winter and heat gain in summer. The well-designed ventilation system will help control odors and increase the lifetime of the building.

Most producers are quick to see the advantage of limiting the feed intake to sows, but most only go half-way with the solution. Many producers provide the correct amount of feed to a pen of sows and allow the sows the opportunity to compete for their fair share. The overall result is a better conditioned sow herd than when full feeding, but underfeeding of those sows not capable of competing for their fair share. Sows and gilts which become too fat during gestation are likely to have some of the following problems:

1.) Reproductive performance being reduced due to breeding problems.
2.) Fewer pigs farrowed.
3.) Farrowing difficulties experienced.
4.) More crippled sows in herd.
5.) Shorter reproductive life in the sow herd.
6.) Higher feed costs.

Sows should probably not gain more than 0.75 pounds per day, and gilts no more than 1.00 pounds per day during the gestation period.

A quick comparison of feeding levels illustrates the tremendous potential for feed cost savings.

- 720 sows eating ten pounds per day during 114 day gestation period consumes 820,800 pounds of feed.
- 720 sows eating four pounds per day during 114 day gestation period consumes 328,320 pounds of feed.
- at four cents per pound of feed, the feed savings per gestation period is 492,480 pounds x 6¢ per pound, or $2954.88.
- this means that for two such periods per year, a savings of $5909.76 may be realized.
- if 10,800 pigs are produced from these sows, the resulting savings is $5.47 per pig marketed.

Electric sow feeding stalls are designed to automatically control the sow feeding operation. All of the sows are fed an equal amount at the same time. The stalls are designed to control all sows so they will eat at equal speeds. In this manner, the "boss" sow finishes eating her share at the same time as the timid sow. Therefore, each sow receives her fair share. The system can be designed for easy operation and requires a minimum of labor.

Now look at the gestation building plan. The small groups of nine sows per pen reduces the stresses of sow fighting. Each sow has her own feeding stall to further reduce possible sow fighting. By reducing possible fighting between sows, less stress is placed on the sows. Stress of any kind can cause the loss of a baby pig during the gestation period. The necessity of a proper gestation system can be illustrated by a sow's average production. Presently a sow will ovulate 16 eggs, of which fifteen will be fertilized. But only 10 to 12 pigs will be born. Therefore, for maximum genetic potential, maintain a constant control over the environment with a minimum of stress on the sows.

FARROWING

The farrowing building is the hub of the swine enterprise. The goal of the farrowing building is not only to keep the sow in a comfortable environment, but to provide the proper environment for the most critical period of the baby pig's life. The number one objective is to wean the maximum number of large, healty pigs with a minimum of labor (not management).

The toal confinement farrowing unit minimizes weather extremes detrimental to the sow and small pigs. The confinement unit allows for a reduction of handling, cleaning, and feeding labor, while providing easy observation of the sow and litter (management duties). The sows and litters are cleared of soil-borne parasites and maintained in a near-optimum environment.

Environmental control is a necessity in the farrowing unit. To obtain an optimum 60° temperature for the sow and 90° temperature for the small pigs, proper ventilation and supplemental heat are required to keep the small pigs at optimum temperature. Use of brooder heaters or heaters in the floor must maintain the 90° pig creep while allowing the rest of the building to remain comfortable for the sows and operators. Additional heating, other than creep heaters, may be required to maintain a 60° building temperature.

TABLE II. BABY PIG LOSSES*

	CAUSES OF BABY PIG LOSSES
CRUSHED BY SOW	49.3%
FARROWED DEAD	16.3%
CHILL	9.0%
STARVATION	6.0%
EATEN	4.7%
TOO WEAK (LIGHT BIRTHWEIGHT)	4.3%
SCOURS	1.0%
OTHER	9.4%
	100.0%
	WHEN LOSSES TAKE PLACE
FIRST WEEK	56.2%
SECOND WEEK	15.1%
THIRD WEEK	8.3%
FOURTH WEEK	6.3%
FIFTH WEEK	4.4%
SIXTH WEEK	3.4%
SEVENTH WEEK	2.9%
EIGHTH WEEK	2.4%
	99.0%

*University of Nebraska Research

Farrowing stalls are a must to reduce the number of baby pigs crushed by the sow. Stalls require less floor space than pens, and can contain the most rambunctious sow, reducing possible injury. All feeding and watering can be done in the stalls for additional labor savings.

Automatic waterers provide clean, fresh water to the sow and litter at all times. Easy adjustment of the water flow conserves water but meets the large sow's needs. The small pigs also learn to drink from the farrowing stall waterer.

NURSERY

The nursery building is very often overlooked in the swine enterprise, but the nursery allows the most flexibility when scheduling becomes critical or difficult. The goals of the nursery unit are to insure the proper environment for the small pig, to ease the schedule of the farrowing and finishing building, and to do so with a minimum of labor.

The small pigs are totally confined to minimize the stress caused by extremes in weather. These stresses can have a severe effect on rate of gain and feed efficiency on the small pigs. The small pigs are easier to observe in confinement, and feeding, cleaning and handling labor is reduced. Soil-borne parasites do not hamper the small pigs and the pasture area not used by the pigs can be utilized for crop production.

An environmentally controlled unit is important since the small pig requires temperatures of 70° to 80°. Increases in rate of gain and improved feed efficiency can be expected by controlling temperature and humidity. Proper ventilation and insulation reduces condensation, while better controlling heat losses in the winter and heat gain in the summer. The ventilation system should control odors and increase building life. A proper environmentally controlled system will benefit the operator, as well as the small pigs.

