DOE/RA/50354
Volume I

FEASIBILITY STUDY FOR A 10-MM-GPY FUEL ETHANOL PLANT, BRADY HOT SPRINGS, NEVADA

Volume I - Process and Plant Design

September 1980

Prepared by
Geothermal Food Processors, Inc.
Fernley, Nevada
and
The Andersen Group

For the U.S. Department of Energy
Office of Alcohol Fuels
Under Grant No. DE-FG07-80RA50354

Printed in the United States of America

Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161
NTIS Price Codes: Printed Copy A07
Microfiche A01

DOE/RA/50354
Volume I

FEASIBILITY STUDY FOR A 10 MM GPY FUEL ETHANOL PLANT BRADY HOT SPRINGS, NEVADA

Volume I - Process and Plant Design

September 1980

Prepared by
Geothermal Food Processors, Inc.
Fernley, Nevada
and
The Andersen Group

For the U.S. Department of Energy
Office of Alcohol Fuels
Under Grant No. DE-FG01-80RA50354

MBW

THIS PAGE

WAS INTENTIONALLY

LEFT BLANK

EXECUTIVE SUMMARY

The enclosed feasibility study was conducted under DOE contract number DE-FG01-80RA50354 by Geothermal Food Processors, Inc. of Fernley, Nevada in conjunction with its subcontractors, Morrison-Knudsen, GeothermEx and Ag-West.

It concerns the technical and economic viability of constructing and operating a geothermally heated, bio-mass, motor fuel alcohol plant at Brady's Hot Springs, where Geothermal Food Processors presently operates the world's largest existing geothermal onion dehydration facility.

The results of the study are positive, showing that a plant of innovative, yet proven design can be built to adapt current commerical fermentation-distillation technology to the application of geothermal heat energy. The specific method of heat production from the Brady's Hot Spring wells has been in sucessful use for some time at the onion drying plant. Further development of the geothermal resource to add the capacity needed for an ethanol plant is found to be feasible for a plant sized to produce 10 million gallons of motor fuel grade ethanol per year.

A very adequate supply of feedgrains are found to be available for use in the plant without impact on the local or regional feedgrain market. The effect of diverting supplies from the animal feedlots in Northern Nevada and California will be mitigated by the by-product output of high-protein feed supplements that the plant will produce. The plant will have a favorable impact on the local farming economies of Fallon, Lovelock, Winnemucca and Elko, Nevada. It will make a positive and significant socieconomic contribution to Churchill County, providing direct employment for an additional 61 persons. Environmental impact will be negligible, involving mostly a moderate increase in local truck traffic and railroad siding activity.

The market for gasohol in the California-Nevada region is potentially very large, but almost totally undeveloped. The total plant output when converted into gasohol, would only supply 0.8% of the regions gasoline needs. Hence, only minimal penetration of the motor fuel market will be necessary to absorb the plant's annual ethanol production. At present there are no tax exemptions for gasohol sales in Nevada and California. A bill extending limited exemptions in California is currently on the Governor's desk. If it becomes law, it will ensure a gradual growth in the demand for ethanol in the region. However, in Nevada and California, the use of gasohol has come more out of need to extend motor fuel supplies in times of gasoline shortages, than out of economic desire-ability. This is particularly true in Nevada where gasoline shortages can have serious negative influences on the states predominant tourist revenues. The growth in demand for ethanol will come mainly from independent oil companies and gasoline blenders in the region who are most vulnerable in times of short supply. Excluding low-cost Brazilian ethanol imports, current demand for ethanol is nearly at the point that it could support a price that would ensure breakeven operation of the plant. Due to further increases that can be expected in the price of gasoline over the next few years, the study finds that ethanol prices will be sufficient to sustain profitable operations by the time that the plant could be commissioned. This analysis does not consider the military demand for motor fuel, which is very large in Nevada relative to the state's economy, and will grow substantially if MX Missile Project is built. The market conclusions of the study are, therefore, highly conservative.

In national terms, the availability of an additional domestic source of motor fuel is important. The unique aspect of this project is that it converts a remotely located, fixed energy source into a commerically useful, and easily transportable form. In this sense it has a very desireable "energy ratio."

It will require an estimated $26.8 million capital investment to increase and prove the production of geothermal heat, obtain permits, prepare the plant site, design the facilities, construct the ethanol plant with attendant rail siding loading facilities, and make all necessary feedstock supply and marketing arrangements to bring the plant on stream in 24 months. In order to generate adequate cashflows and profit returns to attract private investors, low interest rate government loans will be necessary. Given the additional 10% investment tax credit on the alternative fuel production facilities, and the 15% added tax credit on the geothermal resource portions, the project would be economically attractive if a 50% government loan at 5% interest were obtained, and accelerated depreciation of the plant over five years were allowed. As a consequence of this conclusion, application will be made for consideration of a cooperative agreement in response to DOE solicitation DE-PS01-80RA-50413. This study report will serve as the economic viability justification for that application.

The report is presented in two volumes. Volume 1 deals with the technical design aspects of the plant. The second volume addresses the issue of expanded geothermal heat production at Brady's Hot Springs, goes into the details of feedstock supply eocnomics, and looks at the markets for the plant's primary ethanol product, and the markets for its feed supplement by-products. The report concludes with an analysis of the economic viability of the proposed project.

VOLUME 1

TABLE OF CONTENTS

VOLUME 2
TABLE OF CONTENTS

SECTION 1

SUMMARY

Geothermal Food Processors, a subsidiary of the Andersen Group, presently operates a vegetable dehydration facility adjacent to the proposed alcohol plant site. This plant is the nation's largest direct-use application of geothermal energy.

Geothermal Food Processors received funding from the US Department of Energy to investigate the feasibility of fuel ethanol production at Brady's Hot Springs, Nevada. The proposed plant will utilize agricultural feedstocks and geothermal process heat.

The feasibility study is divided into two volumes. Volume 1 deals with the ethanol plant design. Reservoir evaluation, feedstock assessment, market evaluation, and economic analysis are the subjects of Volume 2.

Morrison-Knudsen Company, Inc., was retained by Geothermal Food Processors to develop a preliminary design and cost estimate for the process plant at Brady's Hot Springs. Ag-West, Inc., of Sacramento, California, was assigned the agricultural-related work while GeothermEx, Inc., of Berkeley, California, served as the geotechnical consultant. The economic and market analysis portion was retained by the Andersen Group and its consultants, Johan Wassenaar and Robin Grace, with input from Morrison-Knudsen and other study participants.

Morrison-Knudsen's portion of the feasibility study presents heat and material balances for ethanol production, describes the required unit operations, defines the geothermal heat system, discusses plant utilities and illustrates the relationship between the existing vegetable drying facility and the proposed ethanol plant. It also develops capital and operating cost estimates as well as a preliminary project schedule.

Economically, Western barley and Midwest corn are the preferred feedstocks. Both can be used interchangeably in the proposed ethanol plant. Most of the grain will be shipped by rail to Fernley, approximately 20 miles west of the process plant site. Brady's Hot Springs is at least 10 miles from the nearest railroad. Feedstock is transported in end-dump trailer trucks from Fernley to the ethanol plant. The primary grain storage facility is located in Fernley and is described in the agricultural section of this feasibility study.

At the alcohol plant, starch in the grain is converted first to fermentable sugars, and then to ethanol. The protein and fiber present in the feedstocks pass through the process essentially unchanged. They are concentrated and sold as animal feed. Most of the fiber is collected as a wet cake, while the protein is recovered as concentrated solubles. The market analysis has indicated that local markets for wet cake are limited and drying of this material is necessary. The technical report, however, gives the option of dry or wet spent grains.

The nominal fuel ethanol production rate is set at 10 million gallons per year. Although originally proposed as a 5 million gallon per year project, the Brady's geothermal reservoir apparently has adequate capacity to support a larger plant. A larger plant is also more cost effective when most of the feedstock is imported from outside Nevada.

The ethanol production process consists of feedstock storage and preparation, mash cooking and saccharification, fermentation, alcohol distillation including dehydration, product storage and shipping, by-product concentration, and by-product storage and shipping. By-product drying may be required. Ancilliary facilities include the geothermal heat system and plant utilities.

Process heat requirements are met using 290°F geothermal fluid from the Brady's reservoir. Experience with this low salinity fluid at the existing vegetable drying facility indicates that scaling is minimal when pressure within the distribution system is high enough to prevent flashing and release of noncondensible gases. After removal of sensible heat, the spent fluid is reinjected to provide for reservoir recharging.

The fuel ethanol plant will have very little impact upon the environment. Only carbon dioxide produced during fermentation is vented to the atmosphere. All other air emissions including dust from solids handling and hydrocarbon vapors from alcohol, gasoline, and benzene storage will be controlled. Liquid wastes are transferred to a secondary treatment plant. The aerated effluent discharges into a transpiration pond resulting in a zero discharge facility.

For wet cake by-product drying alternative, the total investment at Brady's Hot Springs will total $21 million. This includes the process plant and ancillary facilities, but excludes additional agricultural, environmental, reservoir and preliminary engineering studies. It also does not include project management. By-product drying would cost an additional $1.2 million. The cost figures include a 5 percent contractors fee and a 20 percent contingency. The estimates have an accuracy of plus or minus 30 percent.

Although a truck maintenance shop is included in the cost of the ancillary facilities, feedstock and by-product haul trucks are not included in the estimate. The cost of the required feedstock storage facility at the Fernley railhead is also not included. Costs associated with feedstock transshipment are being addressed in the agricultural section of this feasibility study.

Process operating expenses total $1.82 per gallon product using a corn feedstock or $1.93 per gallon for barley. Operating costs include corn or barley purchased at $3.00 and $2.65 per bushel, respectively, freight to Fernley, maintenance material, utilities, labor and certain miscellaneous expenses. They do not include operating the railside storage facility at Fernley and transshipment of the feedstock to the process plant at Brady's Hot Springs.

The proposed project schedule encompasses a 25-month period from inception of preliminary design to commercial operation. Preliminary engineering, detailed design, environmental permitting, procurement, construction and plant start-up are included in the schedule. No procurement of major equipment or construction of the facility will commence until all major permits are obtained.

SECTION 2

INTRODUCTION

This section summarizes the scope of the feasibility study. It also presents the design guidelines used on the project.

2.1 SCOPE OF WORK

Geothermal Food Processors, a subsidiary of the Andersen Group, presently operates a vegetable dehydration facility adjacent to the proposed alcohol plant site. The plant is the nation's largest direct-use application of geothermal energy. During the 1979 processing season, over 27 million pounds of raw onions were dried using geothermal heat from the Brady reservoir. The 1980 processing season, presently underway, is also proceeding on schedule and at the design production rate.

In July 1980, Geothermal Food Processors received funding from the Department of Energy under solicitation number DE-PA01-80RA-50185 to investigate the feasibility of fuel ethanol production at Brady's Hot Springs near Fernley, Nevada. The proposed plant will utilize agricultural feedstocks and geothermal process heat.

The feasibility study is divided into four parts: ethanol plant design, geothermal reservoir evaluation, feedstock assessment, product and by-product marketing, and economic analysis. Morrison-Knudsen Company, Inc., was retained by Geothermal Food Processors to develop a preliminary design and cost estimate for the process plant at Brady's Hot Springs. Ag-West, Inc., of Sacramento, California, was assigned the agricultural-related work, while GeothermEx, Inc., of Berkeley, California, served as the geotechnical consultant. The economic analysis portion was retained by the Andersen Group and its consultants, Johan Wassenaar and Robin Grace, with input from Morrison-Knudsen and other study participants.

Morrison-Knudsen completed its portion of the feasibility study in September, 1980. Major study tasks included:

- Prepare heat and material balances for the alcohol production facility.
- Describe the various unit operations required for alcohol production.
- Define feedstock and by-product handling requirements at the process plant.
- Discuss the proposed process heat supply system and define plant utilities.
- Prepare a site plan illustrating relationship between the proposed alcohol plant and the existing onion drying facility.
- Estimate capital and operating costs with an accuracy of plus or minus 30 percent.
- Present a preliminary project schedule.

2.2 DESIGN BASIS

Design guidelines used in preparing the fuel ethanol plant portion of the feasibility study are listed below.

- Alcohol Plant Capacity

  The nominal fuel ethanol production rate is set at 10 million gallons per year (MMGPY). Although originally proposed as a 5 MM GPY project, the Brady geothermal reservoir apparently has adequate capacity to support a larger plant. Also, most of the feedstock will be imported from neighboring states or the Midwest making a larger plant more cost effective.

- Alcohol Plant Operating Schedule

  The fuel ethanol plant operates 3 shifts/day and 330 days/year (7920 hours/year).

- Feedstock

  The most economically viable feedstocks are corn and barley.

- Feedstock Composition

  Typical corn and barley analyses used in preparing material balances are detailed in Table 2-1.

TABLE 2-1
FEEDSTOCK COMPOSITION

Component	Corn	Barley
Starch	72.00 Wt.%	65.79 Wt.%
Protein	10.12	14.2
Fat	4.59	2.13
Fiber	2.35	6.04
Other Solids	9.53	8.71
Ash	1.41	3.13
TOTAL (Moisture Free Basis)	100.00	100.00
Moisture Content	15.5	10.95
Weight per Bushel	56	48

- <u>Feedstock Storage</u>

  Storage capacity at the process plant is sufficient for 40 hours of ethanol production. Most of the feedstock storage will be located at the rail receiving facility in Fernley.

- <u>Product Properties</u>

  Physical properties of motor fuel grade ethanol are summarized in Table 2-2.

TABLE 2-2
PRODUCT CHARACTERISTICS

Concentration in volume % ethanol -	99.5
weight % ethanol -	99.19
proof ethanol -	199°
Specific gravity at 60°/F -	0.796
Pounds per gallon -	6.642
Heat of combustion, anhydrous ethanol -	12,800 Btu/lb
Heat of combusion, anhydrous ethanol -	84,747 Btu/gal
Heat of combustion, 199° proof ethanol -	84,060 Btu/gal

- <u>By-Products</u>

  Whole stillage containing non-fermentable fiber, protein and dissolved solids is recovered from the ethanol production process. The suspended fiber will be collected as stillage cake with a moisture content of 65 percent. The protein and other dissolved nonfermentables will be concentrated to 35 percent solids for marketing as concentrated distillers solubles. Both by-products are sold as animal feed. If local markets for stillage cake cannot consume the amount generated by the ethanol plant, the cake will be dried and pelletized. It can then be sold nationwide or exported as distiller's dried grain without solubles.

- By-Product Storage

Storage requirements for the different by-products are tabulated in Table 2-3. Distiller's dried grains are produced only if local markets do not exist for stillage cake.

TABLE 2-3
BY-PRODUCT STORAGE

Type	Days Production Stored
Stillage Cake	2
Concentrated Solubles	5
Distiller's Dried Grains (optional)	5

- Extraneous Materials

Certain extraneous materials other than ethanol are produced in the fermentation of sugar produced from the starch contained in the feedstock. These are fusel oils (a complex mixture of higher molecular weight alcohols), yeast (saccharomyces cervisiae) and light ends (primarily acetaldehyde). Approximately one pound of acetaldehyde will be formed per 1000 pounds of ethanol produced. Table 2-4 lists the assumptions used in this study with regard to fusel oil formation and Table 2-5, for yeast formation.

TABLE 2-4
FUSEL OIL FORMATION

Gallons fusel oil formed per 1000 gallons ethanol	- 5
Average molecular weight of fusel oil	- 82.6
Specific gravity of fusel oil at 60°F	- 0.814
Pounds carbon dioxide formed in fusel oil reaction per pound fusel oil	- 3.94

Analysis of typical fusel oil formed from corn:

Component	Weight Percent
N-propyl alcohol	10.64
Isobutyl alcohol	11.09
Active amyl alcohol	21.27
Isoamyl alcohol	54.27
Hexyl alcohol	2.73
TOTAL	100.00

TABLE 2-5
YEAST FORMATION

Pounds yeast formed per pound ethanol	- 0.08
Pounds water produced per pound yeast	- 0.291
Pound carbon dioxide produced per pound yeast	- 0.709

The yeast solids become a part of the plant by-products.

- Denaturing

The fuel ethanol product will be denatured according to the U.S. Bureau of Alcohol, Tobacco and Firearms' Formula CDA-20. This requires blending 5 gallons of unleaded gasoline with 100 gallons of 199° proof ethanol.

- Site Data

Plant location is 4100 feet above sea level with a corresponding atmospheric pressure of 12.5 psia. All equipment sizing is based upon local atmospheric pressure. The facility is designed for seismic zone 4 due to the proximity of ground faults supplying geothermal fluid.

- Climatological Data

Cooling tower design is based upon a wet bulb temperature of 64°F with a 10°F cooling water approach and a 30°F cooling water range. The prevailing wind direction is from the south-southwest.

- Process Heat Supply

Geothermal fluid is obtained from the Brady's Hot Springs reservoir at a temperature of 290°F. Experience with this low salinity fluid indicates that scaling is minimal when pressure within the distribution system is high enough to prevent flashing and release of noncondensible gases. A typical, partial analysis is found in Table 2-6.

TABLE 2-6
GEOTHERMAL FLUID ANALYSIS

Parameter	Concentration (mg/l)
Alkalinity	80
Arsenic	0.13
Bicarbonate	98
Calcium	43
Carbonate	0
Chloride	1,100
Fluoride	52
Hardness	112
Iron	0.08
Magnesium	1
Manganese	0.01
Nitrate	0.0
Potassium	42
pH	7.18
Sodium	827
Silica	140
Sulfate	301
Total Dissolved Solids	2,528

- Spent Fluid Disposal

  After removal of sensible heat, the spent geothermal fluid is reinjected to prolong reservoir life and prevent subsidence.

