DOE/ET/27256--19

DE82 015109

DISTRICT HEATING SYSTEM, COLLEGE INDUSTRIAL PARK

Klamath Falls, Oregon

October, 1981

DISCLAIMER

DISCLAIMER

DISCLAIMER

The following study is the result of a request to the Geo-Heat Center for Technical Assistance.

INTRODUCTION

The College Industrial Park (CIP) is located to the northwest of the OIT campus. Waste water from the OIT campus geothermal heating system flows through an open ditch to the south of the Park. Being aware of this, City personnel have requested the Geo-Heat Center design a distribution network for the Park to eventually utilize an estimated 600 GPM of the 130°F waste water.

Geothermal water from each campus building is discharged into storm drains which also collect surface run off from parking lots, roofs and grounds. Waste water temperatures are generally between 120°F and 130°F, however, it may drop as low as 90°F when mixing occurs with large amounts of surface run off.

Peak heating load requirements for the OIT campus are estimated to be 17.8 X 10^6 Btu/hour for 567,000 square feet of space. Peak flow rate of geothermal fluid to satisfy this load is then 593 GPM based on a net 60°F temperature differential. Three wells are available to supply the necessary flow and are specified in Table 1.

TABLE 1

OIT GEOTHERMAL WELL DATA

Well No.	Depth (Ft)	Temperature(F)	Flow Rate(GPM)
2	1,288	180°	200
5	1,716	192°	450
6	1,805	192°	400

Variable speed drives are connected to each pump which results in flow rate variations from 50 to 600 GPM depending on space heating requirements from summer to winter months.

A Lithium-Bromide Absorption Chiller (185 ton) was installed in 1980 to provide space cooling. The chiller requires a constant flow rate of 550 GPM and discharges 170°F water to the storm drains during summer months.

Separation of geothermal fliuds from surface run off will be accomplished by approximately 1985 according to Mr. W.M. Douglass, Dean of Administration. Mini tunnels will be installed to each building from the main loop tunnel which circles the campus. Separation of geothermal fluids (see Figure 1) is essential for end use after campus heating. Particles, motor oil and lowering of temperature make the waste water undesirable for use in other heating systems.

COLLEGE INDUSTRIAL PARK OPERATING DEMAND

The proposed system for the College Industrial Park should be developed in several phases. The first phase would supply existing tenants on

Tracts 3 and 4 of Blk 2 for which heat loads can be calculated. Heat loads for potential tenants on other tracts are estimated based on building design assumptions and buildable land area.

A permanently insulated pipe should be installed up to the existing tenants sized to accomodate the distribution network for the entire park. Insulated piping is necessary due to the low flow rates required for the first customers.

Heat load demand for Quality Components, Inc. on Tract 4, Blk 2 has been calculated to be 650,000 Btu/hour at peak, requiring 56.6 GPM of geothermal flow assuming 115°F in and 95°F out. Higher delivery temperatures will result in lower flow rate requirements. For example, if 130°F geothermal fluid is supplied, the flow rate could be reduced to approximately 35 GPM. A heat pump is currently used for office space and propane gas unit heaters for the shop area. Appendix A gives a preliminary analysis of converting the heating system for the Quality Components, Inc. building to geothermal.

Heating requirements for proposed buildings on the 22 other tracts were based on buildable land area as shown on Figure 2. The following assumptions were used to estimate peak heating loads:

1. Inside design temperature = 65°F.
2. Outside design temperature = 0°F.
3. Ceiling insulated R7.
4. Walls constructed of masonry and fir.
5. Window area = 30% of wall area.

6. Normal infiltration.

7. Domestic water heating = 10% of space heating requirements.

Based on the above assumptions, it was determined the unit peak heating load is 20 Btu/hour - square foot for both space and domestic water heating. Flow rate requirements were determined assuming a ΔT = 50°F with a 15°F approach temperature to the 65°F inside design temperature for forced air heating systems.

Individual building systems would consist of two piping loops, intersecting at a heat exchanger. The geothermal loop, containing water from the main distribution network would consist of a small booster pump, temperature control valve and plate heat exchanger. The building loop would consist of a circulating pump, terminal equipment and plate heat exchanger. The plate type exchanger, while somewhat more expensive than more common shell and tube designs, provides the superior thermal performance required for low temperature applications such as this. It is important to note that the temperatures involved will require the use of some non-standard equipment in the area of water to air heat exchangers. This will tend to increase the cost of the heat exchangers over that of standard hot water heating equipment. However, the effect on the total system cost will not be significant.

Table 2, Design Capacity summarizes to design energy to be supplied to the College Industrial Park. This amounts to 21.75 million Btu per hour to be furnished by 869 gallons per minute of 130°F geothermal water.

TABLE 2

DESIGN CAPACITY FOR COLLEGE INDUSTRIAL PARK TRACTS

Tract	Buildable Area (square ft)	Peak Heat Load ($X 10^6$ Btu/h)	Flow Rate (GPM)
Blk 1			
1	35,403	0.71	28.3
2	30,456	0.61	24.4
3	35,618	0.71	28.5
4	43,518	0.87	34.8
5	79,765	1.60	63.3
6	49,898	1.00	39.9
7	38,172	0.76	30.5
8	38,915	0.78	31.1
9	58,879	1.18	47.1
10	44,416	0.89	35.5
11	32,603	0.65	26.1
12	46,970	0.94	37.6
13	49,141	0.98	39.3
14	66,180	1.32	52.9
15	92,304	1.85	73.8
16	50,439	1.01	40.4
17	33,844	0.68	27.1
18	118,128	2.36	94.5
Blk 2			
1	15,751	0.32	12.6
2	18,243	0.37	14.6
3	17,235	0.35	13.9
4	32,633	0.65	26.1(56.6)*
5	58,156	1.16	46.5
Totals	1,086,667	21.75	869.0

Higher supply temperatures could result in proportionately lower flow rates. As the number of park customers increase, it may be desirable to consider a conventional fired peak heating boiler.

DESCRIPTION OF DISTRICT HEATING NETWORK

Figure 3, Piping Layout for CIP, shows design pipe sizing to supply 130°F

*Calculated flow rate based on retrofit design (Appendix A).