Looking at the nursery plan, the small pigs are placed in five foot by ten foot pens. The small pens reduce the amount of mixing required when pigs are first brought into the unit. Typically two litters can be placed in one pen. Sixteen to twenty pigs per pen allows the animals 2.5 to 3.0 square feet each.

Automatic waterers are provided for each pen of pigs. This insures a clean, fresh supply of water for the small pigs, with no more than 20 head per bowl. The water bowls are easily adjustable to control the water flow. The same bowl is used in the nursery as was used in the farrowing stalls to prevent loss of water when pigs are moved. The automatic waterer is the same so the animal does not need to relearn where to drink.

The slotted floor should cover at least half the floor to insure a clean, dry area for the small pigs. The pens stay clean to provide a warm, dry area for the pigs.

The nursery building provides the flexibility in the farrowing and finishing units needed for tight fitting schedules. Extra space can be realized for the small pigs at relatively low costs because of the small area required for the small pigs.

FINISHING

The swine finishing unit must be designed to allow the hogs to perform at their maximum genetic ability. The unit must allow the hogs to achieve maximum daily gains with optimum feed efficiency. This should be accomplished with a minimum of labor.

The animals are placed in total confinement to minimize the stress caused by mud and extremes of cold, heat, wind, rain, and snow. Minimizing these stresses increases the rate of gain and improves feed efficiency by reducing the animal maintenance requirements. The hogs are cleared of soil-borne parasites and the pasture area saved by confining hogs can be used for crop production. Confining the animals to a concentrated area makes them easier to observe and reduces handling, cleaning, and feeding time.

An increase in rate of gain and improved feed efficiency is realized by controlling the environment. The environmentally controlled building held at the optimum 60° to 70° should prevent prevent condensation with proper insulation. Utilizing the insulation with proper ventilation will control heat loss in the winter and heat gains in the summer.

The animals are placed in long, narrow pens.—The five foot by sixteen foot pens will provide a logical place for the pigs to feed on the solid floor, upper end, and a place to dung on the slotted floor, lower end. If the same 16 to 20 pigs are moved from the nursery pen to the finishing pen, no stress is placed on the small pigs due to mixing. As the hogs become larger, they can be separated into two pens to meet the space requirements listed in Table III.

TABLE III. SLOTTED FLOOR SPACE REQUIREMENTS*

PIG WEIGHT	WINTER	SUMMER
25# - 40#	3 Sq. Ft.	3 Sq. Ft.
40# - 100#	4 Sq. Ft.	4 Sq. Ft.
100# - 150#	6 Sq. Ft.	6 Sq. Ft.
150# - 210#	8 Sq. Ft.	9 Sq. Ft.

*Midwest Plan Service

The controlled floor feeding system is designed to automatically drop a pre-determined amount of feed on the solid floor. The system should not be set to limit the amount of feed the pigs each receive, but to control the amount of feed wasted.

The controlled floor feeders are hung from the ceiling to eliminate animal damage, allow easy operator adjustment, and provide all pen space available for the hogs. See the comparison of floor feeding versus self-feeding in long, narrow pens below:

TABLE IV. COMPARISON OF FEEDING METHODS*

CRITERIA	SELF-FED	FLOOR FED
Daily Gain	Slightly Faster	Slightly Slower
Feed Efficiency	Slightly More Eff.	Slightly Less Eff.
Days to Market	Fewer	More
Feed Intake	More	Less
Backfat	Increased	Decreased
Carcass Grade	Poorer	Better
Pen Condition	Dirty	Clean
Cleaning Time	Higher	Nil

*Iowa State University, Ames, Iowa

Although average daily gains may be slightly higher for self-fed hogs, careful adjustment allows close to full feeding. In the experiment listed above, there was no feed wastage from the self-feeders, as all wasted feed was scooped up and put back into feeders. With cleaner pens and better carcass grades, a more profitable swine enterprise could be realized with the floor feeding system.

The floor feeding system goes hand-in-hand with partially slotted floors and liquid manure handling. The hogs can be easily trained to dung on the slotted floors when fed on the upper end of the long, narrow pens sloped one half inch per running foot. The pen arrangement eliminates bedding and the spreading of bedding, while keeping the pens and hogs clean.

CONSLUSION

The evolution of confinement is not over, many changes are occurring everyday. This status report is an attempt to show where we are today, how we got there, and why.

APPENDIX B

SPROUTED GRAINS IN NUTRITION AND METABOLISM OF LIVESTOCK FEED

Richard H. Matherson

Introduction

The roles of Nutrition and Metabolism in animals are critical to the proper formulations of livestock feeds. Yet the understanding of these factors is a relatively recent event in the field of agriculture. Nutrition is defined as the interrelated activities or processes by which plants and animals take in and utilize food materials. The more specific areas of how this is accomplished and the factors relating to the foods ingested by the body of the animal are of prime concern. Metabolism is specifically defined as the elaborate biochemical process of assimilation which occurs in the plant's or animal's digestive system. It is the intent of this paper to bring to light pertinent current views and to broadly review some of this scientific data, relating to the understanding of nutrition and metabolism in the context of livestock feeds.

The past few decades have shown many new advances in the food industry. Major processing changes have occured in the freezing, cooking, dehydration, and preservation of food, in general. These new developments have, in turn, opened new areas of understanding related to nutrition and the metabolism of food. When the frozen vegetable industry began, there was much concern that newly frozen vegetables were not as good as fresh vegetables. The public soon realized and accepted the convenience of frozen vegetables. During the years to follow, there have been constant improvements on freezing techniques as well as packaging and storage improvements. These improvements have provided an end-product that is far superior to the frozen foods of earlier years. A similar trend has occured in the dehydration industry. Vegetables with low solids which were previously dehydrated have now been replaced with vegetables four to six times greater in solids. This has resulted in a considerable increase in the nutritional value of the vegetables (on a dry weight basis). Most processed foods for both humans and animals have improved in nutritional quality, shelf-life and economy. Increased food costs, consumer advocate groups, as well as the national news media, have caused the public to become aware of the nutritional value of food--and the food industry, in general.