- Process Water Supply

  A cold water well is drilled near the plant site to provide process and cooling tower make-up water. Condensates are recovered from the by-product evaporators to minimize outside make-up water requirements.

- Wastewater Treatment

  Following stabilization in a secondary treatment plant, plant wastewater is transferred to a transpiration pond for absorption into the desert or evaporation.

- <u>Power Supply</u>

  Electric power is obtained from Sierra Pacific Power Company's existing 120 Kv transmission line located adjacent to the proposed plant. A new substation serving the ethanol production facility is necessary because the existing substation serving the onion dryer is not large enough to serve both plants.

- <u>Capital and Operating Costs</u>

  The cost estimates are based upon August, 1980 dollars.

SECTION 3

PROCESS OVERVIEW

Section 3 lists the various unit operations required for ethanol production and briefly discusses the general processing scheme. Material, energy and water balances are also found in this section.

3.1 GENERAL

The alcohol plant is sized to produce 10 MM GPY of motor fuel grade ethanol from grain feedstocks. Theoretically, 2.92 gallons of anhydrous ethanol can be produced from a bushel of corn and 2.67 gallons from a bushel of barley. However, competing side reactions and miscellaneous process losses result in a practical yield of 2.57 gallons per bushel of corn and 2.06 gallons per bushel of barley.

The ethanol plant, in general, uses existing process technology currently employed in grain alcohol plants. The production process consists of feedstock storage and preparation, mash cooking and saccharification, fermentation, alcohol distillation including ethanol dehydration, by-product concentration, and by-product storage and shipping. Ancilliary facilities include the geothermal heat system, cooling tower, and plant utilities.

Feedstock preparation consists of size reduction or milling. The resulting meal is cooked and the starch present in the feedstock converted to fermentable sugars. Following saccharification, the mash is cooled and sent to fermentation. The sugars in the mash slurry are then fermented to ethanol and the resulting beer transferred to distillation where 190° proof ethanol is recovered from the enriching tower. The ethanol is dehydrated in additional columns to produce a 199° proof product. Residue from distillation, consisting of nonfermentable solids or stillage, is recovered and sold as an animal feed. Suspended solids in the stillage are separated into a cake by centrifuging, while dissolved solids are concentrated by multiple effect evaporation.

Unlike the concentrated solubles, stillage cake has a tendency to spoil if stored longer than 48 hours. It also cannot be economically shipped long distances due to its high water content. The northern Nevada cattle feed market is not large enough to consume the quantities of stillage cake produced by the ethanol plant. As a result, the cake will be dried from 65 percent to 10 percent moisture. Following pelletization, the resulting solids can enter the national and export feed supplement market for distiller's dried grains.

The plant operates as a continuous flow process except for fermentation which is operated batchwise to allow for frequent sterilization of tankage and piping. A more detailed description of each unit operation is presented in Section 4.

3.2 MATERIAL BALANCES

Key material flows in a 10 MM GPY fuel ethanol plant are diagrammed in Drawing 66-0-001 for corn and Drawing 66-0-002 for barley. All of the values shown on the material balances represent quantities expressed in pounds per hour. They are based upon a plant operating 24 hours per day and 330 days per year and do not include wet cake by-product drying.

Major plant inputs and outputs are summarized in Table 3-1. Extraneous products, consisting of fusel oil and light ends, are also shown on the table. Fusel oil is blended into the ethanol product while the light ends are utilized in a small boiler to generate a portion of the injection steam required in mash cooking.

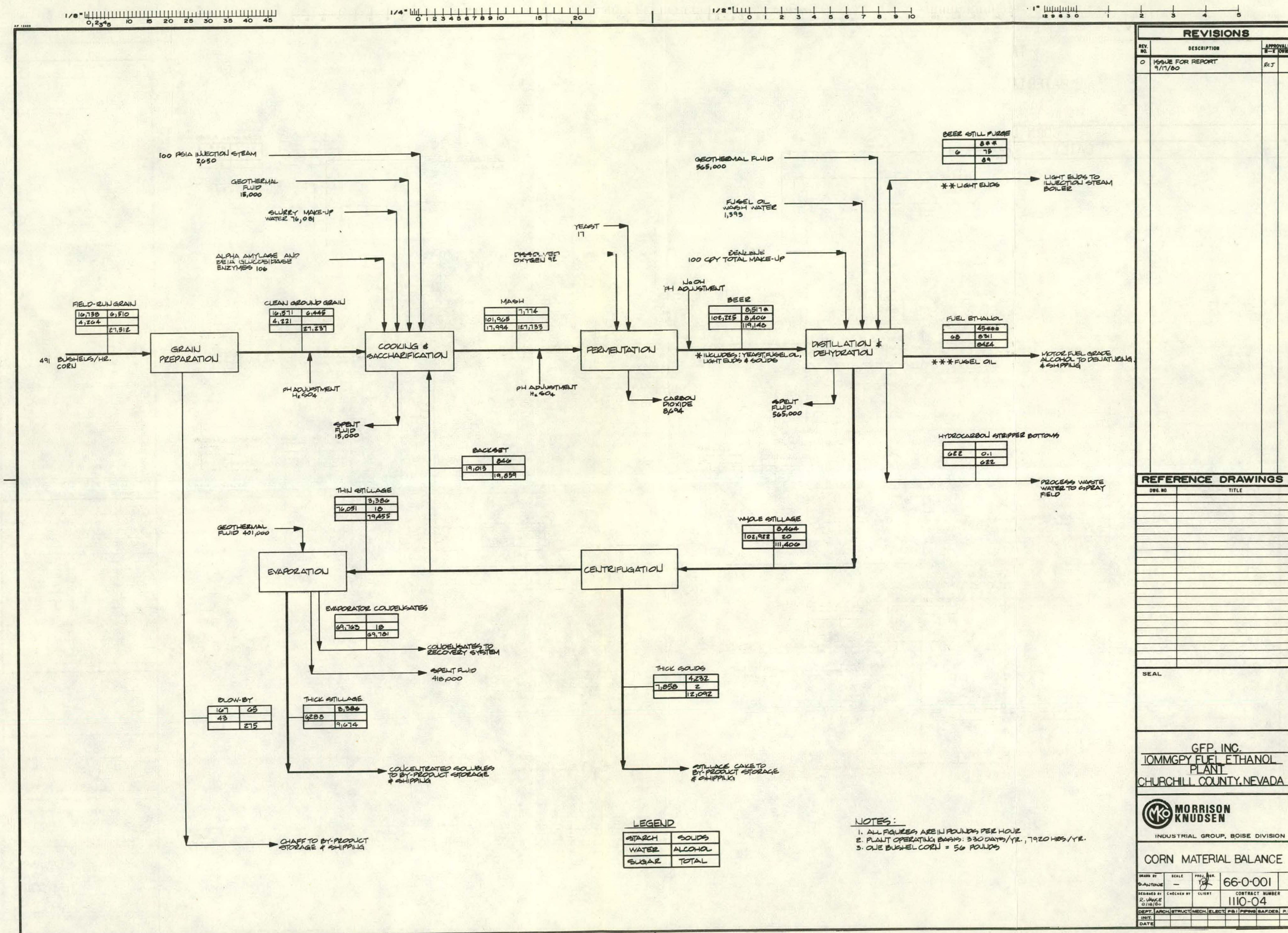
In the formation of the extraneous products, a small amount of oxygen is required. Since alcohol fermentation is an anaerobic process, the oxygen required for these secondary reactions must come from oxygen present in the water portion of the fermentation mash. This oxygen quantity is identified in the materials balance diagrams as "dissolved" oxygen.

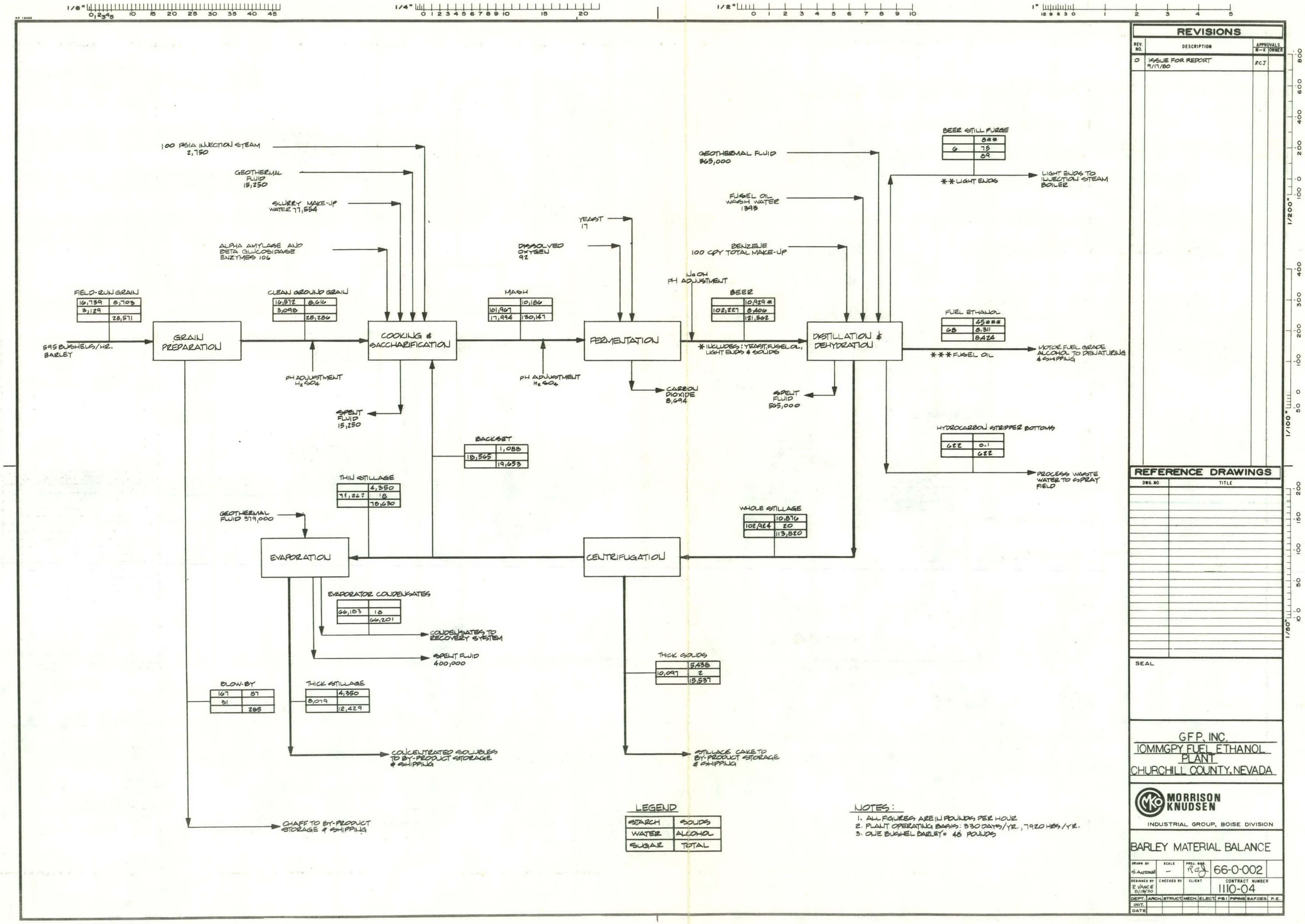
Because barley contains less starch than corn on a unit weight basis, the barley option results in a slightly higher process flow rate to produce ethanol at the design rate. Barley also contains proportionally more non-fermentable solids than corn resulting in increased by-product production.

TABLE 3-1

MATERIAL QUANTITIES

MATERIAL	CORN OPTION DAILY	CORN OPTION ANNUAL	BARLEY OPTION DAILY	BARLEY OPTION ANNUAL
1. Plant Imports				
A. Feedstock	330 tons	109,000 tons	343 tons	113,000 tons
B. Denaturant Gasoline (unleaded gasoline)	1,515 gal	500,000 gal	1,515 gal	500,000 gal
C. Enzymes	1.3 tons	429 tons	1.3 tons	429 tons
D. Yeast	400 lbs	66 tons	400 lbs	66 tons
2. Plant Exports				
A. Principal Product				
(1) 199° Proof Ethanol	30,300 gal	10,000,000 gal	30,300 gal	10,000,000 gal
(2) Fusel Oil	162 gal	53,460 gal	162 gal	53,460 gal
(3) Denaturant	1,515 gal	500,000 gal	1,515 gal	500,000 gal
(4) Total	32,000 gal	10,550,000 gal	32,000 gal	10,550,000 gal
B. By-Products				
(1) Concentrated Distillers Solubles (35% Solids)	116 tons	38,300 tons	149 tons	49,200 tons
(2) Stillage Cake, Wet (35% Solids)	145 tons	47,850 tons	186 tons	61,400 tons
(3) Chaff (Blend with Cake)	3.3 tons	1,089 tons	3.4 tons	1,122 tons
C. Light Ends	1.1 tons	363 tons	1.1 tons	363 tons
D. Optional By-product (in lieu of Stillage Cake)				
Distillers Dried Grains Without Solubles (90% Solids)	60 tons	19,700 tons	76 tons	25,000 tons


100 PSIA INJECTION STEAM 2,050
GEOTHERMAL FLUID 15,000
SLURRY MAKE-UP WATER 76,081
ALPHA AMYLASE AND BETA GLUCOSIDASE ENZYMES 106
DISSOLVED OXYGEN 92
YEAST 17
FIELD-RUN GRAIN
16,738 | 6,510
4,264 |
| 27,512
491 BUSHELS/HR. CORN
GRAIN PREPARATION
CLEAN GROUND GRAIN
16,571 | 6,445
4,221 |
| 27,237
PH ADJUSTMENT H_2SO_4
COOKING & SACCHARIFICATION
SPENT FLUID 15,000
MASH
| 7,774
101,965 |
17,994 | 127,733
PH ADJUSTMENT H_2SO_4
FERMENTATION
CARBON DIOXIDE 8,694
NaOH PH ADJUSTMENT
BEER
| 8,517*
102,225 | 8,406
| 119,148
* INCLUDES: YEAST, FUSEL OIL, LIGHT ENDS & SOLIDS
GEOTHERMAL FLUID 565,000
FUSEL OIL WASH WATER 1,393
BENZENE 100 GPY TOTAL MAKE-UP
DISTILLATION & DEHYDRATION
SPENT FLUID 565,000
BEER STILL PURGE
| 8**
6 | 75
| 89
** LIGHT ENDS
LIGHT ENDS TO INJECTION STEAM BOILER
FUEL ETHANOL
| 45***
68 | 8311
| 8424
*** FUSEL OIL
MOTOR FUEL GRADE ALCOHOL TO DENATURING & SHIPPING
HYDROCARBON STRIPPER BOTTOMS
622 | 0.1
| 622
PROCESS WASTE WATER TO SPRAY FIELD
BACKSET
| 846
19,013 |
| 19,859
THIN STILLAGE
| 3,386
76,051 | 18
| 79,455
GEOTHERMAL FLUID 401,000
EVAPORATION
CENTRIFUGATION
WHOLE STILLAGE
| 8,464
102,922 | 20
| 111,406
EVAPORATOR CONDENSATES
69,763 | 18
| 69,781
CONDENSATES TO RECOVERY SYSTEM
SPENT FLUID 418,000
THICK SOLIDS
| 4,232
7,858 | 2
| 12,092
BLOW-BY
167 | 65
43 |
| 275
THICK STILLAGE
| 3,386
6288 |
| 9,674
CONCENTRATED SOLUBLES TO BY-PRODUCT STORAGE & SHIPPING
STILLAGE CAKE TO BY-PRODUCT STORAGE & SHIPPING
CHAFF TO BY-PRODUCT STORAGE & SHIPPING
LEGEND
STARCH | SOLIDS
WATER | ALCOHOL
SUGAR | TOTAL
NOTES:
1. ALL FIGURES ARE IN POUNDS PER HOUR
2. PLANT OPERATING BASIS: 330 DAYS/YR., 7920 HRS./YR.
3. ONE BUSHEL CORN = 56 POUNDS
REVISIONS
REV. NO. | DESCRIPTION | APPROVALS M-K OWNER
0 | ISSUE FOR REPORT 9/17/80 | RCJ
REFERENCE DRAWINGS
DWG. NO. | TITLE
SEAL
GFP, INC.
10MMGPY FUEL ETHANOL PLANT
CHURCHILL COUNTY, NEVADA
MORRISON KNUDSEN
INDUSTRIAL GROUP, BOISE DIVISION
CORN MATERIAL BALANCE
DRAWN BY S. ANTONE
SCALE —
PROJ. MGR.
66-0-001
DESIGNED BY R. VANCE
CHECKED BY
CLIENT
CONTRACT NUMBER 1110-04
DEPT. ARCH. STRUCT. MECH. ELECT. P&I PIPING SAF.DES. P.E.
INIT.
DATE