TABLE 3

SUPPLY PIPE HEAD LOSS (PHASE 1)

Segment Number	D Nominal Diam (in)	Q Flow Rate (GPM)	T Temperature (F)	C Coefficients	V Velocity (ft/sec)	HF Head Loss Friction (ft/100 ft)	L Length (ft)	Total Friction Head Loss (psi)
PB 1	4	100	140	150	2.6	0.52	1580	3.50
FRP 2 - 7	8	100	140	150	0.6	0.02	1115	0.08

TABLE 4

PIPE HEAT LOSS (PHASE 1)

Segment Number	D Nominal Diam. (in)	D Pipe (in)		D Jacket (in)		k Pipe (Btu/ft²/h/f/in)	k Insul	k		h Conduc-tance	T Water (F)	L Length (ft)	HL/LF Heat Loss (Btu/h/LF)	HL Total (Btu/h)	ΔT Peak Load (F)	ΔT Minimum Load (F)
		ID	OD	ID	OD			Jacket	Soil							
Bare (PB) 1	4	3.834	4.167			1.5	6	6	6	2	140	1580	87.6	138,410	2.3	13.3
Insul (FRP) 2 - 7	8	8.22	8.42	11.78	12.24	2.3	0.12	1.0	6	2	140	1115	24.9	27,760	0.6	2.8
Bare (PB) 2 - 7	8	7.347	7.986			1.5	6	6	6	2	140	1115	178.3	198,800	4.0	20.0

TABLE 5

SUPPLY PIPE HEAD LOSS (PHASE 2)

Segment Number	D Nominal Diam (in)	Q Flow Rate (GPM)	T Temperature (F)	C Coefficients	V Velocity (ft/sec)	HF Head Loss Friction (ft/100 ft)	L Length (ft)	Total Friction Head Loss (psi)
1	4	100	140	150	2.8	0.64	1580	4.38
2	8	816	130	150	6.2	1.33	235	1.34
3	8	781	130	150	5.9	1.23	145	0.76
4	8	718	130	150	5.4	1.05	75	0.34
5	8	678	130	150	5.1	0.94	80	0.32
6	8	619	130	150	4.7	0.80	350	1.19
7	8	561	130	150	4.2	0.66	250	0.71
8	6	474	130	150	6.1	1.76	250	1.88
9	6	392	130	150	5.0	1.24	546	2.89
10	6	366	130	150	4.7	1.09	528	2.46
11	6	301	130	150	3.9	0.76	142	0.46
12	6	221	130	150	2.8	0.43	213	0.39
13	6	168	130	150	2.2	0.26	80	0.09
14	3	95	130	150	4.4	2.00	435	3.72
								22.55

TABLE 5

SUPPLY PIPE HEAD LOSS (PHASE 2)

Segment Number	D Nominal Diam (in)	Q Flow-Rate (GPM)	T Temperature (F)	C Coefficients	V Velocity (ft/sec)	HF Head Loss Friction (ft/100 ft)	L Length (ft)	Total Friction Head Loss (psi)
1	4	100	140	150	2.8	0.64	1580	4.38
2	8	816	130	150	6.2	1.33	235	1.34
3	8	781	130	150	5.9	1.23	145	0.76
4	8	718	130	150	5.4	1.05	75	0.34
5	8	678	130	150	5.1	0.94	80	0.32
6	8	619	130	150	4.7	0.80	350	1.19
7	8	561	130	150	4.2	0.66	250	0.71
8	6	474	130	150	6.1	1.76	250	1.88
9	6	392	130	150	5.0	1.24	546	2.89
10	6	366	130	150	4.7	1.09	528	2.46
11	6	301	130	150	3.9	0.76	142	0.46
12	6	221	130	150	2.8	0.43	213	0.39
13	6	168	130	150	2.2	0.26	80	0.09
14	3	95	130	150	4.4	2.00	435	3.72
								22.55

TABLE 6

DISCHARGE PIPE HEAD LOSS (PHASE 2)

	D	Q	T	C	V	HF	L	
Segment Number	Nominal Diam (in)	Flow Rate (GPM)	Temperature (F)	Coefficients	Velocity (ft/sec)	Head Loss Friction (ft/100 ft)	Length (ft)	Total Friction Head Loss (psi)
2	3	53	130	150	2.4	0.68	235	0.68
3	3	88	130	150	4.0	1.74	145	1.08
4	6	151	130	150	1.9	0.21	75	0.07
5	6	191	130	150	2.5	0.33	80	0.11
6	6	250	130	150	3.2	0.54	350	0.80
7	6	308	130	150	4.0	0.79	250	0.85
8	6	395	130	150	5.1	1.25	250	1.34
9	6	477	130	150	6.1	1.78	546	4.15
10	6	503	130	150	6.5	1.96	528	4.43
11	8	568	130	150	4.3	0.68	142	0.41
12	8	648	130	150	4.9	0.87	213	0.79
13	8	700	130	150	5.3	1.00	80	0.34
14	8	869	130	150	6.6	1.49	700	4.47
								19.52

TABLE 7

PIPE HEAT LOSS (PHASE 2)

Segment Number	D Nominal Diam. (in)	D Pipe (in) ID	D Pipe (in) OD	D Jacket (in) ID	D Jacket (in) OD	k Pipe ($Btu/ft^2/h/f/in$)	k Insul ($Btu/ft^2/h/f/in$)	k Jacket	k Soil	h Conductance	T Water (F)	L Length (ft)	HL/LF Heat Loss (Btu/h/LF)	HL Total (Btu/h)	ΔT Peak Load (F)	ΔT Minimum Load (F)
Insul(FRP)																
1	8	8.22	8.42	11.78	12.24	2.3	0.12	1.0	6	2	130	940	23.1	21,710	0.1	5.0
2	8	8.22	8.42	11.78	12.24	2.3	0.12	1.0	6	2	130	1115	23.1	35,790	0.1	1.0
3	6	6.26	6.44	9.80	10.20	2.3	0.12	1.0	6	2	130	1794	18.5	33,190	0.2	2.1
4	3	3.22	3.36	5.86	6.14	2.3	0.12	1.0	6	2	130	400	13.7	5,480	0.1	1.2
															0.5	9.3
Bare (PB)																
1	4	3.834	4.167			1.5	6.00	6.0	6	2	140	1430	129.2	184,740	3.7	18.5
2	8	7.347	7.986			1.5	6.00	6.0	6	2	130	1115	165.6	184,640	0.5	5.2
3	6	5.643	6.134			1.5	6.00	6.0	6	2	130	1794	124.7	223,710	1.4	13.9
4	3	2.982	3.241			1.5	6.00	6.0	6	2	130	400	61.4	24,560	0.5	5.2
															2.8	27.9

geothermal fluid to the tracts listed in Table 2. Supply pipe head loss, segment velocities and heat losses for Phases 1 & 2 are listed in Tables 3 through 7.