Nutrition has become an important buzz word in the American Society; a subject of considerable controversy as well as interest to industry, government and the average consumer.

More research has been conducted on animal feed requirements than on food for humans. This is logical as an animal, by nature of our society, is a better research vehicle. The National Academy of Science has published numerous books on the Nutritional requirements of the various animal groups. In Nutrient Requirements of Swine, published by the National Academy of Science, it states: "When breeding stock or 'growing-finishing' pigs are maintained in complete confinement, all nutrient requirements must be met from the feed. The animals have no access to pasture or other nutrient sources." This statement makes the assumptions that supplemental materials will have to be used as well as that the animals were being fed dry food. This consideration of only dry feed warrants review and is a key item of discussion in this paper.

Discussion

In order to present a logical discussion on the subject of nutrition and feed, it is advisable to define a few terms that are commonly used in the industry:

Amino Acids = A group of organic compounds...which are basic constituents of protein.

DE = Digestible Energy

DP = Digestible Protein

Dry Matter = The portion of a feed or food material that is present after all free moisture is removed from the material.

Enzymes = Those particular proteins produced by living organisms that are specifically required for proper digestion and metabolic processes.

Lignin = The organic substance which, with cellulose, forms the chief part of woody material of a plant. Animals generally do not digest this material. However, the gut of a worm will digest this material.

ME = Metabolizable Energy -That part of the energy source which is completely useable.

NFE = Nitrogen Free Energy (that feed constituent which is obtained from sources other than amino acids or protein).

Protein = A substance thought to be the essential nitrogenous component of all organic bodies.

T.D.N.(TDN) = Total Digestible Nutrient. The combined completely digestible portion of the feed or nutrient material.

TP = Total Protein. The summation of the complete protein present in a feed material. It should be noted here that TP does not imply that it is the total amount of protein that is useable; but the total present.

A review of the literature on animal feed formulation will reveal that the normal procedure is to base feed requirements on a dry weight formulation. This is, basically, a logical procedure to follow as this compensates for the various moisture contents of the material being formulated, and makes calculations easier to handle. This, however, does not present the complete picture of the elements present in a feed substance when it is being fed to or used by the animal.

The easiest way to discuss this subject is to take a common analysis tag off a bag or lot of feed and review the label. The writer would like to show how misleading an analysis tag can be. (An animal nutritionist would require more data than that listed on the tag.) Such a tag, taken from commercial feed, reads as follows:

Crude Protein not less than 18%
Including not more than 8% non-protein Nitrogen (UREA)
Crude Fat not less than 1.5%
Crude fiber not more than 22.0%
(Minerals & Vitamins are next listed)
Ingredients: 30% Ground rice hulls
Alfalfa Meal
Bean Meal
Cane Molasses
4% Betanite
8% UREA

A nutritionist will have to determine separately the Digestible Protein (DP) as well as the Metabolizable Energy (ME). If one were to trace this feed through the digestive system of an animal, one could determine the amount of protein actually assimilated and that amount eliminated, unused, as manure. The animal's intestinal bacteria will assist in the formation of a higher grade useable protein which is eliminated than the original grade of useable protein ingested. In this case, the commercial feed protein is present in the intestine, still in a pre-digested form because it is broken down too slowly for absorption and, hence, eliminated. The point being: a protein may be listed on the label and may be confirmed by chemical analysis, but may be present in a form not readily useable by the animal. Hence, nutritional research and ultimate feed formulation requires consideration of the total protein intake, the total blood protein present in the animals being fed, and the total protein eliminated in the manure after digestion has occurred. For proper use and effective formulations, more definitive labeling practices will be required.

Mineral supplements currently on the market are so compounded that there is no assurance that the amounts originally included in the supplement and stated on the label are actually present in the feed at the time of the feeding. Most organic nutrients, especially vitamins, are unstable when commercially manufactured, premixed and stored in the presence of high levels of mineral supplements. However, when a high-quality fresh material, such as sprouted grains, is incorporated into the feed, on a daily basis, the vitamins, minerals and enzymes are locked in through a natural biological process.

C.E. Sasse, senior swine nutritionist, (Animal Nutrition & Health, July, 1978) and others state that feed should be based on available amino acids present and not on the percentage of protein, as the latter is misleading.

Protein in plants and animals is a combination of amino acids bound together in a chain fashion. Such amino acids are classified as essential (those which must be supplied in the diet) and non-essential (those which can be synthesized by the animal).

To date, the major swine-raising areas in this country have been in the Midwest. In this region, the predominant feed has been corn. Hence, many nutritional formulae and feeding programs are based on corn as a primary constituent. Dick Carlisle, at the University of Illinois, has been studying the reduction of protein costs through the use of other protein sources. He states that other constituents such as soybean meal, wheat, barley (when available), and more pasture protein should be used. Lysine should also be included. Universities at Illinois, Indiana, Ohio and Iowa have been reviewing swine nutrition and have published similar comments on the use of products other than corn as the major feed source. Duckworth, Hepburn & Woodham, at Rowett Institute, Bucksburn, Aberdeen, have shown that protein extracted from young wheat leaves was equivalent to white fish meal for newly-weaned pigs. They have done extensive research on the use of extracted grass juice diets for swine and have shown that the lysine (an amino acid essential for proper digestion) levels are higher in the natural source than in prepared feeds. They also showed greater weight gains and a leaner pork in the animals given a pasture grass juice supplement.