595 BUSHELS/HR. BARLEY
FIELD-RUN GRAIN
16,739 | 8,703
3,129 |
| 28,571
GRAIN PREPARATION
CLEAN GROUND GRAIN
16,572 | 8,616
3,098 |
| 28,286
PH ADJUSTMENT H2SO4
100 PSIA INJECTION STEAM 2,750
GEOTHERMAL FLUID 15,250
SLURRY MAKE-UP WATER 77,554
ALPHA AMYLASE AND BETA GLUCOSIDASE ENZYMES 106
COOKING & SACCHARIFICATION
SPENT FLUID 15,250
MASH
| 10,186
101,967 |
17,994 | 130,147
PH ADJUSTMENT H2SO4
YEAST 17
DISSOLVED OXYGEN 92
FERMENTATION
CARBON DIOXIDE 8,694
NaOH PH ADJUSTMENT
BEER
| 10,929 *
102,227 | 8,406
| 121,562
* INCLUDES: YEAST, FUSEL OIL, LIGHT ENDS & SOLIDS
GEOTHERMAL FLUID 365,000
FUSEL OIL WASH WATER 1393
BENZENE 100 GPY TOTAL MAKE-UP
DISTILLATION & DEHYDRATION
SPENT FLUID 565,000
BEER STILL PURGE
| 8**
6 | 75
| 89
** LIGHT ENDS
LIGHT ENDS TO INJECTION STEAM BOILER
FUEL ETHANOL
| 45***
68 | 8,311
| 8,424
*** FUSEL OIL
MOTOR FUEL GRADE ALCOHOL TO DENATURING & SHIPPING
HYDROCARBON STRIPPER BOTTOMS
622 | 0.1
| 622
PROCESS WASTE WATER TO SPRAY FIELD
BACKSET
| 1,088
18,565 |
| 19,653
THIN STILLAGE
| 4,350
71,262 | 18
| 78,630
WHOLE STILLAGE
| 10,876
102,924 | 20
| 113,820
GEOTHERMAL FLUID 379,000
EVAPORATION
CENTRIFUGATION
EVAPORATOR CONDENSATES
66,183 | 18
| 66,201
CONDENSATES TO RECOVERY SYSTEM
SPENT FLUID 400,000
THICK SOLIDS
| 5,438
10,097 | 2
| 15,537
BLOW-BY
167 | 87
31 |
| 285
THICK STILLAGE
| 4,350
8,079 |
| 12,429
CONCENTRATED SOLUBLES TO BY-PRODUCT STORAGE & SHIPPING
STILLAGE CAKE TO BY-PRODUCT STORAGE & SHIPPING
CHAFF TO BY-PRODUCT STORAGE & SHIPPING
LEGEND
STARCH | SOLIDS
WATER | ALCOHOL
SUGAR | TOTAL
NOTES:
1. ALL FIGURES ARE IN POUNDS PER HOUR
2. PLANT OPERATING BASIS: 330 DAYS/YR., 7920 HRS/YR.
3. ONE BUSHEL BARLEY = 48 POUNDS
REVISIONS
REV. NO. | DESCRIPTION | APPROVALS M-K | OWNER
0 | ISSUE FOR REPORT 9/17/80 | RCJ
REFERENCE DRAWINGS
DWG. NO | TITLE
SEAL
GFP, INC.
10MMGPY FUEL ETHANOL PLANT
CHURCHILL COUNTY, NEVADA
MORRISON KNUDSEN
INDUSTRIAL GROUP, BOISE DIVISION
BARLEY MATERIAL BALANCE
DRAWN BY S. ANTONE
SCALE —
PROJ. MGR. RCJ
66-0-002
DESIGNED BY R VANCE 8/18/20
CHECKED BY
CLIENT
CONTRACT NUMBER 1110-04
DEPT. ARCH. STRUCT. MECH. ELECT. P&I PIPING SAF.DES. P.E.
INIT.
DATE

3.3 ENERGY BALANCE

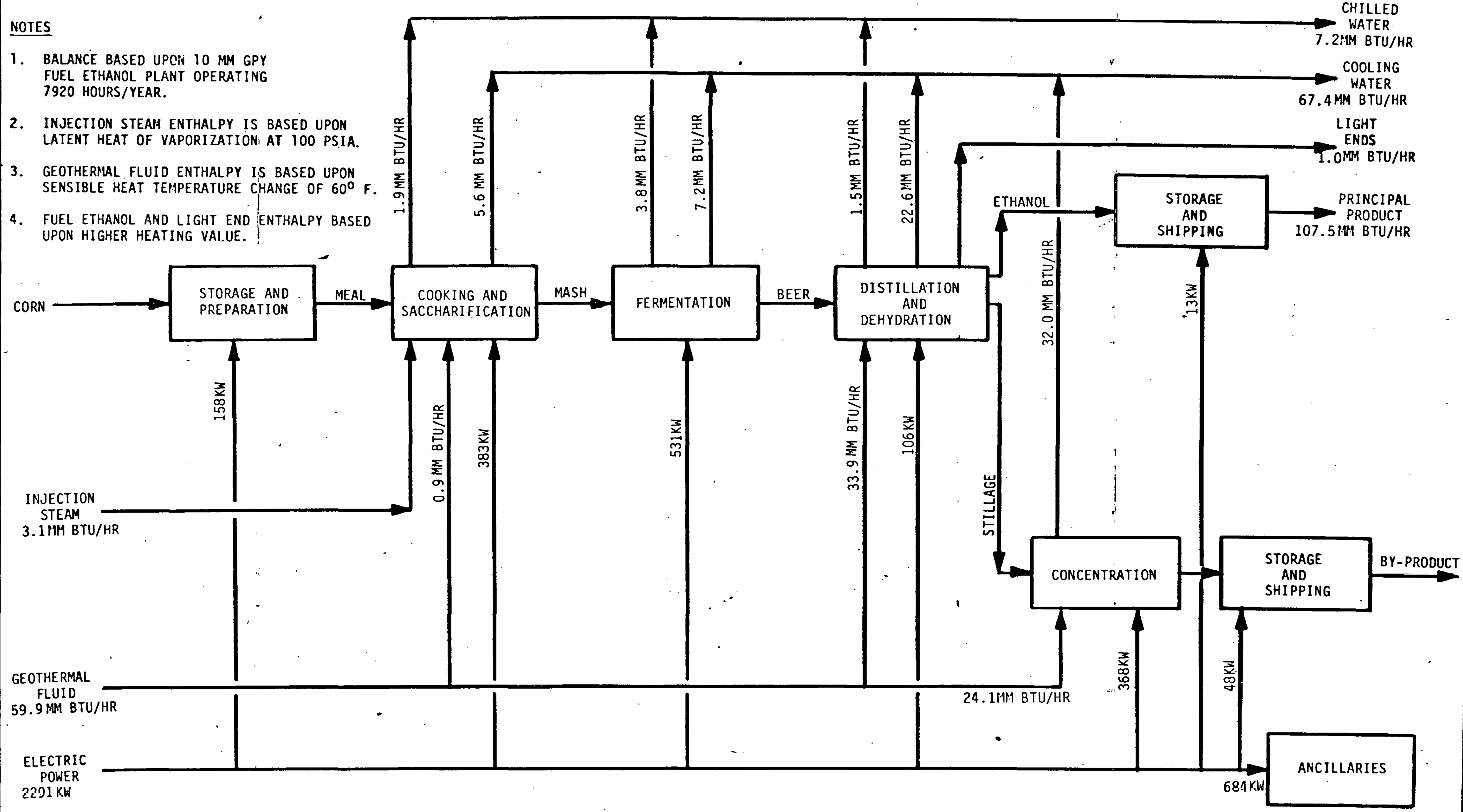
Drawing 66-0-003 summarizes energy requirements for the corn feedstock option, while Drawing 66-0-004 contains the barley energy balance. The block diagrams show the amount of electric power, cooling water, chilled water, injection steam and geothermal fluid required in the various plant areas. Energy requirements for stillage cake drying are not shown on the drawings but are reported separately below.

Electric power is purchased from the local utility. Most of the process cooling requirements are met using 74°F cooling water. This water is reused by recycling through a cooling tower. Low temperature process cooling needs require 40°F chilled water. The chilled water is produced by a commerical refrigeration unit. Refrigeration power is included in the electrical load for fermentation where most of the chilled water requirement exists. A small quantity of 100 psia injection steam is needed for mash cooking. It is generated in a boiler partially fired by light ends recovered from distillation.

The remaining process heat requirements are met using 290°F fluid from the geothermal reservoir. Geothermal energy requirements are converted into fluid flows in Table 3-2. Flow requirements are based upon a fluid sensible heat temperature drop of 60°F. A portion of spent fluid at 230°F is used for space heating within the process plant. The remainder will be available for other cascading uses as they become identified.

NOTES

1. BALANCE BASED UPON 10 MM GPY FUEL ETHANOL PLANT OPERATING 7920 HOURS/YEAR.
2. INJECTION STEAM ENTHALPY IS BASED UPON LATENT HEAT OF VAPORIZATION AT 100 PSIA.
3. GEOTHERMAL FLUID ENTHALPY IS BASED UPON SENSIBLE HEAT TEMPERATURE CHANGE OF 60° F.
4. FUEL ETHANOL AND LIGHT END ENTHALPY BASED UPON HIGHER HEATING VALUE.



DATE	REVISION OR ISSUE	NO.	BY	DATE	REVISION OR ISSUE	NO.	BY

CORN ENERGY BALANCE

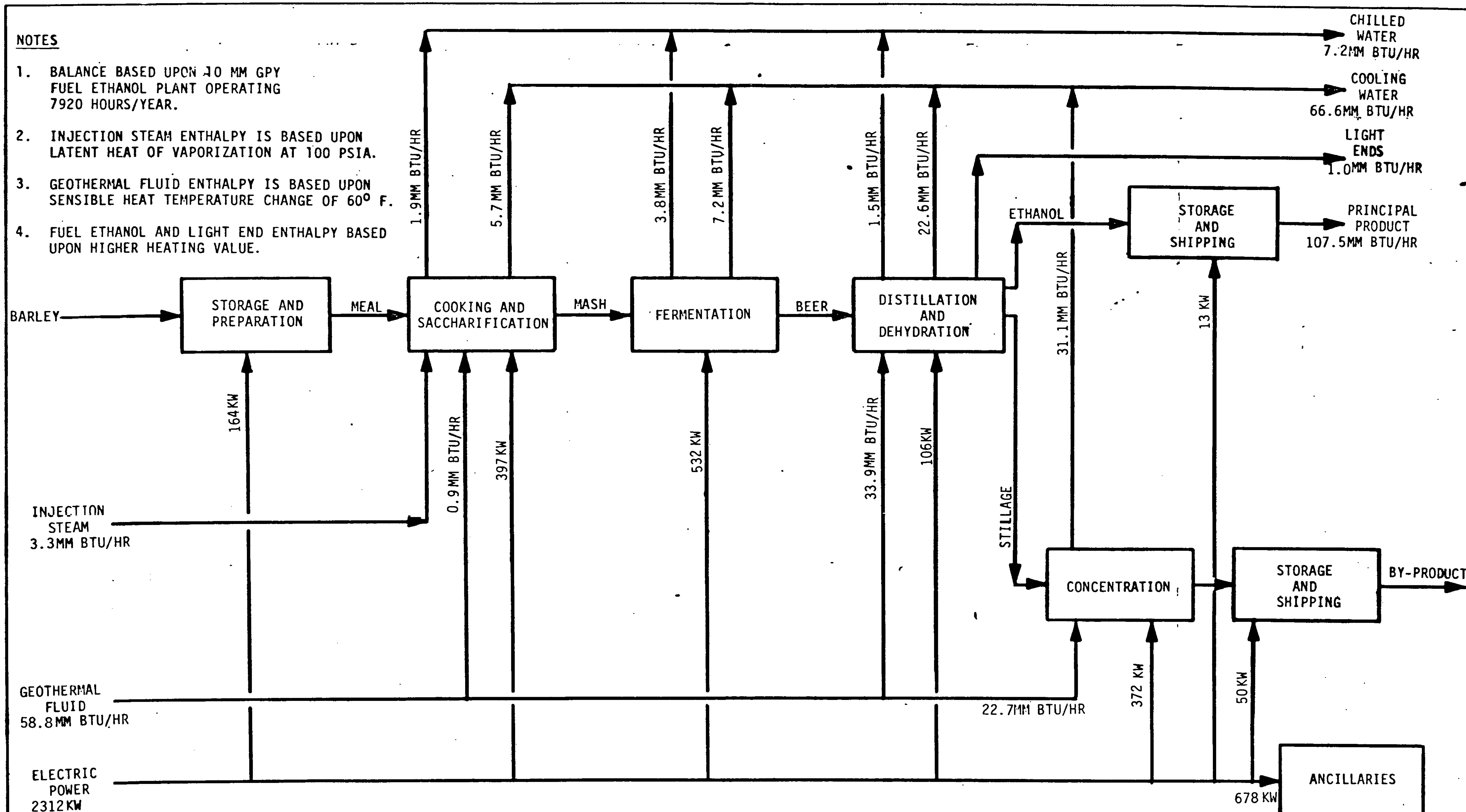
DRAWN BY	APPROVED BY	CONTRACT NUMBER
S ANTOINE		1110-04
CHECKED BY	**SCALE**	**SHEET NUMBER**
B VANCE		66-0-003

MORRISON KNUDSEN

3-5a INDUSTRIAL DIVISION

NOTES

1. BALANCE BASED UPON 10 MM GPY FUEL ETHANOL PLANT OPERATING 7920 HOURS/YEAR.
2. INJECTION STEAM ENTHALPY IS BASED UPON LATENT HEAT OF VAPORIZATION AT 100 PSIA.
3. GEOTHERMAL FLUID ENTHALPY IS BASED UPON SENSIBLE HEAT TEMPERATURE CHANGE OF 60° F.
4. FUEL ETHANOL AND LIGHT END ENTHALPY BASED UPON HIGHER HEATING VALUE.



DATE	REVISION OR ISSUE	NO.	BY	DATE	REVISION OR ISSUE	NO.	BY

BARLEY ENERGY BALANCE

DRAWN BY	APPROVED BY	CONTRACT NUMBER
S ANTOINE		1110-04
CHECKED BY	**SCALE**	**SHEET NUMBER**
B VANCE		66-0-004

MORRISON KNUDSEN

3-5b INDUSTRIAL DIVISION

TABLE 3-2

GEOTHERMAL FLUID REQUIREMENTS

OPERATION	FLOW (GPM) CORN OPTION	BARLEY OPTION
Mash Cooking and Saccharification	30	31
Distillation	1,130	1,130
Concentration	836	800
Subtotal	1,996	1,961
Contingency	254	289
Total	2,250	2,250

Stillage cake drying increases the process heat requirement approximately 1300 Btu's per pound of water evaporated. There is also an increase in the amount of electric power consumed. Dryer blower requirements result in an additional load of approximately 200 kw.

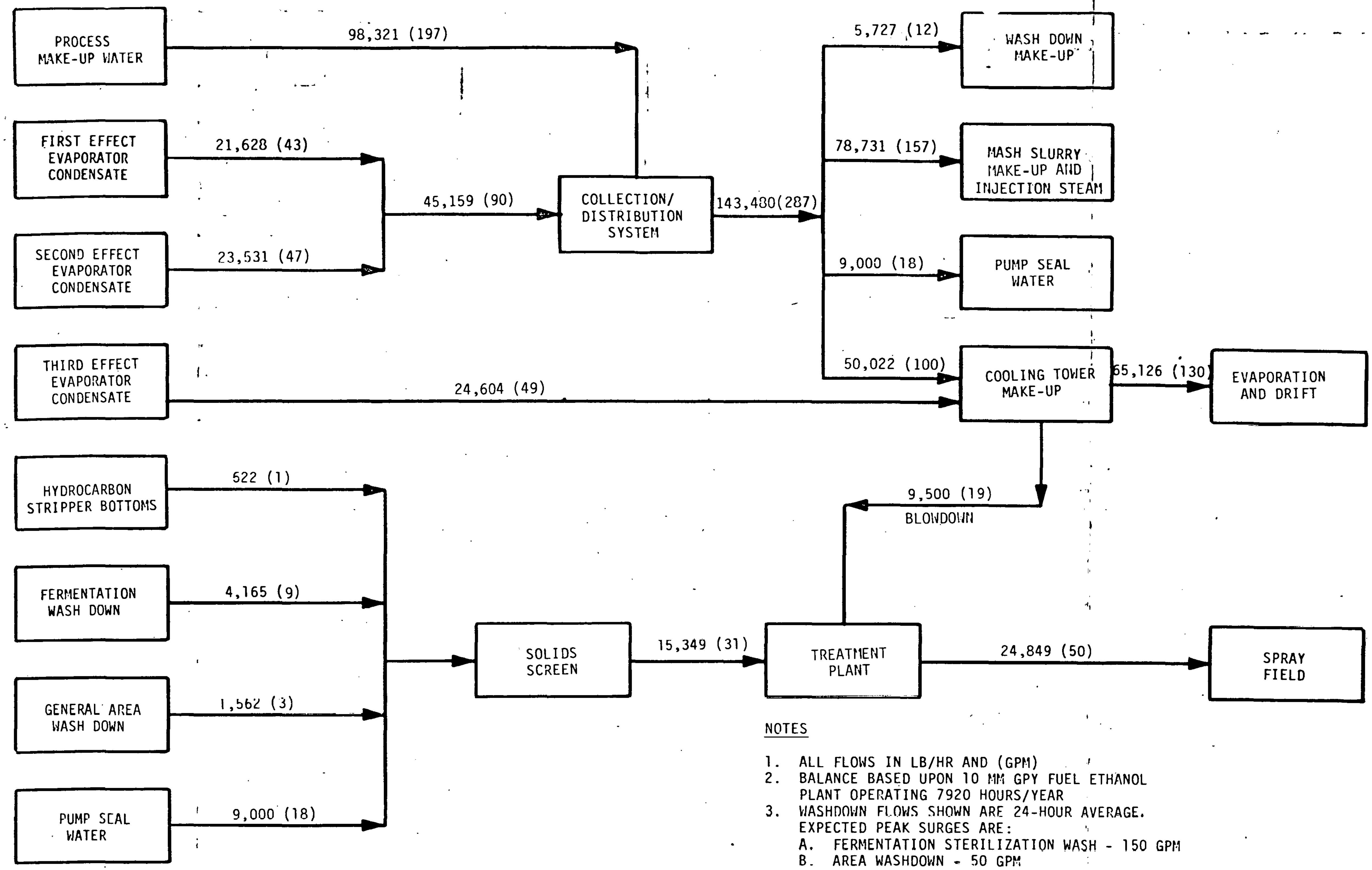
The geothermal fluid demand for stillage cake drying is 160 gpm for a corn feedstock and 205 gpm for barley. The flow rates are based upon reducing the moisture content of the cake to 10 percent and a fluid sensible heat temperature change of 120°F. The existing onion dryer operated satisfactorily under this fluid temperature range.