The supply pipe in the CIP is constructed in two phases. Phase 1 is direct buried insulated FRP, 8 inch diameter and 1115 feet in length including segments 2 through 7 on Figure 3. Initially, this pipeline would supply existing customers located on Tracts 3 & 4, Blk 2, approximately 100 GPM geothermal fluid at peak load. Waste water from these customers would be disposed of to natural drainage. Insulated piping is necessary due to design size (8") and low flow rates (100 GPM). Temperature losses for insulated piping would be approximately 0.6°F and base pipe, 40°F at design conditions. Minimum flow rates would have temperature losses of 2.8°F and 20.0°F respectively for insulated and base pipe as shown on Table 4.

Phase 1 geothermal fluid supply is from Cornett Hall where water is separated from storm drains at four temperature limiting valves located near the ceiling as shown in Figure 5. Discharge temperature at these valves is 140°F at an estimated peak flow rate of up to 100 GPM. Water flows by gravity from the valves to a 2,000 gallon vertical storage tank installed in Room 105, Cornett Hall. Since flow rates vary from each valve, a common collection and storage tank is necessary from which the water can be pumped to the CIP.

Figure 4 shows the storage tank and pump arrangement. Geothermal water at 140°F gravity flows from the four temperature limiting valves (Figure

5) to the storage tank. A 2.0 hp centrifugal pump delivers 100 GPM of geothermal water to the CIP. A globe valve on the discharge side of the pump maintains a constant water level in the tank as the supply varies. A pressure control valve at the discharge point in the Park maintains operating pressure to customers. A temporary four inch direct buried bare polybutylene pipeline is recommended for carrying the geothermal water from Cornett Hall to the CIP. This pipe comes in 40 foot lengths with heat fusion used at the joints, thus installation is rapid and low cost.

Phase 2 would consist of installing 1794 feet of six inch and 400 feet of three inch for the remainder of the Park as shown on Figure 3. Discharge piping would also be installed during Phase 2, which would parallel supply piping and consist of 1135 feet of eight inch, 2079 feet of six inch and 380 feet of three inch direct buried pipe. Head loss and corresponding velocities for both supply and discharge piping are listed by segments on Tables 5 and 6. Design condition pipe heat loss and corresponding temperature losses for Phase 2 are listed on Table 7 for both insulated and bare piping in the Park. Phase 2 geothermal supply is from the entire OIT campus heating system. Geothermal fluid waste water is estimated to be separated for all OIT buildings by 1985. This waste water will be collected from the utility tunnel near Cornett Hall as shown on Figure 1.

A permanently installed insulated eight inch, main geothermal pipe-line from the OIT utility tunnel to the CIP should be planned for 1985.

The routing would be the same as the four inch temporary supply pipeline.

CAPITAL COSTS

Table 8 summarizes the capital and operating costs. Total capital cost is estimated to be $44,220 for Phase 1. This does not include excavation, installation and backfill of the pipelines.

TABLE 8

SUMMARY OF CAPITAL & OPERATING COSTS
DISTRICT HEATING SYSTEM
COLLEGE INDUSTRIAL PARK

CAPITAL COSTS PHASE 1

Cornett Hall	
Steel pipe suspended from ceiling; 1 1/2" - 170', 2" - 265', 4" - 40' diameter.	$ 4,340
Storage tank installed (2000 gallons)	1,500
Centrifugal booster pump installed (2 hp) B&G series 1510 type B, unit 106T.	1,000
Controls and valves.	3,000
Supply Pipeline	
Polybutylene bare pipe, 1580' of 4" diameter (material cost only) $3.05/LF.	4,820
CIP Distribution Pipeline	
FRP insulated pipe, 115' of 8" diameter (material cost only) $21.98/LF.	24,510

CIP Distribution Pipeline, cont'd:

Pressure control valve, 4" globe valve	$ 1,050
Subtotal	$40,220
Contingency @ 10%	4,000
TOTAL CAPITAL COST	$44,220

Cost of the centrifugal booster pump was quoted by Ray Bozlee, Larry Harrington Company, Inc., Portland (228-4324). Polybutylene piping material costs from Don McGlinchy, Western Rahn Corp. (415) 471-8856, and FRP piping from Rovanco, Joliet, Illinois.

Unit material costs for piping are shown on Table 9.

TABLE 9

UNIT PIPE COSTS

D Nominal Diam.	Bare PB* Sept. 1981	Bare FRP May 1980	Insulated PB Sept. 1981	Insulated FRP May 1980
2	1.45	5.34		8.00
3	3.22	4.55	10.14	9.97
4	5.29(3.05**)	5.84	13.36	11.98
6	11.27	9.05	21.05	16.37
8	19.09	13.62	30.32(25.02**)	21.98

*SDR11 Resin Desig. 4121, working at 190°F, 70 psi with surges up to 100 psi. Insulation is isocyanurate.

**Working at 140°F, 50 psi cost for 4 inch bare quoted $3.05 and $25.02 for 8 inch insulated with 2 to 1 safety factor on pressure delivered FOB Klamath Falls (2 October 81).

All other costs are based on the 1981 Means Mechanical & Electrical Cost Data.