Other feed materials should be looked at beside corn for the feed of swine and other animals in the western and northwestern areas of the United States. Swine Science, (Ensminger), states that barley ranks in importance among U.S. grain crops and is the world's most ancient and most widely-grown cereal. He further states that barley, as compared with corn, contains somewhat more protein and fiber. The Nutritional Tables, "Composition of Feeds Commonly Used," in the National Academy of Science publications, indicate that the average protein level of barley is generally 2% higher than that of corn. Gordon M. Reistad, Oregon State University, in his publication on Geothermal Fluids in the Klamath Basin, Oregon, (Bulletin No. 55, March, 1978), points ou that 80% of the barley which has been produced in this country has been grown in the Midwest, but that in recent years barley production is moving to the West, including the states of Idaho and Oregon. Hence, consideration of the use of this product in livestock feeds is both nutritionally sound and geographically economical. Reistad further states that barley sprouts can replace the protein concentrates required in growing-finishing and sow rations, and that barley sprouts can replace one half of the commercial feed mix. His studies were based on the use of a commercial feed mix at $165 per ton as compared with barley sprouts at $94 per ton.

Environmentally-controlled growing of barley sprouts, grown in commercial equipment in the United States, is being accomplished at a 1978 cost of $56 to $60 per ton in California, Colorado, Wyoming, Illinois, New Hampshire, Florida, and Arizona. In addition, modern systems are producing sprouted barley for feed formulation in Canada, Iran, Japan, France, England, Germany and Africa.

Environmentally-controlled growing facilities are a modern form of a phase of hydroponic culture. These systems can be traced back to 1699 and an English scientist by the name of Woodward. Other literature indicates that a variation of such growing conditions dates back to the Babylonian days. The actual use of sprouted cereal grains and grasses developed in the Scandinavian countries about a century ago. Such sprouted grains were utilized during the winter for dairy cattle in order to keep milk production up and also to flush the dairy cow prior to breeding.

Harvestore (Pacific Harvestore Ltd., Abbotsford, British Columbia) has conducted tests which show that high-moisture barley sprouts, when used as a feed constituent for livestock, result in an increased digestibility of the total feed material. The tests indicate a better feed conversion than that obtained from feeding dry barley. The University of Wisconsin Agricultural Experiment Station has shown that the nutritive value of sprouted green grass reaches its maximum at about 7 inches in height. Calcium, Phosphorus, Potassium, and Protein are at higher levels than in the mature plant. At the Wisconsin Research Foundation, Research Department No. 4, a comparison was made between oat grain and sprouted oat grass. Research results show that an increased level of protein occurs in the sprouted grain (compared on a dry basis). Fat levels, and many of the vitamins such as "A", "E", "C", and "B" were found to be at higher levels in the sprouted grains than in the unsprouted grains. Enzymes and Trace Minerals were also noted in the green grass phase of early growth. This parallels work done in the Malting industry. It is known that sprouted barley produces enzyme activity available for biochemical digestion that is not present in the unsprouted grains or in the mature grass pod, according to Reistad. Feed efficiencies and feed conversions have been improved by feeding swine such sprouted material (Reistad, Schmisseur, Shay, Fitch -Oregon State University). Dr. Paul Burkholder (Yale University) has done significant work on the nutrient value of sprouted grains. He has found that the increase in vitamin value is dramatic at around five days of sprouted growth. The magnitude of increase will vary from 100% to 200% depending on the particular "B" complex vitamin analyzed. Dr. C.W. Bailey, of the University of Minnesota, has duplicated this work with equally significant results. Drs. Chattopadhyay and Banerjee,of President College in Calcutta, India, have also noted significant increases in choline (the lipotrophic agent which helps keep fat stable in the body and which is necessary for firm textured meat). Significant work done by Drs. Graves and Miller (Agricultural Experiment Station, Beltsville, Maryland) has concerned fertility improvement of livestock through the use of sprouted grains as a feed constituent. T.W. Perry, R.A. Pickett, and R.J. Hiller (Purdue University, Research in Hog Production) have done some interesting evaluations of pregnant gilts (young sows) under confined conditions. Their studies were related to the need for certain quality green elements present in alfalfa meal and/or hydroponically-grown grass. Their studies showed that both the average birth weight of the pigs and the number of pigs born per litter was increased by feeding sprouted grains during pregnancy. To date, analysis of these young grass plant (sprout) juice factors is not complete. Researchers define the difference as an "X" factor in sprouted grass juice (liquified sprout plants). Studies conducted by government researchers in the Department of Agriculture,show that white rats on diets relatively rich in protein will die if the "X" factor is missing from these diets. They will live, thrive, and grow, on the same diet, if it is supplemented by the "X" factor. This "X" factor may be comparable to the exact mineral content of blood which cannot be determined in a laboratory, nor be artificially synthesized for transfusions, but which must be produced in a living being; just as the grass juice "X" factor must be produced in a growing plant.