3.4 WATER BALANCE

Water balances for corn and barley are detailed in Drawings 66-0-005 and 66-0-006. Condensates are recovered from the multiple effect stillage evaporators. Water losses include cooling tower evaporation and drift, a small amount of process waste and washdown and the moisture contained in the plant by-products. Although every effort has been made to use as much recycled water as possible, a cold water well is necessary to supply plant make-up water.

Well water introduced into the process to prepare a mash slurry requires demineralization. Heavy metals and hydrogen sulfide are toxic to the enzymes used in saccharification and to yeast activity in fermentation. Total hardness should not exceed 50 ppm. Cooling tower make-up water quality requirements are less stringent but softening is necessary.

Liquid wastes from the plant contain high levels of BOD. Process wastewater is stabilized in a secondary treatment plant and transferred to a percolation pond for final disposal. Here, a portion of the aerated waste is evaporated, and the remainder allowed to percolate into the soil. The overall system is designed for zero discharge; no wastewater is allowed to leave the plant site.



NOTES

1. ALL FLOWS IN LB/HR AND (GPM)
2. BALANCE BASED UPON 10 MM GPY FUEL ETHANOL PLANT OPERATING 7920 HOURS/YEAR
3. WASHDOWN FLOWS SHOWN ARE 24-HOUR AVERAGE. EXPECTED PEAK SURGES ARE:
   A. FERMENTATION STERILIZATION WASH - 150 GPM
   B. AREA WASHDOWN - 50 GPM

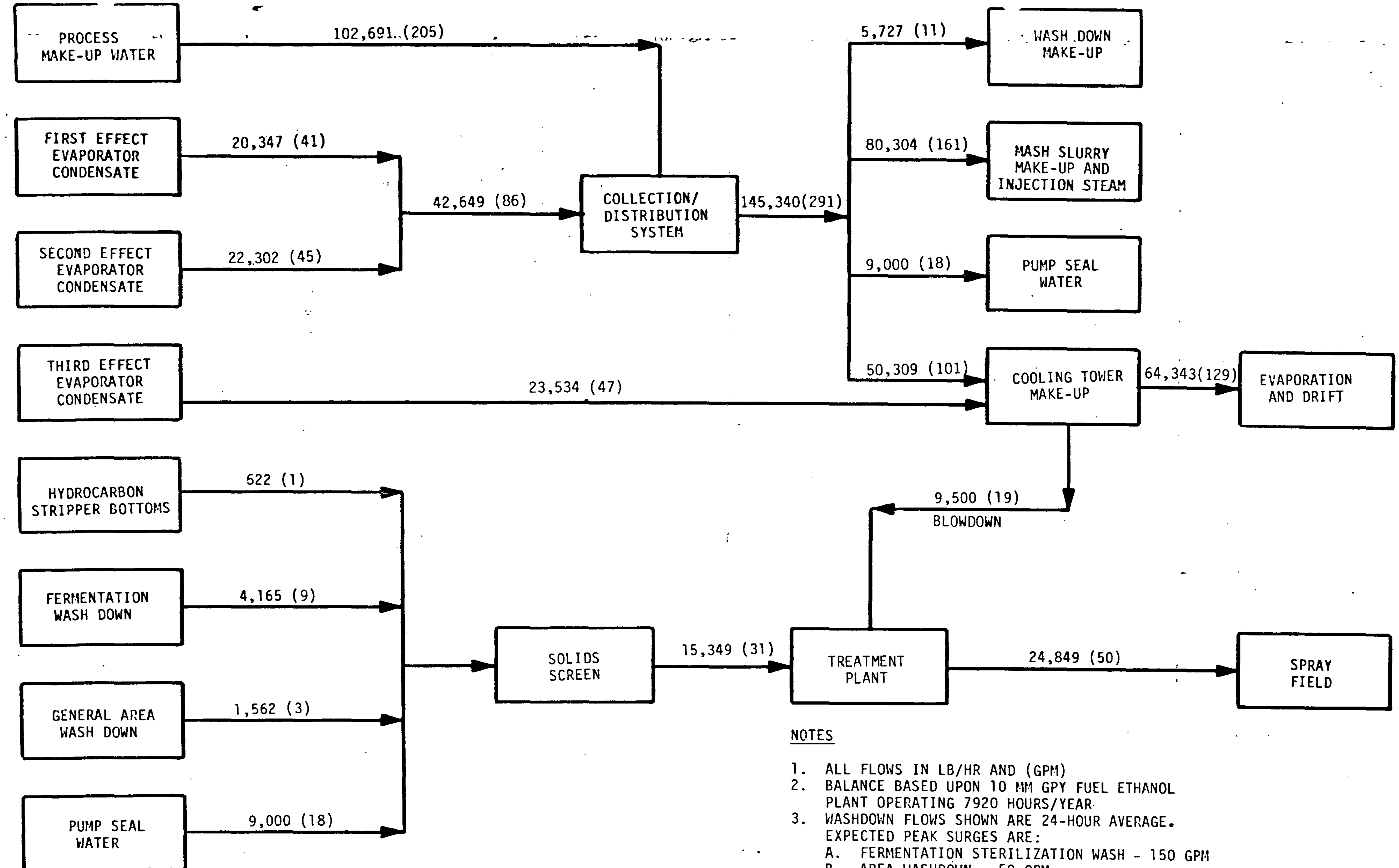
DATE	REVISION OR ISSUE	NO.	BY	DATE	REVISION OR ISSUE	NO.	BY

CORN WATER BALANCE

DRAWN BY	APPROVED BY	CONTRACT NUMBER
S.Antoine		1110-04
CHECKED BY	SCALE	SHEET NUMBER
B.Vance		66-0-005

MORRISON KNUDSEN

INDUSTRIAL DIVISION



NOTES

1. ALL FLOWS IN LB/HR AND (GPM)
2. BALANCE BASED UPON 10 MM GPY FUEL ETHANOL PLANT OPERATING 7920 HOURS/YEAR
3. WASHDOWN FLOWS SHOWN ARE 24-HOUR AVERAGE. EXPECTED PEAK SURGES ARE:
   A. FERMENTATION STERILIZATION WASH - 150 GPM
   B. AREA WASHDOWN - 50 GPM

DATE	REVISION OR ISSUE	NO.	BY	DATE	REVISION OR ISSUE	NO.	BY

BARLEY WATER BALANCE

DRAWN BY	APPROVED BY	CONTRACT NUMBER
ANTOINE		1110-04
CHECKED BY	SCALE	SHEET NUMBER
B.Vance		66-0-006

MORRISON KNUDSEN

3-9 INDUSTRIAL DIVISION

SECTION 4

PROCESS DESCRIPTION

This section discusses the various processing steps and unit operations required to produce fuel ethanol. The production process includes feedstock storage and preparation, mash cooking and saccharification, fermentation, distillation, product storage and shipping, by-product concentration and by-product storage and shipping.

4.1 FEEDSTOCK RECEIVING AND PREPARATION

Most of the feedstock required for ethanol production will arrive by rail in Fernley from the Midwest and neighboring states. Brady's Hot Springs does not have railroad service. It is approximatley ten miles from the Southern Pacific Railroad's main line.

Feedstock is transported from the primary storage facility at Fernley to the ethanol plant in end-dump trailer trucks. Brady is 23 miles east of Fernley via Interstate 80. When available, locally grown feedstocks will be delivered directly to the plant. However, Nevada currently does not produce sufficient feedstock to supply all of the plant's requirements.

Upon arrival at the gate, the haul trucks are weighed using the existing scale at the onion drying facility. They then proceed to a dump station where the tractor is disconnected and the trailer elevated by a hydraulic tilter. A conveyor transfers grain from the dump hopper to a bucket elevator. The elevator supplies a bin distribution conveyor which feeds seven storage bins. Total storage capacity is sufficient for 42 to 44 hours operation of the ethanol plant. The high capacity feedstock receiving equipment is sized to allow operation on one or two per day trucking schedule.

The stored grain is cleaned and ground to prepare it as a substrate for starch conversion and fermentation. Feedstock is withdrawn from storage at a rate based upon the 24-hour-per-day and 7-day-per-week ethanol plant operating schedule. It is conveyed from the storage bins to a bucket elevator where it is lifted to the preparation plant surge bin. The surge hopper is sized to provide a nominal holdup time of approximately four or five hours. Grain discharges from the surge hopper to a cleaner where materials foreign to the process such as sand and tramp metal are separated from the feedstock stream. Light material or chaff picked-up from the cleaning screens is pneumatically conveyed to by-product storage and shipping for mixing with stillage cake. The grain suitable for processing is then cracked in a hammermill and air transported to mash cooking and saccharification.

4.2 MASH COOKING AND SACCHARIFICATION

Grain meal from the preparation area is delivered to an elevated surge bin. The output from the bin is split and delivered to one of two processing trains consisting of weigh tanks, a mash mixing tank, a mechanical mash cooking extruder and a saccharification vessel. A batch weigh tank provides an accurate record of the total grains used, while a continuous weigh tank provides an indication of the grain used within any given time period.

The cracked grain from the continuous weigh tank drops into an agitated tank where process water is added to form a solution containing 40 percent moisture. Sulfuric acid is added to reduce the pH to 4.0 to 5.5. The mash leaves the mix tank through a live bottom surge bin and is force fed to the cooker using screw conveyors.

Due to the relatively low temperature of the geothermal fluid, the Wenger continuous extrusion system is recommended for mash cooking or gelatinization. Unger/Seagram pipeline reactors, normally used for cooking in modern plants, require a source of 150 psig, 365°F injection steam. In the proposed extruder, mechanical energy is substituted for process heat decreasing the 12,000 to 14,000 lb/hr pipeline cooker injection steam requirement to appproximately 2700 lb/hr. Geothermal fluid is used for extruder barrel heating and supplies about one fourth of the total heat requirement.

Although Wenger continuous extrusion systems have long been used in the commercial production of cereals, snack and pet foods, their introduction into alcohol prodcution is relatively new. A 1.5 MM GPY commercial unit is presently being installed in North Pacific Energy Company's fuel ethanol plant in Pasco, Washington. Plant start-up is scheduled for October, 1980. An additional 6 MM GPY unit has also been ordered for delivery later in the year.

Other advantages of the Wenger system include reduced saccharification retention time, compatibility with additional feedstocks, and high yields. The shearing action of the extruder decreases the time required for subsequent starch conversion to as little as 10 to 15 minutes, minimizing saccharification tankage. The extruder can process alternative feedstocks such as cull potatoes with several changes to the feedstock handling and preparation system. Modifications include construction of a slab storage area and installation of washing and additional conveying equipment. Installation of potato disintegrators is not necessary. Laboratory tests of both pilot and full-scale extruders have repeatedly shown higher yields than conventional processes. Use of Wenger equipment could slightly increase the practical ethanol yield used in the material balance calculations discussed in Section 3.2.

The cooked mash at approximately 200° F from the extruder drops into saccharification tanks where enzymes and dilution water are added. The make-up water primarily consists of recycled thin stillage or backset, and evaporator condensates from by-product concentration along with a small quantity of treated process water. The dilution water cools the hot mash to 145° F for saccharification. Following conversion, the resulting glucose solution containing 17 to 18 percent fermentable sugars is cooled to 80° F and continuously pumped to fermentation.

4.3 FERMENTATION

The fermenters are batch operated and consist of eight vessels arranged in sets of four with one heat exchanger and circulation pump for each set. Since cooling is needed for only about nine or ten hours out of the 48-hour fermentation cycle, one exchanger and pump serves the needs of four fermenters. The fermentation tanks are filled over a six-hour period with yeast and nutrients added along with the feed.

As the exothermic ethanol reaction proceeds to completion, the temperature in the fermenter gradually rises to a maximum of 95°F. Cooling is provided during this peak fermentation period because yeast activity rapidly decreases at higher temperatures. Vessel contents are circulated through the fermenter cooler which also serves to agitate the tank. Chilled water necessary for mash cooling will be produced by a commercial refrigeration unit located near the fermenters.

At the end of the fermentation period, the resulting beer is pumped to a beer well and then transferred to distillation. Sodium hydroxide is added to the beer prior to introduction into the beer well to increase pH and allow use of carbon steel construction in downstream processing. Due to their large size, the fermenter tanks are also constructed using carbon steel. Because they contain non-neutralized beer, a high corrosion allowance is specified in lieu of stainless steel construction.

After each fermentation cycle, the fermenters are cleaned and sterilized using clean-in-place equipment. Two high-pressure, rotojet machines are installed in each tank. The fermenters are washed with a cleaning solution and sterilized with an iodine solution in preparation for the next cycle.

Carbon dioxide produced during fermentation is vented to the atmosphere. If a suitable market for this gas develops, carbon dioxide can be recovered and sold as a by-product.

4.4 DISTILLATION

Fuel grade ethanol is separated from the dilute beer by distillation. Stripping and rectification is separated into two columns to reduce individual tower height for zone 4 seismic requirements. Major equipment items include stripping, enriching, dehydration and hydrocarbon stripping towers. Means are also provided for removal of the extraneous products.

A. Stripping Tower

The dilute beer feed contains 7.6 weight percent ethanol and 7 to 9 weight percent solids. The solids consist of approximately equal amounts of soluble and suspended solids. The beer, which left the beer well at a temperature of approximately 90° F, undergoes two preheating steps before it enters the first stage of distillation. The first preheating step partially condenses the overhead vapors from the enriching tower. Approximately 50 percent of the total preheating is accomplished in this condenser-feed preheater. The warmed beer then passes into the second heat exchanger where the remaining preheat is completed using the whole stillage bottoms stream from the stripping column. The saturated feed next passes into a degassing drum where any carbon dioxide dissolved in the feed is flashed off. Any ethanol or water vapor, accompanying the vented carbon dioxide, is condensed in a vent condenser and returned to the feed stream.

In the stripping tower, ethanol is stripped from the dilute beer. The saturated feed enters the top tray of the tower. Because of the high suspended solids content of the beer feed, disc and donut-type trays will be used in the tower. These trays are effective contacting devices which tend to be self-purging and do not allow the build-up of solids which would block ordinary sieve trays. The special trays are patented by Ralphael Katzen Associates International, Incorporated.

The non-volatile soluble solids and suspended solids in the beer flow downward through the stripping section of the tower. A very dilute ethanol stream, containing less than 0.02 weight percent alcohol, is removed from the bottom of the tower. This whole stillage stream, containing the dissolved and suspended solids, then passes through the stillage-feed preheater where its temperature is reduced to approximately 165°F from 225°F. Solids in the stillage are concentrated for use as animal feed in another area of the plant.

Process heat is supplied to the stripping tower from the hot geothermal fluid. A reboiler is located at the base of the tower.

B. Enriching Tower

The enriching tower is designed to produce 190° proof ethanol. It contains sieve trays and has a reduced diameter compared to the stripping tower. Since the enriching column is simply an extension of the stripping column, a reboiler is not required.

Ethanol-rich vapors pass overhead from the tower and are utilized as a source of feed preheat by condensing a portion of them in the condenser-feedheater. The balance of this vapor is condensed using cooling water in the final vapor condenser. The condensate from both exchangers is collected in a reflux drum and pumped back to the top tray of the tower.

The upper five trays of the enriching column operate in nearly total reflux. The product from the tower is removed as a liquid side draw about five trays from the top. The stream is then transferred to the mid-section of the dehydration tower.

C. Dehydration Tower

A hydrocarbon such as a benzene is added to the concentrated ethanol-water solution in the dehydration tower. The hydrocarbon breaks the binary azeotrope allowing additional separation of the two components. Heat is supplied to the base of the column through a reboiler using geothermal fluid.

The bottoms stream from the tower is anhydrous motor fuel grade alcohol. The product stream has a concentration of 99.3 weight percent ethanol with the balance being water. The product is first pumped through a cooler where its temperature is reduced to 100°F and then to storage and shipping.

The overhead product from the dehydration tower is a ternary minimum boiling azeotrope consisting of the hydrocarbon, ethanol, and water. The vapors are condensed in a primary condenser which utilizes cooling water to remove the heat of condensation. The condensate then passes to a reflux cooler where it is subcooled by cooling water. Next, the subcooled liquid is transferred to a decanter.

The subcooled liquid entering the decanter separates into two layers. The upper layer is the largest in volume and is the hydrocarbon-rich layer. The lower layer is a water-rich, but contains some alcohol and hydrocarbon. The upper layer from the decanter is pumped back to the top tray of the dehydration tower while the lower layer is returned to the top tray of the hydrocarbon stripping column.

D. Hydrocarbon Stripper

The hydrocarbon stripping column recovers the hydrocarbon and ethanol present in the decanter bottoms to minimize process losses. Thermal energy is supplied to the base of the tower by geothermal fluid in a reboiler.

Overhead vapors from the column contain ethanol, water and the hydrocarbon. They are condensed and returned through a reflux cooler to the decanter.

The bottoms stream from the hydrocarbon stripper is sent to the waste water treatment plant. This aqueous stream contains less than 0.02 percent ethanol and only a trace of entrained hydrocarbon. Expected hydrocarbon loss is less than 100 gallons per year.