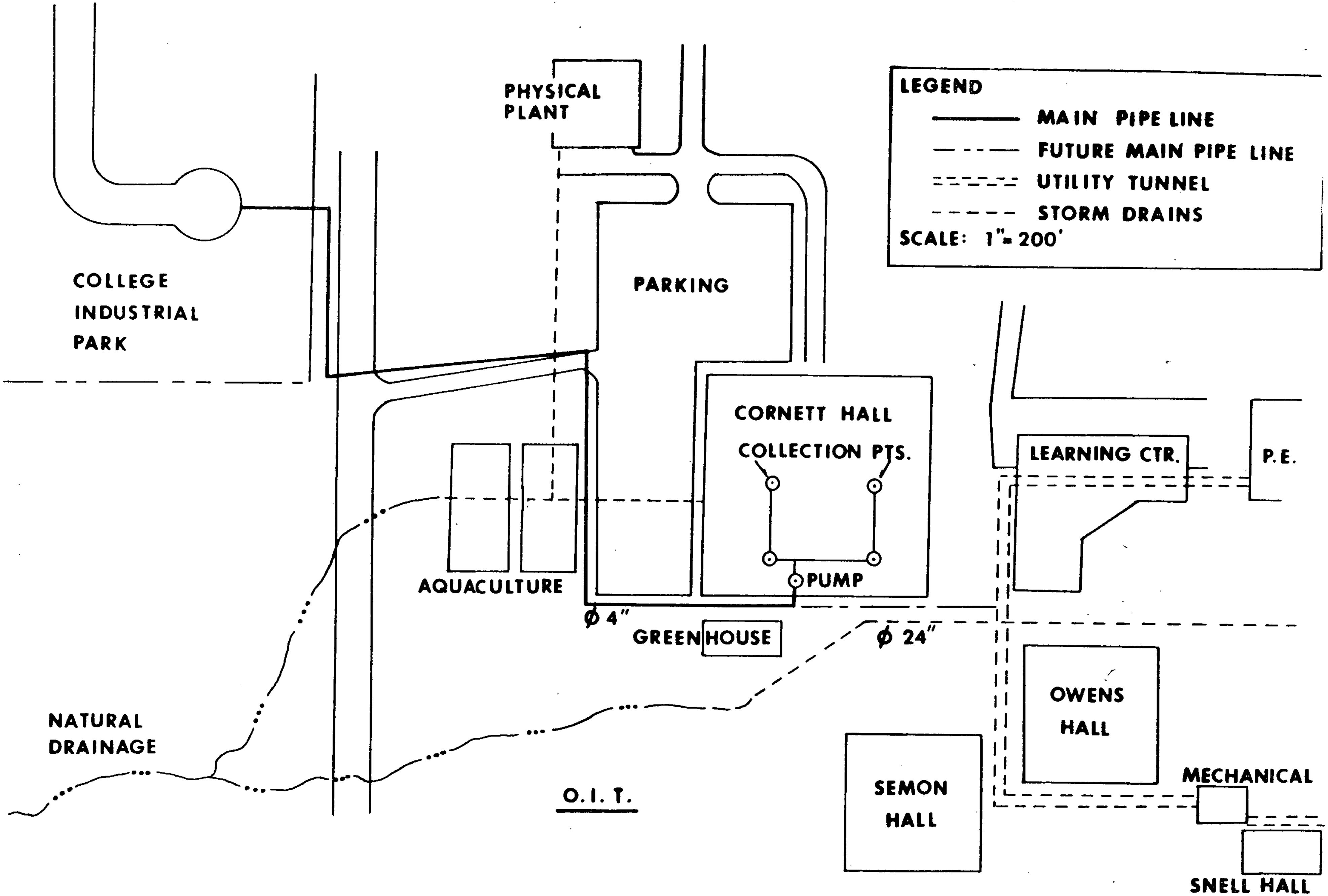


FIGURE 1. SUPPLY PIPING LAYOUT FOR COLLEGE INDUSTRIAL PARK

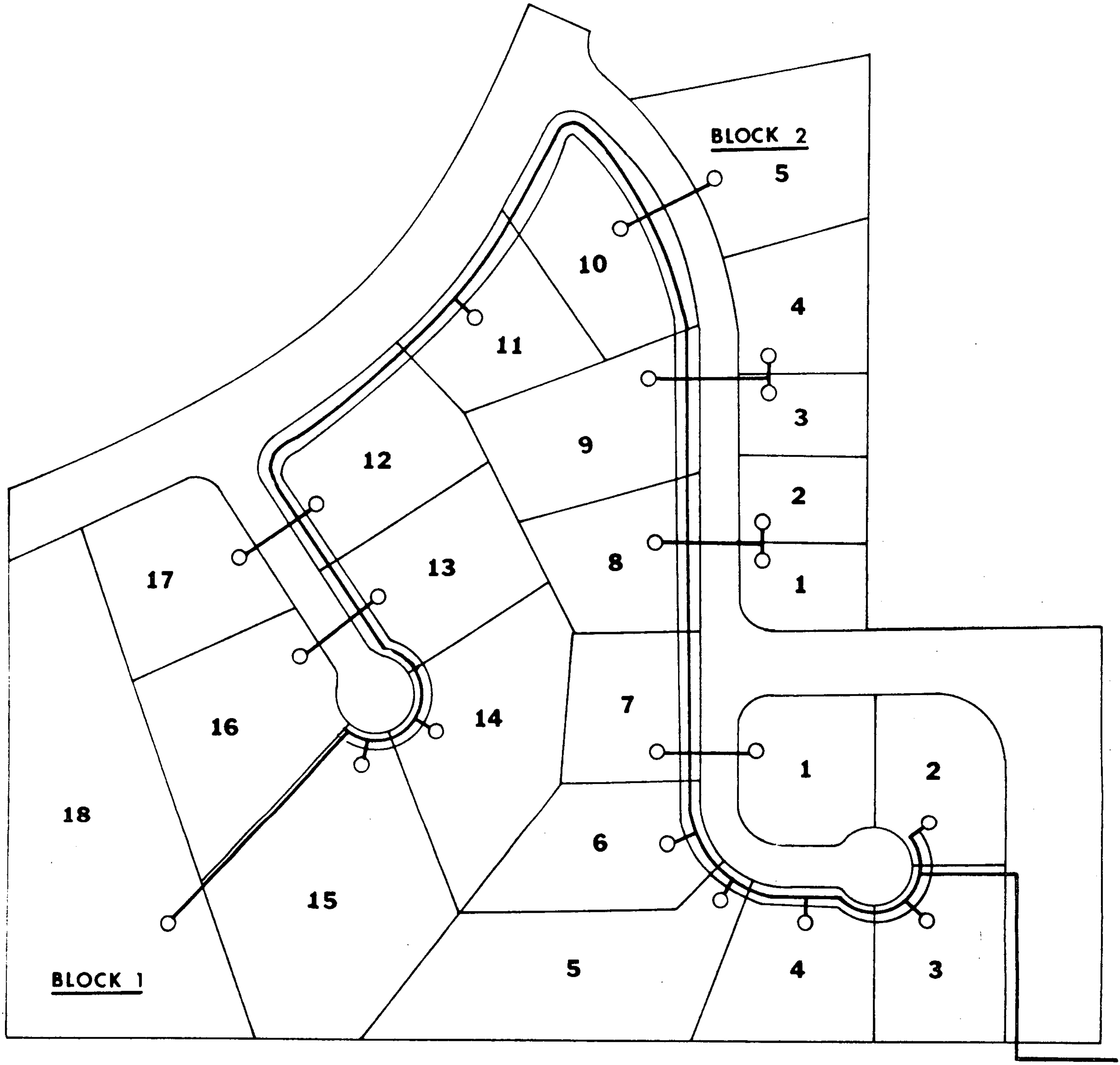


FIGURE 2.