Dr. George Kohler, of Cerophyl Laboratories (Kansas City), has reported that it will be many years before the chemical nature and physiological importance of the unidentified factors in grass are fully known and understood. What is essential is that adequate amounts be included in livestock and poultry rations. In addition to the "identified vitamins, green vegetation is an excellent source of a variety of unidentified vitamins." To quote from Dr. M. E. Ensminger, Ph.D., noted nutritionist:

"Unidentified Growth Factors" include those vitamins which the chemist has not yet isolated and identified. For this reason, they are sometimes referred to as the vitamins of the future. There is mounting evidence of the importance of unidentified factors for both man and swine. Among other things, they lower the incidence of ulcers in each species...they appear to increase growth and improve feed efficiency and breeding performance when added to rations thought to be complete with regard to know nutrients. Unidentified factors appear to be of special importance during breeding, gestation, lactation and growth."

Albers Feed (owned by the Carnation Company) has recently released a specialized horse feed. Their literature and research information provides some data that is timely to this review. The nutritional and metabolic data is equally valuable in other animal groups. They quote: "Conventional feeds start with corn and oats as a base which is a 12% low quality protein." This is compared to malt sprouts with a high quality digestible protein of 32%. The digestibility of sprouted grain is emphasized." Their nutritionalists emphasize that the quality of protein in oats and corn is not good. "Stockmen knew years ago that certain feeds produced what they termed 'soft flesh' and other feeds produced 'hard flesh." (Cattle being fattened for Grand Champion status were fed barley). They further emphasize and quote the United States Department of Agriculture comments relating to soft flesh of cattle. This is compared with the hard flesh of cattle and livestock when fed barley. It is quoted that "Corn and oats, which have considerably more fat than other grains, have some tendency to softer flesh. Oats have a more marked effect than corn while barley, wheat and rye produce hard flesh."

The writer has recently reviewed the ingredient and nutritional composition of numerous commercial swine feed formulations for the Western United States. The general base line for comparison, in the past, has been the Iowa, Ohio and Missouri corn-fed hogs. It is of interest to note that nutritionally adequate feed formulae are presently being used in the Western United States, derived from ingredients readily available in the specific geographic locations observed. Barley, wheat and other grains are more available in the West. Corn is also available and should be blended for its nutritional and economic value when the formula so demands.

The eastern hog belt's swine industry generally feeds corn. The farmers have been educated to believe that this is the only feed. It is interesting to note that barley and other grains are not geographically as readily available to them. From a nutritional evaluation, what would their attitude be if other grains, such as barley, rye and newer varieties of Triticale, were more accessible to them?

An example for future interest is the current seed development of Siskiyou, California: Triticale. It may be of interest in the future as this variety has exceptionally high levels of natural lysine (an amino acid of special importance to proper swine and poultry nutrition). Current trials indicate that has a potential for use in Northern California areas (California Agriculture, page 4, September, 1978.)

In the book, Forages, by H.D. Hughes, Iowa University; M.E. Heath, Purdue University; and D.S. Metcalfe, University of Arizona, the co-author, Reid, states that early spring grass has a TDN (Total Digestible Nutrient) value of 70-80%. After the harvest of this first cut, the TDN value of after growth is much lower; on the level of 60%. That same cut, during the same season, in a drought, can drop the TDN to 50%. There is also a parallel reduction in the TDN in hay or cut grass after it has been dried and stored for a period of time.

Conclusion:

What is the significance of the above scientific observations? To date, corn is a major feed element of eastern swine operations. However, other food elements should be considered for swine feeding in areas where corn is not economically available. Nutritional data shows that the cereal grains such as oats, barley, soy and other ingredients, can readily augment corn. When properly balanced, they can provide a feed material that is equal to, or better than the eastern corn feeding. There may be a need for some new thinking in the eastern corn-fed areas as future corn harvests are projected more for human consumption, as well as for a source of fuel energy, such as alcohol. The United States federal nutritional feed analysis programs are stressing more consumption of lean beef and lean pork. Therefore, more grass and forage appear to be the future trend. These latter comments are a rephrasing of U.S. Department of Agriculture observations for trends in the immediate future. Hence, a more thorough understanding of the animals' metabolic needs will be required to enable correct selection of alternative feed elements which will provide equal or better conversion factors. Stress is a critical element in any confined swine, poultry, rabbit, or cattle livestock operation. Therefore, a fresh feed that is more comparable to top quality fresh field condition is very important. Compounding of feed elements for livestock can be done through analysis and utilization of by-products that are indigenous to the specific area or location of the feed mill.

Environmentally-controlled growing systems (ECGS) should be considered to achieve improved feed quality, better health for the animal, improved nutritional value to the animal, and lower production costs. Fresh feed constituents, in proper formulation, are capable of providing greater assimilation of feed in all animal groups at lower feed cost, and still provide vitamin and enzyme elements to improve metabolism and produce better weight gains per unit of feed consumed by the animal.

APPENDIX C

FINANCING ALTERNATIVES FOR DIRECT APPLICATIONS OF GEOTHERMAL ENERGY

by ROBERT D. DELLAS, PRESIDENT
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OVERVIEW

The various alternative forms of financing available for geothermal projects are innumerable. The sources of capital range from risk taking entrepreneurs to regulated pension funds. As with all financing, the most crucial concept to fund raising is the perception of risk versus potential rewards. This concept can be encapsulated in the paradox that a lender is most desirous of lending to the entity that least requires it. Conversely, the organization with the greater need to borrow, represents a greater risk to the lender or investor. Fortunately, capital markets can adapt to and reflect these various perceptions of risk in the form of varying interest rates and required potential return on investments.

In addition to the classical supply and demand factors accompanying the capital markets' perception of risk, government policy in the form of tax laws and legislated incentives can often direct investment into areas that might not otherwise attract capital. Direct applications of geothermal energy are presently recipients of such favorable legislation from both the federal and state levels.