E. Extraneous Products

In the fermentation process, certain extraneous products in addition to ethanol are formed. These are primarily higher molecular weight alcohols, known as fusel oils, and light ends, consisting mostly of acetaldehyde. Fusel oil and light ends must be removed because their presence would upset the equilibrium associated with the dehydration and decantation steps.

The fusel oils have the property of being more volatile than ethanol in dilute aqueous solutions, but are less volatile in concentrated solutions. Therefore, they tend to concentrate on some intermediate tray in the enriching tower. They can be removed from the tower as a liquid side draw. Following cooling, the side draw is transferred to the fusel oil washer.

The washer consists of an extraction tower in which the ethanol contained in the fusel oil mixture is recovered under reduced temperature by counter-currently contacting the side draw stream with cooling water. The heavy aqueous stream, containing the extracted ethanol is removed from the base of the washer. It is returned to an intermediate tray of the stripping tower for ethanol recovery. The lighter fusel oil stream is decanted from the top of the washer and pumped to a storage tank. The fusel oil has a heating value and is reblended into the product. Fusel oil has no harmful effect upon motor fuel grade ethanol.

Light ends are removed from the distillation system by withdrawing a very small purge from the total reflux stream passing back to the top tray of the enriching tower. This purge stream cannot be reblended into the product ethanol. The light materials tend to cause vapor lock whenever they are mixed with gasoline. Therefore, the light ends are pumped to an injection steam boiler where their fuel value is recovered. The injection steam is used to aid mash cooking as discussed in Section 4.2.

4.5 PRODUCT STORAGE AND SHIPPING

Fuel grade ethanol from distillation is collected and temporarily stored in one of two receiver tanks for precise measurement. Receiver tanks are required by the U.S. Bureau of Alcohol, Tobacco and Firearms. Each tank is sized for one days production. While one tank is being filled, the contents of the other can be checked for quality and quantity.

The 199° proof ethanol is then pumped to the product storage area, which is sized to hold five days production. During transfer, denaturant is added to the ethanol at the rate of 5 gallons of unleaded gasoline per 100 gallons alcohol using continuous in-line blending equipment.

The denatured ethanol will be shipped by truck to refineries for blending with gasoline to produce gasohol. A loading station and associated metering equipment is provided for loading the tank trucks. Product losses during loading and unloading are minimized by use of a vapor recovery system.

4.6 BY-PRODUCT CONCENTRATION

Whole stillage from distillation is first collected in an agitated surge tank. It is then pumped through two continuously operating centrifugal separators. The solid bowl centrifugals divide the flow into two fractions: thin stillage containing 5-10 percent total solids and thick stillage containing about 35 percent solids.

Part of the thin stillage is recycled to the mash mixing tank in the cooking and saccharification area of the plant. This backset corresponds to approximately 20 percent of the total thin stillage flow. The remaining thin stillage is concentrated in a multiple effect evaporator to about 35 percent dissolved solids.

The thin stillage advanced to the evaporator drops into an agitated surge tank and is then transferred to the first effect of a three effect evaporator. The system is operated with forward feed. Geothermal fluid is used to supply the heat necessary to preheat the evaporator feed and to supply the energy necessary for first effect evaporation. Overhead vapor from this effect is condensed to supply the heat of evaporation for the second effect. In turn, second effect vapor is used to supply heat to the third effect. Last effect vapor is condensed in a direct contact barometric condenser using cooling water. The other effects have surface type condensers. The condensed vapors from all three effects are a major source of process make-up water. Each effect operates at a successively lower temperature and pressure maintained by a vacuum pump. The pump, which is located at the final vapor condenser, removes noncondensible gases from the system. Uniform liquor distribution within each evaporator vessel is maintained by a recycle pump. The thick syrup from the third effect is transferred to an agitated surge tank and then pumped to the concentrated solubles storage area.

Most of the fiber and other suspended solids leave with the thick stillage fraction. This wet cake is conveyed to storage bins for direct sale as an animal feed.

Thick stillage cannot be economically shipped long distances due to its high water content. If local markets do not exist for the quantities of stillage cake produced by the ethanol plant, the material will be dried to 10 percent moisture. It can then enter the national and export market for distiller's dried grain.

If required, a horizontal belt conveyor dryer similar to the existing installation at the onion drying plant is recommended for cake drying. This equipment already has a proven record of success in geothermal service. Present plant employees also have operating and maintenance experience with this type of equipment.

Rotary tube dryers were considered for grain drying. They commonly use steam inside tubes to provide process heat. Use of the geothermal fluid in lieu of steam would considerably decrease the overall heat transfer coefficient and result in larger equipment than normaly necessary. The capital cost of a rotary tube dryer installation is significantly higher than the proposed conveyor drying facility. Rotary dryers also have higher maintenance costs due to rapidly fouling heat transfer surfaces.

4.7 BY-PRODUCT STORAGE AND SHIPPING

The plant by-products are stillage cake and concentrated distillers solubles. Both are sold as is for animal feed.

The stillage cake from the centrifuges is transferred to one of three specially designed storage bins using a series of conveyors and a bucket elevator. The elevated storage bins have a total storage capacity of two days production. Storage of the wet material for longer than 48-hours invites spoilage.

The cake is periodically discharged through specially designed clamshell gates into haul trucks for delivery to area feedlots and dairies. Sixty degree side slopes on each bin prevent material bridging during truck loading.

If the cake is dried and pelletized instead of shipped wet, standard cylindrical bins can be used for storage. Standard pelletization, grain handling and loadout equipment will also be specified.

The concentrated distillers solubles (CDS) stream is a viscous liquid which is similar in appearance to molasses. Unlike stillage cake, CDS is storable. It also has a higher nutrient value and can be economically shipped greater distances.

CDS is handled using conventional equipment designed for molasses service. It is pumped from the evaporation area to one of two storage tanks. The tanks provide a combined storage capacity of five days production. CDS is then periodically transferred to tank trucks for direct delivery to market or transshipment by rail.

SECTION 5

ANCILLARY FACILITIES

Section 5 discusses the support services necessary for producing ethanol at Brady's Hot Springs. These ancillary facilities consist of the geothermal heat system and the plant utilities including water, wastewater, steam and compressed air distribution.

5.1 GEOTHERMAL HEAT SYSTEM

All of the process heat needs can be met using low salinity fluid from the geothermal reservoir with one exception. Mash cooking requires a small amount of high pressure injection steam. The temperature of the fluid is not high enough to allow heat recovery via a flash steam process. The steam required for the Wenger mash cooking process is only about five percent of the total process heat requirement.

Based upon the reliable operation of the onion drying facility, sensible heat will be recovered from the geothermal fluid using shell and tube heat exchangers at the proposed fuel ethanol plant. Carbon steel construction is used for all equipment and piping in contact with the geothermal fluid. Experience at the onion plant indicates that chlorides present in the fluid cause accelerated corrosion in stainless steel.

Scaling within the distribution system is prevented by keeping the pressure of the fluid above saturation. If the liquid is allowed to flash, release of carbon dioxide increases fluid pH resulting in carbonate precipitation.

A separate study was conducted by GeothermEx to confirm geothermal reservoir capacity and evaluate well design. The assumptions used in preparing the cost estimate for the fuel ethanol plant are discussed below.

If stillage cake drying is not required, the geothermal reservoir must supply the fuel ethanol plant with 290°F fluid at a rate of 2250 gpm. Fluid requirements for the unit operations in ethanol production are summarized in Section 3.3.

Stillage cake drying requires a maximum geothermal fluid flow of approximately 205 gpm. This flow rate is based on the same fluid temperature drop found satisfactory for onion drying: a delta "T" of 120°F. The 10 percent contingency designed into the geothermal fluid production system provides adequate heat for cake drying without drilling of additional wells.

The two production wells presently serving the onion drying facilities are approximately 1200 feet deep. One of the wells is in standby service. Each well is pumped at a maximum rate of 750 gpm using a line-shaft pump set at a depth of 250 feet. Distribution system pressure at the dryer is approximately 120 psig. This experience indicates that an additional three wells should be drilled to serve the proposed ethanol plant. The existing standby well for the dryer can also serve the new ethanol facility. New production wells may be deeper than the existing wells.

Withdrawal of large amounts of geothermal fluid will likely result in reservoir depletion unless reinjection is practiced. The residual pressure remaining in the fluid distribution system after heat exchange is designed to be high enough to allow reinjection without additional pumping. For the purpose of this feasibility study, two reinjection wells are included in the cost estimate. One well is assumed to be in operation, while the other serves as a spare. The relatively small geothermal fluid sensible heat temperature drop may allow locating the reinjection wells relatively close to the production wells without reducing the fluid supply temperature. A program will be developed for testing the proposed reinjection system prior to final design. For a more detailed discussion of the geothermal production system, see Section 3 of Volume 2.

5.2 UTILITY SYSTEMS

A. Plant Water Systems

Even after recovery of evaporator condensates, the ethanol plant will require approximately 200 gpm of process make-up water. As shown in Section 3.4, the water is primarily needed for cooling tower make-up and mash slurry preparation.

An existing well producing cold water of good quality is located approximately one mile north of the plant site on land owned by others. Preliminary discussions with the landowner indicate that satisfactory arrangements can be made for drilling an additional well or wells near the present well. However, exact well locations and resulting water quality are not at present known. Additional exploratory work by a hydrological consultant is necessary.[1]

The degree of treatment depends upon the final use of the water. Water introduced into the process to prepare a mash slurry should be demineralized. It should not contain arsenic or heavy metals which are toxic to the enzymes used in saccharification and fermentation. Total hardness should not exceed 50 ppm. Cooling tower make-up water quality requirements are less stringent but softening will likely be necessary.

For the purposes of this feasibility study, all make-up water will be sent through a lime-soda treatment plant. Following sand filtration to remove residual turbidity, the softened water will be used directly for cooling tower make-up, chlorinated for use in the potable water system and, after further treatment, used for process make-up.

[1]GeothermEx, Inc., future work.

A mixed-bed ion exchange system followed by carbon absorption polishing is recommended for the water used to prepare the mash slurry and high quality injection steam.

In addition to the process and potable water loops, a fire protection water loop is required. The plant fire protection system includes a motor-driven fire pump, a diesel-driven fire pump and a motor-driven jockey fire pump. The jockey pump maintains pressure in the fire loop. In the event of a drop in loop pressure, the motor-driven fire pump is activated. The diesel-driven pump starts only upon a continued loss of line pressure. Fire protection water is stored in the bottom portion of a combined process/fire protection water storage tank.

The remaining plant water loops are for cooling and chilled water. A mechanical draft cooling tower recycles warm water from the process heat exchangers and returns it to the process at a maximum temperature of 74°F. For lower temperature process cooling requirements, a commercial refrigeration unit produces 40°F chilled water. The cost of the refrigeration system is included in the fermentation equipment list. The largest chilled water demand is found in the fermentation operation.

B. Waste Water Systems

Process wastewater production is minimized in fuel ethanol production by recycling as much water as possible within the plant. Contaminated water that cannot be returned to the process includes fermentation vessel washdown, area washdown, pump seal water, hydrocarbon stripper bottoms, cooling tower blowdown and area washdown. Estimated waste water quantities are found in Section 3.4. The small amount of sanitary waste from the ethanol plant is not mixed with the process waste. A septic tank and drain field is provided for sanitary waste disposal.

The proposed process water treatment system consists of flow equalization, followed by secondary treatment and absorbtion/evaporation in a percolation pond. The overall system is designed for zero discharge; no wastewater is allowed to leave the plant site.

The recommended treatment process is an oxidation ditch or carrousel raceway. This process is especially suited for treatment of wastes when shock loads are common, where cold temperatures are anticipated and where little operator attention is required. It is a modification of the complete mix, extended aeration process. The plant consists of a shallow, concrete-lined channel with floating or rotor aerators.

C. Injection Steam System

The mash cooling operation requires a source of 100 psia steam. A small, 100 Bhp steam generator is used to produce the required amount of injection steam. The standard commercial unit is equipped with dual burners capable of burning either a liquid or gaseous fuel. The cost of the boiler package is included in the mash cooking and saccharification area.

Approximately one third of the fuel required for steam production can be met using the light ends collected in distillation. The difference is supplied by propane. The onion drying facility has a surplus 30,000 gallon storage vessel and vaporizer which can be relocated.

D. Plant Air System

In addition to the water loops, a plant air loop is required. Compressed air is needed for gate and valve activation and for various maintenance functions.

The plant air system consists of two compressors with aftercoolers, two dryers, a central receiver and the pipe loop. One of the compressors and dryers is in standby service.

The dryer removes moisture from the compressed air down to a dew point of -20°F at line pressure. This prevents freezing during periods of cold weather.

SECTION 6

SITE LAYOUT

This section presents a preliminary site plan showing the relationship between the fuel ethanol plant and the existing onion drying facility. It also discusses the number and type of buildings required at the ethanol plant.

6.1 SITE PLAN

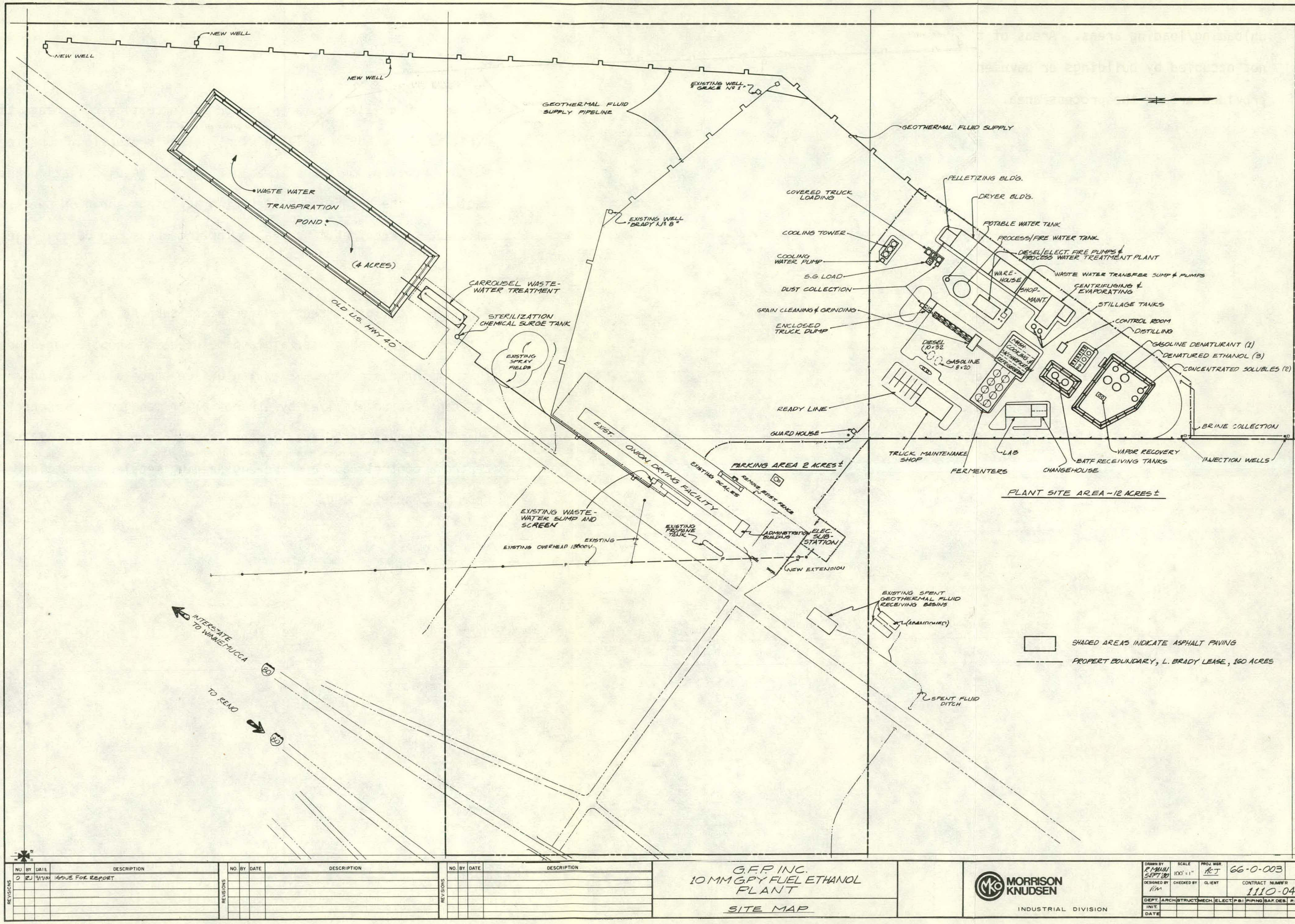
The ethanol plant and ancillary facilities are located on fee land adjacent to the onion drying facility. Drawing 66-0-003 contains a preliminary site plan.

The 12 acre process plant site is located approximately 600 feet southeast of the onion plant. The wastewater treatment facility is about 500 feet north of the drying facility. Assumed geothermal production well locations are found along the eastern boundary of the property, while injection wells may be located south of the process plant. Exact well locations will depend upon a detailed reservoir evaluation.[1] Electrical power is obtained from Sierra Pacific Power Company's main 120 Kv transmission line between Winnemucca and Reno. The existing feeder line to the onion drying plant is rated at 13.6 Kv. An additional substation for the ethanol plant is located just south of the drying plant. The ethanol plant cooling tower is located north of the process complex because the prevailing wind is from the south-southwest.

Minimum site grading is required. The storm drainage system consists of ditches, culverts and small areas of storm sewers. Plant roads and parking areas are asphalt pavement with sections of concrete pavement at

[1]GeothermEx, Inc., future work.

unloading/loading areas. Areas of the site disturbed by construction, but not occupied by buildings or pavement, are graveled. A perimeter fence is provided around the process area.