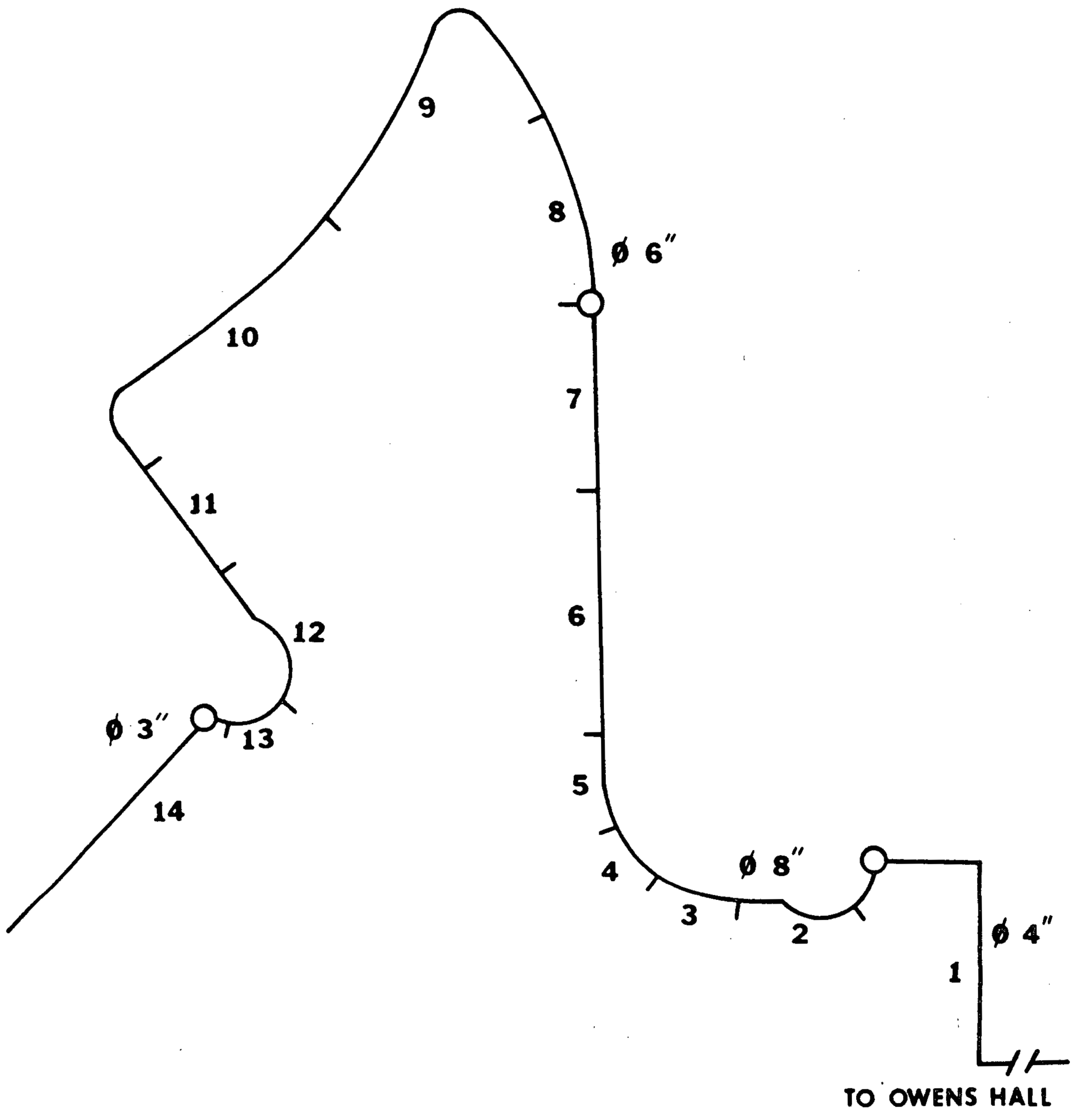


FIGURE 3. SUPPLY PIPING LAYOUT FOR INDUSTRIAL PARK

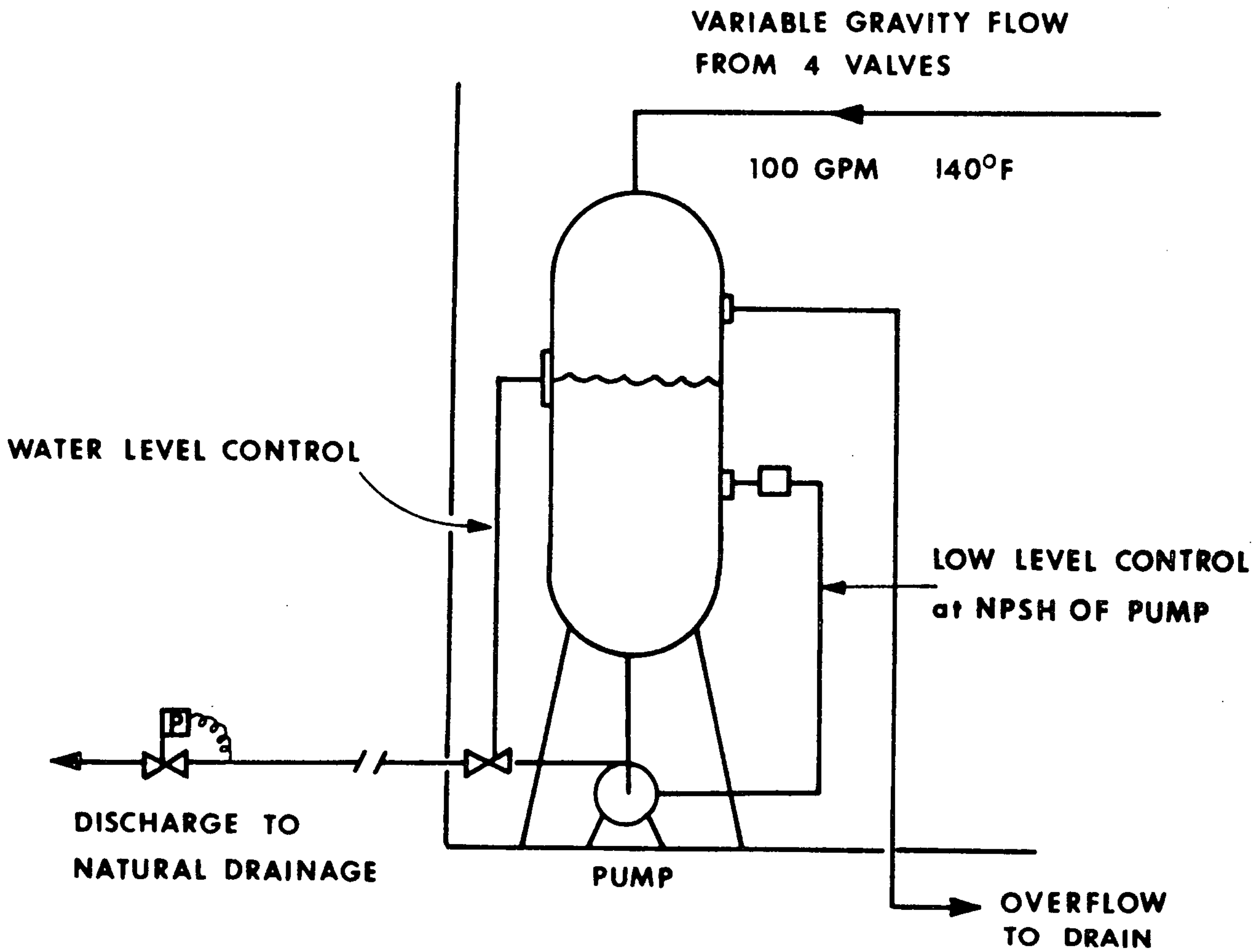


FIGURE 4. CORNETT HALL - COLLECTION SYSTEM FOR GEOTHERMAL WASTE WATER

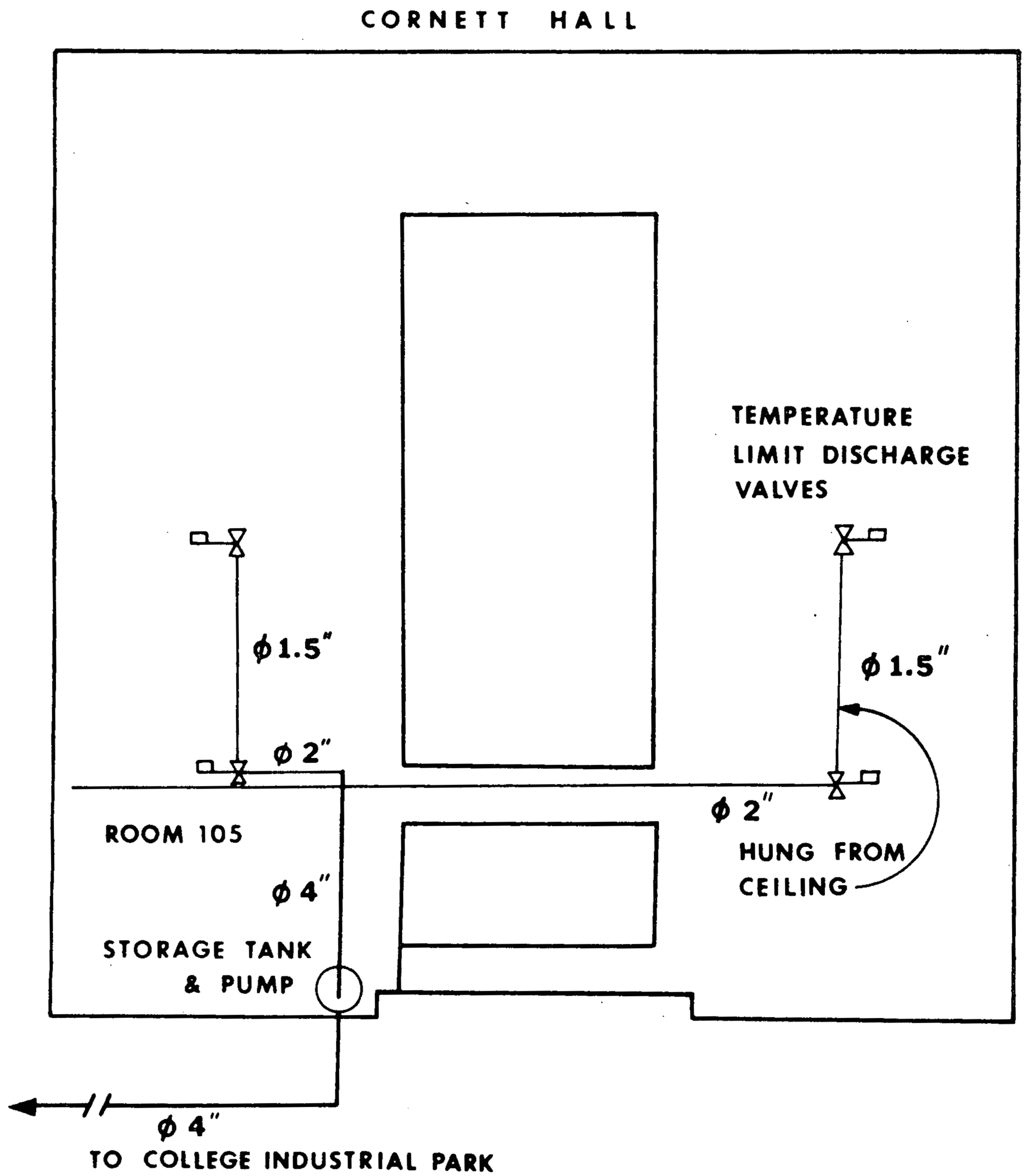


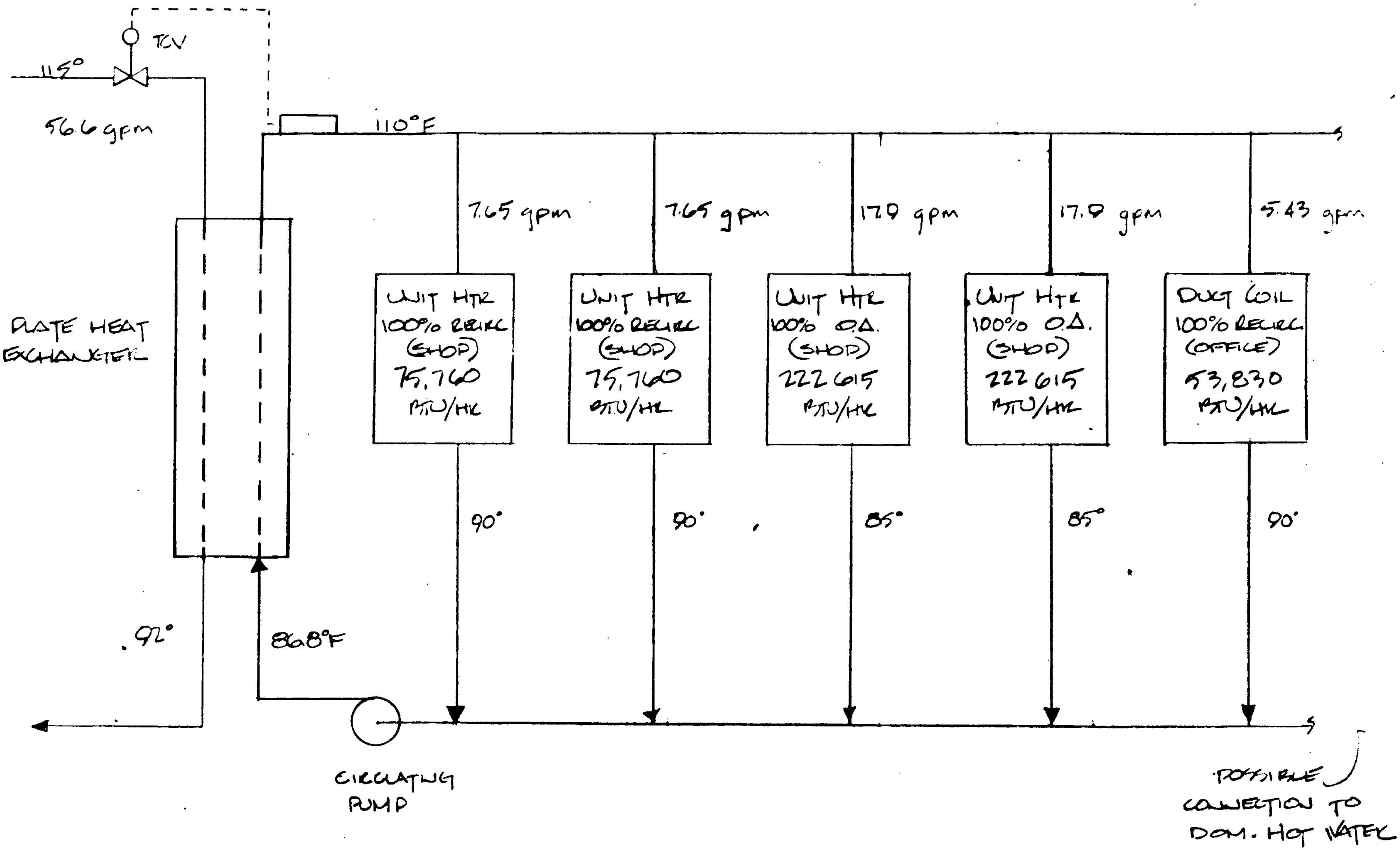
FIGURE 5. CORNETT HALL GEOTHERMAL WATER SEPARATION AND COLLECTION

APPENDIX A

Quality Components, Inc.

Retrofit to Geothermal

FLOW DIAGRAM FOR QUALITY COMPONENTS INC.
FIG 1



EXHAUST FAN CALCULATIONS

PRESENT SYSTEM -