Some of the most recent factors that have made investment in geothermal projects relatively more attractive include:

1. An additional 10% investment tax credit (ITC) for "energy property" that is designed to use fuel other than oil and natural gas

2. A clear definition of geothermal energy for exploratory and developmental purposes in the Revenue Act of 1978 including the granting of percentage depletion allowances and current deductibility of intangible drilling costs

3. An apparently aggressive posture by the Department of Energy in implementing the Federal Loan Guarantee Program for Geothermal Energy Utilization.

As these new laws and programs are implemented, review by the Internal Revenue Service (IRS) will ultimately have a determining input on the most appropriate form of investment vehicle for the various levels of geothermal energy implementation. In order to achieve the optimum financing vehicle for each level or step of implementation, it is necessary to segment large projects into sub-tasks that would each have unique financing characteristics. It would be inappropriate and virtually impossible to finance such a project as the Mountain Home Geothermal Project in a single transaction. Instead, the entire implementation project should be segmented into sequential milestones, the achievement of one triggering the commencement of the next. Each segment would be financed separately as the overall risk diminished with each successive accomplishment.

From the financing point of view, the parameters that might help define a particular implementation segment would include the amount of money to be raised for the sub-project, the perception of risk, the prospects for repayment upon successful completion of the sub-project, the time before repayment, collateral or additional security, the experience of the borrower and his underlying creditworthiness.

As a simplistic example, a typical geothermal direct application project might be broken down into a broad chronological sequence of events as follows:

1. Acquire geothermal lease rights
2. Drill for the resource
3. Ascertain the resource and its characteristics
4. Design the plant or application to coincide with the resource
5. Construct the facility
6. Operate the facility

It should be noted that this sequence of events is a theoretical abstract. Actual implementation might begin with a potential user defining his site location requirements before looking for a resource. However, most geothermal projects develop from the resource. The important factor in financing is to breakdown the overall project into component parts according to their financing characteristics, namely, risk vs. potential reward. The risk involved in drilling a well is substantially greater than constructing a plant on a site that has a proven reservoir and definite geophysical characteristics. Consequently, it would be inappropriate to combine the financing of two such endeavors. Different investment situations appeal to different investor types. By creating various investment situations out of a single project, more investment dollars become available through more investor groups whose investment criteria are more easily matched to projects. The important fact is that the financing must fit the situation and the more clearly defined the investment situation is, the easier it is to locate the appropriate financing source.

CATEGORIES OF FINANCING VEHICLES

There are two fundamental aspects of any financial vehicle which must be considered: 1) the program structure or form of organization; and 2) the various tax treatments available, particularly with regard to Federal tax statutes. Selecting the appropriate program structure and tax treatment of a financial vehicle for any particular project (geothermal or otherwise) is greatly influenced by both the size of that project (i.e., the total amount of funds required) and by the profile of the potential investors in that project. This profile would include such information as: the "status" of the investor (individual, corporation, partnership, etc.); the investor's tax bracket and tax requirements; the minimum/maximum amount of funds available from the investor; the minimum return on investment requirements of the investor, both in terms of percentage return and the amount of time the investor is willing to wait for initial cash flow, for peak cash flow and for the total return on investment. Additional, more detailed information would also be required should there be a specific investor(s) in mind for a particular project.

The various program structures availabe for a project are, generally speaking, as follows:

1) Full registration with the Federal Securities and Exchange Commission:

   a) Form S-1. This is a general form for registration of securities (either debt or equity) under the Securities Act of 1933. This requires complete audited financial statements; full review by the SEC in Washington, D.C.; and registration of the offering in the states where offered. There is no limit to the dollar amount of the offering. Basically, Form S-1 is used when none of the following Forms apply.

   b) Form S-2. Similar to the Form S-1, this Form is for start-up, exploratory or developmental companies. This requires audited start-up cash flow statements; review by SEC headquarters; and state registration. The dollar amount raised is not limited.

   c) Form S-18 (Proposed). As proposed, this Form applies to issues of up to $3 million only. Audited financial statements for the past two years would be required and the offering would be reviewed by the appropriate Regional Office of the SEC. As proposed, this Form would not be available to Limited Partnerships.

2) There are exemptions to the Federal registration Forms available, as follows:

   a) Regulation "A". Limited to offerings up to $1.5 million, this is considered a "short form" of registration. It should be noted that the U.S. Congress has authorized an increase in the dollar amount limitation to $2 million, but to date the SEC has not incorporated that change in its regulations. No audited financials are required and the Reg "A" is subject only to review by the Regional Office of the SEC. State registration is still required, however.

b) Rule 146. This is considered a "private offering" and is not subject to SEC review as long as a number of restrictions are strictly adhered to, including no advertising; a maximum of 35 investors; and restricted resale by the original purchasers. The offering must be either registered in the states where offered or meet a state's exemption qualifications. It should be noted that a number of states impose more restrictive conditions than Rule 146 on "private offerings", including restrictions on the number of offerees, the retention of stock holdings of initial investors in escrow, etc.

c) Rule 147. Similar to Rule 146 in that it is an exempt offering with regard to the SEC, this is an "intrastate" offering, meaning the offers of sale, the purchases and the operations of the business all must occur within the confines of a single state. The offering still must be registered with that particular state and thus is considered a "public" offering within that state. Like Rule 146, there is no dollar limitation to such an offering.

With regard to the tax treatment of the various investment vehicles available, there are basically two approaches:

1) Partnerships, both general and limited, whereby the profits and losses of the venture pass through to the individual investors, who are then responsible for reporting such profits and losses on their own tax returns. Losses are, however, subject to the IRS "at risk" rules, meaning that aggregate losses declared by an investor cannot exceed the capital contributions plus debt for which an investor is personally liable.