NEW WELL
NEW WELL
NEW WELL
EXISTING WELL GRACE No 1
GEOTHERMAL FLUID SUPPLY PIPELINE
GEOTHERMAL FLUID SUPPLY
WASTE WATER TRANSPIRATION POND
(4 ACRES)
EXISTING WELL "BRADY No 8"
CARROUSEL WASTE-WATER TREATMENT
STERILIZATION CHEMICAL SURGE TANK
OLD U.S. HWY 40
EXISTING SPRAY FIELDS
PELLETIZING BLD'G.
DRYER BLD'G.
COVERED TRUCK LOADING
POTABLE WATER TANK
PROCESS/FIRE WATER TANK
DIESEL/ELECT. FIRE PUMPS & PROCESS WATER TREATMENT PLANT
COOLING TOWER
COOLING WATER PUMP
S.G LOAD
DUST COLLECTION
WARE-HOUSE
SHOP-MAINT.
WASTE WATER TRANSFER SUMP & PUMPS
CENTRIFUGING & EVAPORATING
STILLAGE TANKS
GRAIN CLEANING & GRINDING
CONTROL ROOM
ENCLOSED TRUCK DUMP
DISTILLING
DIESEL
GASOLINE
GASOLINE DENATURANT (1)
DENATURED ETHANOL (3)
CONCENTRATED SOLUBLES (2)
READY LINE
GUARD HOUSE
BRINE COLLECTION
TRUCK MAINTENANCE SHOP
FERMENTERS
LAB
CHANGEHOUSE
BATF RECEIVING TANKS
VAPOR RECOVERY
INJECTION WELLS
PARKING AREA 2 ACRES±
PLANT SITE AREA ~12 ACRES±
EXIST. ONION DRYING FACILITY
EXISTING SCALES
EXISTING WASTE-WATER SUMP AND SCREEN
EXISTING PROPANE TANK
ADMINISTRATION BUILDING
ELEC. SUB-STATION
EXISTING
EXISTING OVERHEAD 13800V
NEW EXTENSION
INTERSTATE TO WINNEMUCCA
TO RENO
EXISTING SPENT GEOTHERMAL FLUID RECEIVING BASINS
(ABANDONED)
SPENT FLUID DITCH
SHADED AREAS INDICATE ASPHALT PAVING
PROPERT BOUNDARY, L. BRADY LEASE, 160 ACRES
NO BY DATE DESCRIPTION
0 ISSUE FOR REPORT
REVISIONS
G.F.P. INC.
10 MM G.P.Y. FUEL ETHANOL PLANT
SITE MAP
MORRISON KNUDSEN
INDUSTRIAL DIVISION
DRAWN BY R MANN SEPT '80
SCALE 100' = 1"
PROJ. MGR. RCJ
66-0-003
DESIGNED BY RM
CHECKED BY
CLIENT
CONTRACT NUMBER 1110-04
DEPT. ARCH. STRUCT. MECH. ELECT. P&I PIPING SAF. DES. P.E.
INIT.
DATE

6.2 BUILDINGS

Process and utility equipment, with the exception of storage tanks and bins, is enclosed in buildings for weather protection. Due to their height, however, only the lower portion of the distillation towers is enclosed. The dryer and pelletizing buildings shown on the site plan will not be required if suitable local markets can be developed for stillage cake.

Additional buildings required for plant support include a control room, a laboratory/changehouse, a plant maintenance shop, a warehouse and a truck maintenance shop. Existing office space at the onion drying facility can also be utilized by ethanol plant managerial personnel. Additional office space is located in the laboratory building. All buildings except the control room are pre-engineering metal construction. The control room is concrete block construction.

SECTION 7

COST AND SCHEDULE

Section 7 estimates the capital and operating cost of the fuel ethanol plant at Brady's Hot Springs. It also presents a preliminary engineering and construction schedule for project completion.

7.1 CAPITAL COST

The required capital investment needed for the process plant and ancillary facilities is summarized by unit operation or plant area in Table 7-1. The figures include a 5 percent construction contractors fee and a 20 percent contingency. If stillage cake by-product drying is not required, the total investment at Brady's Hot Springs will total approximately $21 million. This includes the process plant and ancillary facilities, but excludes additional agricultural, environmental, reservoir and preliminary engineering studies. It also does not include project management. Construction of a stillage cake dryer and pelletizing plant would cost an additional $1.2 million.

Although a truck maintenance shop is included in the cost of the ancillary facilities, feedstock and by-product haul trucks are not included in the estimate. The cost of the required feedstock storage facility at Fernley is also not included. Costs associated with feedstock transshipment are being addressed in Volume 2 of this report.

The estimate is based upon the current price of major equipment items. Equipment costs used in the study are based upon verbal vendor quotations, costs from previous studies and data on hand. The installed cost is then determined by applying factors to the cost of the equipment. The accuracy of the resulting estimate is plus or minus 30 percent. A detailed breakdown of the equipment costs and installation factors used in preparing Table 7-1 is found in Appendix 1.

TABLE 7-1

CAPITAL COST SUMMARY

AREA	OPERATION	COST
01	Feedstock handling and preparation	$ 1,147,700
02	Mash cooking and saccharification	3,538,700
03	Fermentation	1,804,800
04	Distillation	1,835,600
05	Alcohol storage and shipping	883,600
06	By-product concentration	2,028,700
07	By-product storage and shipping	1,134,900
08	Ancillary facilities	
	Geothermal fluid production/reinjection system	3,200,000
	Other ancillary facilities	5,470,600
	SUBTOTAL PLANT	21,044,600
09	Optional Stillage Cake Drying and Pelletizing	1,200,000
	GRAND TOTAL (AREAS 01 THROUGH 09)	$22,244,600

7.2 OPERATING COST

The annual operating cost of the fuel ethanol plant is tabulated in Tables 7-2 and 7-3. The first table is based upon a corn feedstock while the second is for barley. The operating cost summaries include feedstock, freight to Fernley, other raw materials, maintenance material, utilities, labor and certain miscellaneous expenses. They do not include operating the railside storage facility at Fernley, transshipment of the feedstock to the process plant at Brady's Hot Springs, and the additional 200 kw electrical demand required for stillage cake drying.

The estimated total unit operating cost is $1.82 per gallon of fuel ethanol produced from corn and $1.93 per gallon from barley. The total annual expenses are $19.1 million for the corn option and $20.3 million for the barley alternative. Over 75 percent of the operating cost goes toward feedstock purchase and transportation to Fernley.

Although the process plant operating cost for barley is slightly higher than corn, the total sales revenue generated by a barley feedstock will also be higher. As discussed in Section 3.2, the barley option produces greater amounts of by-product solids for sale as animal feed. The most economical feedstock will also depend upon the by-product selling price as well as the operating cost. By-product pricing is addressed in Section 5 of Volume 2.

Labor requirements and payroll rates used in developing the operating cost estimate are found in Tables 7-4 and 7-5. The plant administrative staff consists of the 16 people identified in Table 7-4. The operating labor force, described in Table 7-5, totals 61 people. This personnel requirement is based upon a three shift per day and seven day per week operating schedule. The salary or wage shown for each classification is based upon average 1980 rates for Northern Nevada.

A payroll burden is added to direct labor costs developed from Tables 7-4 and 7-5. Burden includes retirement benefits, health insurance, sick leave, jury duty, Workmen's Compensation, Social Security System employer contributions and safety clothing. A burden rate of 29 percent of direct labor expenses is typical in the Western US chemical industry.

TABLE 7-3
ANNUAL OPERATING COSTS FOR BARLEY FEEDSTOCK OPTION

ITEM	BASIS	ANNUAL COST (Dollars)	UNIT COST ($/Gallon Denatured Ethanol)	PERCENT OF TOTAL UNIT COST
1. Raw Materials				
Midwest Corn (Exec. Freight)	109,000 tons @ 107.14/ton	11,678,600		
Yeast	67 TPY @ $.55/lb freight allowed	73,700		
Enzymes and Nutrients	420 TPY @ $.80/lb freight allowed	672,000		
	170 TPY NH3 @ $240/ton freight allowed	40,800		
	50 TPY Diammonium Phosphate @ $330/ton FA	16,500		
Sulfuric Acid - 66° BE	135 TPY @ $100/ton freight allowed	13,500		
Caustic Soda - 50% Liquid	198 TPY @ $200/ton freight allowed	39,600		
Unleaded Gasoline Denaturant	500,000 gal @ $1.20/gal freight allowed	600,000		
Subtotal		13,134,700	1.251	68.8
2. Feedstock Freight	109,000 tons @ $22/ton	2,398,000	0.223	12.5
3. Ethanol Plant Maintenance Matl's				
Plant Vehicle Gasoline	1500 gal/month @ $1.20/gal freight allowed	21,600		
General Plant Maintenance	4% of equipment and field materials cost	340,000		
Safety and Sanitation	Allow $1200/Month	14,400		
Chlorine(Pot & Cool Water Trtmt)	30 TPY @ $325/ton freight allowed	9,800		
Cooling Water Treatment	Ph control & phosphate trtmt @ $.05/100 GPM/hr	19,800		
Laboratory Supplies	Allow $1500/month	18,000		
Office Supplies	Allow $2000/month	24,000		
Roads, Grounds and Ponds	Allow $250/month	3,000		
Vapor Recovery Carbon	2,000 lb Carbon/yr @ $.50/lb freight allowed	1,000		
Biocide	(Iodine, Phosphoric Acid & Detergents) @ $1300/month	15,600		
Subtotal		467,200	0.044	2.4
4. Utilities				
Power	2300 kw, 7920 hr/yr @ $0.046/kwhr	837,900		
Geothermal Fluid	$50,000/yr lease royalty	50,000		
Process Water	Allow $5,000/yr lease royalty	5,000		
Propane	660 gallons/day @ $.70/gal	152,500		
Subtotal		1,045,400	0.100	5.5

TABLE 7-3 (continued)
ANNUAL OPERATING COSTS FOR BARLEY FEEDSTOCK OPTION

ITEM	BASIS	ANNUAL COST (Dollars)	UNIT COST ($/Gallon Denatured Ethanol)	PERCENT OF TOTAL UNIT COST
5. Labor				
Administrative	Table 7-4	315,000		
Operating	Table 7-5	1,082,600		
Burden	29% of Direct Labor (Admin plus Operating)	405,300		
Subtotal		1,802,900	0.172	9.5
6. Miscellaneous Expenses				
Telephone	$1,000/month	12,000		
Local Property Taxes	1.1% of total capital investment	205,700		
Insurance	$0.20/$1.00 capital investment per year	37,400		
Permits	Allow $1500/yr for envir. permit fees	1,500		
Subtotal		256,600	0.024	1.3
7. TOTAL		19,104,800	1.820	100.00

TABLE 7-4
ANNUAL OPERATING COSTS FOR BARLEY FEEDSTOCK OPTION

ITEM	BASIS	ANNUAL COST (Dollars)	UNIT COST ($/Gallon Denatured Ethanol)	PERCENT OF TOTAL UNIT COST
1. Raw Materials				
Western Barley (Exc. Freight)	113,000 tons @ 120.00/ton	13,560,000		
Yeast	67 TPY @ $.55/lb freight allowed	73,700		
Enzymes and Nutrients	420 TPY @ $.80/lb freight allowed	672,000		
	170 TPY NH3 @ $240/ton freight allowed	40,800		
	50 TPY Diammonium Phosphate @ $330/ton FA	16,500		
Sulfuric Acid - 66° BE	135 TPY @ $100/ton freight allowed	13,500		
Caustic Soda - 50% Liquid	198 TPY @ $200/ton freight allowed	39,600		
Unleaded Gasoline Denaturant	500,000 gal @ $1.20/gal freight allowed	600,000		
Subtotal		15,016,100	1.430	74.1
2. Feedstock Freight	113,000 tons @ $15/ton	1,695,000	0.161	8.3
3. Ethanol Plant Maintenance Matl's				
Plant Vehicle Gasoline	1500 gal/month @ $1.20/gal freight allowed	21,600		
General Plant Maintenance	4% of equipment and field materials cost	340,000		
Safety and Sanitation	Allow $1200/Month	14,400		
Chlorine(Pot & Cool Water Trtmt)	30 TPY @ $325/ton freight allowed	9,800		
Cooling Water Treatment	Ph control & phosphate trtmt @ $.05/100 GPM/hr	19,800		
Laboratory Supplies	Allow $1500/month	18,000		
Office Supplies	Allow $2000/month	24,000		
Roads, Grounds and Ponds	Allow $250/month	3,000		
Vapor Recovery Carbon	2,000 lb Carbon/yr @ $.50/lb freight allowed	1,000		
Biocide	(Iodine, Phosphoric Acid & Detergents) @ $1300/month	15,600		
Subtotal		467,200	0.044	2.3
4. Utilities				
Power	2300 kw, 7920 hr/yr @ $0.046/kwhr	837,900		
Geothermal Fluid	$50,000/yr lease royalty	50,000		
Process Water	Allow $5,000/yr lease royalty	5,000		
Propane	660 gallons/day @ $.70/gal	152,500		
Subtotal		1,045,400	0.100	5.2

TABLE 7-4 (continued)
ANNUAL OPERATING COSTS FOR BARLEY FEEDSTOCK OPTION

ITEM	BASIS	ANNUAL COST (Dollars)	UNIT COST ($/Gallon Denatured Ethanol)	PERCENT OF TOTAL UNIT COST
5. Labor				
Administrative	Table 7-4	315,000		
Operating	Table 7-5	1,082,600		
Burden	29% of Direct Labor (Admin plus Operating)	405,300		
Subtotal		1,802,900	0.172	8.9
6. Miscellaneous Expenses				
Telephone	$1,000/month	12,000		
Local Property Taxes	1.1% of total capital investment	205,700		
Insurance	$0.20/$1.00 capital investment per year	37,400		
Permits	Allow $1500/yr for envir. permit fees	1,500		
Subtotal		256,600	0.024	1.2
7. TOTAL		20,283,200	1.931	100.00

TABLE 7-4

ADMINISTRATIVE STAFF

POSITION	NUMBER REQUIRED	TOTAL ANNUAL SALARY
General Manager	1	$ 50,000
Commodities Manager	1	30,000
Office and Personnel Manager	1	35,000
Plant Engineer	1	40,000
Chief Chemist	1	28,000
Accountant	1	18,000
Receptionist	1	6,000
Traffic Clerk	1	12,000
Secretaries ($9000 each)	2	18,000
Security Officers ($12,000 each)	4	48,000
General Clerk	1	6,000
Safety and Sanitation Supervisor	1	24,000
TOTAL		$315,000

TABLE 7-5

OPERATING PERSONNEL

LOCATION	CLASSIFICATION			
	Leadmen ($12.50/hr)	Operator "A" ($8.50/hr)	Operator "B" ($7.00/hr)	Laborer ($4.50/hr)
1. Feedstock receiving and preparation	0	4	0	0
2. Mash room and fermentation	4	1	4	4
3. Distillation and product storage	4	1	1	0
4. By-product concentration and storage	4	0	1	0
5. Laboratory	4	4	1	0
6. Maintenance	4	1	4	4
7. Safety and Sanitation	1	1	1	8
8. Total Personnel	21	12	12	16
9. Annual Wages	$546,000	$212,160	$174,720	$149,760

7.3 PROJECT SCHEDULE

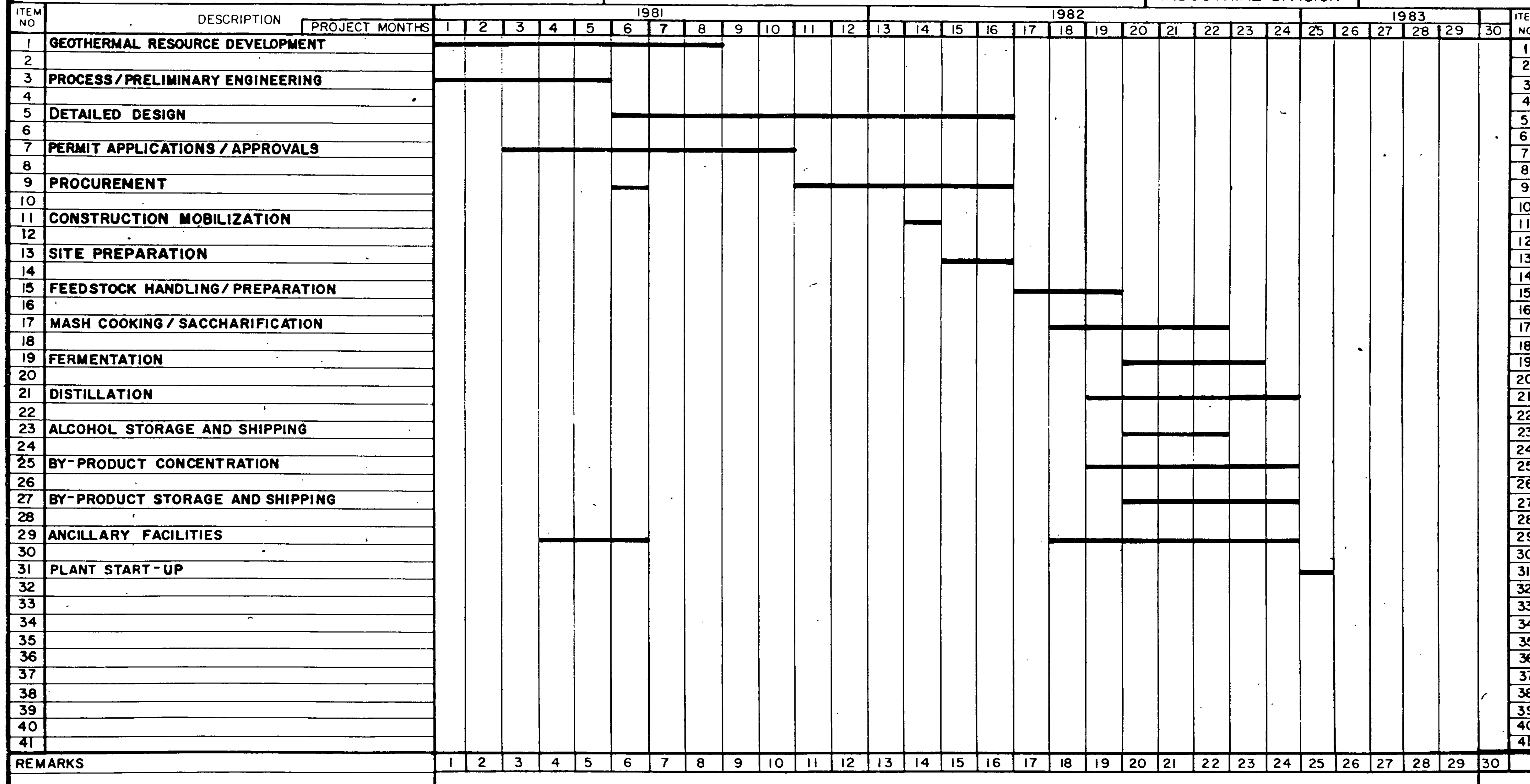
The proposed project schedule encompasses a 25-month period from inception of process engineering to commerical operation. The time allocated for process and preliminary engineering, detailed design, environmental permitting, procurement, construction and plant start-up is illustrated in Figure 7-1.