- 2 UNITS RATED 8082 CFM
- RUN 3 MIN OUT OF EVERY 10 MIN

60 MIN / HR ÷ 10 = 6
6 · 3 = 18 MIN / HR

18 MIN / HR · 2 · 8082 FT³/MIN
= 290,952 FT³/HR

290,952 FT³/HR ÷ 60 MIN/HR
= 4849 FT³/MIN

4849 FT³/MIN ÷ 8082 FT³/MIN
= .60

RUN 1 EXHAUST FAN @ 60% OF PRESENT SPEED FOR CAPACITY OF 4850 CFM SHOULD BE ABLE TO ACCOMPLISH THIS WITH LARGER FAN PULLEY IN UNIT.

4850 ÷ 2 = 2425 CFM EA. FOR MAKE UP AIR UNITS

ONE EA IN NORTHWEST AND SOUTHEAST CORNERS ADJACENT TO EXISTING GAS FIRED UNITS.

TABLE 1
FINNED COIL CHARACTERISTICS

	SHOP ** 100% O.A. (2 REQ'D)	SHOP ** 100% RECIRC. (2 REQ'D)	OFFICE 100% RECIRC. (1 REQ'D)
ENTERING AIR (°F)	0	68	68
LEAVING AIR (°F)	85	95	95
ENTERING WTR (°F)	110	110	110
LEAVING WTR (°F)	85	90	90
AIR FLOW (CFM)	2425	2598	1846
FACE AREA (FT^2)	5.31 (30×25)	5.31 (30×25)	3.75 (30×18)
NO. OF FEEDS	4	3	2
CODE	1	1	1
ELEVATION (FT)	4500	4500	4500
ROWS	4	4	4
FINS PER INCH	10	9	9
AIR ΔP (IN WG.)	.32	.33	.34 *
PASSES	16	22	22
WATER ΔP (FT)	12.2	5.9	6.7
GPM	17.9	7.65	5.43
TUBES	16	16	11