2) Corporations, which are treated as separate tax entities. All profits and losses generated by the business venture are reported on a corporate tax return and do not flow through to the investor. Any dividends paid by the corporation out of profits to the investors must be reported by the individual investors.

   A corporation may elect a "Subchapter S" status, whereby profits and losses do pass through to the investors (similar to a partnership). The "Sub S" corporation is also subject to IRS "at risk" rules, and there are strict limitations on the number of investors in a "Sub S" corporation.

The preceding discussion of the various types of financing vehicles that are commonly used for raising funds for business ventures should not be construed as a thorough and definitive description of all alternatives. This is intended simply as a brief, general overview of possible fund raising vehicles in order to indicate the variety of approaches that are available. There are numerable additional restrictions, variations and alternatives that have not been discussed and which would require the review of competent legal and tax counsel prior to public discussion.

In addition to the possibility of raising new funds from new investors as outlined above, an on-going business organization can use its prior proven earnings capability to finance a new project, such as a direct application of geothermal energy. The first and most obvious way is for the organization to reinvest its income into such a project in lieu of distributing the profits or paying dividends. However, retained earnings financing is limited to profits and restricts the size of projects that can be undertaken. Also, the continuous deferment of payback may be contrary to shareholders' desire for a current return on their investment. Most ongoing businesses retain at least a portion of profits to help finance growth and new projects. This increases the equity value in the company for the existing owners or shareholders.

An existing business is most likely to parlay the profits retained from operations by using debt. Debt can be raised in the public marketplace through one of the financing vehicles described above, but is usually procured from institutional lenders such as banks, insurance companies or pension funds. The primary concern of a debt lender is security and consequently loans are usually only made to established businesses in proportion to a company's net worth (i.e., equity and retained earnings). The DOE's Federal Loan Guarantee Program for Geothermal Energy Utilization should greatly increase the amount of debt money available for geothermal projects by extending this attractive form of financing to many businesses that would otherwise be precluded from borrowing. The United States Government guarantee on a loan makes it the most secure debt instrument available. This guarantee, in effect, allows the most highly regulated pension fund to make a loan on a geothermal project and assures the borrower of getting the best interest rate possible. In addition, the interest on debt is a tax deductible expense in the operation of a business.

Another related form of debt is leasing. The lending institution, the lessor, is again primarily concerned with security as to the lessee's ability to repay in the form of scheduled lease payments. Structuring a lease transaction for all or a significant portion of a geothermal project is possible, but would have to be done carefully by an expert in the field. Leasing structures vary significantly with differing benefits and tradeoffs accruing to the lessors and lessees. Sophisticated leveraged leases usually seek to match and maximize the desired lending criteria of various parties into a single complex transaction. Tax benefits such as ITC, accelerated depreciation and interest expense can be assigned to the party that can best use these deductions, while an institutional lender can meet his return requirements for a specified period of time and the borrower gets the best financing terms available. Every leveraged lease must be uniquely structured to the situation being financed, but leasing represents an extremely attractive financing tool for an existing organization because of the available Investment Tax Credits and the possibility of using the Government Loan Guarantee Program in a leveraged lease transaction.

APPROPRIATE FINANCING FOR VARIOUS PROJECTS

The above referenced financing vehicles can all be used in various combinations to finance a direct application geothermal project. Some are more appropriate than others depending on how the project is to develop and who will be the operator of the "direct application". One of the most unique characteristics of direct applications is the diversity of operations involved. By definition, such a project requires one business entity to extend its operation into another major industry. Either the entity familiar with the energy source must become involved in the "application" industry or the end-user must integrate the energy production industry into its pre-existing operations. Either of these alternatives represent a major extension of a company's operations into a new area. This involvement in two distinctly different industries is difficult because the historical financing criteria for each are basically incompatable.

On the energy side, the high risk of developing any one resource area is usually spread over several areas by a company that would then sell the energy to a multitude of users. Several failures can be recovered by a single success and risk is reduced by the number of projects being developed. On the other hand, financial decisions by production type organizations are usually based on more predictable and ascertainable results as they pertain to a series of individual production situations. The inherent uncertainties of developing energy cannot be tolerated by these organizations whose primary concern is the uninterrupted production of their end-product. The paradox of the situation can be summarized as follows. Direct application projects of geothermal energy must be segmented into sub-projects in order to be financed. However, subsequent operation of a direct application project requires the combining of these sub-projects into a totally integrated operating entity.

Due to the multiplicity of variables that must be combined in such an integrated operation, a detailed outline for financing such projects cannot be made in the abstract. Financing is dependent on the specific results of prior developments which must be formulated into the specific situations as they arise. However, some general recommendations can be made that would pertain to most direct application geothermal projects

Since geothermal projects involve such diverse financing requirements, expert opinion on overall structuring, legal matters, tax consequences and actual raising of the funds is crucial. An overall financing plan, including the breakdown of a project into financable components, must be formulated prior to raising any funds. The amount to be raised for each stage of implementation and the amount of equity and tax benefits to be given the investor at each stage must be planned and adhered to. The original investors must also make a return and must be careful not to give up too much too early which might preclude subsequent financing required to complete the project or keep it operational. For example, it would be unwise to assign a fixed percentage of profits to an early investor since such an arrangement limits the profits that could be offered to attract additional capital that might subsequently be required. The overall financing plan also requires some flexibility and contingencies in order to be prepared for unpredictable conditions in the financial marketplace.