Geothermal reservoir evaluation and development will proceed concurrently with process plant design. No procurement of major equipment or facility construction will commence until all major permits are obtained. Work at the railside feedstock storage facility at Fernley must be integrated into an overall project schedule.

FIGURE 7-1
MASTER SCHEDULE

MORRISON KNUDSEN
INDUSTRIAL DIVISION

CONTRACT 1110-04
STATUS DATE ______
REVISION DATE ______
REVISION NUMBER ______



GFP INC.
FUEL ETHANOL PLANT
FEASIBILITY STUDY

APPENDIX

CAPITAL COST ESTIMATE AND EQUIPMENT LIST

CONTENTS

TABLE 1

FEEDSTOCK HANDLING AND PREPARATION

A. Major Equipment List

Item	Design Conditions	Material of Construction	Estimated Cost
Truck Trailer Tilter Hydraulic Lift 25 hp	amb	CS	$60,000
Storage Bin Bucket Elevator 3000 bu/hr 7 1/2 hp	amb	CS	14,000
Feedstock Storage Bins 15 ft dia by 32.5 ft high cone roof and bottom (7 required)	amb	CS	95,000
Roof Distribution Conveyor 3000 bu/hr 15 hp	amb	CS	23,600
Roof Catwalk Steel Grating	amb	CS	9,200
Feedstock Supply Conveyor 600 bu/hr - 5 hp	amb	CS	12,400
Preparation Plant Bucket Elevator - 600 bu/hr 2 1/2 hp	amb	CS	8,100
Feedstock Surge Bin 15 ft dia by 28 ft high cone top and bottom	amb	CS	9,000
Grain Cleaner 600 bu/hr with chaff transport air blower (2hp) and tramp metal bin	amb	CS	9,700
Hammermill 600 bu/hr with surge bin 125 hp	amb	CS	15,200
Meal Transport Air Blower 8,000 cfm - 40 hp	amb	CS	18,100

Item	Design Conditions	Materials of Construction	Estimated Cost
Truck Dump Area Baghouse 15,000 cfm 30 hp fan	amb	Mfr. Std.	$ 29,600
Preparation Plant Baghouse 5000 cfm 10 hp fan	amb	Mfr. Std.	13,300
		TOTAL EQUIPMENT COST	$317,200

B. Field Materials

Piping	$ 54,000		
Equipment Foundations	38,600		
Miscellaneous Steel	12,900		
Instruments	2,600		
Electrical	30,900		
Insulation	1,800		
Paint	5,100		
		TOTAL FIELD MATERIALS COST	$145,900

C. Buildings and Structures

Enclosed Truck Dump	$ 60,000		
Grain Cleaning Building	62,500		
		TOTAL BUILDINGS COST	$122,500

D. Direct Labor

Installation of Major Equipment	$ 70,900		
Installation of Field Materials	51,200		
		TOTAL DIRECT LABOR COST	$122,100

E. Indirects

Payroll Burden	$ 36,600		
Field Supervision	9,800		
Temporary Facilities	6,100		
Construction Equipment	12,800		
Small Tools	3,700		
Misc. Cost	1,200		
Sales Tax	14,100		
Freight	12,100		
Engineering	114,100		
		TOTAL INDIRECT COST	$210,500

F. Total Cost Summary - Feedstock Handling and Preparation

1. Major Equipment	$317,200		
2. Field Materials	145,900		
3. Buildings and Structures	122,500		
4. Direct Labor	122,100		
5. Indirects	210,500		
		Subtotal	$918,200
		Contractor's Fee	44,900
		Contingency	183,600
		AREA TOTAL	$1,147,700

TABLE 2

MASH COOKING AND SACCHARIFICATION

A. Major Equipment List

Item	Design Conditions	Materials of Construction	Estimated Cost
Meal Cyclone Collector 8000 acfm	amb	CS	$ 12,000
Meal Surge Tank 4-ft dia by 5-ft high cone bottom	amb	CS	3,600
Rotary Feeder Valve 900 cu ft/hr 1 hp (2 required)	amb	CS	3,600
Batch Weigh Tank 4-ft dia by 4-ft high cone bottom and scale (2 required)	amb	CS	3,400
Slide Valve Air-operated (2 required)	amb	CS	1,000
Continuous Weigh Tank 9-ft dia by 9-ft high cone bottom and scale (2 required)	amb	CS	26,700
Rotary Feeder Valve 450 cu ft/hr 1 hp	amb	CS	3,600
Mash Mixing Tanks 4-ft dia by 9-ft high with live bottom surge bin 15 hp each (2 required)	150°F	304 SS	Included with Mash Cooker
Force Feeders screw conveyor 3 hp (2 required)	150°F	304 SS	Included with Mash Cooker

Item	Design Conditions	Materials of Construction	Estimated Cost
Mash Cookers 15,000 lb/hr 250 hp mechanical extruder with 90 psig steam injection (2 required)	200°F	Alloy Steel	$ 775,000
Conversion Tanks 8-ft dia by 20-ft long (2 required)	atm 150°F	304 SS	76,000
Conversion Tank Agitators 25 hp (2 required)	150°F	304 SS	24,000
Surge Tank Feed Pumps 140 gpm at 50 ft TDH 3 hp (2 required)	150°F	316 SS	3,600
Surge Tanks 8-ft dia by 20-ft high flat top and cone bottom (2 required)	atm 150°F	304 SS	50,000
Surge Tank Agitators 10 hp (2 required)	150°F	304 SS	12,000
Fermenter Feed Pumps 140 gpm at 150 ft TDH 10 hp (2 required)	150°F	316 SS	6,400
Mash Cooler 5.8 MM Btu/hr	ts-75 psig 150°F ss-50 psig 150°F	304 SS CS	17,300
Mash Chiller 2.0 MM Btu/hr	ts-75 psig 150°F ss-50 psig 150°F	304 SS CS	11,000
Alpha Amylase Enzyme Tank 6-ft dia by 6-ft high flat top and conical bottom with 5 hp agitator	atm 150°F	304 SS	7,400

Item	Design Conditions	Materials of Construction	Estimated Cost
Beta Glucosidase Enzyme Tank 6-ft dia by 6-ft high Flat top and conical bottom with 5 hp agitator	atm 150°F	304 SS	$ 7,400
Alpha Amylase Pumps Metering 0.25 gpm at 150 ft TDH 1/4 hp (2 required)	150°F	316 SS	3,000
Beta Glucosidase Pumps Metering 0.25 gpm at 150 ft TDH 1/4 hp (2 required)	150°F	316 SS	3,000
Sulfuric Acid Pumps Metering 0.25 gpm at 150 ft TDH 1/4 hp (2 required)	amb	316 SS	3,000
Injection Steam Generator 3000 lb/hr 100 psia steam with fuel tank (light ends) and chemical treatment (oxygen scavengening)	amb	Mfr. Std.	45,000
		TOTAL EQUIPMENT COST	$1,098,000

B. Field Materials

Piping	$211,500	
Equipment Foundations	19,800	
Miscellaneous Steel	19,800	
Instruments	18,700	
Electrical	30,200	
Insulation	8,300	
Paint	3,100	
	TOTAL FIELD MATERIALS COST	$311,400

C. Buildings and Structures

	$150,000	
	TOTAL BUILDINGS COSTS	$150,000

D. Direct Labor

Installation of Major Equipment	$281,800	
Installation of Field Materials	243,700	
	TOTAL DIRECT LABOR COST	$525,500

E. Indirects

Payroll Burdens	$157,700
Field Supervision	26,300
Temporary Facilities	16,800
Construction Equipment	53,100
Small Tools	32,100
Miscellaneous Cost	21,500
Sales Tax	49,300
Freight	28,200
Engineering	361,100
TOTAL INDIRECT COSTS	$746,100

F. Total Cost Summary - Mash Cooking and Saccharification

1. Major Equipment	$1,098,000
2. Field Materials	311,400
3. Buildings and Structures	150,000
4. Direct Labor	525,500
5. Indirects	746,100
Subtotal	$2,831,000
Contractor Fee	141,500
Contingency	566,200
AREA TOTAL	$3,538,700

TABLE 3

FERMENTATION

A. Major Equipment List

Item	Design Conditions	Materials of Construction	Estimated Cost
Yeast Mix Tank 4-ft dia by 5 ft high flat top and dished bottom	atm 120°F	304SS	$ 5,500
Yeast Mixing Agitator 1-1/2 hp	atm	304SS	1,500
Fermenters 26-ft dia by 26-ft high cone top roof and sloped bottom (8 required)	atm 120°F	CS	307,200
Heat Exchangers 4 MM Btu/hr each (2 required)	ts-50 psig 120°F ss-150 psig 120°F	304SS CS	76,000
Recycle Pump 900 gpm at 50 ft TDH 15 hp (2 required)	120°F	316SS	7,000
Beer Well Pump 250 gpm at 50 ft TDH 5 hp	120°F	316SS	2,900
Beer Well 26-ft dia by 26-ft high cone top and sloped bottom	atm 120°F	CS	38,400
Distillation Feed Pump 250 gpm at 200 ft TDH 20 hp	120°F	316SS	2,400
Sterilization Pump 75 gpm at 150 ft TDH 10 hp	120°F	CS	1,900
Sterilization Tank 7-ft dia by 7-ft high with 2 hp agitator	atm 120°F	CS	4,800

Item	Conditions	Materials of Construction	Estimated Cost
Cleaning Pump 100 gpm at 150 ft TDH 10 hp	120°F	CS	$ 1,900
Cleaning Tank 7-ft dia by 7-ft high with 2 hp agitator	atm 120°F	CS	4,800
Spray Cleaing Machines (16 required)	120°F	316SS	36,000
Sulfuric Acid Storage Tank 6-ft dia by 14-ft long with mounting saddles	atm amb	CS glass-lined	3,000
Sulfuric Acid Metering Pump 0.25 gpm at 150 ft TDH 1/4 hp	amb	316SS	1,500
Caustic Storage Tank 8-ft dia by 16-ft long with mounting saddles	atm amb	CS	6,000
Caustic Metering Pump 1 gpm at 150 ft TDH 1/4 hp	amb	316SS	1,500
Water Chiller 600 ton refrigeration system - 700 hp	40° chilled water	Mfr. Std.	95,000
		TOTAL EQUIPMENT COST	$597,300

B. Field Materials

Piping	$102,000	
Equipment Foundations	9,500	
Miscellaneous Steel	9,600	
Instruments	9,000	
Electrical	14,600	
Insulation	4,000	
Paint	1,500	
TOTAL FIELD MATERIALS COST		$150,200

C. Buildings and Structures $150,000

TOTAL BUILDINGS COST $150,000

D. Direct Labor

Installation of Major Equipment	$130,500		
Installation of Field Materials	112,900		
		TOTAL DIRECT LABOR COST	$243,400

E. Indirects

Payroll Burden	$ 45,100		
Field Supervision	7,500		
Temporary Facilities	4,500		
Construction Equipment	4,000		
Small Tools	9,200		
Miscellaneous Cost	6,200		
Sales Tax	22,800		
Freight	19,600		
Engineering	184,000		
		TOTAL INDIRECT COSTS	$302,900

F. Total Cost Summary - Fermentation

A. Major Equipment	$597,300		
B. Field Materials	150,200		
C. Buildings and Structures	150,000		
D. Direct Labor	243,400		
E. Indirects	302,900		
	Subtotal		$1,443,800
	Contractor Fee		72,200
	Contingency		288,800
		AREA TOTAL	$1,804,800

TABLE 4

DISTILLATION

A. Major Equipment List

Item	Design Conditions	Materials of Construction	Estimated Cost
Whole Stillage Pump 250 gpm at 100 ft TDH 10 hp	250°F	316SS	$ 3,200
Overhead Condenser-Feed Preheater 6.9 MM Btu/hr	ts-50 psig 200°F ss-15 psig 250°F	304SS CS	17,000
Stillage-Feed Preheater 6.3 MM Btu/hr	ts-15 psig 250°F ss-50 psig 200°F	304SS 304SS	16,000
Final Vapor Condenser 8.1 MM Btu/hr	ts-50 psig 250°F ss-15 psig 250°F	CS CS	8,600
Stripper/Rectifier Reboiler 18 MM Btu/hr	ts-30 psig 250°F ss-125 psig 350°	CS CS	34,500
Degasser Drum 3 ft dia by 3 ft high	15 psig 250°F	CS	1,500
Stripping Tower Reboiler Pump 3,500 gpm at 50 ft TDH 60 hp	250°F	DI	6,000
Stripping Tower 78-in diameter 76 disc and donut trays 57-ft shell height	15 psig 250°F	304SS shell and trays	77,500
Enriching Tower 66-in diameter 22 perforated trays 41-ft shell height	15 psig 250°F	CS shell CS trays	42,500

Item	Design Conditions	Materials of Construction	Estimated Cost
Degassing Vent Condenser 0.1 MM Btu/hr	ts-50 psig 250°F ss-15 psig 250°F	304SS CS	1,800
Enriching Tower Relux Pump 100 gpm at 80 ft TDH 5 hp	175°F	DI	1,300
Rectifier Vent Condenser 0.5 MM Btu/hr	ts-50 Psig 250° F ss-15 psig 250°F	CS CS	3,000
Stripping Tower Reflux Pump 30 gpm at 80 ft TDH 1 hp	250°F	DI	1,000
Rectifier Reflux Drum 5-ft dia by 4-ft high Dished Heads	15 psig 250°F	CS	3,400
Product Cooler 0.5 MM Btu/hr	ts-50 psig 250°F ss-15 psig 250°F	CS CS	2,000
Dehydration Tower Reboiler 14 MM Btu/hr	ts-30 psig 250°F ss-125 psig 350°F	CS CS	18,000
Dehydration Tower Reboiler Pump 3,000 gpm at 50 ft TDH 50 hp	250°F	DI	6,000
Dehydration Tower 66-in diameter 50 perforated trays 18-in tray spacing	15 psig 250°F	CS shell CS trays	80,000
Product Pump 25 gpm at 100 ft TDH 3 hp	250°F	DI	1,200
Dehydration Condenser 13 MM Btu/hr	ts-50 psig 250°F ss-15 psig 250°F	CS CS	24,000

Item	Design Conditions	Materials of Construction	Estimated Cost
Dehydration Vent Condenser 1 MM Btu/hr	ts-50 psig 250°F	CS	24,000
	ss-15 psig 250°F	CS	
Decanter 4-ft dia by 5-ft high dished top head and cone bottom	15 psig 100°F	CS	2,700
Dehydration System Reflux Cooler 1.7 MM But/hr	ts-50 psig 250°F	CS	5,000
	ss-15 psig 250°F	CS	
Stripper Feed Pump 8 gpm at 90 ft TDH 1/2 hp	100°F	DI	900
Dehydration Reflux Pump 150 gpm at 120 ft TDH 10 hp	100°F	DI	900
Hydrocarbon Stripper 24-in diameter 30 perforated trays	15 psig 250°F	CS shell CS trays	16,000
Stripper Reboiler Pump 500 gpm at 50 ft TDH 10 hp	250°F	DI	3,000
Hydrocarbon Stripper Reboiler 2.4 MM Btu/hr	ts-30 psig 250°F	CS	5,200
	ss-125 psig 350°F	CS	
Fusel Oil Cooler A = 10 sq ft Heliflow Type	ts-15 psig 250°F	CS	1,000
	ss-75 psig 250°F	CS	
Fusel Oil Washer 12-in dia by 15-ft high with 18-in dia by 12-in high settling drum and skirt bottom	15 psig 100°F	CS	2,200

Item	Design Conditions	Materials of Construction	Estimated Cost
Wash Water Pump 3 gpm at 100 ft TDH 1/4 hp	100°F	DI	600
Fusel Oil Storage Tank 4-ft dia by 4-ft high	atm 100°F	CS	2,500
Fusel Oil Pump Metering 0.25 gpm at 100 ft TDH 1/4 hp	100°F	DI	1,000
		TOTAL EQUIPMENT COST	$396,600