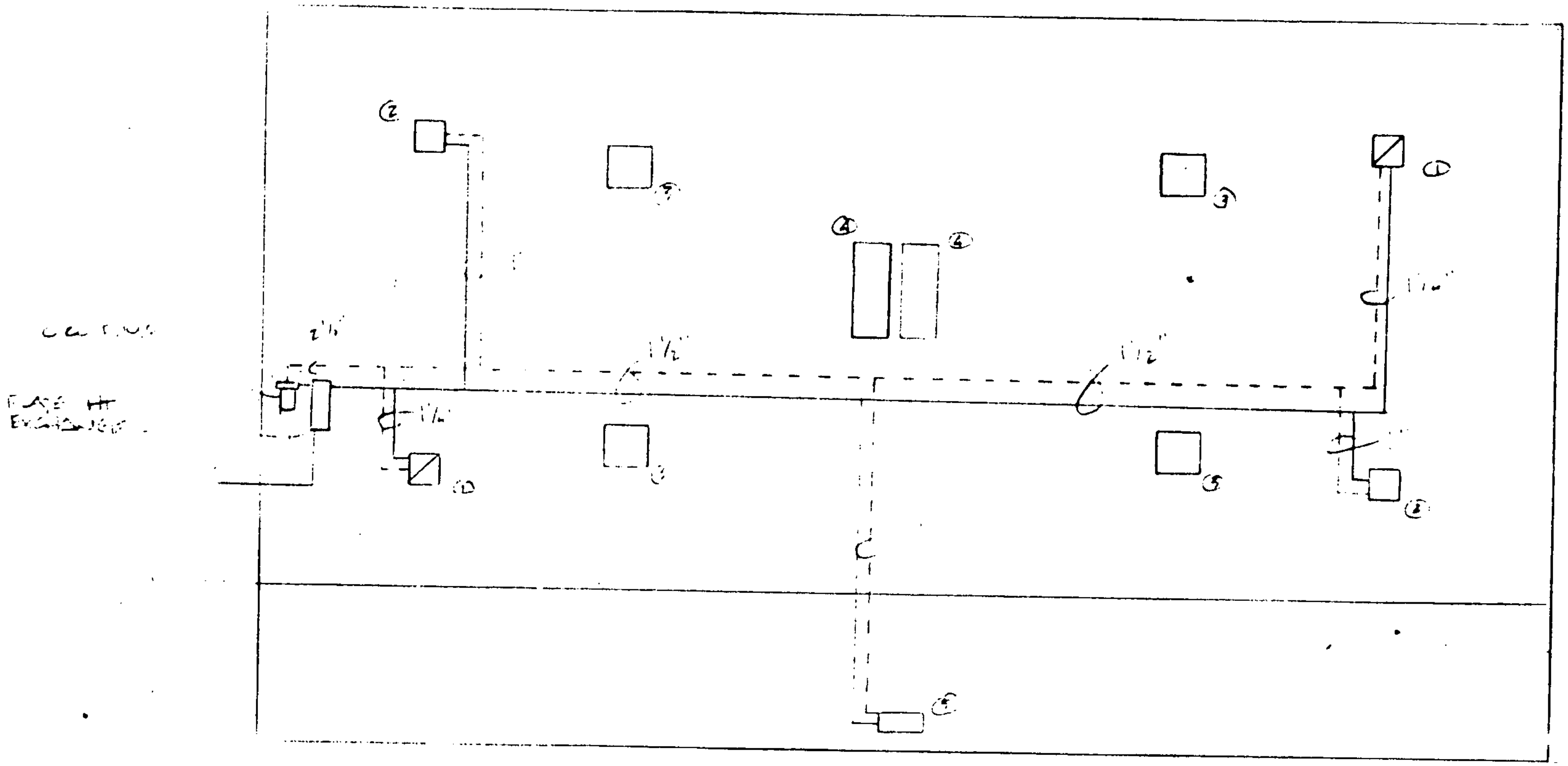
* AIR SIDE PRESSURE DROP ACROSS OFFICE COIL MAY EXCEED CAPACITY OF HEAT PUMP BLOWER THUS REQUIRING REPLACEMENT OF MOTOR IN ROOFTOP UNIT.

** BLOWERS FOR SHOP UNITS SHOULD BE RATED @ 2500 CFM @ .5 IN.WG.

SYSTEM LAYOUT · QUALITY COMPONENTS

FIG 2

——— SUPPLY LINE ---- RETURN LINE



KEY

① - 100% OA UNIT HTR

② - 100% RECIRCULATION UNIT

③ - SWAMP COOLER

④ - EX. INLET (ONE ONLY)

⑤ - DUCT COIL FOR OFFICE AREA

QUALITY [illegible] INC — HEAT LOSS AND ANNUAL ENERGY

HEAT LOSS
SHOP AREA

WALLS:

CONCRETE	.70 · 2043 · .68	= 97,230
FRAME	.0698 · 2043 · 68	= 9720
ROOF	.0229 · 8120 · 68	= 12688
FLOOR EDGE	255' · 37.5	= 9570
GARAGE DOORS	230 · 1.29 · 68	= 20175
STD. DOORS	63 · .49 · 68	= 2099
VENTILATION	.8082 · 2 · 18 · .075 · 24 · 68	= 356,125
		501,607

OFFICE AREA

WALLS	.70 · 256 · .68	= 12186
	.0698 · 6225 · 68	= 2954
GLASS	337.5 · .45 · 68	= 10327
FLOOR EDGE	152 · 37.5 ·	= 5700
ROOF	.07 · 2160 · 38	= 5747
INFIL	.80 · 288 · 1.08 · 68	= 16920
		53,835

ANNUAL ENERGY REQUIREMENT

OFFICE:

$$\frac{(53835 - 5747) \cdot 6516 \cdot 24}{1.8 \cdot 3413 \cdot 68} \cdot .72$$

= 12,961 kwh/YR

SHOP

$$\frac{(501607 - 76315) \cdot 24 \cdot 1933}{68 \cdot 90501 \cdot .80} \cdot .72$$

= 2924 GAL/YR

$$\frac{15148.2 \cdot 24 \cdot (6516 - 1933)}{68 \cdot 90501 \cdot .80} \cdot .72$$

= 2435 GAL/YR

= 5359 GAL/YR