With the recent passage of tax laws that directly concern the geothermal industry, expert legal opinion and tax counsel could possibly be the most important input to a successful financing. In certain areas of geothermal financing, there exists no precedence under the current tax laws. Consequently, the language in any offering circular or tax position statement must be painstakingly prepared, researched and reviewed in the absence of any pre-existing boilerplate. Even in areas of traditional financing, expert legal and tax opinions are required in order to insure absolute compliance with the numerous, complex and ever-changing laws governing the raising of funds. The marketing of funds is also highly regulated in certain aspects. The developer or company looking to raise money is advised to seek guidance from an organization with an extensive knowledge of the financial marketplace. Such an organization will save valuable time and money, where an operating organization might not know how or where to look for capital.

The acquisition of geothermal mineral rights is a highly risky proposition. It usually requires equity money from the party securing the leases. This phase of developing geothermal energy is not usually financable through traditional lending sources and has the lowest priority as to a loan guaranty under the DOE program. The acquisition of the mineral rights should always be done by the use of a lease with the option to build on the site if commercial levels of geothermal resource are ascertained. This is much cheaper than buying the land outright in the hope that a geothermal reservoir will be discovered. Mineral right leases have evolved from the oil and gas industry which generally include a royalty to the landowner based on the value of the resources extracted. Since the resource used in a direct application has only a specific use value rather than a readily ascertainable market value, the royalty issue should be resolved before any drilling commences. It would be unwise to relate the royalty for the resource to the economics or performance of a totally unrelated, end-use application.

The drilling of a geothermal resource is also an extremely risky venture. Even in KGRA's, the drilling of a development well can prove elusive due to unpredictable geological, geophysical, hydrological or geochemical characteristics. The high risk of drilling a geothermal well is offset by the potentially lucrative returns that could accrue and the recently legislated tax incentives afforded such a venture.

The Energy Tax Act of 1978 provides the option to expense intangible drilling costs and also provides for a 22% depletion allowance. These tax incentives are more beneficial to higher bracket taxpayers than those in lower brackets. An individual in the 70% tax bracket can reduce his present year's tax bill by \$.70 for each \$1 written off as an intangible drilling expense. Since most drilling costs are intangibles, such as labor and non-recoverable material, the net investment to an investor could be as little as \$.30 for each dollar spent on the project, assuming 100% deductibility of costs. Furthermore, if the well provides revenues to the investor, 22% of gross income is tax-free due to the income depletion allowance. Under these circumstances, a drilling project does not appear as risky and presents an attractive investment opportunity to individuals in extremely high tax brackets.

Since the highest corporate tax rate is presently less than that of many individuals, the drilling portion of a geothermal project should always be financed by individuals in higher tax brackets. This is most readily accomplished by the use of a Limited Partnership administered by a general partner familiar with the development of geothermal applications. Individuals would be the limited partners who would contribute most or all of the money required for the drilling. In turn, these limited partners would receive all of the tax benefits in the year of their investment and some form of cashflow if the well generates income. Since in direct applications, geothermal energy has a limited marketability due to its distribution characteristics, some purchase committment from a potential user of the resource would be desirable. Such a committment should not be that difficult to secure if specific minimum characteristics of the resource and the price are clearly defined. Such a committment beforehand would be beneficial to raising the funds for the drilling venture and offer protection to both parties in the subsequent development of the geothermal project.

The provision to allow the write-off of intangible drilling costs could prove to be the most helpful aspect in the further development of direct applications of geothermal energy. Previously, all incentives for direct applications were well down the road and did not materialize until a project was actually in operation. The new tax law should encourage the drilling of direct application wells and help bring together the resource owners and potential users. The ability to finance this high risk early stage that is critical for all subsequent development of a direct application project was desperately needed. Results of the new tax law should be evident soon.

Direct application geothermal projects have an alternative to acquiring geothermal lease rights and subsequent drilling for a resource. Such projects can make use of the geothermal wells that have been drilled for electrical power generation that have proved inadequate for that purpose. Although these wells may not always be made available for direct applications, they represent an energy resource and potential income source to the companies that originally drilled them. These wells often have well defined characteristics that can be fitted to an application. In view of the risks involved with drilling, this alternative could prove to be a very economic course to take in the development of a direct application project. Payment for these wells could most likely be financed by either the seller or an institutional lender, provided the data of the well could support a viable direct application plan. A way to achieve the former could be the issuance of a preferred stock to the company that originally drilled the wells. In this case, the original cost of drilling could be arbitrarily assigned as the value of the preferred stock and this amount would constitute equity in the project for purposes of securing a loan guarantee from the DOE.

As a direct application geothermal project becomes further developed, i.e., toward the point of constructing a facility, the traditional funding sources for that industry should become readily available to the project. For it is at this point that the energy source becomes less significant of a risk as to the overall financing. The reservoir will have been evaluated to the extent possible and the facility designed accordingly. The financial marketplace would know the end application and could relate its payback to predictable revenues and comparables in that industry. The risk of the geothermal energy source being prematurely depleted will be assumed to be be covered by a Department of Energy Loan Guarantee. As a last resort, it would be possible to convert the facility to use fossil fuels if the geothermal energy ran out and such a course of action was economically feasible.

In summary, the financing of a direct application geothermal project is a long process with diverse risks preceding expected cashflow returns. Through the recent passage of favorable tax incentives pertaining to geothermal energy, the high risk, early stages of a project should be more readily financable than in the past. By getting beyond this high risk stage, conventional sources of financing for the end use application should become available when aided by the Department of Energy's Loan Guarantee Program.

We are at the forefront of financing a new industry. The policies of the IRS and the DOE will have a significant impact on how successful we are. As of now, these policies are relatively uncertain.

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