B. Field Materials

Piping	$125,700	
Equipment Foundations	34,900	
Miscellaneous Steel	6,700	
Instruments	28,600	
Electrical	2,800	
Insulation	79,000	
Paint	4,900	
TOTAL FIELD MATERIALS COST		$282,900

C. Buildings and Structures

Buildings and Structures	$48,000	
TOTAL BUILDINGS COST		$48,000

D. Direct Labor

Installation of Major Equipment	$ 59,100	
Installation of Field Materials	257,500	
TOTAL DIRECT LABOR COST		$316,600

E. Indirects

Payroll Burden	$ 95,000	
Field Supervision	25,300	
Temporary Facilities	15,800	
Construction Equipment	30,400	
Small Tools	18,400	
Miscellaneous Cost	5,100	
Sales Tax	23,800	
Freight	20,400	
Engineering	190,200	
TOTAL INDIRECT COSTS		$424,400

F. Total Cost Summary - Distillation

A. Major Equipment	$396,600		
B. Field Materials	282,900		
C. Buildings & Structures	48,000		
D. Direct Labor	316,600		
E. Indirect Costs	424,400		
		Subtotal	$1,468,500
		Contractor Fee	73,400
		Contingency	293,700
		AREA TOTAL	$1,835,600

TABLE 5

ALCOHOL STORAGE AND SHIPPING

A. Major Equipment List

Item	Design Conditions	Materials of Construction	Estimated Cost
Ethanol Receiver Tanks 18-ft dia by 18-ft high cone roof and flat bottom (2 required)	atm amb	CS	$35,600
Receiver Pumps 250 gpm and 100 ft TDH 10 hp (2 required)	100°F	316 SS	6,400
Denatured Ethanol Tanks 20-ft dia by 25-ft high cone roof and flat bottom (3 required)	atm amb	CS	78,000
Gasoline (Denaturant) Tank 12-ft dia by 24-ft high cone roof and flat bottom	atm amb	CS	10,400
Vapor Recovery System dual bed, carbon adsorbtion unit with chilled solvent recovery system 11 hp (total vacuum pumps and blowers)	amb	Mfg. Std.	150,000
Tank Truck Loadout with 300 gpm pump, 7-1/2 hp and meter	100°F	316SS (pump)	20,000
		TOTAL EQUIPMENT COST	$300,400

B. Field Materials

Piping	$ 63,800	
Equipment Foundations	46,000	
Miscellaneous Steel	8,600	
Instruments	25,400	
Electrical	8,900	
Insulation	2,400	
Paint	7,700	
TOTAL FIELD MATERIALS COST		$162,800

C. Buildings and Structures

	$7,000	
TOTAL BUILDINGS COST		$7,000

D. Direct Labor

Installation of Major Equipment	$12,800	
Installation of Field Materials	51,300	
TOTAL DIRECT LABOR COST		$64,100

E. Indirects

Payroll Burden	$ 19,300	
Field Supervision	3,200	
Temporary Facilities	1,300	
Construction Equipment	20,100	
Small Tools	10,100	
Miscellaneous Cost	8,000	
Sales Tax	16,000	
Freight	6,900	
Engineering	87,700	
TOTAL INDIRECT COST		$172,600

F. Total Cost Summary - Alcohol Storage and Shipping

A. Major Equipment	$300,400	
B. Field Materials	162,800	
C. Buildings and Structures	7,000	
D. Direct Labor	64,100	
E. Indirects	172,600	
Subtotal		$706,900
Contractor Fee		35,300
Contingency		141,400
AREA TOTAL		$883,600

TABLE 6

BY-PRODUCT CONCENTRATION

A. Major Equipment List

Item	Design Conditions	Materials of Construction	Estimated Cost
Whole Stillage Tank 14-ft dia by 14-ft high Cone roof and flat bottom	atm	CS	$ 11,500
Whole Stillage Agitator 50 hp	180°F	CS	18,000
Whole Stillage Pump 250 gpm at 60 ft TDH 7-1/2 hp	180°F	DI	1,600
Centrifugal Separators solid bowl type 125 hp each (2 required)	180°F	Mfr. Std.	440,000
Thin Stillage Tank 14-ft dia by 14-ft high cone roof and flat bottom	atm 180°F	CS	7,500
Thin Stillage Agitator 10 hp	180°F	CS	11,500
Thin Stillage Pump 225 gpm at 60 ft TDH 5 hp	180°F	DI	1,500
Evaporator Feed Heater 3 MM Btu/hr	ts-50 psig 250°F ss-125 psig 350°F	304SS CS	10,000
Second Effect Condensate Pump 60 gpm at 40 ft TDH 1 hp	250°F	DI	1,800
Third Effect Condensate Pump 60 gpm at 80 ft TDH 2 hp	190°F	DI	1,000
Evaporator Condensate Tank 12-ft dia by 12-ft high cone roof and flat bottom	atm 200°F	CS	8,600

Item	Design Conditions	Materials of Construction	Estimated Cost
Cooling Water Return Pump 2000 gpm at 50 ft TDH 40 hp	125°F	DI	$ 4,000
First Effect Heat Exchanger 24 MM Btu/hr	ts-20 psig 250°F ss-125 psig 350°F	CS CS	33,000
Second Effect Heat Exchanger 24 MM Btu/hr	ts- -3 psig 190°F ss-20 psig 250°F	304SS CS	33,000
Third Effect Heat Exchanger 24 MM Btu/hr	ts- -12 psig 125°F ss- -3 psig 190°F	304SS CS	33,000
Evaporator Condenser, Direct Contact 27 MM Btu/hr	Full Vacuum	CS	10,500
Vacuum Pump 75 lb air/hr at 4-in Hg abs	125°F	CS	1,500
Evaporator Flash Drum 1st effect 60" dia x 120" high	20 psig 250°F	CS	5,900
Evaporator Flash Drum 2nd effect 72" dia x 144" high	-3 psig 190°F	CS	8,300
Evaporator Flash Drum 3rd effect 108" dia x 216" high	Full Vacuum 125°F	CS	17,200
Evaporator Circulation Pumps 3500 gpm at 25 ft TDH 50 hp each (3 required)	225°F	DI	20,700
Concentrated Solubles Tank 6-1/2 ft dia by 6-ft high cone roof and flat bottom	atm 125°F	CS	5,800
Concentrated Solubles Pump 25 gpm at 100 ft TDH 1 hp	125°F	DI	1,100

Item	Design Conditions	Materials of Construction	Estimated Cost
Second Effect Condensate Flash Pot 16-in dia by 24-in high dished heads	20 psig 250°F	CS	$ 800
Third Effect Condensate Flash Pot 16-in dia by 30-in high dished heads	-3 psig 190°F	CS	1,100
Evaporator Vent Condenser 2.6 MM Btu/hr	ts-50 psig 250°F ss-20 psig 250°F	CS CS	3,200
Vacuum Pump 10 lb air/hr at 4-in Hg abs	200°F	CS	900
Wet Cake Transfer Conveyor 16,000 lb/hr, 2 hp	180°F	CS	4,800
Condensate Cooler 3.0 MM Btu/hr	ts - 50 psig 200°F ss - 50 psig 200° F	304SS CS	10,000
		TOTAL EQUIPMENT COST	$711,600

B. Field Materials

Piping	$70,500		
Equipment Foundations	4,100		
Miscellaneous Steel	12,400		
Instruments	10,400		
Electrical	13,800		
Insulation	11,700		
Paint	1,000		
		TOTAL FIELD MATERIALS COST	$123,900

C. Buildings and Structures — $120,800

		TOTAL BUILDINGS COST	$120,800

D. Direct Labor

Installation of Major Equipment	$105,100		
Installation of Field Material	161,300		
		TOTAL DIRECT LABOR COST	$266,400

E. Indirects

Payroll Burden	$ 77,300
Field Supervision	21,300
Temporary Facilities	10,400
Construction Equipment	15,500
Small Tools	6,900
Miscellaneous Cost	1,600
Sales Tax	33,500
Freight	24,400
Engineering	209,400

TOTAL INDIRECT COST $400,300

F. Total Cost Summary - Concentration

A. Major Equipment	$711,600
B. Field Materials	123,900
C. Buildings & Structures	120,800
D. Direct Labor	266,400
E. Indirect Costs	400,300

Subtotal	$1,623,000
Contractors Fee	81,100
Contingency	324,600

AREA TOTAL $2,028,700

TABLE 7

BY-PRODUCT STORAGE AND SHIPPING

A. Major Equipment List

Item	Design Conditions	Materials of Construction	Estimated Cost
Concentrated Solubles Storage Tank 18-ft dia by 26-ft high cone roof and flat bottom (2 required)	atm 125°F	CS	$ 44,700
Concentrated Solubles Agitator, 25 hp (2 required)	125°F	CS	19,200
Tank Truck Loadout with 300 gpm transfer pump, 7 1/2 hp	125°F	Mfr. Std.	10,000
Wet Cake Supply Conveyor 16,000 lb/hr 2 1/2 hp	180°F	CS	5,400
Bucket Elevator 16,000 lb/hr 1 1/2 hp	180°F	CS	7,000
Roof Distribution Conveyor 16,000 lb/hr, 2 hp	180°F	CS	5,100
Roof Catwalk steel grating	amb	CS	8,000
Wet Cake Storage Bins elevated double pyramid 12-ft dia midsection by 20-ft high by 25-ft long (3 required)	atm 180°F	CS (epoxy-lined)	395,000 (erected)
Loadout Gates clamshell type air-operated (3 required)	amb 180° F	CS	40,000 (erected)
		TOTAL EQUIPMENT COST	$534,400

B. Field Materials

Piping	$ 38,400		
Equipment Foundations	27,400		
Miscellaneous Steel	9,200		
Instruments	4,000		
Electrical	22,000		
Insulation	1,300		
Paint	3,700		
		TOTAL FIELD MATERIAL COST	$106,000

C. Buildings and Structures

Buildings and Structures	$ 0		
		TOTAL BUILDINGS COST	$ 0

D. Direct Labor

Installation of Major Equipment	$ 50,900		
Installation of Field Materials	36,700		
		TOTAL DIRECT LABOR COSTS	$ 87,600

E. Indirects

Payroll Burden	$ 26,300		
Field Supervision	7,000		
Temporary Facilities	4,400		
Construction Equipment	9,200		
Small Tools	2,600		
Miscellaneous Cost	1,000		
Sales Tax	10,000		
Freight	8,700		
Engineering	110,600		
		TOTAL INDIRECT COSTS	$179,900

F. Total Cost Summary - By-Product Storage and Shipping

A. Major Equipment	$534,400		
B. Field Materials	106,000		
C. Buildings and Structures	0		
D. Direct Labor	87,600		
E. Indirects	179,900		
		Subtotal	$907,900
		Contractors Fee	45,400
		Contingency	181,600
		AREA TOTAL	$1,134,900

TABLE 8

ANCILLARY FACILITIES

A. Major Equipment List

Item	Design Conditions	Materials of Construction	Estimated Cost
Diesel Fuel Storage Tank 10-ft dia by 32-ft long underground installation	atm amb	CS	$ 9,800
Gasoline Storage Tank 8-ft dia by 20-ft long underground installation	atm amb	CS	5,500
Vehicular Fueling Island gasoline and diesel fuel dispensers 1/2 hp each	amb	Mfr. Std.	2,000
Cooling Tower 70 MM Btu/hr 10°F wet bulb approach 30°F cooling water range 100 hp fans (2 required)	64°F Wet bulb	Treated Redwood	163,000
Cooling Water Circulation Pumps - 4700 gpm at 100 ft TDH 150 hp (2 required)	74°F	CS	22,700
Process Water Distribution Pumps - 250 gpm at 100 ft TDH 10 hp (2 required)	amb	CS	1,600
Process/Fire Protection Water Storage Tank 50-ft dia by 34-ft high 2 hrs fire water reserve 32 hrs process water reserve cone roof and flat bottom	amb	CS	78,700
Diesel-Driven Fire Pump 1000 gpm at 335 ft TDH 125 hp	amb	CS	19,000
Motor-Driven Fire Pump 1000 gpm at 335 ft TDH 125 hp with 2 hp jockey pump	amb	CS	8,400

Item	Design Conditions	Materials of Construction	Estimated Cost
Potable Water Tank 8-ft dia by 16-ft high	amb	CS	$ 4,500
Potable Water Pumps 60 gpm at 90 ft TDH 3 hp	amb	CS	1,200
Process Water Treatment Plant 225 gpm cold lime-soda process	amb	Mfr. Std.	82,000
Waste Water Screen 48-in wide hyperbolic	125°F	316 SS	4,500
Waste Water Pumps 50 gpm at 231 ft TDH 5 hp (2 required)	125°F	CS	2,000
Plant Air Compressors reciprocating 120 cfm at 110 psig 30 hp with dryer (2 required)	-20°F dewpoint	Mfr. Std.	40,600
Plant Air Receiver 30-in dia by 8 ft high	125 psig	CS	2,800
Process Make-up Water/Boiler feedwater polisher mixed-bed ion exchanger with carbon absorption final step 100 gpm	amb	Mfr. Std.	120,000
		TOTAL EQUIPMENT COST	568,300

B. Field Material

Piping	$113,700		
Concrete	45,500		
Miscellaneous Steel	45,500		
Instruments	19,400		
Electrical	28,400		
Insulation	22,700		
Paint	11,400		
		TOTAL FIELD MATERIALS COST	$286,600

Item	Design Conditions	Materials of Construction	Estimated Cost
C. Buildings & Structures			
Laboratory/Changehouse 5,200 sq ft	$260,000		
Truck Maintenance Shop 6,000 sq ft	312,000		
Warehouse & Plant Maintenance Shops 12,000 ft	270,000		
Control Room 1,000 sq ft	100,000		
Process and Fire Water Pumphouse and Process Water Treatment Plant 3200 sq ft	72,000		
		TOTAL BUILDINGS COST	$942,000
D. Capitalizable Expenses			
Spare Parts 3% of major equipment cost all areas	$125,000		
TOTAL SPARE PARTS	$125,000		
Office & Shop Costs			
Furniture	$ 25,000		
Laboratory Equipment	5,000		
Telephone Installation	50,000		
Shop Equipment	100,000		
Lockers	50,000		
TOTAL OFFICE AND SHOP COSTS	$225,000		
Mobile Equipment			
Sedan	$ 9,000		
Pick-ups (3 required)	30,000		
Front-end Loader	15,000		
Fork Lift	15,000		
TOTAL MOBILE EQUIPMENT COST	$ 69,000		
		TOTAL CAPITALIZABLE EXPENSE COST	$419,000
E. Direct Labor			
Installation of Major Equipment	$104,500		
Installation of Field Materials	81,800		
		TOTAL DIRECT LABOR	$186,300

Item	Design Conditions	Materials of Construction	Estimated Cost
F. Indirects			
Payroll Burdens	$ 56,000		
Field Supervision	14,900		
Temporary Facilities	9,300		
Construction Equipment	28,600		
Small Tools	5,600		
Miscellaneous Cost	1,900		
Sales Tax	30,000		
Freight	25,600		
Engineering	688,400		
	TOTAL INDIRECT COST		$860,300
G. Geothermal Heat System			
Geothermal Production Wells 8-in dia 3500-5000 ft depth (3 required)	290°F	--	Per drilling estimate
Reinjection Well 8-in dia 3500-5000 ft depth (2 required)	230°F	--	Per drilling estimate
Drilling Estimate			
mobilization/demobilization			$ 150,000
drilling contract			1,750,000
casing, cementing services			350,000
site geologist			78,000
drilling engineer			32,000
Geothermal Fluid Pumps 750 gpm 150 hp (3 required)	350°F	CS	$ 75,000
Geothermal Fluid Supply and Spent Fluid Discharge Lines 10-in dia pipe	300°F	CS	$ 125,000
	TOTAL GEOTHERMAL HEAT SYSTEM COST		$2,560,000

Item	Design Conditions	Materials of Construction	Estimated Cost
H. Other Major Systems			
Process Water Well 300 gpm with 40 hp lineshaft pump	amb	--	150,000
Process Water Supply Line 4-in diameter	amb	CS	Included with well cost
Process Water Well pump electric power supply	amb	Mfr. Std.	43,000
Process Water Loop 4-in diameter	60 psig	FRP	40,000
Potable Water Loop 2-in diameter	60 psig	FRP	20,000
Fire Protection Water Loop 8-in diameter	150 psig	FRP	80,000
Wastewater Treatment Plant Carrousel Raceway 50 gpm, 3000 ppm Bod 25 hp aerators (2 required)	120°F	Concrete Channel	148,000
Percolation Field 4 acres	amb	Permeable Fill	100,000
Septic Tank and Leach Field 2500 gallons/day	amb	FRP	10,000
Site Clearing and Drainage	--	--	100,000
Electrical Power Distribution 3000 Kva	amb	Mfr. Std.	248,000
Yard Lighting	amb	Mfr. Std.	38,000
Roadways and Parking 50,000 sq yds	amb	Asphalt Paving	127,000
Propane Storage Tank and Vaporizer 30,000 gallons relocate existing equipment	200 psig	CS	10,000
		TOTAL OTHER SYSTEMS COST	$1,114,000

I. Total Cost Summary - Ancillary Facilities

1.	Major Equipment	$ 568,300
2.	Field Materials	286,600
3.	Buildings and Structures	942,000
4.	Capitalizable Expenses	419,000
5.	Direct Labor	186,300
6.	Indirects	860,300
7.	Geothermal Heat System	2,560,000
8.	Other Major Systems	1,114,000

Subtotal	$6,936,500
Contractor Fee	346,800
Contingency	1,387,300
AREA TOTAL	$8,670,600